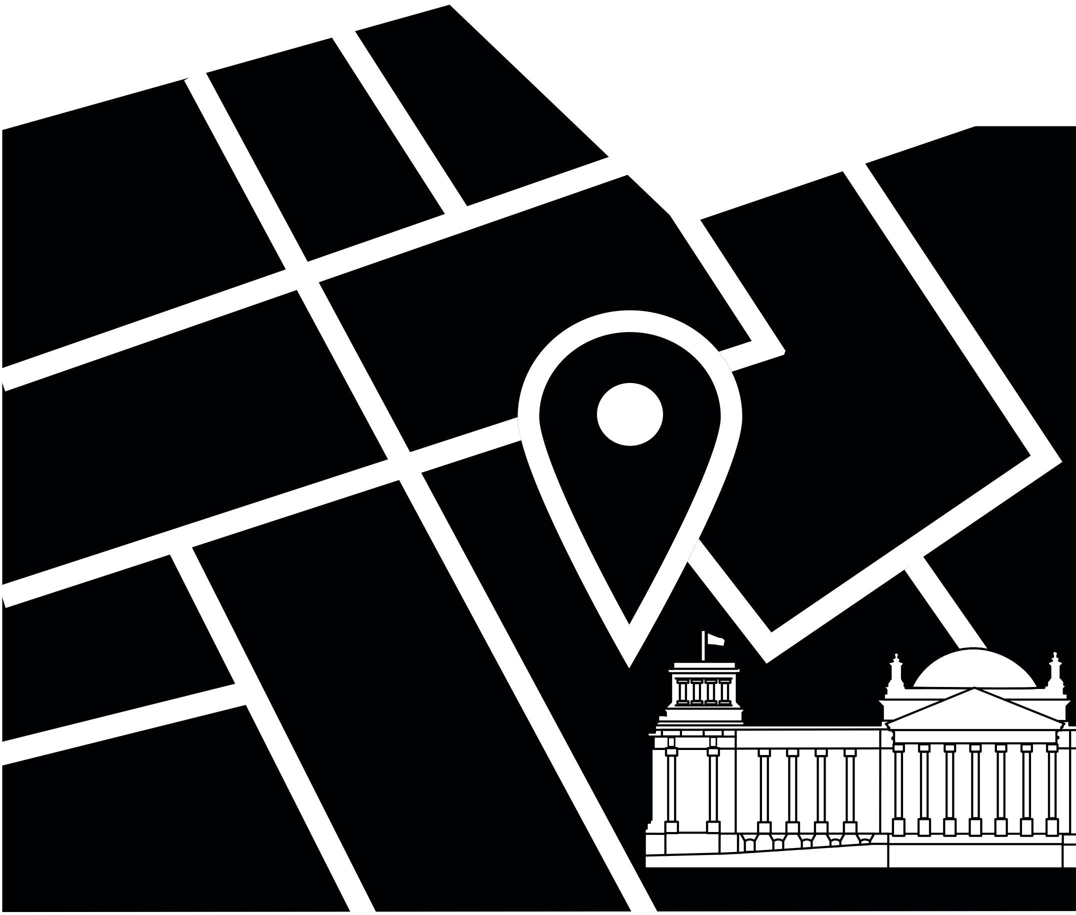
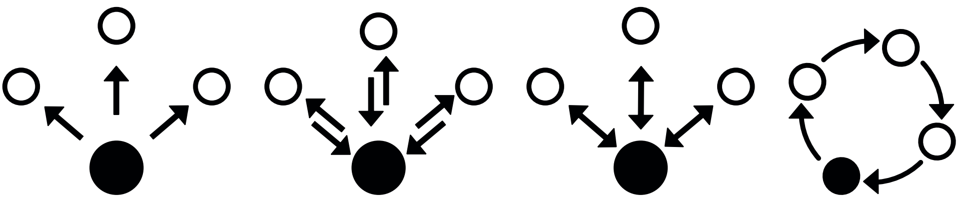
Integrating Augmented Interactive Geo-visualizations and Open Government

Thore Fechner





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Integrating Augmented Interactive Geo-visualizations and Open Government

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Lastly, I owe a debt of gratitude to friends and family for understanding, helping, and encouraging me throughout the past years. Thank you for constantly backing me.

Abstract

High hopes are pinned to reshaping civic engagement in Open Government Initiatives that seek to open up governmental processes and data by using modern information and communication technologies. The aim is to facilitate citizen engagement through open interactions and access to data by emphasizing transparency, participation, and collaboration. However, a key need for Open Government Initiatives is to create and adopt information and communication technologies that are easily accessible and that reflect the envisioned cultural change. The intended cultural shift needs to be supported by the technical innovation, and existing approaches need to be rethought, renegotiated, and augmented.

This thesis formulates and evaluates an approach to facilitate citizen engagement with Augmented Interactive Geo-visualizations (AIGs) to address the need. AIGs use space and time as integrators that allow citizens to contextualize, visualize, and engage in different ways. The central research question of this thesis investigates the effects of AIGs on citizen engagement. Four guiding questions inform the research question and look at pre-requisites and challenges. First, a design space is conceptualized that identifies aspects that AIGs should support for different levels of citizen engagement. Second, potential roles of civil society actors in Open Government Initiatives are described to understand the target audience and their needs. Third, best practices for providing geospatial Open Government Data are established to facilitate subsequent use. Fourth, three AIG prototypes have been developed and evaluated for specific instances and levels of citizen engagement to investigate their effects.

Readers can use the contributions of this thesis, for example, to inform their Open Government strategy, consider the best practices to enhance the provision of Open Government Data, and adapt or draw inspiration from the AIG design space and the prototypes.

Zusammenfassung

Es gibt große Hoffnungen, zivilgesellschaftliches Engagement im Rahmen von Open Governement Initiativen neu zu gestalten, da diese es zum Ziel haben, staatliche Prozesse und Daten mittels moderner Informations- und Kommunikationstechnik zu öffnen. Das Ziel ist es, Bürgerbeteiligung mittels offener Interaktionen und Zugang zu Daten zu stärken und einen Schwerpunkt auf Transparenz, Partizipation und Kollaboration zu legen. Deshalb ist es eine zentrale Notwendigkeit für Open Government Initiativen, Informations- und Kommunikationstechniken zu entwerfen oder anzupassen, die den gewünschten kulturellen Wandel abbilden. Dieser Kulturwandel muss von den technischen Innovationen unterstützt, und existierende Herangehensweisen überdacht, neu verhandelt und erweitert werden.

Vor dem Hintergrund dieser Notwendigkeit formuliert und untersucht diese Arbeit einen Ansatz zur Förderung von bürgerschaftlichem Engagement mittels erweiterter und interaktiver Geo-visualisierungen (AIGs). AIGs nutzen Raum und Zeit als Integratoren, um Bürgern Kontextualisierung, Visualisierung und verschiedene Möglichkeiten zum Engagement zu bieten. Die Hauptforschungsfrage dieser Arbeit untersucht die Effekte von AIGs auf bürgerschaftliches Engagement. Vier Leitfragen strukturieren die Forschungsfrage und untersuchen Vorbedingungen und Herausforderungen. Zuerst wird ein Design Space konzeptualisiert, der Aspekte identifiziert, die AIGs in Bürgerbeteiliungsverfahren unterstützen sollten. Zweitens werden potentielle Rollen von zivilgesellschaftlichen Akteuren in Open Government Initiativen beschrieben, um die Zielgruppe und ihre Bedürfnisse zu verstehen. Drittens werden Best Practices zur Bereitstellung von öffentlichen Daten formuliert, um deren Nutzung zu fördern. Viertens sind drei AIG Prototypen entwickelt und evaluiert worden, um ihre Effekte auf einzelne Bürgerbeteiligungsverfahren und Stufen zu untersuchen.

Leser können die Forschungsbeiträge dieser Arbeit zum Beispiel als Anregung für ihre Open Government Strategie nutzen, die Bereitstellung von öffentlichen Daten anhand der Best Practices verbessern und sich vom AIG Design Space oder den Prototypen inspirieren lassen und diese adaptieren.

Contents

List of Publications

Major parts including texts, ideas, and fragments of this thesis have been published previously. Literal or rephrased pieces—including complete texts—of all publications listed below are spread across *all parts* of this thesis and are not separately denoted. Most notably, P2-P5 are the basis for parts III and IV. P2 corresponds to chapter 10 while P3–P5 correspond to chapter 12 that presents the three prototypes that were developed for this thesis.

P1 Thore Fechner and Christian Kray, "Geo-referenced Open Data and Augmented Interactive Geo-visualizations as Catalysts for Citizen Engagement," EJournal of eDemocracy and Open Government, vol. 6, no. 1, pp. 14–35, 2014.

P2 Thore Fechner and Katharina Obuch, "Civil Society and Open Government Data: Challenges and Opportunities," in Civil Society and Innovative Public Administration, 1st ed., M. Freise, F. Paulsen, and A. Walter, Eds. Baden-Baden: Nomos, 2015, pp. 353–376. DOI: 10.5771/9783845246086-353

P3 Thore Fechner, Dominik Schlarmann, and Christian Kray, "Facilitating Citizen Engagement in Situ: Assessing the Impact of Pro-active Geofenced Notifications," in Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services – MobileHCI '16, New York, New York, USA: ACM Press, 2016. DOI: 10.1145/2935334.293537 (in print).

P4 Thore Fechner and Christian Kray, "Presenting Citizen Engagement Opportunities Online: The Relevancy of Spatial Visualization," in Lecture Notes in Geoinformation and Cartography, T. Sarjakoski, M. Y. Santos, and T. Sarjakoski, Eds. Springer International Publishing, 2016, pp. 105-121. DOI: 10.1007/978-3-319-33783-8_7

P5 Thore Fechner, Dennis Wilhelm, and Christian Kray, "Ethermap—Real-time Collaborative Map Editing," in Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems – CHI '15, New York, New York, USA: ACM Press, 2015, pp. 3583–3592. DOI: 10.1145/2702123.2702536

P6 Christian Kray, Dennis Wilhelm, Thore Fechner, and Morin Ostkamp, "Natural Interaction with Video Environments Using Gestures and a Mirror Image Avatar," in Human-Computer Interaction — INTERACT 2015, J. Abascal et al., Eds. Springer International Publishing, 2015, pp. 387–394. DOI: 10.1007/978-3-319-22668-2_29

List of Figures

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List of Abbreviations

AIG Augmented Interactive Geo-visualization

API Application Program Interface

AttrakDiff AttrakDiff 2

CKAN Comprehensive Knowledge Archive Network

CSCW Computer Supported Collaborative Work

CSO Civil Society Organization

CSV Comma Separated Values

CTO Chief Technology Officer

DCAT Data Catalog Vocabulary

EC European Commission

EDP European Data Portal

ETFA European Free Trade Association

EU European Union

FOI Freedom of Information

FOIA Freedom of Information Act

FOSS Free and Open Source Software

GDI-DE Geodateninfrastruktur Deutschland

GIS Geographic Information System

GPS Global Positioning System

HCI Human-Computer Interaction

HOT Humanitarian OpenStreetMap Team

IAP2 International Association for Public Participation

ICT Information and Communication Technology

INSPIRE Infrastructure for Spatial Information in the European Community

LBS Location Based Service

MC-SDSS Multi-Criteria Spatial Decision Support System

NASA-TLX NASA Task Load Index

NGO Non-governmental Organization

NRW North Rhine-Westphalia

NUTS Nomenclature of Territorial Units for Statistics

OG Open Government

OGC Open Geospatial Consortium

OGD Open Government Data

OGI Open Government Initiative

OGP Open Government Partnership

OKFN Open Knowledge Foundation

OSM OpenStreetMap

PDF Portable Document Format

PPGIS Public Participation Geographic Information System

PSI Public Sector Information

RDF Resource Description Framework

SBM Stiftung Bürger für Münster

SDI Spatial Data Infrastructure

SDSS Spatial Decision Support System

SUS System Usability Scale

TEU Treaty on European Union

UI User Interface

UK United Kingdom

USA United States of America

UUID Universally Unique Identifier

W3C World Wide Web Consortium

WFS Web Feature Service

WMS Web Mapping Service

XML Extensible Markup Language

I

Introduction

1 Overview

Faced with the challenges of the 21st century such as accelerating globalization, climate change, demographic shifts, poverty, and migration flows governments need new strategies and a cultural change. Existing workflows and coping strategies reach their scaling limit as problem complexities rise and additional stakeholders are involved in government actions. Expectations of the population regarding information and participation shift with the increasing digitization, as it is increasingly interconnected and enabled by modern Information and Communication Technologies (ICTs). As such, governmental communication habits and structures need to be rethought, renegotiated and augmented.

In this context, "Open Government" is the often heard catch phrase that encapsulates the necessary multifaceted and tiered government reforms. The underlying premise is simple but hard to achieve as governments' relationships with citizens and between authorities need a new footing. The idea of Open Government (OG) revolves around two main pillars: open access to government data and open interaction between involved stakeholders. Open access means that government data produced by public bodies should be transparent, easily available, and re-usable for everybody. This kind of open access to government data is commonly called Open Government Data (OGD). Open interaction emphasizes collaboration and participation between government, civil society, and private sector entities.

Open Government is *as much about cultural change as it is about technical innovation:* enabled by modern ICTs, governments can supply digital data related to government actions and decisions in a cost efficient and greatly simplified way compared to analog forms. Furthermore, as society's digitization increases, governments need to adopt and use the digital space not only for service delivery in the sense of e-government, but rather as a complementary structure that facilitates transparency and open interaction between stakeholders.

ICTs are the vehicle to help drive this cultural change towards OG and Figure 1.1 shows an example of modern ICT use. The website of the Open Government Partnership (OGP) visualizes participating countries using an interactive geo-visualization that fosters exploration. Website visitors can explore participating countries in different ways using the geo-visualization as it is interactive instead of static: a mouse hover above a country superimposes the country's name. Clicking on a country opens up additional information on a dedicated page. Visitors can zoom and pan in the geo-visualization to focus on specific parts. The OGP is a voluntary multilateral initiative that provides an international forum to share experience among governments and Civil Society Organizations (CSOs) with Open Government Initiatives (OGIs).

Several websites and applications offer informative geo-visualizations. They are often present in services such as public transportation, tourism, wayfinding or anything that uses spatial information. Informative geo-visualizations have become ubiquitous as they evolved from once purely static representations to interactive artifacts that are customizable "windows" to the world. Spatial structures underpin our societies—from local and communal levels like neighborhoods, districts, and cities to global levels like states and countries. Humans can easily relate to space and place as concepts, since everybody lives in spatial structures.

Hence, interactive geo-visualizations seem like a natural fit for OGIs. As OGIs aim to strengthen civic engagement by explicitly focusing on participation and collaboration it is odd that interactive geo-visualizations are often used to inform citizens, but rarely if ever adopted for consultation, involvement, or collaboration.

The idea of OG has gained traction. Since September 2011 when eight countries launched the OGP, 66 countries have declared their commitment and signed the declaration. Members of the OGP commit to supporting civic participation, fighting corruption, and to pro-actively providing high-value information including raw data, that the public can easily use. Explicitly included in the declaration is a passage about increasing access to new technologies for openness and accountability.

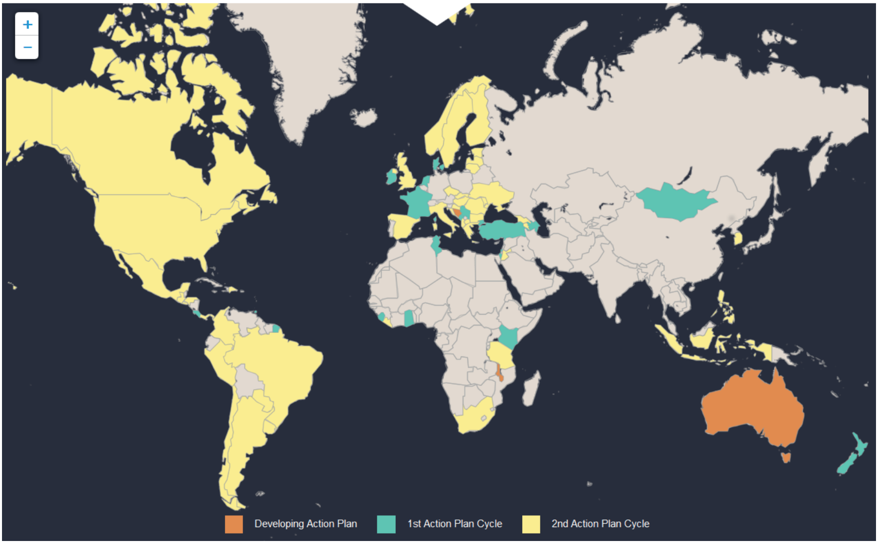


Figure 1.1.: An interactive geo-visualization found on the landing page of http://www.opengovpartnership.org/, accessed in September 2015. Visitors can explore participating countries and the status of their national action plan.

The goal is "to harness these technologies to make more information public in ways that enable people to both understand what their governments do and to influence decisions".[1]

With this in mind, the overall objective of this thesis is to examine the effects of Augmented Interactive Geo-visualizations (AIGs) on citizen engagement in OGIs. The presented research focuses on the relation between government and citizens. Civil society actors' roles in OGIs are investigated, and factors that determine the effects of geospatial OGD inspected. Also, properties of geoinformation technologies are identified that may help in citizen engagement scenarios. Consequently, this thesis was written with the following audience in mind:

[1]See http://www.opengovpartnership.org/about/opengovernment-declaration, accessed October 08, 2015.

Open Government practitioners. OG aims at society as a whole, but until "open" becomes the norm it is crucial to have flagship projects and practitioners that demonstrate the value of the notion. Practitioners may benefit from this thesis as it outlines best practices and challenges for publishing geospatial OGD from existing geospatial infrastructures. The presented insights are based on a study that the author co-authored for the federal government of North Rhine-Westphalia (NRW), and the author's involvement in the realization of the European Data Portal (EDP). The EDP aims to federate all available (open) data of the European Union (EU). Additionally, practitioners can use and adapt three prototypical geo-visualizations that were developed as descriptions and source code are publicly available under open licenses.

Civil servants. Civil servants are called upon to implement OG in the day-to-day operations of public administration. They are affected by factors like the political will or budgetary constraints. This thesis can serve as a starting point to understand the OG notion, as it examines the key concepts and challenges. In addition, civil servants can draw upon the arguments that are put forth in this thesis to convince hesitant colleagues or rebut internal resistance in their organization. Civil servants that implement OG are also OG practitioners. As such, the gained insights on providing geospatial OGD and the developed prototypical geo-visualization can help and inform them to formulate their own OG strategies.

Citizens. Everybody is a citizen. OGIs only recently gained traction and only in retrospect it will be possible to tell if governments embraced open access to their data and open interaction with all stakeholders. However, OGIs requires not only governments to change: Citizens are equally called upon to engage in the political process and take action. This thesis allows citizens to take a look behind the curtain and understand the complexities that OGIs face. Citizens might be interested in the identified challenges, the concept of OG or the prototype geo-visualizations. If citizens wish to engage or understand OGIs better after reading this thesis, they have already contributed to the OG idea.

Researchers. OG is just emerging—but researchers are already investigating the notion. The existing body of knowledge contains viewpoints from fields like politics, law, sociology, economy, and informatics, among various others fields. This thesis is part of Human-Computer Interaction (HCI) research (see chapter 4 for details) and thus primarily targets researchers from this and adjacent fields. Still, other researchers might find it useful as the existing body of knowledge is complemented with an exploratory overview of OG. The review and subsequent conceptualization exhibits how intertwined OG and geoinformatics techniques and technologies are, ranging from the provision of OGD to engaging citizens via geo-visualizations. Furthermore, researchers may obtain new insights from the evaluations of the three prototypes and benefits from their open publication as well.

Five contributions are made in this thesis, see chapter 15. The first contribution identifies and describes four effects that AIGs have on citizen engagement. Aspects that make geoinformation technologies useful for citizen engagement were identified and conceptualized in an AIG design space for the second contribution. The roles civil society actors might take on in OGIs are looked at in the third contribution. For the fourth contribution, the provision of geospatial OGD is investigated and best practices formulated how existing infrastructure and processes can be adapted and leveraged. The final contribution evaluated three prototypical implementations of AIGs and their effect on citizen engagement.

The following chapter of this first part of the thesis expands on the motivation that drives the research. It looks at various open movements, placing them into context, and explains the motivation to integrate OG and AIGs. Next, objectives including the research question and scope of this thesis are presented. Subsequently, the research design is laid out, explaining the multi-method approach applied in this thesis. This first of four parts closes by outlining the remaining three parts of this thesis.

2 Motivation

> My dear boy, it is a contradiction in terms—you can be open or you can have government.
> *Sir Arnold in BBCs "Yes, Minister"*
> *Episode 1 entitled Open Government, aired in 1980*

One has to see this fictional quote in its context: "Yes, Minister" is a satirical British comedy series that aired more than three decades ago. The show looked at public administration and politics in a humorous way depicting politics as a world full of double talk and scheming.[1]

A short overview of the idea and current state of OG was provided in the previous chapter. This chapter motivates the research presented in this thesis, explaining *why open and government are not a contradiction in terms and how Augmented Interactive Geo-visualizations (AIGs) can act as a facilitator for Open Government.*

Different motivations for OG and openness in general are briefly examined in section 2.1. This chapter closes with section 2.2 motivating why OG and AIGs are heavily intertwined. For a more comprehensive review of the body of knowledge on OG, OGD, citizen engagement, and geo-visualizations please refer to part II of this thesis that looks at key concepts and related work.

[1] "Yes, Minister" follows Jim Hacker, as he is introduced into and runs his new office as the "minister of administrative affairs". In the first episode, Hacker starts out with the goal to introduce Open Government to "cut through the red tape" and to raise transparency. By the end of the first episode, Hacker quietly drops the idea of Open Government to avoid a potential scandal he is involved in. The scandal might come out if the public gets access to certain documents that detail his involvement. The twist in the plot is that the entire situation was fabricated by the Permanent Secretary of the Ministry, Sir Humphrey, who is not interested in Open Government and a streamlined department.

2.1. Open Movements

Multiple "open movements" are in existence. They aim to provide free and open access to, for example, data, information or cultural work:

The Free and Open Source Software (FOSS) movement is well established, enabling various applications and devices worldwide [1, 2]. Open Access aims to provide free access to research online, without placing restrictions on the use [3]. Open Culture gained traction as well as portals like Europeana[2] collect and provide online access to cultural works from the public domain using open licenses if possible.

Several nuances apply to each particular movement, e.g., distinctions are made between Open Source and Free Software [4], but the underlying premise stays the same [5]: Individuals or groups are enabled to interact and engage with information on their own terms. In this open process, benefits can be accumulated over time. Synergies are explored, learning and understanding fostered, and value is added during the process [6, p. 188]. The common denominator of all open movements is transparent access to the object of interest, and freedom to use, build something with or change it.

The same holds true for OGD and OG in general. Maier-Rabler *et al.* [7] write that the "Open" in Open Government and Open Data stands for the changing relationship between citizens and authorities. They elaborate further that "in the *open* approach socio-technical aspects meet political demands for co-creation by citizens and authorities in the online or offline world [...]" [7, p. 185].

According to Tapscott [8] governments need to switch from industrial-age workflows that operate on vertical information flows towards interconnected networks that co-innovate. They need to share resources that were previously closely guarded and to stop behaving as confined department or jurisdiction. The motivations for governments to do so are to meet the demand of the public for greater transparency and

[2] See http://www.europeana.eu/ and Europeana's Open Culture App, both accessed October 29, 2015.

influence, to operate effectively while under fiscal pressure, to build and keep trust, and to engage stakeholders to foster reforms [9].

The idea of OG is best illustrated with a simple example: Public transport agencies decide to publish data about their facilities and network as OGD. Various elements are present in the data and a CSO takes note. The civil society actors decide to create a simple application based on this data. Additional data from the website of the public transport agencies is processed by the CSO and added to the application. The goal is to support citizens with mobility impairments by making broken lifts known.

After a while, the created service gains popularity in the general population. Subsequently, the public transport agencies reach out to the civil society actors. They publish additional data like planned lift repairs and help to enhance the application. A second and improved version of the application is launched collaboratively by the public transport agencies and the CSO.

This is a real-world example: The website BrokenLifts[3] provides this kind of information, based on data from the public transport agencies in Berlin. The idea was conceived during a hackathon and the first version implemented in under 48 hours in 2011. A collaboration of involved stakeholders led to an improved relaunch of the website in 2014. The take home message is: *Good ideas can come from everywhere.*

Some readers might find other challenges more pressing than broken lifts. Nonetheless, it is important to note that this is an actual example of a collaboration between large public agencies with a stakeholder. The collaboration came into existence because some data was available, an idea to meet a certain need was conceived and addressed by a stakeholder. In a joint effort, a subsequent iteration was developed by the public agencies and the civil society actor. This is the behavior OG advocates rally for—collaboration and participation. Figure 2.1 shows the relaunched website.

Cultural change that emphasizes collaboration and participation in conjunction with open access to data can lead to unexpected outcomes,

[3] See http://www.brokenlifts.org/, accessed January 14, 2016.

Figure 2.1.: BrokenLifts was created in a collaboration of civil society actors and public transport agencies in Berlin while the first version was implemented during a hackathon. See http://www.brokenlifts.org/, accessed January 14, 2016.

small or large. Management of change processes take a tremendous amount of time and have to be build up slowly. Albeit the above example is centered around data, it illustrates the process of open collaboration. OG is not just about the usage of ICTs for better public service delivery. Instead, it focuses on transparent and open processes while engaging the public in government affairs [10, p. 45]. Broken lifts seem trivial, but *the value lies in the changed behavior pattern of all parties.*

Aside from strengthening collaboration between stakeholders, OG is said to have economic effects. While the estimations differ considerably, the potential of opening up public sector information is considered to have a significant impact. Neelie Kroes, former Vice-President of the European Commission (EC) and Commissioner for the Digital Agenda, stated that by opening up Europe's public data, up to € 70 billion in economic activity could be generated per year [11]. Other estimations by the EC place the generated economic activity around € 40 billion per year [12].

The OECD [9, p.13] concluded its OG report stating that reinventing the partnership between civil society and the public sector to foster collaboration will become a cornerstone of future public sector reform. However, the OECD also concluded that this reinvention will surely be one of the key challenges the public sector faces in the 21st century.

As with every vision, the arising question is how well it can be implemented. Realizing open access to data and open interaction in the day-to-day operations of public administrations requires reforms, flagship projects, and a cultural change. The necessary processes will likely occupy researchers, practitioners, civil servants, and policymakers from various fields in the foreseeable future.

2.2. Geo-visualizations and Citizen Engagement

The previous section provided a brief overview of the cultural shift that is currently taking place enabled by various open movements. Yet, the question how open interaction and access to data can manifest themselves in government operations needs to be addressed. This section examines the intertwined nature of geospatial information and citizen engagement. Furthermore, it motivates why AIGs are one potential way to facilitate open interaction in OGIs.

The argument that is made here has two components: The first part is that everybody can easily relate to space and place as we live in spatial structures. As such, geospatial information can act as an *integrator for citizen engagement*. The second part of the argument is that *augmented and interactive* visualizations of geospatial information can facilitate citizen engagement. Augmented Interactive Geo-visualizations can help to structure the content by fostering exploration and interaction, establish a connection to the engagement case, and frame the process.

Researchers have shown how data and spatial dimension blend: Taylor *et al.* [13] report on the physical and social dimension and on how “data, people, and things intermingle to continuously enact place” [13, p. 2846].

Crivellaro *et al.* [14] highlight that associations to place prompted citizens to rediscover, contest and understand their city. They used digitally supported urban walks and a city map as a rhetorical artifact to connect city residents with their cities' processes and mechanisms. The importance and impact of "localness" in the creation of user-generated content and data is documented similarly [13, 15].

Hence, it is not surprising that Kuhn [16] sees spatial information as one of the most powerful information integrators and as a transdisciplinary enabler for societal problem solving. Governmental actors share a similar view as, e.g., the EC [12] views geospatial data as a vital component of OGD and explicitly mentions its importance. As geo-visualizations already visualize and contextualize geospatial information they seem like a natural fit to engage citizens. Yet, they need to do more. Different types and levels of citizen engagement need to be addressed, as citizen engagement varies depending on the intent, context, policy or program [17, 18]. Some form of communication and exchange is always required, be it with citizens directly or with intermediaries. "Citizens need information to *see* what is going on inside government and participation to *voice* their opinions about this" [19, p. 11].

As OGIs are about openness in *information* and *interaction* [19] the used ICTs need to support and foster this kind of behavior. The geo-visualizations need to be *interactive* to allow citizens to engage, explore, participate, and collaborate with public administrations. Furthermore, they need to be *augmented* to support the different levels of citizen engagement conceptually. For example, collaborations benefit from advanced communication functions such as textual chats if collaborators are not co-located but work on a project at the same time. Similarly, questions of provenance are often important in collaborations to find out what was added, edited or deleted by whom. If information is only provided to citizens, communication between citizens and the information provider is likely not as important, but taking individual citizen preferences into account benefits the information distribution.

Several indications are present that AIGs and citizen engagement are a good fit: CSOs already use geo-visualizations to structure encounters between their organization and audience.

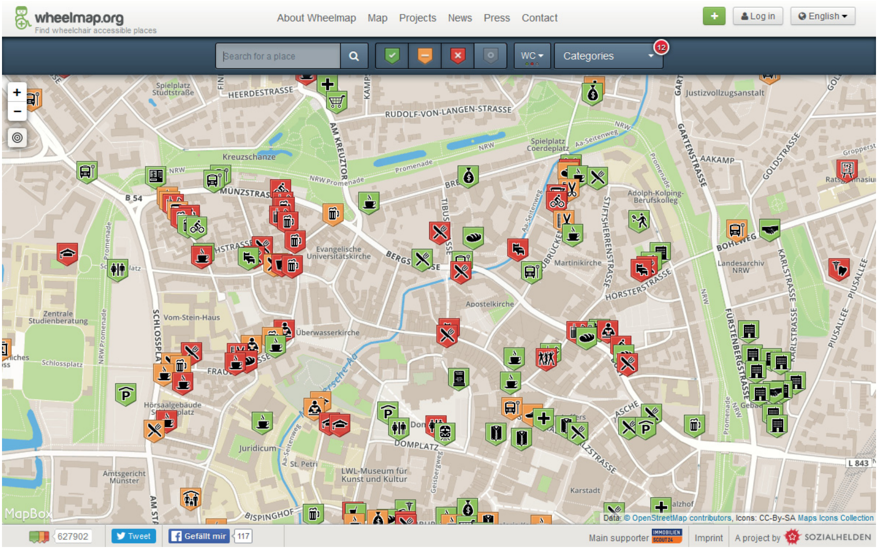


Figure 2.2.: WheelMap allows users to visualize, search, create, and rate wheelchair user accessible places worldwide. The figure shows the situation in the inner city of Münster, North Rhine-Westphalia, Germany. See http://www.wheelmap.org/, accessed January 14, 2016.

According to Elwood *et al.* [20] CSOs use geo-visualizations to encourage donation, facilitate communication, raise awareness, and for monitoring purposes. She provides and discusses examples such as Ushahidi. Ushahidi was created ad-hoc in January 2008 by civic activists at the height of the post-election violence in Kenya. The website allowed to report acts of violence via mobile phone text messages and visualized the reports on an interactive map. Ushahidi is one well-known example how civic activists developed and used geo-visualizations to raise awareness and facilitate sharing of information [21]. Ushahidi has since evolved into an open-source platform that supports crowd-sourcing and geo-visualization for various purposes. Another example for an interactive geo-visualiation that was created by a CSO is WheelMap, see

Figure 2.2. WheelMap allows users to visualize, search, mark, and rate wheelchair-accessible places, raising awareness for places that exclude mobility-impaired citizens.

Both examples, Ushahidi and Wheelmap, have in common that they are interactive, and allow citizens to contribute in some way.[4] These specifically designed geo-visual interfaces help to structure the overall experience and interaction with and about a certain topic that the CSOs care about [20]. Interactivity is a necessary cultural, social and technological condition that supports interaction, which is the first step to participation [22].

Aside from structuring the experience, activists and CSOs also use geo-visualizations to create cartographic narratives to emphasize a certain point of view [23]. These geo-visualizations convey a message or narrative and form a canvas that relays or highlights information. The role of speech, narrative and rhetoric is re-emphasized as equally important to their visual or analytical capabilities [24, 25]. With this emphasis, geo-visualizations are recognized as social constructs that give priority to data exploration over data presentation. They are used in a sense-making activity, compared to standard cartographic practices that aim to deliver answers [26].

Depictions of geospatial information are readily available at our fingertips at every moment through the rise of mobile or ubiquitous computing [27]. They are present on our smartphones, on websites, public displays or printed to help us navigate, contextualize information or visualize facts. Geo-visualizations can foster communication, facilitate rapid insights into what is known by whom, how it is understood, and they encourage reasoning [28–30].

[4] See http://www.ushahidi.com/ and http://www.wheelmap.org/, the websites were accessed January 14, 2016.

3 Objectives

After discussing the motivation that drives this thesis in the previous two chapters, this chapter describes the research questions of this thesis. Section 3.1 presents the overarching research question and corresponding guiding questions. Furthermore, the scope is specified in section 3.2, detailing included and excluded aspects. A visual guide of this thesis' structure that links the research questions to concrete chapters is available in chapter 5.

3.1. Research Question

This thesis investigates one central research question. As OG and citizen engagement are complex topics four guiding questions accompany the central research question. The guiding questions subdivide and inform the central research question, detailing individual aspects of it. Also, they structure part III of this thesis that investigates how AIG and OG can be integrated.

The overall objective of this thesis is to examine the effects of Augmented Interactive Geo-visualizations (AIGs) on citizen engagement while pre-requisites and challenges of the integration of AIGs and OG are identified as well. Hence, the research question is phrased as follows:

Research Question: What are the effects of Augmented Interactive Geo-visualizations on citizen engagement in Open Government Initiatives?

From this central question four aspects arise that are dealt with in the course of this thesis. They are additional questions—detailed and described as follows.

Guiding Question 1: What are aspects that Augmented Interactive Geo-visualizations should support to facilitate citizen engagement?

To develop useful AIGs, aspects of geoinformation technologies need to be identified that can help to enable citizen engagement on different levels. Therefore, the potential design space of AIGs is systematically described with a conceptual model that is based on a literature review. By taking citizen engagement level and needed aspects into account the design space describes how AIGs can support OGIs. The conceptualization can serve as a guide for citizen engagement organizers, designers, OG practitioners or anybody that wants to include geo-visualizations in ICT enabled participatory settings.

Guiding Question 2: What roles do civil society actors have in Open Government Initiatives?

As citizens are the primary audience of OGIs, their role and needs need to be understood. OGIs explicitly emphasize collaboration and participation. Hence, citizens are not only receivers but are called upon to contribute. The goal of this guiding question is to better understand the various roles individual citizens or CSOs might have with regard to OGs and OGD. Insights on this guiding question are gathered through expert interviews with CSO representatives and experts from the domain.

Guiding Question 3: What are best practices in the provision of geospatial Open Government Data?

A lot of OGD contains geospatial reference or is inherently geospatial. As such, the geospatial nature should be accounted for in the provision if possible. This guiding question investigates best practices and opportunities on how to provide geospatial OGD and considers existing infrastructures and processes. The results are based on the author's involvement in two projects of public administrations that provide OGD. Insights were obtained during the author's practical involvement in the realization of the EDP and Open.NRW. The EDP federates (Open) Government Data for the entire EU, while Open.NRW is the OGI of the federal state of NRW that provides OGD as well.[1]

Guiding Question 4: What effects do specific instances of Augmented Interactive Geo-visualizations have on a selected subset of citizen engagement activities?

To gain insights into different potential effects of AIGs on citizen engagement three prototypes were designed, implemented, and evaluated with citizens on a selected subset of citizen engagement cases. Each prototypical AIG was designed for a different citizen engagement level. Please refer to chapter 6 for a breakdown of citizen engagement typologies. The obtained evaluations provide insights into citizens responses, their engagement, and usage patterns of the individual prototypes.

The first prototype investigates the use of Location Based Services (LBSs) in conjunction with geofences to inform citizens about engagement opportunities ubiquitously. A citizen "app" notifies citizens while they are moving through their city, informing them about engagement opportunities in their current context. Citizens can tailor notifications to their needs with spatial filters and preferences. This augments the search process for citizen engagement opportunities as citizens can not only actively "pull" information but also receive customized "pushed-based" notifications in their current context.

The "Dialog Map" is the second prototype and examines how participation and consultation can be supported and integrated with AIGs. By tightly coupling textual and geospatial dimensions in one combined highly responsive interface citizens can explore, add or provide feedback on engagement opportunities using different lenses and modalities. Citizens can use textual or geospatial interactions in the "Dialog Map" to explore the citizen engage-

[1] See http://www.europeandataportal.eu/ and https://open.nrw/, both websites accessed November 16, 2015.

ment case, while either form of interaction influences the overall status and representation in the application.

The third prototype called "Ethermap" investigates the process of non-blocking real-time geospatial collaboration. Real-time collaboration has found its way into several web-based applications. Non-blocking means that collaborators do not have to wait until a collaborator finishes a certain part of the work to start working on it as well. "Real-time" refers to the fact that everybody sees what is happening simultaneously within the same workspace at the same time. This kind of collaboration allows easy co-creation while individuals can work at or from different locations or devices, effectively removing the need to merge pieces of work afterward.

Guiding questions one to four allow to provide a comprehensive answer to the central research question, as not only concrete AIGs are investigated but the pre-requisites and challenges for their integration into OGIs as well. The central research question is answered and summed up in part IV of this thesis. It is a corroboration of all guiding questions, as the processes that allow a potential integration already have an impact. If governments provide open access to data and emphasize open interaction, this influences existing government processes and engagement opportunities already.

3.2. Scope

Many interesting and worthwhile research topics are available that investigate OGIs from viewpoints like politics, informatics, sociology, urban planning, communication sciences or decision-making.

As this thesis is exploratory in nature, its scope is already quite broad. The aim is to provide an entry point to the field from a geospatial perspective—while making a case for the relevance of geospatial information and geo-visualizations in OGIs.

To make the worldwide phenomenon that the OG movement is more manageable, Germany and the EU are primarily targeted and looked upon in this thesis. Germany was chosen as it is the authors' home country and existing connections to domain experts and stakeholders could be leveraged. Concrete OG implementation strategies vary from country to country, but even with a focus on Germany the obtained results should contain generalizable or adaptable insights.

As Germany is influenced by European legislation, such aspects are taken into account. For example, the provision of OGD is heavily influenced by two European Directives: The Public Sector Information (PSI) Directive [31, 32] and the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive [33]. A European perspective is also needed as OGD is often federated by other portals. In Germany's case, local OGD portals are consolidated in federal state portals and these are harmonized in a national portal. Then, national portals from the EU member states are federated in a Europe-wide supranational portal. This chaining directly affects the provision and potential impact of OGD as the national standards have to be interoperable.

An exception to the scoping is made to answer guiding question two comprehensively. Concrete OG activities in Germany have formed later compared to the United States of America (USA). The recent impetus for OG can be attributed to a push by the Obama administration in 2009 [6, 34]. As such, interview partners were recruited from Washington D.C. in the USA as these CSOs had more time to take on different roles and work in the field.

Aside from this exception, all research questions are answered with a focus on Germany and the city of Münster in North Rhine-Westphalia in particular. The developed AIG prototypes were evaluated in Münster as existing contacts to local researchers and CSOs could be used. For example, connections to the Institutes for Sociology, Politics, and Geography of the University of Münster or CSOs like the "Stiftung Bürger für Münster" were helpful. The three developed prototypes are examples for AIG uses for different levels of citizens engagement. The prototypes explore aspects of AIGs uses that could be helpful for a particular level and form of citizen engagement. At the same time, they represent only a fraction of the potential applications as every citizen engagement case is different and requires unique tools and approaches [17].

4 Methodology

Research interests and motivation were described in the previous chapters. Chapter 3 introduced the research questions and accompanying guiding questions that structure this research.

Section 4.1 of this chapter provides an overview of the research approach of this thesis. The approach is explained and grounded in the general research area. An overview and justification about the applied methods for each research question is also provided.

Applied research methods for data collection and their accompanying evaluation are outlined and explained in section 4.2. Detailed descriptions of procedure and participants are presented in the individual chapters of part III of this thesis as they depend on each scenario and its individual characteristics.

4.1. Multi-Method Approach

The common thread in the central research question and all guiding questions is *the human factor.* As AIGs are technological artifacts that are used by humans this thesis is placed in the research area of Human-Computer Interaction (HCI) with a focus on user studies.

HCI researchers are very aware of the fact that their methods need to account for different and subjective viewpoints. As such, the "toolbox" of HCI methods is large and draws from various fields [35]. Also, HCI research tends to produce more practical results as outcomes "need to be able to influence interface design, user training, public policy, or something else" [35, p. 4]. This statement seems to hold true as HCI researchers increasingly turn to supporting matters of concern, including supporting democratic practices, with technological artifacts that facilitate socio-political actions and participation of the public [14]. Crivellaro *et al.* [14] mention research by Dourish [36] and Aoki *et al.* [37] but work by Kriplean *et al.* [38] and Hansen *et al.* [39] equally match this kind of description.

The research methods that are applied in this thesis are informed by and draw from well-established HCI methods. According to Lazar *et al.* [35, p.2 ff] HCI is a complex amalgamation of fields that draws from several disciplines. They continue to elaborate that there are no perfect approaches or methods as multiple stakeholders are involved and not all of them can be satisfied:

Trade-offs are made and often better solutions are accepted instead of optimal ones. Entirely new and radical design changes may increase performance and satisfaction in the long term, but users might oppose spending the time to learn completely new designs. Short term satisfaction and performance are directly impacted in the learning process, even if the new design is superior. Accounting for such factors is possible, but they can not be measured with only one approach [35, p. 9ff].

> Good HCI research allows us to understand the various factors at play, which design features work well for which users, and where those trade-offs are, so that we can make an informed decision. That's not to say that we make perfect or optimal decisions. —Lazar *et al.* [35, p.9]

As reported by Lazar *et al.* [35], HCI researchers increasingly use *multi-method approaches* that involve several methods from various fields (e.g. social sciences) combining them with more traditional methods. Case studies, observations, interviews, data logging, and other longitudinal techniques are involved in understanding complex socio-technical systems. Multi-method approaches are needed to not only answer "how often?" or "how long?" the designed systems are used, but also to answer "why?" the systems are used or why they are not used [35, p. 11ff].

The central research question of this thesis investigates the effects that AIGs have on citizen engagement in OGIs. Explicitly pre-requisites and challenges are included. As such, it would not be enough to measure, e.g.,

Table 4.1.: Research methods that are applied in this thesis, sorted by research questions. Except the literature review, used methods are identified according to Lazar *et al.* [35] and are used to conduct user studies.

	Research Method(s)	**Description**
RQ	Informed and answered by GQ1, GQ2, GQ3, GQ4	
GQ1	Literature review	Establishing a conceptualization of AIGs.
GQ2	Semi-structured interviews; Literature review	Interviews with Washington D.C. based civil society actors to understand their role in OGIs.
GQ3	Participation in the workplace & participatory design	Insights and best practices from the realization of the EDP and involvement in Open.NRW.
GQ4	Custom-built data collection software; Semi-structured interviews; Standardized & custom surveys	Evaluating specific instances of AIGs in citizen engagement cases with different engagement levels.

interfaces and task response times in a laboratory setting as the central research question is not a theoretical question [35, p. 5]. Open interaction and open access to data in OGIs involves multiple stakeholders, e.g., individual citizens and CSOs, civil servants, researchers, and designers. Therefore, the multi-method approach that is applied in this thesis strives to answer the central research question and guiding questions by applying different lenses. A breakdown of the applied user research methods is provided in Table 4.1.

In essence, the central research question (RQ) of this thesis is the overall summary of all guiding questions. It is answered in part and informed by each guiding question—these investigate individual aspects. Obtained insights are corroborated in a process that is known as data triangulation [35, p. 148ff]. Data triangulation cross-validates data to validate or refine the obtained insights. The goal of data triangulation is to check whether insights that were obtained from one specific method are confirmed or validated by another. One can draw a stronger conclusion if multiple data sources confirm the obtained insights. However, diverging or even contradicting results are not necessarily bad. They may point towards problem complexities or research design issues that would not have been caught otherwise. Data triangulation helps to refrain from overly strong claims and can demonstrate the need to dig deeper by asking additional questions in future work. After all, iteration over time, with different lenses from different groups are needed to gain scientific explanations [35, p. 6ff].

The answer to the first guiding question (GQ1) is based on a literature review drawing and combining research from areas such as Open Government (OG), Open Government Data (OGD), Computer Supported Collaborative Work (CSCW), Public Participation Geographic Information Systems (PPGISs), geo-visualizations, and citizen engagement. Thus, the design space is based on common understandings and conceptualizes how Augmented Interactive Geo-visualizations (AIGs) can support different levels of citizen engagement in OGIs.

Guiding question two (GQ2) establishes an understanding of the target audience, civil society. Civil society actors in OGIs range from individual actors to highly structured international organizations. As the field is diverse, Bates [40] recommends to engage with local individuals, established actors and domain experts as a whole to avoid biased or one-sided views. Due to the diverse nature and backgrounds, semi-structured interviews were used. This type of interview allows HCI researchers to understand their audience to capture needs, concerns, preference, and attitudes. Surveys were disregarded as they require a firm understanding of the investigated aspect beforehand, do not offer the chance to look at details as they appear, and because the OG community often relies on a personal and informal exchange, e.g., during events such as hackathons.

Guiding question three (GQ3) investigates best practices for providing geospatial OGD. Providing OGD is mainly a practical task, particularly since geospatial OGD primarily originates from existing infrastructures. The author was involved in two real-world projects with public administrations that provide geospatial OGD. This involvement allowed the collection of first-hand insights to describe the challenges public administrations face in the provision of geospatial OGD. As such, guiding question three's answer is based on insights obtained through an ethnographic research method—participation in the workplace—and complemented by an analyzation of published geospatial data.

Guiding question four (GQ4) draws data from multiple sources to cross-validate evidence as it deals with actual software prototypes following good HCI practice [35]. Automated and custom-built data collection software was used in conjunction with established tracking software during the evaluations of all AIGs prototypes to establish a baseline. If the scenario allowed it, well-established and standardized questionnaires were used to collect additional data before and after deployments. Custom questionnaires were used to extend the surveys to cover specific details. Two of the three prototypes were evaluated "in-the-wild" with actual citizens to obtain insights into their usefulness. The third prototype was evaluated with a real-world scenario but was evaluated in the lab due to practical reasons as it deals with real-time collaboration. For this prototype, interviews with domain experts provided additional data points as no actual real-world deployment was conducted.

4.2. Descriptions of Methods

The following descriptions of methods are all based on the textbook "Research Methods in Human-Computer Interaction" by Lazar *et al.* [35] unless noted otherwise. The supplied descriptions are intentionally short, as this section is not a guide that introduces these methods. Readers that are interested in learning more about these and other methods should consult the textbook as it provides an exhaustive overview.

Actual applications of these methods are detailed in the chapters of part III. This section provides a short overview of the specific methods that are applied in this thesis in general. The descriptions are written from the perspective that they are used to corroborate each other in concrete scenarios.

Semi-structured interviews. Semi-structured interviews are neither fully structured strictly adhering to a script, nor fully unstructured with only a couple of questions or topics that are explored in any order. They usually have guiding questions that act as narrative prompts to steer the conversation [41], while the interviewer is prepared and free to clarify or inquire interviewees' responses. Semi-structured interviews were applied in several cases throughout this thesis to have the opportunity to "dig deeper".

In general, interviews help HCI researchers to understand their audience at any stage of their research. Needs, practices, concerns, preferences, and attitudes are captured as interviews can be more open-ended and provide deeper insights into current or future systems. Interviews are usually recorded in some form and accompanied by notes that were taken during the interview. For the analysis in this thesis, they were transcribed, coded and paraphrased in an iterative fashion. Additional information about the used process can be obtained from two textbooks by Kuckartz [42, 43] while Lazar *et al.* [35, p.208 ff] provide a general introduction.

The question whom to interview is crucial and depending on the context and research interest. Diverse sets of users are a good fit if novel interfaces are evaluated, while stakeholders or domain experts might be a better fit to inquire affects by the use of a system. In long term projects, certain individuals may act as key informants as they turn out to be particularly knowledgeable or forthcoming. However, expectations and relationships must be carefully managed and validated with data from other sources.

Custom-built data collection software. AIGs prototypes used existing automated and custom-built data collection software to record user interactions. Standard web logging and tracking frameworks like Google Analytics or Piwik[1] were complemented by custom developments to gain additional data for the evaluation. For ex-

[1] See http://www.google.com/analytics/ and http://piwik.org/, both websites were accessed November 21, 2015.

ample, every modern browser generates event data, but the events are not captured in standard web logging frameworks. Mouse hovers, clicks, zoom events on a map or object manipulations were collected with such custom-built software to allow for a deeper analysis. Then the logged data was post-processed, analyzed, and often visualized in exploratory data visualizations that were created for the particular case. Examples of such visualizations can be found in Chapter 12 that deals with the AIGs prototypes.

The collected data was used to corroborate findings from other sources, e.g., interviews or standardized surveys to establish a baseline. Gathering data in this manner is possible for almost every user that uses the system, but individual users are only identified automatically, by, e.g., browser fingerprinting[2] [44]. This type of data collection needs careful consideration and disclosure especially during real-world deployments to inform users. Furthermore, the impact of ad-blocking systems or script blockers needs to be considered in browser-based systems.

Participation in the workplace and participatory design. In order to cover intricate details, understand groups of users, informal knowledge, processes, believes and context HCI researchers may apply ethnographic methods. While ethnographic researchers emphasize and expand on these aspects, HCI researchers usually have the goal to create a technological artifact that could help the investigated group. The subsequent software creation process can heavily involve the group in a development method that is known as participatory design or co-design. Participation in the workplace is an ethnographic research method, while participatory design is a software development method and design philosophy. Both methods were used in conjunction in this thesis, as the author had the unique opportunity to be involved in the realization of the EDP. Furthermore, he was involved in Open.NRW and helped

[2] See http://github.com/Valve/fingerprintjs/ for one possible implementation, accessed November 21, 2015.

to create a concept on how to best publish OGD from existing geospatial infrastructures.

Participation as a research method varies in the degree of involvement as a complete observer, participating observer or full member of the group are possible. As in most HCI research, the work that was conducted in this thesis can be classified as a participating observer. The author was an external individual or part of a team that was involved in a group of civil servants that aimed to publish OGD. The participation in the workplace and participatory design is special in this case as this involvement happened as a regularly contracted software engineer and consultant. It took place as part of the author's dual-track Ph.D. at the Graduate School of Geoinformatics. Full disclosure was provided during the projects and consent given.

Similarly to the other methods, obtained insights were used to corroborate findings from other sources or to understand the problems that might exist in the first place. As it is the case with the other described methods, ethnographic research is based on an underlying iterative process of question formulation, data collection, analysis, and subsequent revisions of models and theories to converge on insights.

Standardized and custom surveys. Surveys are often used in HCI research. Surveys or questionnaires (the terms are used interchangeably here) are any number of well-worded and defined questions that surveyed participants' answer on their own. Follow-up questions and adjustments during the survey are not possible. As such, surveys are a good tool to get a broad overview of a topic, but surveys do not offer the chance to look more closely at details as they might appear.

Surveys are relatively cheap, scale well and can quickly capture responses from the studied group. However, they need to be conducted carefully, as question design, structuring, and pilot testing are needed to avoid biased data. Hence, HCI researchers often rely on standardized surveys that are robust and well-tested. Standardized surveys that were used in this thesis include the NASA Task Load Index (NASA-TLX) [45, 46], the System Usability Scale (SUS) [47, 48], and the AttrakDiff 2 (AttrakDiff) [49, 50]. Custom open-ended and closed questions were added to gain additional insights in concrete use-cases. These questions were added separately and did not change the structure and design of the standardized surveys to ensure the comparability of results with other research.

As recommended by Lazar *et al.* [35, p.121] survey results were used in conjunction with other methods to allow for a deeper analysis. Survey results were analyzed according to the recommendations of the individual surveys, while custom questions were analyzed using descriptive statistics.

5 Thesis Outline

Previous chapters provide an introduction to this thesis and its research interest. As this thesis is written with several different readers in mind, it is important to provide a clear overview of its structure. Figure 5.1 serves as a visual guide to the outline of this thesis.

The presented work consists of four distinct parts. Part I ends with this chapter and introduces the general area of research. Part II examines key concepts and related work. Definitions are provided with a short historical overview and origin. Subsequently, noteworthy research is discussed that supplies the scientific background for this thesis.

Part III deals with the integration of AIGs and OG. It is the main part of this work and structured by the four guiding questions, introduced in chapter 3. The first chapter of part III describes the design space of AIGs and serves as a basis for the next chapters, as it integrates the related work in a conceptual model. Following chapters deal with the remaining guiding questions two to four: chapter 10 investigates the roles of the target audience, while chapter 11 deals with best practices for providing geospatial OGD. The largest portion of Part III is chapter 12 as it describes and evaluates the three AIGs prototypes individually with varying use cases and citizen engagement types. The main part of this thesis is briefly summarized in chapter 13.

This thesis closes with Part IV discussing and summing up the conducted work. Most importantly, the central research question is answered during the discussion in chapter 14. Each guiding question is looked upon individually while the chapter finishes with a general look at limitations and implications. Scientific and tangible contributions are recapitulated in chapter 15 and aspects of future work presented.

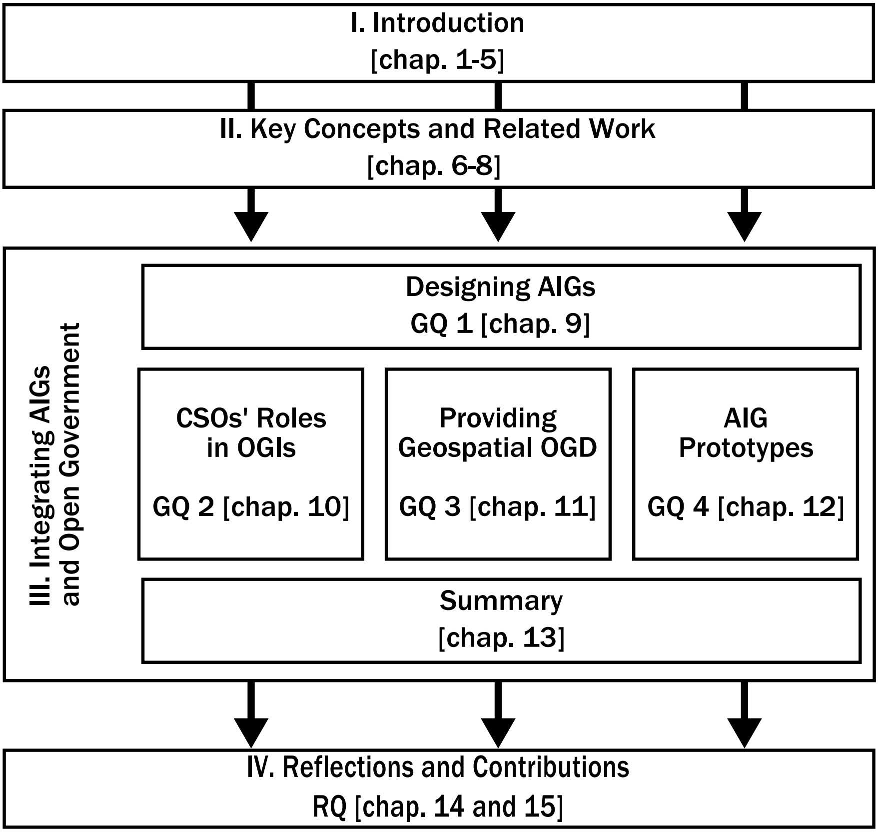


Figure 5.1.: Visualization and guide to the structure of this thesis. Part I introduces the area and motivates the work. Part II provides an overview about key concepts and related work. GQ one to four are investigated in part III, structuring the entire part into corresponding chapters. Part IV concludes this thesis by reflecting on the central RQ and each GQ, examines limitations and implications, provides an outlook of future work, and summarizes contributions.

II

Key Concepts and Related Work

6 Key Concepts in the Open Government Movement

The previous part laid out the research interest, specified the research approach, and provided an introduction to the field. This first chapter of part II specifies key concepts in the OG movement. Each section traces the origins of the concepts briefly and provides definitions, pointing out how the used terminology is understood. This chapter does not add yet another conceptualization to the already available ones, but rather serves as a reference point for further reading. The intention is to provide an overview to establish a common understanding of key terms in this research field that was presented in chapter 3.

Section 6.1 supplies definitions of OG and discusses them briefly. Section 6.2 looks at OGD, and how the PSI and INSPIRE directive influence the provision of OGD in the EU. Key concepts for citizen engagement are presented in section 6.3. The next section defines the difference between a geo-visualization and a map, elaborating why the former term is used primarily in this thesis. Finally, this chapter closes with a summary of the situation of OG in Germany at the time of writing in section 6.5.

6.1. Open Government

The term Open Government (OG) gained visibility in recent years but appeared earlier actually. According to Yu *et al.* [6, p.185 ff] the earliest known occurrences date back to the 1950s and the first printed instance is found in a posthumously published article by Parks [51] in 1957.

The article was part of a legislative campaign that led to the Freedom of Information Act (FOIA) in the USA in 1966. Parks [51] did not explicitly define what he meant by OG but uses it in conjunction with the term good government in a way that indicates that he saw OG as a matter of accountability [6]. The phrase “Open Government” was used with varying frequency in subsequent years and even found its way into public mass media: The introductory quote from chapter 2 originates from the first episode of BBC’s satirical comedy series “Yes, Minister”, entitled “Open Government” that aired in 1980. Recent pop culture works include a short film and song.[1]

The contemporary impetus and surge of the term can be attributed to the very first act of the Obama administration in the USA in 2009. President Obama issued a memorandum on his first day of the office that deals with the “Open Government Directive” [52–54]. The memorandum [34] details deadlines for actions to implement OG and outlines three principles that the Obama administration considers as the cornerstones of OG: transparency, participation, and collaboration.

According to the memorandum [34], transparency promotes accountability by providing information about government actions to the public. Participation shall allow the public to contribute ideas and expertise. Furthermore, the Obama administration views collaboration as a way to improve the effectiveness of government by encouraging partnerships and operations between government actors, across levels, and private institutions. These dimensions are commonly found in several definitions or explanations [see 7, 19, 55]. They are also found in visualizations that were created by civil society actors such as the Open Government Diagram. The diagram was created by the French non-partisan and non-profit organization Démocratie Ouverte.[2] Figure 6.1 shows a version of this figure that has been translated and slightly adapted to enhance the readability in this thesis.

While the dimensions mentioned above are often encountered different definitions exist. Academics, OG practitioners, civil society actors, and governments place different emphases and debate what OG should

[1] See http://youtu.be/k7uuLp5FpJA for the short film and http://youtu.be/J180r2U2KnY for the song, both accessed January 04, 2016.

[2] See http://democratieouverte.org/, accessed January 04, 2016.

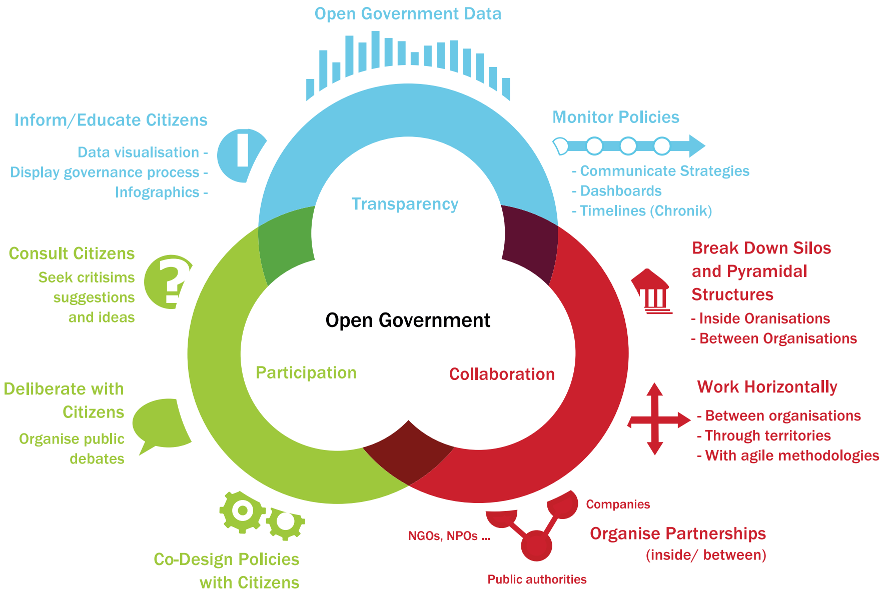


Figure 6.1.: Open Government Diagram, visualizing commonly found dimensions in OGIs. Adapted and translated version, original work CC-BY-3.0 Armel Le Coz and Cyril Lage from Démocratie Ouverte.

contain as a concept [e.g. 6, 56]: Yu *et al.* [6] fear that the term can be misused as the meaning blurred and shifted towards open technology and lost its hard political edge that referred to the disclosure of politically sensitive information. Weinstein *et al.* 's [56] retort to Yu *et al.* 's [6] paper argues that the "big tent" of OGD and OG creates opportunities for reform as technology and innovation are merged in one movement with OGD as entry point that paves the way for comprehensive OG reforms.

Beth Noveck was the former Deputy Chief Technology Officer in the Obama administration and responsible for the implementation of OG. Her reflections about the wording of OG were published in a newspaper article in the Huffington Post. An improved version of the article can be found in her blog[3] (reference found in [57]). In the article, Noveck states that the term was a bad choice in retrospect, as it created confusion placing too much emphasis on transparency.

According to her, OG "was actually a shorthand for open innovation or the idea that working in a transparent, participatory, and collaborative fashion helps improve performance, inform decision-making, encourage entrepreneurship, and solve problems more efficiently."

The idea of openness and participation is also prominently featured in the foundational treaties of the EU [19]. In the consolidated version of the Treaty on European Union (TEU) [58], last amended by the Treaty of Lisbon, the first articles deal with the idea of openness:

> **Article 1**: [...] This Treaty marks a new stage in the process of creating an ever closer union among the peoples of Europe, in which decisions are taken as openly as possible and as closely as possible to the citizen. [...]
>
> **Article 10 (3.)**: Every citizen shall have the right to participate in the democratic life of the Union. Decisions shall be taken as openly and as closely as possible to the citizen.
>
> **Article 11 (2.)**: The institutions shall maintain an open, transparent and regular dialogue with representative associations and civil society.

The last important note in this short overview of the emergence of OG is that it is by no means a purely "western world" phenomenon. Countries that have joined the OGP are present across the globe. A short look at Figure 1.1 shows that, for example, several Latin American states are equally involved. While joining the OGP represents a commitment to OG it is not necessarily the only or best indicator to assess if a country pursues or sustains an OG agenda.

As stated in the introduction of this thesis OG is understood here as a socio-technical movement that revolves around two main pillars:

[3] See http://cairns.typepad.com/blog/2011/04/whats-in-a-name-open-gov-we-gov-gov-20-collaborative-government.html, accessed December 20, 2015.

Open access to government data and open interaction between involved stakeholders. OGD is seen as a precursor [56] that should be part of an OG strategy. Meijer *et al.* [19] stress that "vision and voice" need to be connected, as "citizens need information to see what is going on inside government and participation to voice their opinions about this" [19][][p. 11]. They define openness in OG as follows:

> Openness of government is the extent to which citizens can monitor and influence government processes through access to government information and access to decision-making arenas. —Meijer *et al.* [19, p. 13]

In summary, Francoli's [55] definition of OG is used in this thesis. In her view, OG "includes a culture of governance that transcends ICTs where the goals of openness, sharing and collaboration are reflected, more broadly, in government operations and priorities" [55, p. 152].

6.2. Open Government Data

In the case of the EU, two directives have heavily influenced and still shape the way in which Open Government Data is provided. To properly assess the influence of the two directives "openness" in terms of data or content needs to be looked upon beforehand. One of the most well-known, succinct, and universal definitions is provided and maintained by the Open Knowledge Foundation (OKFN), a non-profit organization committed to fostering open knowledge:

> Open data and content can be freely used, modified, and shared by anyone for any purpose.
> —http://opendefinition.org/

Key points that must be fulfilled to meet the Open Definition are an *open license or status* of the work, *open access* to it, *machine readability* and an *open format*. The following explanations of these four core aspects are paraphrased, the complete definition and translations into several languages can be found online.[4]

An open license must allow free use, redistribution, modification, separation and/or compilation of any part of the work. It does not discriminate persons or groups, allows propagation, is free of charge, and ensures all these aspects for any purpose. Open access is given if the whole work is publicly available, preferably as download via the Internet without charge or otherwise at a reasonable one-time reproduction cost. Information about the license must accompany the work. Machine readability ensures that the work or any individual element can easily be processed and modified with a computer. Open formats have to be used that do not place any restrictions on subsequent use, and at least one free/open-source software tool needs to be available that allows subsequent processing. Certain conditions for the usage of open data are acceptable, for example, attribution of contributors or the source.

If these aspects apply, data, content, information or "the work" is considered to be open by the Open Definition. Other definitions of OGD draw from the "ten principles for opening up government information" that were released by the Sunlight Foundation in 2010.[5] In these definitions, certain aspects such as timely and permanent release, the need for primary "raw" data and ease of access to the data are added and emphasized. The ten principles of the Sunlight Foundation are used or recognized broadly. They are present in the guidelines on OGD for citizen engagement by the United Nations [10], academic publications [59, 60], and they also appear in a study on OGD that was conducted by the German Ministry of the Interior [61].

In summary, legal openness in terms of licensing and technological openness in terms of processing are required if data is published openly. With this in mind, the next paragraphs describe the influence the Public Sector Information (PSI) Directive and the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive have in

[4] See http://opendefinition.org/od/2.1/en/ for the English translation in its current version, accessed January 06, 2016.

[5] See http://sunlightfoundation.com/policy/documents/ten-open-data-principles/, accessed January 08, 2016.

the EU. The first directive primarily aims to provide a legal basis for re-using public sector information, while the latter focuses on particular kinds of data and its technical provision.

The PSI Directive was established in 2003 [31], amended in 2013 [32], and introduced a legislative framework for re-use of public sector information. The goal was to stimulate the re-use of public sector data as public agencies are one the largest creators and collectors of data in different domains such as geographic data, tourist information, weather information or business data [62]. Janssen [62] reviewed the initial directive and pointed out the reasons why it was introduced: The EU wanted to stimulate its markets as the importance of digitally available data grows, and concerns were present that the European markets could not compete with the USA.

As such, the PSI Directive targeted the information sector primarily, introducing steps to harmonize policies and practices that affect the re-use of public sector data in Europe. According to Janssen [62] “the cry for opening up public sector data is not new. The European Commission has been trying to develop the potential of these data since the end of the 1980s” [62, p. 446].

An official review of the directive was published in 2009 [63], detailing progress and shortcomings in the implementation: several member states failed to implement the PSI directive fully or correctly, and the EC noted that members states simply did not publish information about the availability of public sector data. The directive was amended and updated in 2013 [32]. It is crucial to recognize that the directive deviates from certain OGD principles. Open licenses are not required and public agencies allowed to charge marginal costs or even above marginal costs in some instances. However, open licenses and no fees are explicitly encouraged in the amended directive and the accompanying guidelines [64]. Even while the PSI Directive does not detail aspects of technical openness or enforces all OGD principles, it “has undoubtedly contributed to the success of open government data” as “it is a first step in the harmonization of the policies and practices of the Member States” [62, p. 545].

The second directive that influences the provision of OGD in Europe is the INSPIRE Directive [33]. INSPIRE entered into force in 2007 aiming to harmonize the delivery of geospatial data in the EU. The purpose is to create an interoperable Spatial Data Infrastructure (SDI) that contains relevant environmental data. In a staged process 34 data "themes" are to be published until 2020 that are specified in three annexes of the directive. Themes range from topics like addresses, elevation models, land use, and population distribution to demographic data.

As the INSPIRE Directive aims to create an actual infrastructure, it includes a focus on technical aspects. For example, the directive formulates five distinct types of network services for discovering, viewing, downloading, transforming or invoking spatial data services [33, Article 11]. Several accompanying documents specify how the geospatial data should disseminated [65–67] or detail how metadata should be provided [68, 69]. INSPIRE's strong focus on technical aspects ensured technical interoperability and openness but not necessarily legal openness. License types and texts of published geospatial data are communicated, but any license can apply, and data publishers may and often do restrict access or charge fees.

As such, INSPIRE data is easy to discover through various geoportals that are built on top of SDIs, easy to process with different kinds of open and closed software as the specifications are publicly available, but the data licenses often prohibit or limit re-use. This aspect is a major drawback from an OGD point of view as users are highly interested in geospatial data. An open consultation by EC revealed that geospatial data is the top category and in high demand from users [64].

Both directives have lead to the publication of governmental data in the member states, but both directives do not require the publication as OGD. INSPIRE and PSI provide the groundwork on which the provision of OGD can take place in the member states. Recognizing this, the EC mentions both directives in a communication outlining actions to overcome the existing fragmentation of the member states to reap the full potential of OGD [12]. In a similar fashion, Van Loenen *et al.* [70] describe how an extended scope of data covered by INSPIRE in combination with the PSI Directive would benefit re-users of public sector information as both directives complement each other.

The definition used in this thesis agrees with the notion of the Open Definition and the ten principles of the Sunlight Foundation: any open work needs to be legally and technically open, while OG and OGD are recognized to be part of the same notion [10, 56].

6.3. Citizen Engagement

One of the most well-known pioneers in citizen engagement research is Sherry R. Arnstein. She published an article called "The Ladder of Citizen Participation" [71] in 1969. Her article presents a typology of citizen participation, arranging it in the image of a ladder with eight rungs, see figure 6.2 for the original illustration.

The extent of citizens' power in decision-making processes correspond to the rungs ranging from the lowest that she categorized as "Nonparticipation" to the highest that represent "Degrees of citizen power". Arnstein's work represents the degree of citizen participation on a continuum [72], although according to Connor [73], Arnstein was very aware of the fact that the proposed ladder is a simplification. She knew that citizen power is not distributed as neatly as the used divisions suggest. Also, she was mindful of the fact that real world people and programs might require a lot more rungs, and factors like racism, paternalism, ignorance, and disorganization were omitted.

Nonetheless, her typology spawned discussions and the resulting conclusions inform researchers to this day. Several researchers have provided iterations and extensions [e.g. 73, 74] or analyzed "ladders" that researchers proposed [72, 75, 76] in an effort to understand the different forms and executions of citizen engagement.

According to Sheedy *et al.* [17] "there is no one-size-fits-all in citizen engagement" [17, p. 1]. Policies, programs and development processes require adopted tools and unique approaches that address the specific needs in each context. The notion is "premised on the belief that people should have and want to have a say in the decisions that affect their

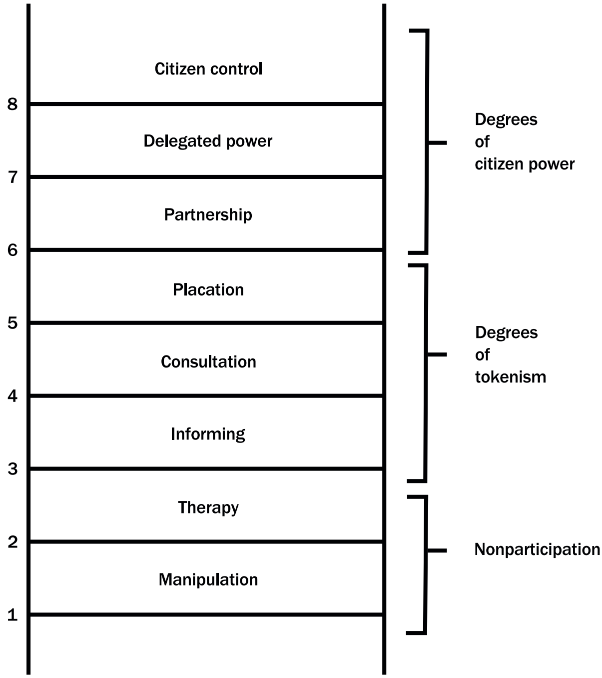


Figure 6.2.: Arnstein's typology of citizen participation as illustrated in her 1969 article [71] (redone to enhance readability). The image of a ladder to describe citizens power in decision-making processes is still popular.

lives" [17, p. 1]. Sheedy *et al.* [17] provide the following definition of citizen engagement in their textbook:

> Above all, citizen engagement values the right of citizens to have an informed say in the decisions that affect their lives.
> —Sheedy *et al.* [17, p. 4]

The provided definitions for OG match this notion well (see section 6.1). For example, Meijer *et al.* [19] define openness of government as the extent to which citizen are able to monitor and influence government

Table 6.1.: Rowe *et al.* 's [18] public engagement typology that is based on the direction of the information flow. "Sponsor" refers to the commissioning party of the engagement initiative, usually a public administration.

Type	Flow of Information
Public Communication	Sponsor $\rightarrow$ Public Representative; one way from the sponsor to the representative
Public Consultation	Sponsor $\leftarrow$ Public Representative; one way from the representative to the sponsor
Public Participation	Sponsor $\leftrightarrow$ Public Representative; two way between sponsor and representative

processes by accessing government information and decision-making arenas. However, Sheedy *et al.* [17] refer only to individual citizens and exclude organized groups. As OGIs emphasize collaboration and participation between government institutions, civil society, and private sector entities this definition is too restrictive. For the purpose of this thesis and in the context of OGIs no difference is made between organized civil society actors or individuals.

In fact CSOs such as the OKFN or the Sunlight Foundation are major proponents of the notion and help to activate individual citizens. For more information on this aspect, please refer to chapter 10 that identifies the different roles civil society actors can take on in OGIs.

Rowe *et al.* 's [18] typology identifies levels of engagement based on the direction of the information flow. This view is helpful in the context of understanding OGIs as it clearly depicts that an exchange between involved parties takes place. Rowe *et al.* [18] identified three public engagement levels based on an extensive survey of used engagement mechanisms. The three levels are public communication, public consultation, and public participation. Public communication disseminates information to public representatives, public consultation gathers feedback from them, and public participation represents an exchange of information based on a dialogue. Table 6.1 shows Rowe *et al.* 's [18] typology and the difference in the flow of information for each level.

While Arnstein's [71] ladder and Rowe *et al.* 's [18] typology are useful to differentiate the levels or types of citizen engagement in their own right, this thesis uses the public participation spectrum. Participation practitioners from the International Association for Public Participation (IAP2) created the spectrum that differentiates between five main types: *inform*, *consult*, *involve*, *collaborate*, and *empower*.

The spectrum ranges from weaker to stronger forms of participation, and each of the levels has a clear participation goal and promise to the public. Please refer to table 6.2 for the individual levels and explanations or see [17, 77] or the website[6] for the original. The public participation spectrum is used in this thesis for two reasons:

First, researchers reference it, or the underlying core values in the literature [17, 77, 78] viewing it as a useful summary and categorization of the available work on participation and community involvement [77]. Second, the spectrum is actively used in the OG context. Members of the Open Government Partnership (OGP) have to use it to rate their activities and the impact of public input on the outcomes and processes. The spectrum is used in the Independent Reporting Mechanism (IRM) that produces biannual progress reports allowing all stakeholders to track the progress of participating countries.[7]

The level of "empowering" citizens to conduct final decision-making is consciously omitted in this thesis. OGIs aim to strengthen collaboration and participation of citizens in decision-making processes, but they do not aim to place final decision-making in citizens' hands. Additionally, the scoping of this thesis focuses on Germany that has a representative democracy where elected representatives conduct final decisions in a parliament. Final decision-making by citizens can be found in direct democracies, where elected representatives implement these decisions.

[6] See http://www.iap2.org/page/A5, accessed February 15, 2016.

[7] See the IRM procedures manual, available at http://www.opengovpartnership.org/irm/about-irm/, accessed February 15, 2016.

Table 6.2.: IAP2's Public Participation Spectrum that distinguishes between five levels of increasing public impact. Please refer to http://www.iap2.org/page/A5 for the original depiction of the spectrum, accessed February 15, 2016.

Level	Public Participation Goal	Promise to the Public
Inform	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives and opportunities and/or solutions.	We will keep you informed.
Consult	To obtain public feedback on analysis, alternatives and/or decisions.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.
Involve	To work directly with the public throughout the process to ensure that the public concerns and aspirations are consistently understood and considered.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.
Collaborate	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.
Empower	To place final decision-making in the hands of the public.	We will implement what you decide.

Therefore, only the four levels of *informing*, *consulting*, *involving*, and *collaborating* with citizens are considered in the remainder of this thesis.

In summary, it is unsurprising that the intent of the citizen engagement and OG definitions match given the scope of OGIs. Still, there are a few pitfalls: OG explicitly includes ICTs to strengthen citizens involvement in government affairs. However, this inclusion is not exclusive of other forms. Administrations could easily create one online citizen engagement portal and claim that they provide engagement opportunities. Inclusive citizen engagement entails online and offline activities and recognizes that different types and forms are present, with different levels. To succeed, OG practitioners should remember to transcend ICTs and reflect the goals of openness, sharing and collaboration in their operations, and priorities [55].

6.4. Geo-visualization

> A map says to you, "Read me carefully, follow me closely, doubt me not." It says, "I am the earth in the palm of your hand. Without me, you are alone and lost."
> *Beryl Markham in "West with the Night", 1983*
> *found in Harley [79]*

Some readers with a background in cartography or geoinformatics might have noticed that the term "geo-visualization" is used in this thesis instead of "map". Colloquially, map and geo-visualization are used interchangeably while "map" is certainly used more often. While both terms refer to some representation of geospatial data, maps are commonly thought of as being precise and accurate, with a strong link between reality and representation [79].

The above quote illustrates this conception nicely: maps are usually used to create an objective representation of the world, the goal is to depict or communicate stored spatial knowledge. While geo-visualizations share these aspects with maps, they do not emphasize them. Instead, geo-visualizations try to facilitate knowledge construction over storing knowledge, as do scientific visualizations [80]. They are part of a sense-making activity aiming to provide answers and focus on interactivity. This interactivity is enabled by modern ICTs and the corresponding technological advances. Today, standard functions in interactive mapping software allow users zooming, panning, adding or removing additional data, or querying and filtering data [26].

MacEachren *et al.* [81] provided an early definition for geo-visualizations that is often found in the literature [e.g. 26, 30, 82]. According to them, geo-visualization research integrates approaches from visualization in scientific computing, cartography, image analysis, exploratory data analysis, and Geographic Information System (GIS). The goal is "to provide theory, methods, and tools for visual exploration, analysis, synthesis, and presentation of geospatial data (with data having geospatial referencing)" [81, p. 3]. MacEachren *et al.* [81] elaborate further that "the map is now an interface that (if well designed) can support productive information access and knowledge construction activities (while it retains its traditional role as a presentation device)" [81, p. 4]. Geo-visualizations emphasize interactive map use and the process of exploration and not the finished product—a map [26].

> Maps and graphics in this context do more than "make data visible," they are active instruments in the users' thinking process. [...] Between the extremes of traditional map presentation and visual data exploration, map-based visualization also supports goal-driven analysis and information synthesis.
> —MacEachren *et al.* [81, p. 5]

MacEachren *et al.* [81] identified several challenges for geo-visualization research that apply directly in the OG context: For example, a human-centered approach to geo-visualizations should be considered. The authors state that thinking, learning, problem-solving, and decision-making are enabled by technological advances that focus on usability. MacEachren *et al.* [81] see a key issue in moving beyond "the current 'build and they will come' and 'one tool fits all' approaches to geoinformation technology" [81, p. 9]. Researchers in the field of citizen engagement see this issue as well. For example, Sheedy *et al.* [17] state that customized tools and unique approaches are needed to address the specific needs in each context.

Another challenge MacEachren *et al.* [81] identified was the development of a new generation of geo-visualizations methods and tools to support group work. While the needed geospatial data for the geo-visualizations was not explicitly focused, MacEachren *et al.* [81] were quite aware that governments are active generators of geospatial data. They saw that national governments have substantially different approaches in collecting, storing, and exchanging geospatial data and advised coordination and harmonization methods.

These aspects demonstrate that geo-visualization research with a focus on HCI and OGIs are good partners: OGIs aim to facilitate open interaction between stakeholders, emphasizing collaboration and participation between government, civil society, and private sector entities by using advances in ICTs. Geo-visualizations accentuate maps as "interactive windows to the world" that facilitate learning, problem-solving and decision-making, by using geospatial data and technological advances [81]. By collecting large amounts of geospatial data and providing it openly, adhering to open standards in the exchange and collection due to the INSPIRE process, governments provide the necessary data.

As citizens and administrations explore, adapt or create geo-visualizations together in open interactive processes, geo-visualizations are part of a social process. The resulting "maps" are valid from a certain perspective, but do not necessary adhere to cartographic standards such as objectivity, accuracy, and truthfulness [79]. AIGs are the facilitator of such processes. They are social-technological artifacts—an active instrument, instead of a mere representation. To highlight this conceptualization, the term Augmented Interactive Geo-visualization (AIG) is used in this thesis instead of "map". Chapter 9 expands on this conceptualization and introduces the design space.

However, two of the three prototypes that are discussed in chapter 12 still have the word "map" in their name as the word geo-visualization and the necessary explanations seem a bit unwieldy for evaluations in citizen engagement contexts.

6.5. Scenario: Open Government in Germany

The situation in Germany is fragmented, and most of the efforts concentrate on the provision of OGD: Some federal state or local governments established OGD portals, but only one federal state pursues a comprehensive OGs strategy.

Nationally, Germany has established an OGD portal. In June 2013, Germany committed to open up government data by signing the G8 Open Data Charter [83]. As required by the G8 Charter, Germany published a “National Action Plan to implement the G8 Open Data Charter” [84] and supports and operationalized a national OGD portal called GovData. While the G8 states agreed on a set of five principles that match the common understanding of OGD, advocates such as the Sunlight Foundation criticized the fact the charter does not require the data to be published free-of-charge.[8] The principle “usable by all” of the charter only recognizes that open data *should* be available free of charge but does not require it [83, p. 4].

Early criticism surrounding the launch of GovData reflected this critique. German activists emphasized that harmonized open licenses that allow commercial use without discrimination are needed. Overall, they feared that German administrations were pursuing a path of least resistance as they excluded commercial use and contradicting licenses were found for the datasets in GovData and on their originating websites.[9]

After establishing the national OGD portal, the progress of the federal government seems to have slowed down, albeit GovData was relaunched in January 2016.[10] The relaunch focused on refining the search functions and established a new visual design. Colors are now used consistently and a responsive layout was introduced. From a geospatial point of view, the most notable addition is the introduction of a map-interface for searching and refining OGD search results. The map-interface allows to specify a simple bounding-box that is applied to the search results. Additional features that could help to improve the spatial search function such as a Gazetteer are missing. See chapter 11 for insights on best practices for providing geospatial OGD.

At the beginning of the term, the coalition of CDU/CSU and SPD formulated that they would strive to join the OGP. The corresponding section in the coalition agreement of the of the 18th legislative period (2013-2017) is located in a general paragraph that deals with the modernization of public administration [85, p. 153]. The paragraph also

[8] See http://sunlightfoundation.com/blog/2014/07/28/g8-open-data-charter-action-plan-open-data-by-default-but-you-may-have-to-pay-for-it/, accessed February 25, 2016.

[9] See http://not-your-govdata.de/, accessed February 25, 2016.

[10] Please refer to the official blog post: http://www.govdata.de/web/guest/neues/-/blogs/relaunch-des-datenportals-govdata/, accessed February 26, 2012.

6

contains a passage that federal agencies should be pioneers in publishing OGD under a harmonized open license based on legislation. Previous progress in the provision of OGD by federal agencies targeted geospatial data. In the 17th legislative term, the Act on Access to Geodata (GeoZG) was amended, and the Geodata Usage Ordinance (GeoNutzV) issued that allows a commercial and non-commercial use of the data free-of-charge [84, p. 8].

OG activists and the federal state of NRW continue to appeal to the federal government to join the OGP. Several civil society actors have joined up in a working group called "Open Government Partnership Deutschland".[11] The actors prepare, assess, and promote Germany's admission in the OGP. Additionally, the federal government of NRW put forward an official motion through the federal assembly urging the current coalition to join the OGP [86] as was formulated by the federal government in the coalition agreement. The appeals seem to have the desired effect as Germany's national government declared in press release 95 of 2016 that Germany would submit its candidateship to join the OGP.[12]

While the initial national effort towards OGD was met with harsh critique from the community, efforts from federal state or local actors were recognized positively. Moers and Rostock were among the first municipalities to establish OGD portals, while the city-state of Hamburg established the "Transparenzportal Hamburg" that is accompanied by a law that opens up governmental data and information by default.[13] The federal states of Baden-Württemberg and Rheinland-Pfalz, and the city-states Berlin and Bremen, follow similar patterns and introduced OGD portals or extended their Freedom of Information (FOI) laws to cover aspects of transparency [87].

So far, only the federal state government of NRW pursues a comprehensive OG strategy [87]. The "Open.NRW" strategy [88, 89] aims to increase participation and collaboration in governmental actions while

[11] See http://opengovpartnership.de/, accessed March 17, 2016.

[12] See https://www.bundesregierung.de/Content/DE/Pressemitteilungen/BPA/2016/04/2016-04-07-deutsch-französischer-ministerrat.html, accessed on May 01, 2016.

[13] See http://transparenz.hamburg.de/, accessed February 25, 2016.

the publication of OGD is a complementary effort. The insights of chapter 11 that formulate best practices on how to publish geospatial OGD are based on the author's involvement in Open.NRW and the European Data Portal (EDP).

Literature that looks and analyzes OG in Germany's context is emerging as well. For example, an analysis of election manifestos of the main German parties about OG was published by Lucke [90]. Other publications include discussions of benefits and reasons why Germany should join the OGP [87] or why it should not [91]. Thoughts on the advantages of a National Open Data Infrastructure were put forward as well, recognizing the benefits of interoperable standards and practices [92]. In summary, OG and OGD seem to be a topic that has established itself in Germany as several early adopters have created OGD portals and NRW committed and formulated an OG strategy.

7 Related Work

Several areas of research informed this thesis and the central research question that investigates the effects of Augmented Interactive Geo-visualizations (AIGs) in OGIs. Chapter 6 established the understanding of key concepts by providing, discussing, and tracing definitions of OG, OGD, citizen engagement and geo-visualizations. This chapter introduces additional related work that guided the presented research in this thesis. The previously established key concepts help to structure the sections of this chapter.

First, section 7.1 examines OG, looking at the role of public administrations in OGIs, hopes, and challenges more broadly. The first section is followed by a discussion of research on OGD in section 7.2. Associated potentials are summarized, literature that discusses practical experiences and use-cases of OGD pointed out, and efforts to assess OGD discussed. Subsequently, section 7.3 takes a short look at civil society research, explaining how the term is used here and how civil society relates to OG in general.

The following section 7.4 briefly discusses Public Participation Geographic Information Systems (PPGISs) and its relation to geo-visualizations. PPGIS is a field of research that aims to involve the public in policy and decision-making processes by using Geographic Information System (GIS). Afterwards, concrete applications and studies that deal with ICT enabled citizen engagement are discussed in section 7.5. The presented work informed and inspired the developed AIG prototypes.

7.1. Open Government

> In a society with a large, multi-level, complicated governmental system, how can democracy be maintained? What can public service practitioners do to facilitate access by citizens to the policy-making process, providing meaningful opportunities for citizens to make decisions about what government does and how it does it? —Box [93, p. xii]

Public administration—here referred to as a set of institutions, persons, and processes carrying out public services—has always played a crucial role as it is said to "deliver democracy" [94, p. 14] and maintain citizen support of democracy [95]. The questions above that were phrased by Box [93] in the introduction of the textbook "Democracy and Public Administration" are probably as old as democracies themselves.

Public servants have to deal with people's general disenchantment with politics, institutions, and the political elite—especially in times of economic crises and increasing social inequality. Furthermore, citizens wish to understand, participate, and collaborate in decision-making processes and policies. They are part of a trend that sees government as a platform instead of a strict hierarchy with centralized decisions and structures [96, 97]. In fact, these pressures and requests seem to have been even enforced through diffusive globalization processes and related power shifts as well as the entering into the digital era. According to Hamilton [94, p. 3f] our present democratic regimes need to have strong, technically competent, effective and efficient administrations to survive. Readers with an interest in examples and discussions of these developments should refer to Lathrop *et al.* 's [98] book "Open Government: Collaboration, Transparency, and Participation in Practice".

With this perspective, OGIs aim to provide answers to the initial questions of this section. OGIs are policy initiatives with an underlying cultural change striving to balance and provide citizens with access to decision-making areas and information about government activities. As such, public administrations are at the center of OGIs. They can provide open access to government data and are in a key position to enable open interaction between stakeholders in governments actions.

At the same time, many people see a tension between public administration and democracy [93, p. xi]. Hamilton [94] provides a discussion of this tension that sees the very existence of public administration in a democracy as a paradox that contradicts the notion of a government by the people. This paradox of public administration being both necessary and contentious in democratic regimes [94, p. 7ff] has been a steady source of criticism and spurred the debate about the use and power of state administrations in democratic regimes. Hamilton's [94] discussion highlights the delicate balance that civil servants are expected to strike: They have to uphold democratic values, promote public interest while managing public institutions. They need to implement public policy as professionals in a moral, ethical, and reliable way. At the same time, they need to be effective and efficient—civil servants need a diverse set of skills. As such, civil servants run the risk to create a gap between the citizens and the expertise citizens might bring to the table as citizens skill-sets might differ considerably, and as citizens push their agendas. Hamilton [94] concludes that democratic regimes need to ensure that civil servants are highly skilled managers that are well grounded in democratic values and principles.

However, OGIs can also be seen as an internal modernization initiative of public administrations: Open access to data removes inter-institutional barriers. OGD is also accessible by civil servants that might have faced the same barriers as citizens before, such as cost, easy access, format obscurity, and license issues. Similarly, open collaboration and participation includes civil servants from different departments or agencies. By opening up pyramidal work structures, inter-institutional work can be fostered while other stakeholders are equally involved.

In conclusion, these circumstances lead to a strong pressure for governments to innovate, seek renewal, and to find answers to above-phrased questions to continue to "deliver democracy" and maintain citizen support. Public administrations need to adapt to new technologies, especially as civil society actors use them already to reach their goals.

Malamud [99] is an example of a public domain advocate who has increased expectations and acts on them using the Internet. He "essentially shamed the government" into making information available by running a particular type of campaign [100, p. 198]. He uses the Internet to create a community around government information that he buys, reverse engineers or collects. This data is then published on a website. After the website manages to gain popularity, and reaches a critical mass of users, Malamud announces that he will remove the website, or somehow increases public exposure. The resulting public attention that he wields is used to pressure the institutions to make the government data available themselves [100, 101].

> The promise of the internet wave is the promise of an opportunity for more efficient government, for more economic activity, and for a better democracy. Artificial and unjust limits on access to information based on money and power can be abolished from our society's operating system, giving us at long last a government that truly is of the people, by the people, and for the people. —Malamud [99, p. 47]

While OGIs rely on ICTs advances, they are not only offering electronic forms for participation and collaboration as it is the case with e-government. OG differs from eGovernment in the sense that it is not just about the usage of digital technology for better public service delivery that replicates existing workflows and processes digitally. As established in section 6.1, OG focuses on transparent and open processes while engaging the public in government affairs [10] transcending the use of ICTs [55]. Pure forms of eParticipation or eDemocracy that solely focus on ICTs and different levels of participation [102] tend to produce fragmented information and communication bubbles [103]. Online communities seem to focus on self-affirmation rather than on deliberation, forming strong group identities and can easily avoid views from other social groups. Thus, Kersting [103] views blended approaches of online and offline instruments as more successful. He sees a risk in the fact that policy makers and administrations nowadays focus on "cheap" online instruments and try to avoid cumbersome offline meetings.

A study by Nam [52] points out “that citizens’ attitudes toward government workings do not change much with the introduction of new goals and tools of e-government” [52, p. 346]. Citizen engagement does not happen automatically and needs proactive involvement [104] and factors such as trust in government and the perceived value of government services shape the collective attitude [52]. Introducing new pieces of technology will not magically increase citizen acceptance or engagement. In fact, Tenner [105] provides a collection of instances where the adoption of new technologies did not solve any problems without introducing new issues or unintended consequences.

As such, the technological dimensions of OG and OGD are discussed critically and viewed to be as vague and ambiguous [6]. Yu *et al.* [6] differentiate between the philosophical idea of OG in the sense of openness and transparency—and its technological realization. The mere provision of data or services just lays a foundation. If the provision is badly implemented or data is mundane or meaningless and simply not used, there is the risk of pretending to be open when it is not the case. The same is true if policies are introduced, but not enforced: Shkabatur [54] investigates if the transparency policies in the USA lead to accountability. She challenges the perspective that introducing technology into transparency policies would overcome existing hurdles for public accountability. In her analysis, she does not see an increase in accountability. She attributes this failure to the fact that existing policies are not enforced or that too much leeway is present in the policies about what is disclosed resulting in the irrelevant disclosure information.

Meijer *et al.* [19] conclude that OG is much too important to leave it to the “techies” and advocate for a broad adoption of the topic by researchers and practitioners from various fields. On the whole, expectations towards open government are immense (see [52, p. 349] for a list) and the above-identified issues await further exploration while issues like privacy [106] received little to not attention so far.

7.2. Open Government Data

From its early beginnings the debate about OGD has been driven by huge expectations, turning the idea into a projection screen for how technology can improve transparency, citizen engagement, and comprehension of democratic government [see 56, 61, 98, 107, 108].

Advocates postulate that once OGD is fully implemented it may "redefine the relationship between citizens and government officials" [98, p. xx] in the long term. Advocates build on the idea that "government information is a form of infrastructure, no less important to our modern life than our roads, electrical grid, or water systems" [99, p. 47]. The following summary lists the potentials associated with OGD that are found in the literature—they are extensive:

Transparency. OGD is deemed to be a key factor in government transparency that provides insights into processes, decisions, and interests of public institutions, with the potential to help to transform public administrations from obscure and closed bodies into modern, transparent, and open agencies [109].

Accountability. The aspect of accountability mixes issues of transparency, citizen engagement, and liability: As OGD is published, advocates await an increase in transparency that should lead to better traceability and accountability of government acting and decisions. This could spark public conversations and allow citizens or civil society actors to investigate the released data, and to generate and publish their own perspectives [56, 59].

Trustworthy Data. OGD is seen as trustworthy information, as it is authoritative data [61, p. 41ff]. High quality and verified data is desirable for all stakeholders, especially in times where the quantity of available information that is generated exceeds its quality significantly.

Economic Development. Publishing OGD is associated with an increase in economic development, especially in times of economic crises and diminishing public spending. Access to data might help companies to develop new strategies and adapt their business models [12, 61]. Additionally, OGD can also be seen as infrastructure project for companies. Software and processes need to be defined, build and applied, and public administrations are likely to acquire external help for these tasks.

Modernized Administrations. Opening up governmental data is said to help public administrations themselves. Open access to government data within institutions should lead to greater efficiency and simplified processes. By exchanging data and providing simple access to it synergistic effects are expected [60, p. 136ff].

Despite the current boom of OGD and the variety of expectations connected to it, uncertainties are present as well. These start with fears of an information overload and continue with issues of data complexity that may lead to even more opacity and disconcertment, enforced through doubts about the quality of provided data [61, p. 41ff]. Barriers that were identified by Janssen *et al.* [108] in a series of interviews are similar. They relate to task complexity, use and participation, legislation, information quality, and technical aspects. For example, Janssen *et al.* 's [108] interview partners feared that users might lack the necessary skills to use their data or that users might find the published data lacking in terms of quality. Additionally, they identified fears related to litigation, the absence of standards, and privacy related concerns.

The fears regarding privacy are diffuse: OGD advocates and practitioners are aware of the fact that the disclosure of large amounts of data necessitates a discussion about the protection of privacy issues and the general use. However, the literature seems deliberately vague stating that OGD that contains personal data or sensitive data should not be published [10, p. 52], access limited [19, p. 23] or precautions taken to ensure privacy [59, p. 272]. Privacy related questions are not new and apply to all kinds processes that use data, but they seem to receive little attention in the current discourse about OGD—see [61, p. 41ff] and [106] for some initial considerations. Still, a privacy related discussion seems necessary to avoid reactionary or thought-terminating clichés and excuses to not publish OGD due to vague privacy concerns.

Aside from the theoretical considerations, there are already OGD success stories. For example, Goldstein *et al.* 's [110] book “Beyond Transparency” provides a “cross-disciplinary survey of the open data landscape, in which practitioners share their own stories of what they've accomplished with open data” [110, p. ix].

Almost all of the presented cases in Goldstein *et al.* 's [110] book are rooted in the USA or written with a U.S. American perspective. Most of the presented cases have a somewhat anecdotal character that OG practitioners or civil servants might find useful for that specific reason. The cases describe how inter-institutional hurdles were tackled or which aspects became important in day-to-day operations. Presented case studies include a look at Chicago's technical infrastructure for OGD [111], how Chicago fostered and built an open ecosystem that activates local activists [112] or lessons learned from the London Datastore [113].

Another book that focuses on the USA and OGD is provided by Tauberer [107]. He provides his personal overview about the history and principles of the OGD movement. His perspective is interesting as he is one of the very early OG activists. As such, he was one of the selected and interviewed civil society actors to answer guiding question two, see chapter 10 for more information.

Tauberer is also well-known for his work on the website GovTrack.us.[1] He launched the website in 2004 with the goal to provide better access to governmental information in an aggregated, modernized, and contextualized form. Tauberer felt that the official government websites were outdated, information was too scattered across several websites, and websites were rarely if ever updated to match technological advances. Hence, he created automated processes (screen scrapers) that pull existing information from government websites. GovTrack.us offers easier and unified access to the pulled data, for humans and for re-users via Application Program Interfaces (APIs) that allow machine-to-machine communication. Today, GovTrack.us reaches 1 million visitors each

[1] See http://govtrack.us/, accessed February 22, 2016.

month [109, p. 203] and while the offered aggregated information is free, the offered service is for profit and differs from most of such projects that are non-profit. Tauberer generates revenue via advertisements on the website to support the project [107].

Readers with an interest in a German perspective may find Barnickel *et al.* 's [60] introduction to OGD more useful. They explain OGD, the concept of linked open data, and include a short look on the situation in Germany. The book [114] that contains this introduction offers a more general overview about open initiatives in research or communities, e.g., on open access. A comprehensive study that targets the provision of OGD in Germany explicitly is provided by Klessmann *et al.* [61]. The study was ordered by the German Ministry of the Interior to clarify organizational, legal, and technical questions.

To judge the provided OGD two models were proposed by Yu *et al.* [6] and Tauberer [107]. Yu *et al.* 's [6] model looks at OGD and places an emphasis on what kind of data is released openly. Their model distinguishes between four quadrants that are created by two dimensions: The first dimension is based on how easy it is for re-users to make innovative use of the published data ranging from *adaptable data* to *inert data*. The second dimension investigates the intent of data provision, looking at the type of anticipated benefits. This dimension ranges from *service delivery* to *public accountability*. Figure 7.1 shows the model and some examples for each quadrant.

Yu *et al.* [6] discuss the fact that governments are hardly open if they only release data that is inert or intended for better service delivery. Their point emphasizes the discussions in chapter 6.1 and 6.2. OGIs aim to do more than to just provide electronic services or some kind of access to government data. Most of Yu *et al.* 's [6] provided examples for OGD do not match the criteria of the Open Definition or the ten principles for OGD. Online Portable Document Formats (PDFs) are not intended for machine processing, neither are online forms or even printed releases. Still, Yu *et al.* 's [6] considerations and model help to highlight and assess released OGD. Their model allows a visual identification of shortcomings in the released data by categorizing the releases in one of the four quadrants.

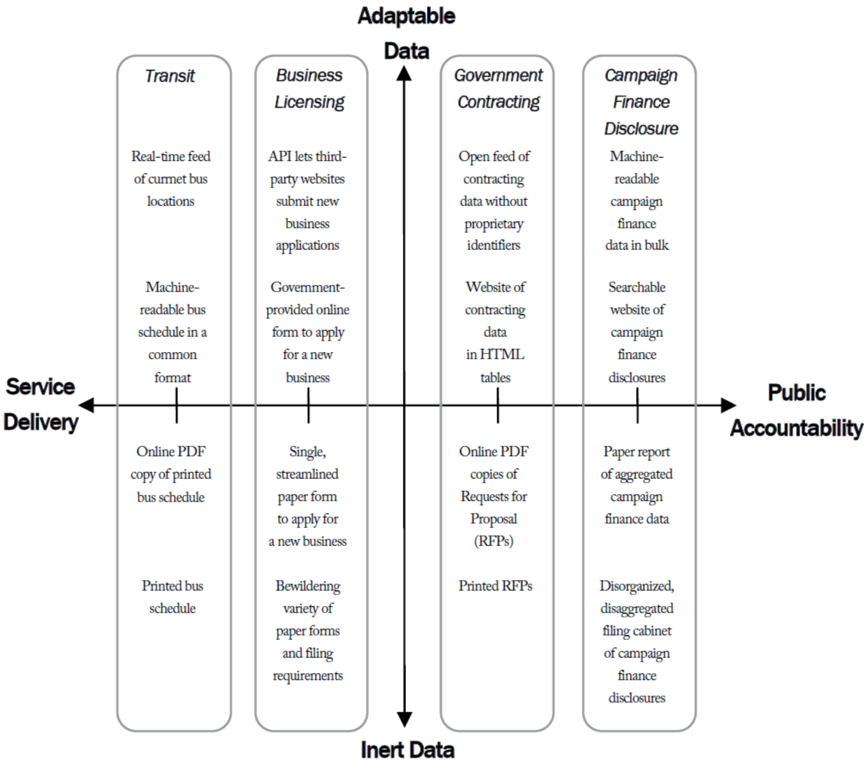
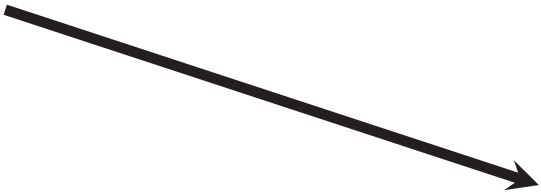


Figure 7.1.: Yu *et al.* 's [6] conceptual model to assess OGD. The vertical dimension describes access and ease of adaptability of the data, while the horizontal axis describes the intent. Examples are provided to illustrate the differences, albeit most of them do not match the Open Definition.

Tauberer [107] proposes "a maturity model for OGD" that can be seen as road map of what governments should publish, see figure 7.1. He distinguishes between a *technological dimension* and the different *domains of government data.* The vertical dimension in his model is a mixture of concrete technological concepts such as APIs or linked data, and policies, e.g., FOI laws to get access to closed government data. The horizontal

Table 7.1.: Tauberer's [107] model proposes a progression of priorities for OGD in terms of technological steps (vertical) and domains of government data (horizontal). Governments should start their efforts in the top left quadrant and progress to the bottom right. Depiction adapted from [107].

	Law	Services	Structure	Operations	Public Data
FOI					
Online/Accessible					
Open					
Structured Data					
Global IDs					
APIs					
Linked Data					



domain distinguishes between data domains such as legal documents, data that is directly produced by governmental agencies (e.g. weather or census data), structural data about governmental organization or public data in general that contains everything that is not already covered.

Tauberer's [107] model poses the question what, how and in which order governmental data should be released more clearly compared to Yu *et al.* 's [6] model that provides a frame for characterizing released data. Still, Tauberer's [107] model can be argued over as there is an ambiguity in the overall progression. While the purely technical steps in the technological dimension build on one another with structured data, global IDs, APIs and finally linked data the mixture with policies (FOI and "Open") seems to be derived from the history of the movement in the USA. The overall ordering of the dimension of government data can be disagreed with as well, and Tauberer recognizes this in his book.

Yet, it is useful to think about a progression of which data should be released and how this should happen, albeit these considerations should not lead to overplanning. The OKFN explicitly encourages governments to "start out small, simple and fast"[2] as there is no requirement to open

[2]See the Open Data Handbook, online http://opendatahandbook.org/guide/en/how-to-open-up-data/, accessed February 24, 2016.

up every dataset right now. Members argue that the innovative potential and process is more important as it facilitates change and builds up momentum. Failures are recognized as an important part of opening up OGD, and it is expected that not every dataset will be useful.

As such, the OKFN encourages civil servants to act sooner rather than later, and to engage often and early with re-users to learn from each other. They pursue a “learning-by-doing” approach with several small steps in short iterations.

A project that actually evaluates released OGD is the OpenDataMonitor[3]. The OpenDataMonitor is a collaborative project that was funded by the EU’s Seventh Framework Programme for research, technological development and demonstration. The project checks published OGD in the EU with an automatic process and aggregates the results for the member states. Machine readability, open license, accessibility, and completeness of metadata (data that describes the data) are analyzed to provide an overview about the overall progress of the implementation in the member states.

Janssen *et al.* ’s [108] summary on OGD fits well as they state that it is not enough to merely establish a portal to make data accessible. Equally important is the quality of information, and the provision of tools, and instruments with which to use the data.

[3] See http://opendatamonitor.eu/, accessed February 22, 2016.

7.3. Civil Society

> The shaping of OGD is a political and social struggle. Failure to engage in this context does not make it apolitical; it simply creates a vacuum for vested interests to harness the power of OGD for private gain. If there is any potential in shaping OGD towards a progressive future, this struggle must be widely appreciated and understood and it must engage those beyond the current OGD community. —Bates [40, p. 7]

Civil society may be defined from diverse perspectives whether based on its organizational or legal form, clientele and target group, the degree of philanthropy or voluntary engagement. A pragmatic definition of civil society is that of a sphere between the market, the state, and the family [115]. For this thesis, a broad definition and focus on all kinds of civil society actors is adopted: Individual activists that address specific goals or organized forms such as Non-governmental Organizations (NGOs) or foundations are here referred to as civil society actors or Civil Society Organizations (CSOs).

From a democratic theory point of view, the term is deeply associated with the values of democracy, participation, and civic engagement [see 116–118]. In democratic regimes, civil society plays a crucial part in citizen information and education. It acts as a "watchdog" over state actions, raises attention for important issues, depicts grievances or takes care of minorities' rights and representation. Besides, it fulfills an intermediate function linking and mediating between the state apparatus and the general population, and serves as a service provider in welfare states [119, 120].

Apart from that, civil society traditionally has a high share in providing and fostering innovations in areas of life. Actors are often specialized experts or visionaries in the promotion of democracy, equality or environmental protection amongst others topics. A prominent example of an influential actor of civil society in the field of OG is the Open Knowledge Foundation (OKFN). Founded in 2004 in Cambridge as a not-for-profit organization the OKFN is specifically dedicated to promoting open knowledge in all its forms. They have launched several projects, prominent among which are the Open Data Index and the Comprehensive Knowledge Archive Network (CKAN) as one possible technology to establish Open Data Portals.[4]

The Open Data Index assesses which countries are most advanced and which are lagging in relation to OGD, looking at several categories like national statistics, pollutant emissions, government budget or national maps—pressuring governments worldwide to keep up. CKAN is used by many administrations as the underlying technology for their OG platforms and is under active development by the OKFN. CKAN is a prime example showing that civil society has not only a crucial share in promoting the idea of OGD but furthermore actively enables governments to publish OGD in the first place. Governments can build and adopt CKAN to their needs as it is developed as open source and free software project. Several governments worldwide seem to embrace the concept as 29 national governments use CKAN for their OGD platform and various federal and local governments. Among them are countries such as the United Kingdom, Canada, Germany, Argentina, and Brazil.[5]

However, there are certain challenges that civil society actors might face in the context of OGD [61]: Firstly, the provision of OGD to the general public may challenge some organizations' predominance as exclusive information sources and gatekeeper. Secondly, an insufficient expertise of different civil society actors to handle data may enforce differences between organizations as it favors only those technically capable and trained for working with OGD. Thirdly, civil society has to be careful in the adaptation of state tasks in its role as an intermediary. After all, the promotion and implementation of OGD is a joint task [61, p. 59f]. Still, initial experiences suggest that a high degree of involvement of CSOs leads to stronger processes and outcomes overall [121].

Besides present challenges, there are certain doubts related to the multiple roles civil society takes up in the field of OGD. These especially

[4] See http://index.okfn.org/ for the Open Data Index and http://ckan.org/ for CKAN, both websites were accessed March 06, 2016.

[5] See http://ckan.org/instances/ for the list of governments who reported back their usage of CKAN, accessed March 06, 2016.

concern civil society's share in the implementation and use of OGD and are linked to their influence in government decisions [122, p. 626].

Such fears pick up in the often cited argument that civil society is not always benevolent, philanthropic or pro-democratic [see 123–126]. Civil society should not carelessly be assigned state duties and responsibilities as civil society actors may represent discriminatory, particularistic and reactionary interests as well. This "dark side" of civil society [125] needs to be considered especially in light of potential instrumentalization and in the context of releasing large quantities of datasets which could potentially be misused or used for uneasy and undemocratic objectives.

Bates's [40] provides relevant insights regarding the potential risk of instrumentalization in the context of the British OGD community. Based on twenty-one interviews he identifies and describes this particular vulnerability of the emerging OGD community. Most prominently, he finds a lack of contextual awareness. British community members seem to be "very unclear about what specifically the political positions are of those advocating on behalf of the community to the state, particularly in relation to their views on the role of the state and the public sector" [40, no pagination]. Bates [40] views this emerging disconnect between the broader community and its "representatives" as crucial and problematic. According to him, this "betrays an elitism that makes the community vulnerable to assimilation into others' agendas" [40, no pagination].

Bates [40] concludes with concrete recommendations for a holistic approach to include civil society as a whole. Instead of just relying on highly visible individuals or well-established actors practitioners and researchers should connect with organized civil society, local communities, and domain experts in and outside of the currently existing OGD community. Practitioners should engage at the grass root level to understand social and economic anxieties that are prone to exploitation by interests in the media or political sphere and promote democratic, inclusive and engaging modes within the OGD communities.

7.4. Geo-visualizations and PPGIS

To understand and relate Public Participation Geographic Information Systems (PPGISs) to geo-visualizations one needs to understand what a Geographic Information System (GIS) is first—as PPGIS emphasis public and participation in GIS use.

Clarke's [127] definition of a Geographic Information System (GIS) is often encountered. He describes GISs as "computer-assisted systems for the capture, storage, retrieval, analysis and display of spatial data" [127, p. 175]. In short, the function and purpose of a GIS is to help solving geographic problems [128, p. 16]. Longley *et al.* [128] compare GISs to word processing tools—they view it as background technology that allows to handle spatial data for various purposes [128, p. 16]. Just like word processing tools, GISs come in many flavors with distinctions for certain purposes. Still, every GIS allows the handling of geospatial data—be it for the purpose of creating maps, running complex geospatial analyzes, supporting spatial decision-making or for other uses that involve geospatial data.

While several other definitions exist (see Longley *et al.* 's [128] textbook) research dealing with PPGIS is best described with Clarke's [127] definition in mind. PPGIS research, also referred to as Participatory GIS, focuses on the ease of use of GIS to involve the public and all stakeholders in the process of official decision-making [129, 130]. Sieber [129] subsumes the entire notion of PPGIS as follows:

> PPGIS provides a unique approach for engaging the public in decision making through its goal to incorporate local knowledge, integrate and contextualize complex spatial information, allow participants to dynamically interact with input, analyze alternatives, and empower individuals and groups. —Sieber [129, p. 503]

Sieber's [129] definition allows to make a distinction between geo-visualizations and PPGIS research. While geo-visualizations are used in PPGIS, they are by choice not a fully functional GIS for handling complex spatial data. As established in section 6.4 geo-visualizations are understood as instruments and social-technical artifacts that are part of a sense-making activity helping in the process of knowledge construction. Geo-visualizations are seen as an interactive medium for information exchange and participation in decision-making.

While geo-visualizations may certainly allow simple adding or manipulation of spatial data, they are more focused on the representation and interaction with the visualization of the information. GIS or PPGIS use geo-visualizations for this as well, but they require a thorough understanding of hardware, software, data, and underlying methods—even while PPGIS focuses on the use by non-experts. PPGIS are complex systems that have a wide range of functions, while geo-visualizations are conceptualized as interactive windows to the world allowing to explore and present dynamic geospatial data [81]. Longley *et al.* [128] explain the relation between geo-visualizations, PPGIS, and GIS as follows:

> The contribution of geovisualization to PPGIS can be viewed as developing and broadening the base of users that not only sources information through GIS, but increasingly uses GIS as a medium for information exchange and participation in decision making. —Longley *et al.* [128, p. 309ff]

Using accessible and interactive geo-visualizations places an emphasis on engagement that may lead to participation, collaboration, and in later stages to decision-making. As previously explained in the motivation (see section 2.2) geo-visualizations are understood as a carrier of a message, as (part of) a canvas, like a spoken dialog, a text or an image. Sui *et al.* 's [24] metaphor of "GIS as a medium" is applied re-emphasizing the role of speech, narrative, and rhetoric [24, 25] as GISs are increasingly used in social media contexts [131].

In contrast, a substantial amount of work regarding PPGIS focuses on creating Spatial Decision Support System (SDSS) or even Multi-Criteria Spatial Decision Support System (MC-SDSS) with highly complex workflows for decision-making [e.g. 132–135]. Researchers have argued that the focus on problem solving undermines "the important process of exploring and reconciling diverse problem understandings among those affected by the problem" [136, p. 1973]. As a result, citizens may simply choose to ignore PPGIS projects as the effort to get involved is too high compared to the expected potential benefit, due to an effect known as rational ignorance [137].

The shift in perception that focuses on citizen engagement, and knowledge production in participatory mapping contexts is best reflected in Participatory Geoweb research [138]—a term coined by Sieber [139]. Participatory Geoweb or Geospatial Web research focuses on online mapping platforms where users can contribute content by using Web 2.0 ideas [140]. With the advances in ICTs and HCI research citizens are now able to integrate official government data and interact with the "government by modifying and contesting 'official' data and how it is used in planning" [141, p. 668]. Elwood *et al.* 's [20] deliberations on "new spatial media" are similar. They conceptualize geovisual artifacts on the Geoweb as opportunities for civic activism and engagement to effect social change. Still, the goal of PPGIS research and activities surrounding the Geoweb remain similar. Both aim to gather input and include the public in government processes [142], as such the available literature is highly relevant for this thesis.

The body of knowledge on PPGIS that led to the idea of a participatory Geoweb is extensive, and several surveys of the literature are available. Dunn [143] looks at the democratization potential of PPGIS and investigates issues of control and ownership of geographic information. Sieber's [129] review traces the social history of PPGIS and identifies four major themes that are present in the literature: place and people, technology and data, process, and outcome and evaluation. Similar to Elwood's [144] review she identifies new research directions while Elwood [144] focuses on identifying ambiguities and challenges.

Elwood [144] discusses barriers that hinder the use of PPGIS systems and how diverse PPGIS are used by experts and non-experts alike. Also, she highlights issues regarding the use of digital technology in citizen engagement by elaborating on the risks to digitally divide and marginalize parts of the population if only digital technology is used. For example, access to digital technology is gated by the financial situation of individuals, and while the costs of hardware, software and data have dropped, Elwood [144] argues that little has changed at the bottom of the digital divide. Other concerns she formulates relate to how technological and knowledge barriers are reinforced in the day-to-day operations even if the goal is to explicitly involve and train the public [145].

Crampton [138] extends these considerations by stressing the importance of net neutrality. As the Internet is used to disseminate and enable most of these applications, it is important that access to an application should not be slowed down, accelerated or even prohibited based on how much was paid for the access. Similarly, the content that is served can not affect the delivery to avoid favoring content that is in line with current political and societal agendas.

Concrete PPGIS applications that have inspired this thesis are reviewed in the next section (7.5) that deals with ICT enabled citizen engagement applications in general. PPGIS researchers continue to investigate participatory urban planning processes [133, 134, 146] or issues of accountability, equity, and legitimacy [76]. After all, maps and political participation make good partners [147], but not everybody should need to be a proficient GIS user to use them.

7.5. ICT Applications for Citizen Engagement

The body of knowledge regarding ICT enabled citizen engagement is extensive. Several specialized communities contribute to it, and the following review presents the subset of related work that informed this thesis. Presented applications and considerations draw mainly from research communities that deal with mobile computing, Location Based Services (LBSs), Computer Supported Collaborative Work (CSCW), Human-Computer Interaction (HCI) and Public Participation Geographic Information Systems (PPGISs). The presented three prototypes in chapter 12 were largely inspired and guided by work from these communities.

Discussed related work in this section does not necessarily have a clear “political” context. Rather, it focuses on the type and level of the interaction that it allows. As such, the presented related work is organized according to the previously established levels of citizen engagement. The review is split in three subsections and starts with research that is related to *informing* citizens. It is followed up by work aiming to *involve* and *consult* citizens. Both levels are reviewed together as most of the presented application could facilitate both levels. Lastly, applications and research that facilitates *collaboration* are discussed.

7.5.1. Information

Informing citizens does not require an exchange of information between involved parties. Information is just provided to citizens by government officials using various forms of communication, e.g., via textual descriptions, visualizations, radio broadcasts or any other type.

However, citizens have to be made aware that information exists in the first place. This aspect is arguably an equally important part compared to communicating the information itself. Arnstein [71] notes on this aspect that “informing citizen of their rights, responsibilities, and options can be the most important step toward legitimate citizen participation” [71, p. 219], albeit she makes clear that citizen engagement should not stop here.

To inform and establish a relation to the engagement case, researchers often use its spatial relation. For example, Han *et al.* [148] developed a mobile application called “Lost Stage College” to raise community awareness of local landmarks, leveraging the potential of user generated content and situated digital storytelling. Their study revealed a relationship between residents and the spatial features of their community similar to the way Taylor *et al.* [13] describe how “data, people and things intermingle to continuously enact place” [13, p. 2864]. Another example that uses digital content and associations to place to raise civic engagement is presented by Crivellaro *et al.* [14]. They used digitally supported urban walks and counterfactual maps to prompt discovery of issues and to reveal (dis-)associations to places and practices in the city.

Some ICT enabled citizen engagement applications rely entirely on the relation to place to gain citizens attention. For example, the situated voting applications [149–151] that are discussed in the next subsection allow citizens to only vote near an engagement case or an affected area.

Using spatial relations to enhance applications or services is one the core pillars of mobile and ubiquitous computing research. Smartphone applications often consume data from the integrated sensors to create location or context-aware applications. Location Based Services (LBSs) provide information related to the current user's location. As such, LBS are considered to be a subcategory of context-aware services that include other factors as well [152, p. 2]. A common example for a LBS are navigation applications that provide navigational instructions from the user's current location to another [e.g. 153].

LBSs can be categorized into reactive and proactive systems. Reactive LBSs require user actions while proactive LBSs do not and act if certain conditions are met, e.g., approaching a location or crossing a virtual barrier [152, p. 3]. Mobile navigation applications are usually reactive as the user starts an inquiry. An example for a reactive LBS in the area of ICT enabled citizen engagement is UbiPOL [154]. UbiPOL aims to increase citizen motivation in policy processes, although the project focuses more on technical aspects and potential workflows to allow citizens to engage in the policy processes ubiquitously.

In 2002, Munson *et al.* [155] described how to use LBSs as general purpose services to provide proactive notifications for users. The idea is straightforward: If a user is in a certain distance to a predefined geographical area, a notification is triggered on a user's phone. One particular case of such location-based notifications are spatial reminders. In 2005, Sohn *et al.* [156] developed and evaluated an application for mobile phones that allows placing reminders on previously visited locations. The limitation to be only able to set reminders on previously visited locations is a byproduct of technological constraints that have now vanished as Global Positioning System (GPS) receivers are available on all modern smartphones. Still, even with this limitation, their evaluation revealed that participants found location based reminders useful and that reminders "were often used for creating motivational reminders to perform activities that would vary in priority over time" [156, p. 248].

Munson *et al.* [155] envisioned several application areas for general location based notification systems like tourism, traffic, information, public service and safety. This concept of triggering spatial notifications proactively based on a spatial area or proximity is known as geofencing and seems to have originated in the area of vehicle- or fleet-tracking [155]. In essence, geofences are virtual barriers that usually generate events if a tracked object or person crosses the virtual barrier. These virtual barriers can have different shapes, ranging from simple circular ones that represent a particular point or area to complex shapes that represent artificial or natural phenomenons like roads, buildings or rivers. Recent developments in the area of LBSs and geofences have focused on the "proactive" aspect of the provision and monitoring spatial and temporal relations between the user and the surroundings [157].

Proactive LBSs are sometimes part of locative media applications: Do *et al.* [158] created a framework called LoMAK that allows non-technical experts to create and play locative media walks. A web-based authoring tool facilitates the creation of geofences with attached media while a smart phone application allows users to experience the locative media walks—triggering media files as soon as a user is near a certain location.

This evolution from reactive systems to proactive systems that act on changes is seen as an important step for the use of LBSs in the field of eParticipation. Themistocleous *et al.* [159] particularly emphasizes the shift of focus towards application-oriented approaches rather than content-centric applications and state that this may help in the adoption of LBS in eParticipation. In summary, LBSs seem to be a suitable tool in the context of mobile participation for socializing and changing the organization of public life [160]. Although their use is not widespread, people usually accept and demand technologies in the context of eParticipation, which are relevant to their everyday life and which are easy to use [161].

As such, one of the presented prototypes in chapter 12 builds on the idea of informing citizens through a proactive LBS based on user preferences and geofences to trigger notifications about engagement opportunities. The implicit action of moving through the city is used to inform users about engagement opportunities in the immediate vicinity.

Furthermore, the developed application provides an interactive geo-visualziation that allows the exploration of all engagement opportunities on the user's smartphone to allow targeted searches.

7.5.2. Consultation and Involvement

Related work that deals with consulting and involving citizens is reviewed in combination as most of the presented applications in this subsection are applicable for both categories. The difference between *consulting* and *involving* citizens lies in the continuity of the process and the degree of consideration and provided feedback to the public. *Consultations* usually only collect public feedback and acknowledge that it was received. If citizens are *involved* this process is extended and happens on a continuous basis: public concerns and aspirations are collected continuously, and feedback is provided on how the involvement influenced the decision.

Typical applications that consult citizens regularly allow voting or commenting on an issue but do not extend the process beyond the initial vote to allow actual involvement. In the following, three situated voting applications are described that were developed and researched in the area of Computer Supported Collaborative Work (CSCW): The first application called PosterVote [149] combines conventional posters, low-tech and low-cost hardware to allow the collection of opinions. A digitally enabled poster is the result, that offers passing citizens the option to vote on the presented topic of the poster. These digitally enabled posters are placed at highly visible and public places in the area in question, e.g., the road that is to be restructured.

The second voting application is Viewpoint [150]. Viewpoint allows similar interactions, although it displays the current status of the poll immediately. Additionally, it offers the option to vote via SMS to avoid being seen using the physical interface, and the system is suited for longer deployment times in comparison to posters. PosterVote and Viewpoint were both found to be an effective tool for local activist groups in deployment studies. MyPosition [151] is the third example for situated voting applications. MyPosition builds upon Viewpoint and offers passing citizens the opportunity to vote on a topic using a natural gesture, raising one's hand, in front of a large public display. The evaluation of MyPosition revealed that participants who used it to vote on controversial questions would prefer a less public setting, albeit the very nature of publicly voting impacted onlookers positively to use the installation themselves.

A well-known example from PPGIS research that allows citizens to provide comments, potentially useful for consulting and involving citizens, was proposed by Rinner [162] in 1999. He formulated the idea of an "Argumentation Map" for the purpose of spatial planning. The basis of his idea is that participants can create textual arguments that can refer to a location on a map within the argument to illustrate it.

In essence, his idea allows participants to "pin" arguments to a place and reply to established arguments in a textual discussion forum. Rinner [162] envisioned "Argumaps" as helpful because the arguments that were put forth "could then better be considered by by planners or politicians" [162, p. 99]. As such, his initial concept for an Argumap envisioned it as a tool for consulting the public. However, if used continuously by officials and citizens alike, the idea seems equally applicable for involving citizens. An expanded version of the initial paper and idea was published in 2001 [163].

Rinner's [162] initial idea gained much attention in recent years, and he kept expanding on it [164, 165]. Additional considerations are discussed by MacEachren *et al.* [166]. They discuss the potential of map-mediated dialogs between human collaborators in face-to-face and group scenarios focusing on spoken words and freehand gestures. Subsequent work by Hopfer *et al.* [28] examines how geospatial annotations support collaboration from a communication theory viewpoint. The main argument here is that geospatial annotations accelerate insights in group discussions into what is known, who knows what, how a problem is understood by group members, and how an issue is negotiated by group members over time. Additionally, Hopfer *et al.* [28] argue that maps can actively encourage explicit contributions of knowledge, reduce redundant information, and highlight underrepresented views.

Several implementations of the Argumap idea are available. An early prototype by Keßler *et al.* [167] focuses on the use of open standards and technical details while Rinner *et al.* [168] evaluated the concept with Keßler *et al.* 's [167] prototype in a deployment study. Their deployment lasted 18 days and acquired 16 participants from the general public. Rinner *et al.* [168] found "that while users were comfortable with the discussion board aspects of ArguMap, they did not readily understand the GIS aspects of the tool" [168, p. 19]. The main function of Argumap that allows linking comments to places on a map was only used once during the deployment. Rinner *et al.* [168] concluded that "the main challenge is that of accessibility" and that such applications need to be highly integrated into the community and its organization to properly promote and to demonstrate the use [168, p. 599].

Cai *et al.* [169] expanded on the idea of the Argumap and support linking between arguments and implemented a complex prototype called "GeoDeliberator". Their prototype allows to create different kinds of arguments and features a moderator systems with different hierarchies and user roles and rights to structure a deliberative space. The authors see their applications primarily use in consulting the public to allow people to contribute ideas [169].

Another implementation is called ArgooMap [170] and focuses on the introduction of Web 2.0 concepts and technologies. ArgooMap was extended by Austerschulte *et al.* [171]. The extension focuses on easing the linking of place references from the textual interface to places on the map with a suggestive geo-tagging assistance mechanism. A recent implementation of 2011 targets cloud computing aspects and scalability of the software [172].

With the exception of the deployment and evaluation of the first initial prototype [168], researchers' center of attention seems to be to integrate new functions or update the technological basis. Deployment studies and evaluations with participants from the general public seem to be scarce and Rinner *et al.* 's [168] evaluation had an arguably small sample size and short duration. For that reason, the second prototype of this thesis—called DialogMap—was evaluated in an extensive deployment study with a partnering CSO to provide additional insights. DialogMap is inspired by the concept of an argumentation map and couples textual and spatial user interface elements tightly compared to the presented related work. The DialogMap prototype was evaluated in a scenario that presented actual engagement opportunities to citizens. It allowed users to obtain information about engagement opportunities based on textual representations with photos, testing weather users preferred the tightly coupled spatial and textual view or only the textual representation. Additionally, it provided them with the chance to leave comments or start discussions similarly to an argumentation map, see chapter 12 for descriptions and results.

7.5.3. Collaboration

Collaboration requires a continuous and ongoing exchange of information. Involved parties are partners and equally involved in all aspects and processes. A prominent example for ICT enabled geospatial collaboration is OpenStreetMap (OSM)[6].

OSM relies on volunteers to collect geospatial data in a crowd-sourcing approach, and the collected data is published under an open license. OSM's data is used to generate custom maps, often encountered as a basic layer in online mapping applications, and certainly a very successful example for collaborative geospatial data collection. Due to OpenStreetMap, citizens can create maps without the need to pay for official data, with comparable accuracy [173].

The need for digital tools that support geospatial collaboration has been recognized by various researchers and predates OpenStreetMap's popularity. For example, Jankowski *et al.* [174] published a paper that saw the need to support collaborative spatial decision-making in 1997. They defined *collaboration* as the process of two or more persons working together on a single task. They used the term *cooperation* to refer to situations where persons are working on several tasks while only sharing the results. MacEachren *et al.* [175] coined the term "geocollaboration" for collaboration focused on geospatial aspects in 2004. Earlier work

[6] See http://www.openstreetmap.org/, accessed March 10, 2016.

by MacEachren [176] identified four scenarios for collaboration: same time/same place, same time/different place, different times/same place, and different times/different places.

These scenarios are identical to scenarios that were previously identified for collaborative groupware systems [177]. Each category differs in terms of the interaction and how well it supports different tasks. Systems supporting synchronous distributed collaboration (same time/different place) are also called (distributed) real-time collaborative editing systems and have been investigated for code or text editors [178], but there is also work looking into graphics [179] and CAD programms [180]. Prominent examples for text-based real-time collaborative editors are Etherpad or Google Docs.[7]

Research targeting *synchronous* distributed collaboration on geospatial data is comparatively scarce. Butt *et al.* [181] describe a prototypical geo-conferencing tool, where their primary focus is on supporting communication via whiteboard interaction. Their application aims at providing a presentation and discussion tool for geospatial data rather than facilitating the editing of geospatial data. Chang *et al.* [182] propose an abstract model for real-time geocollaboration that incorporates technological, geospatial, and social aspects.

Cyclopath is an *asynchronous* distributed geospatial collaboration platform [183]. Priedhorsky *et al.* [183] refer to Cyclopath as a computational "geowiki" that enables cyclists to map bike routes collaboratively. Cyclopath features a version control system, and compensates the lack of face-to-face communication with certain user awareness features. Carroll *et al.* [184] describe the problems that arise due to the lack of face-to-face communication: Most importantly, the field-of-view is limited, gestures are lost as well as facial expressions. These disadvantages are usually alleviated by introducing user awareness features that highlight changes, visualize the working areas of collaborators, and use different colors for different users. Personal communication between collaborators is enabled by introducing text chats, audio and/or video feeds [184].

[7] See http://www.etherpad.org/ and http://docs.google.com/, accessed March 03, 2016.

Version control systems are important for collaborative applications as they allow to manage collected data over time. They allow collaborators to review the development of a document or data, provide the opportunity to revert it to a previous state, and to check authenticity. For these reasons, text-based real-time collaborative editors such as Google Docs or Etherpad tightly integrate version control systems. In contrast, tightly integrated version control for geo-data is an emerging field [183]. Certain version control systems such as Git are becoming increasingly popular for collaboration in complex knowledge-based activities. This is especially true in the area of software development when they are coupled with a social component like in GitHub's case [185].[8]

In general, research in PPGIS and CSCW is strongly linked to geo-collaboration and provides several use cases [186]. Projects such as OpenStreetMap or Cyclopath demonstrate success and the value of asynchronous geocollaboration, albeit actual synchronous geocollaboration applications seem to be sparse. Inspired by this fact, the third prototypes of this thesis, called "Ethermap" realizes such a real-time geocollaboration system for collectively creating and editing geospatial data. Ethermaps potential applications and evaluation are described in detail in chapter 12.

[8]See http://git-scm.com/ and http://www.github.com/, accessed March 16, 2016.

8 Summary

Part II presented the body of knowledge this thesis draws from. Chapter 6 examined key concepts, established the understanding for each of the four key concepts while the subsequent chapter 7 expanded the scope and discussed related work.

Based on the discussions Open Government (OG) is understood as a government reform initiative that surpasses the use of ICTs, reflecting the goals of openness, participation, and collaboration in government operations and priorities—changing the way how governments engage with citizens [55]. Open Government Data (OGD)—data that can be freely used accessed, modified and build upon—is seen as a precursor and complementary part of OG [56].

As OGIs aim is to engage citizens, it is not enough to publish data and hope that such an action mobilizes the population. Each context, policy or program requires a unique approach, and different levels of citizen engagement are possible [17]. Based on the IAP2's public participation spectrum four levels of citizen engagement were identified. They are inform, consult, involve, and collaborate—and describe the increasing level of impact citizens have with each level. The final and fifth level of IAP2's spectrum that "empowers" citizens and places final decision-making in their hands is omitted due to the thesis' scope as Germany is a representative democracy. Still, the underlying assumption is that citizens want to engage and want have an informed say and impact on the decisions that affect their lives [17].

This thesis investigates one possible way to engage citizens that builds on the conceptualization of geo-visualizations. The presented understanding views geo-visualizations as interactive instruments that facilitate human communication and exploration. Geo-visualizations emphasize exploration and knowledge construction rather a finished product like a map that aims to depict stored spatial knowledge [81]. As a result, geo-visualizations address Ramsey's [136] critique that GIS practitioners often focus prematurely on aspects of problem-solving before problem understandings of all involved participants are investigated.

As OGIs provide the context for this research, the conducted investigations and evaluations in part III emphasize input from actual citizens or real-world scenarios: The understanding of potential roles of the targeted audience, civil society, was established by interviewing actual actors and experts in the field. Similarly, presented considerations on best practices for providing geospatial OGD draw from the author's involvement in actual projects of public administrations to provide OGD—Open.NRW and the European Data Portal (EDP). Two of the three AIG prototypes were evaluated "in-the-wild" with actual citizens, while the third prototype was assessed using a real-world scenario with additional feedback from domain experts. The aspiration to include citizens and public administration in the research process is a direct consequence of the given context, but also an answer to MacEachren *et al.* 's [81] call for a change in the prevalent "build and they will come" approach to geoinformation technology [81, p. 9]. As this thesis is part of Human-Computer Interaction (HCI) research it focuses on interactions with an AIG instead of emphasizing engineering aspects as the presented PPGIS applications in section 7.5 do.

Summed up, this thesis builds on the available body of knowledge from citizen engagement and OG research, while conceptualizing AIGs as a potential facilitator for citizen engagement. Existing ICT applications from research areas like CSCW, mobile HCI or PPGIS provided inspirations for the three prototypes that are presented in chapter 12. The evaluations and insights focus on including citizens or are based on the author's involvement in actual projects of public administrations. As the obtained insights are not purely theoretical but originated from actual uses, citizens, civil servants, OG practitioners, and researchers might find the contributions of this thesis equally useful.

III

Augmented Interactive Geo-visualizations and Open Government

9 Designing AIGs to Facilitate Citizen Engagement

> Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers.
> —Rittel *et al.* [187, p. 155]

Several researchers describe the complexities of citizen engagement or governance in general as "wicked" problems [17, 74, 172, 188–191]. In 1973, Rittel *et al.* [187] coined the term in a paper about planning and social policy in the context of the USA. Over 40 years ago, they observed that protests might have become social movements. This observation, which is attributed to George Bernard Shaw, still prevails nowadays. These social movements are equally visible in Germany: prominent recent examples surround major construction projects such as "Stuttgart21"—refer to Kersting [192] for an overview and discussion of German protest movements.

Rittel *et al.* [187] challenge the perspective that every problem can simply be analyzed in a goal-driven and step-by-step manner—installing and operating a definitive, optimal solution as the result. Their paper addresses the fact that "we've been hearing ever-louder public protests against the professions' diagnoses of the clients' problems, against professionally designed governmental programs, against professionally certified standards for the public services" [187, p. 155].

According to Rittel *et al.* [187], these problems are "wicked" as information that is "needed to *understand* the problem depends upon one's idea for *solving* it" [187, p. 163]. Wicked problems have no clear definition as multiple stakeholders with different perspectives are involved, and the understanding of the problem changes over time. They have no stopping rule but are constrained by external factors such as budgets or time and as such no optimal solutions, rather "good enough" or "not good enough" solutions. Furthermore, solutions are notoriously hard to test as all consequences are only understood after a solution is installed, raising the stakes and strain in the process. While Rittel *et al.* [187] identify additional traits of wicked problems and explain them, their case highlights that one should question the paradigm of a purely rational problem-solving approach with distinct phases and definite answers for social problems.

As such, the described design space in this chapter is not an optimal solution in the sense that it "solves" citizen engagement by using geo-visualizations. Rather, it provides a conceptualization of how Augmented Interactive Geo-visualizations (AIGs) can support citizen engagement. The conceptualization answers GQ1 and provides specific features or examples for each aspect that AIGs should support for different levels of citizen engagement. Hence, the design space is not about spatial decision-making, but the identified aspects and features might help the process of decision-making nonetheless.

Based on the literature review of part II four distinct aspects can be identified as important for using AIGs in citizen engagement: *visualization*, *exploration*, *communication*, and *data*. These four aspects are also the reason why geo-visualizations are referred to here as Augmented Interactive Geo-visualizations (AIGs). As explained in section 2.2 the geo-visualizations need to be augmented to support aspects of communication and data creation or manipulation to facilitate all levels of citizen engagement. By introducing and adding communication functions like textual chats or allowing users to create or manipulate data, they expand their interaction functions considerably and do not only allow to visualize and explore or interact with geospatial data.

In the following, the four identified aspects are discussed individually, linked to the related work, and functions or examples provided that illustrate their meaning:

Communication. Citizen engagement requires different forms of communication between stakeholders, see chapter 6.3. While the most basic level of informing citizens only requires distributing information, every other level requires more complex forms of communication. Consulting, involving or collaborating with citizens increases the complexity of the communication as responsibilities are shared. The discussed ICTs for citizen engagement (section 7.5) illustrate this: consultation applications like ViewPoint [150] or PosterVote [149] only allow simple voting on a topic, while the Argumentation Map implementations feature comment or discussion functions [e.g. 167, 169]. Asynchronous collaboration applications such as OpenStreetMap often store knowledge in Wikis that have dedicated discussion pages while synchronous collaboration applications such as Etherpad or Google Docs have inbuilt chat functions to facilitate immediate communication. Hence, the term communication is used here to describe dedicated communication aspects of AIGs that allow expressing views, preferences or opinions between involved parties.

Data. The second identified aspect revolves around data. Similar to the communication aspect, the capabilities and the need for functions to create, add or manipulate data increase with the citizen engagement level, see section 7.5 and 6.3. Collaborative geospatial applications like Cyclopath [183] include mechanisms that allow the co-production of data such as versioning systems. More basic functions to create or handle simple geospatial data can be found in applications that involve or consult citizens, allowing them to "mark a spot" on a map or "pin" an argument to a place. For the level of informing citizens, the ability to link it to published OGD might be sufficient while more complex levels might require including and re-mixing OGD. As such, the aspect of linking, editing or creating data needs to be considered as well to allow citizens to create their views or express opinions.

Exploration. The third identified aspect for AIGs in citizen engagement is exploration. The term is used holistically to describe all kinds of interactions with an AIG, e.g., presenting, sense-making or knowledge construction activities in a citizen engagement case. This understanding is based on MacEachren *et al.* 's [81] definition of geo-visualizations and well reflected in Crampton's [26] deliberations as the aspect of simply presenting geospatial data is de-emphasized for the process of exploring the data—changing or adjusting it many times over. Elwood *et al.* 's [20] discussions reflect this as well, see sections 6.4 or 7.4.

Visualization. While MacEachren *et al.* [81] stress that geo-visualizations "do more than 'make data visible'" [81, p. 5], visualizing data is still one of their core features. According to them, geo-visualizations focus on *visual* exploration, analysis, synthesis and presentation, see section 6.4. Geo-visualizations depict spatial data and contextualize it at the same time while facilitating reasoning and providing insights into the geospatial data. Plenty of options for visualizing geospatial data exist ranging from simple depictions of spatial locations—"markers on a map"—to complete cartographic visualizations, e.g., choropleth maps, dot density maps, mesh or grid maps or cartograms.

Figure 9.1 depicts the design space of the AIGs. The different levels of citizen engagement are stacked vertically, and the identified four aspects are represented as vertical bars alongside the different levels. Each bar contains examples or functions for that particular aspect that was discussed above. Examples or features are loosely clustered within each aspect to a citizen engagement level. However, they are not exclusive to that citizen engagement level nor do they require a strict progression. Rather, the aspects and functions support and build on each other in combination. For example, the option to compare visualizations to explore alternatives requires different visualization

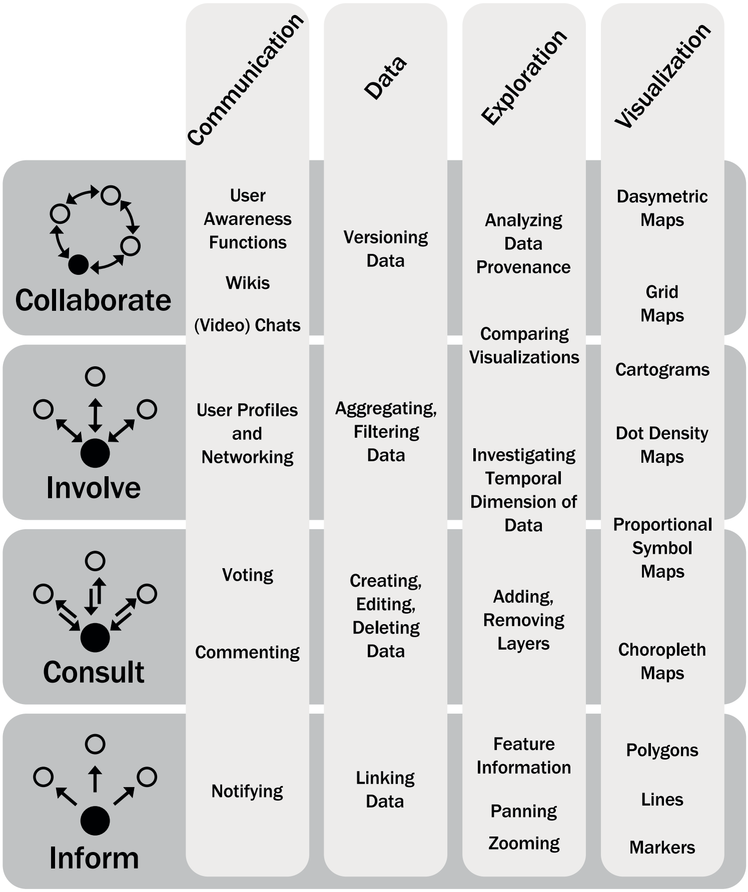


Figure 9.1.: The AIG design space conceptualizes key aspects that are important in citizen engagement scenarios. The visualization aspect contains examples for visualization types while the aspects of communication, data, and exploration provide examples for functions to illustrate their meaning. Examples and functions are loosely clustered to citizen engagement levels but are not exclusive to them, nor do they require a progression. The design space serves as guide to aspects and features for using AIGs in citizen engagement cases.

options or functions to filter or aggregate data. Similarly, different work modes need to be considered as well. For example, synchronous collaboration can be supported by including versioning systems, user awareness functions that highlight work-areas, and integrated (video) chats to facilitate communication between collaborators.

The design space is best read from left to right as this shows which functions of the aspects should be considered for that citizen engagement level. An AIG that is designed to inform citizens requires the two aspects that allow *visualizing* and *exploring* the citizen engagement case as every AIG does. Dedicated communications functions such as sending notifications may help to raise attention to the AIG but do not necessarily have to be included, as these could be provided by an external application as well. Similarly, linking the visualized data to published OGD might help transparency but is not necessarily a hard requirement for the AIG. The first chapter provides a concrete example: figure 1.1 depicts an AIG that *visualizes* the status of the national action plan of Open Government Partnership (OGP) members. Users can *explore* member countries by zooming, panning and clicking on the polygon of a country to obtain additional information, but functions that relate to data or communication are not present.

In contrast, an AIG for collaboration most likely needs features from all four aspects. Stakeholders need to be able to *communicate* with each other to *create, edit or manipulate geodata* together. Enhanced *visualization* and *exploration* functions may help the collaboration process by, e.g., showing how the created data evolved over time and who is currently working on what. An example of a geospatial collaboration application that includes all these functions is Cyclopath [183].

The presented design space can be used in several ways. For example, it can serve as a guide that enables designers, practitioners, and researchers to quickly identify aspects that are important for using AIGs in citizen engagement. Besides this guiding function, the design space could also be used to check existing systems to identify features that might be missing, or that could be extended as the identified aspects are not only relevant for AIGs. Aspects of communication, data, exploration, and visualization are likely to be important for any citizen engagement case—no matter if it has a geospatial relation or deals with geospatial data. Also, it could be used as a starting point for a larger discussion with stakeholders in a citizen engagement case to achieve a shared understanding to illustrate why a developed AIG includes or excludes certain functions.

However, the listed examples or potential functions are neither complete or limited to a particular citizen engagement level—nor do they need to be. The individual functions or examples illustrate the meaning of a particular aspect and provide a starting point for AIG designers or OG practitioners who want to use AIGs in citizen engagement cases. As every citizen engagement case is unique and represents a wicked problem, custom solutions and processes are needed. There are no one-size-fits-all approaches to citizen engagement [17, 187].

10 Civil Society's Role in Open Government Initiatives

This chapter is based on publication P2 "Civil Society and Open Government Data: Challenges and Opportunities" by Thore Fechner and Katharina Obuch. Please refer to the list of publications for the complete citations.

Based on the previously presented related work and six semi-structured expert interviews this chapter looks at civil society's functions in OGIs. It answers GQ2 that aims to understand the target audience and investigates the different roles civil society can take on in OGIs.

Most OGIs are relatively new and primarily focus on publishing OGD. Hence, the investigation reflects this, but as explained in section 6.1 OGD is seen as the first step or precursor in OGIs. With this background, the investigation revealed four central roles that civil society takes on in OGIs: civil society acts as *a driving force*, *a watchdog*, *an intermediary actor* and as *a user* in OGIs. However, the boundaries between those roles are not necessarily sharp—often a single actor takes on multiple roles to reach an overarching objective. Before the four central roles are presented in the following sections, the used method, procedure, and interview partners are described.

Method. Semi-structured interviews were used to capture views, needs, concerns, preferences, and attitudes of the target audience. Additionally, Bates's [40] recommendation was followed to engage with established OG activists, local individuals, and domain experts to avoid biased or one-sided views, see section 4.1 and 7.3. Hence, the selected interview partners are not exclusively civil society actors, but also actors from the government or the private sector. Often, these boundaries are blurry in the first place, as actors might occupy different roles. For example, civil society actors might switch from an NGO to a public administration or vice versa, act as consultants for public administrations, or collaborate with public administrations for specific projects.

The semi-structured interview guidelines were prepared and tested according to Helfferich [41] and interviews recorded using a stereo audio recorder. Recorded interviews were transcribed afterward based on Kuckartz [42, 43] transcriptions rules. The transcripts were analyzed in a process similar to the qualitative summary content analysis that is described by Kuckartz [43, p. 91ff] as it paraphrases, generalizes, and reduces statements.

Procedure. Five interview partners were met in person on a date and place of their choosing in a quiet setting. One interview was conducted via a video chat tool (Skype) due to the interviewee's travel arrangements. Each interview lasted about 30 minutes. During the interview preparations all interview partners were informed verbally and with a written statement about the research and provided consent. Interview partners could stop the interview at any given time, and all interviewees were asked if they preferred to remain anonymous or if they wanted to be referred to in person. All interviewees agreed to be named explicitly.

All interviews took place between February and March 2014 in Washington D.C. in the USA. Washington D.C. was chosen as civil society actors and the entire field had more time to adopt different roles as the recent impetus towards OG originated in the USA in 2009. Additionally, Washington D.C. based actors such as the Sunlight Foundation or Joshua Tauberer are well-known in the OG community and the literature (see sections 3.2, 6.1, and 7.2).

Furthermore, Washington D.C. has one of the largest Open Data Days where OG community actors meet. This opened up the chance to establish contact to additional domain experts and local actors in person. The "Open Data Day DC 2014" at the World Bank was organized in a cooperation of civil society (Joshua

Tauberer and Eric Mill from the Sunlight Foundation) and other actors such as the World Bank. Over 300 participants attended the two-day event on February 22–23, 2014.[1]

Interview Partners. Joshua Tauberer and Tom Lee from the Sunlight Foundation were identified based on the literature review and contacted as interview partners. During the Open Data Day DC 2014 additional actors were identified and contacted that agreed to interviews. In the following, the six interview partners are briefly described and reasons provided why they were chosen.

Tom Lee. Tom is a CSO representative and the Chief Technology Officer (CTO) of the Washington D.C. based and well-known Sunlight Foundation. Tom was chosen as interview partner due to the activities of the Sunlight Foundation. For example, the Sunlight Foundation formulated "the ten principles for opening up government information" (see section 6.2) and developed multiple applications that use OGD. Tom was interviewed on February 20, 2014.

Joshua Tauberer. Joshua is considered to be one of the very early OG activists. He is an individual civil society actor and the developer of GovTrack.us—a website that provides aggregated governmental information. Additionally, he wrote a book about OG and OGD. His work is primarily focused on the USA and he advocates for greater transparency in government, see section 7.2 for more information about his work. Joshua was interviewed on February 25, 2014.

Andrew Turner. Andrew is the CTO of ESRI Inc.'s Washington D.C. based research and development center that develops ArcGIS OpenData—an open data portal for geospatial data.[2] Before Andrew joined ESRI, he wrote a book on the use of

[1] See http://dc.opendataday.org/, accessed March 08, 2016.

[2] See http://www.esri.com/ and http://opendata.arcgis.com/, accessed April 08, 2016. Andrew works for a company associated with the author's employer; please refer to the appendix for additional information and disclosure.

ICT tools, frameworks, and resources that facilitate map creation, an area that he calls neogeograhpy [193]. Andrew's perspective is complementary as he represents a commercial perspective, is a domain expert for geospatial OGD, and active in the OG community, e.g., during the Open Data Days. He was interviewed on February 21, 2014.

Jeanne Holm. Jeanne Holm was interviewed as a USA government official and evangelist for the OGD portal data.gov. As a government official and dedicated evangelist for data.gov her perspective provided valuable insights into the perception of the role of civil society from the government's point of view. Before working as the evangelist for data.gov, Jeanne was part of the open data initiative of the National Space Agency (NASA) of the USA that precedes data.gov. Jeanne was contacted during the Open Data Day and interviewed via a Skype call on February 28, 2014.

Sam Lee. Sam was one of the organizers of the Open Data Day DC 2014 and worked for the World Bank as an open data specialist. Sam was chosen due to his involvement in the organization of the Open Data day to gain a complementary insight into the collaboration with civil society actors. Sam was contacted during the Open Data Day and interviewed on April 03, 2014.

Tariq Khokhar. Tariq was the World Bank's open data evangelist and works as a data scientist. He was interviewed to complement the interview with Sam Lee from a data science point of view and to further elaborate on the World Bank's open data activities and their experiences with civil society actors. Tariq was interviewed on April 06, 2014.

10.1. Civil Society as a Driving Force

First of all, civil society has been and continues to be an important actor in the promotion and proliferation of the idea of OG and OGD, performing the role of a *driving force*.

CSOs with the help of individual activists or loose movements have performed important tasks in OGIs and for the diffusion of OGD all over the world. They have pressured and helped governments to develop OG and OGD strategies, raise public awareness for the idea, and mobilize people to stand up for transparency and information. The significant role civil society plays in the promotion of OGD has been underlined by a CSO representative with view to its status as a public good:

> The fact that it [OGD] is a public good means that it will generally be underprovided by the market though. You can't count on the market forces to push it to the equilibrium that is optimum. And so it is up to those of us in the NGO sector [...] to push for this cause to make sure that it is provided at a level that benefits everyone maximally. —*Tom Lee*

In the USA, a network composed of individual activists, NGOs and foundations have contributed to their pioneering role in the realization of OGD. The network did so by raising public awareness and citizen information through, for example, annually organized Open Data Days, public campaigns to increase the pressure on a government to develop an OGD strategy, but also by allocating technical skills and ideas.

As discussed earlier in section 7.3, CKAN is a well-known example that demonstrates the technical expertise and impact civil society has on OG. CKAN is the underlying technology for several government's OGD platforms and under active development by the OKFN and the open source community. Data.gov, the main OGD portal for the USA, is CKAN based and federates other OGD portals, e.g., from cities while the providing entity is communicated. Since 2009, each agency in the USA is required to publish at least three high-value data sets and needs to register them with data.gov [34, p. 2]. The amount of the available datasets on data.gov has grown tremendously and continuous to do so, as data providers are being pushed and inspired by civil society activists. At the moment roughly 194.000 datasets are clustered into 14 topics such as agriculture, education, health, science and research, or finance—about 132.000 datasets have a geospatial type.[3]

Data.gov's evangelist Jeanne Holm emphasizes civil society's role as an active proponent for OGD. According to her civil society actors "are good partners in being able to both shine light on us when we are not responding well enough but also to help drive that conversation forward as a society about wanting to have more insight into government and more open data available for lots of reasons."

Even before governments proclaim a proper open data strategy, civil society can act as a pioneer in the field as discussed in section 7.2. Joshua Tauberer's GovTrack.us is a renowned example of such a project of a civil society actor that acts as driving force to implement OGD. GovTrack.us screen scrapes the Library of Congress website "THOMAS" to allow citizens to integrate, cross-reference, and follow updates of Congress more easily. THOMAS was built in 1995 to make federal information available to the public through the internet.[4]

Tauberer elaborated in the interview that he started to create GovTrack.us in 2001 and developed the site mostly in his spare time. His initial intention was to allow civic users to hold Congress more accountable, although this goal has shifted over time to innovate public's engagement with Congress [see also p. 208f in 109]. In 2004, GovTrack.us launched and Tauberer played a major role in opening up more information in machine readable formats. In cooperation with a few others, he nudged the Senate's Rule Committee to open up the votes as Extensible Markup Language (XML) files to enable an easier machine processing [109, p. 208f]. During the interview, Tauberer remarked that he tracks the website's users and that a substantial amount seems to be government officials. As such, he created a service that is not only valued by the public but similarly by government officials as well.

[3] See http://www.data.gov/, accessed April 04, 2016.
[4] See https://www.congress.gov/about, accessed April 04, 2016.

At this point, GovTrack.us is an established source for data about Congress for several other websites. Due to Tauberers development, the value of opened up government data became tangible before there was a governmental program. Tauberer created a website that offers easier access to government data. At the same time, he created a service that offers APIs and bulk downloads making the data GovTrack.us screen scrapes freely accessible to re-use for a wider audience. Essentially, GovTrack.us acts as an intermediary for other services or websites, a role that is examined in the next section.

10.2. Civil Society as Intermediary

To foster participation and render possible the idea of OG more is required than free access to raw data in bulk. While the provision of raw data is regarded as central to enable third parties and users to allow them to carry out own analyses of raw data, rather than relying on an existing analysis, these datasets, as well as their formats, can be obscure or require expert knowledge (see 6.2).

In fact, it is highly likely that time and expertise are needed for more complex data. OGD needs to be put into context and processed to allow a wider usage, making it accessible and understandable to a wider public. The risk of digitally dividing the population into groups with and without technological expertise is well-known, see section 7.4. Therefore, once government data has been made freely available and accessible, civil society can play an important role in the re-use and redistribution, processing, and preparation thus performing the role of an *intermediary* between delivering authorities and prospective users.

A central attribute of civil society in OGIs lies in the technical possibilities activists, as well as many organizations, possess: since OGD should be primary data, not aggregated or already analyzed, it is necessary to communicate this raw data in a comprehensible form or to develop analysis tools for others. Technically "smart" CSOs have already demonstrated their capability for the creation of such tools which make the data accessible to a wider audience—enabling other actors to perform independent analyses or to provide a new perspective. Jean Holm refers to this aspect in this way:

> The other role they play is intermediary—in getting it out to people [...] who are often not as tech-savvy or have access to the technology like the hackathon or developer group. So we do not want to be in this situation where we are just giving better access to the privileged elite who have already access to information online. But we want to be able to give better access to knowledge and information to the people who are not as privileged. Civil society is good at helping us to level the playing field. *—Jean Holm*

Moreover, most government websites have long lifecycles and tend to be updated rarely—as such the technological basis they use is often outdated or lacks features which have emerged in the meantime [109, p. 205ff]. Civil society actors are not bound by long release schedules or maintenance considerations, they are more agile and often capable of reacting or adapting quickly—especially if the software in question is developed collaboratively as open source.

Hence, services or websites created by civil society are usually more innovative as their government equivalents. Tailored to one specific use-case with a clear motivation they may feature visualizations or maps featuring OGD, offer mashups or links to other datasets, feature advanced search functionalities or even allow crowed-sourced and collaborative analyzes of the issue at hand [194, p. 85f].

These dynamic new tools and interfaces are often dramatically more useful to citizens [6] and plenty of such examples exist. The Sunlight Foundation created several of these applications. For example, "sitegeist" offers a unique look at the users' current surroundings based upon census data on their smartphone, "scout" allows citizens to subscribe and receive alerts when certain issues or bills are talked about, while the OKFNs "OpenSpending" project visualizes governments' spending.[5]

[5] See http://sitegeist.sunlightfoundation.com/, http://scout.sunlightfoundation.com/ or http://www.openspending.org/, all websites were accessed April 04, 2016.

OGD simplifies the realization of such projects—but as it is not present for all scenarios (and most likely never will be) civil society actors often create, accumulate or curate the necessary data themselves.

The classical example for such activity is the creation of a "scraper". Scrapers are specifically developed pieces of software to harvest websites automatically, collecting data in the process and storing it.

> So we write scripts that go out and collect data [...] and put it into reliable formats that are totally open and re-usable. We provide APIs that make it possible for people who don't have the capacity to store large amounts of data or run scripts on ongoing basis to use them. —*Tom Lee*

Scrapers are not the only options, sometimes civil society actors link datasets to one another, create or enhance metadata or even manually digitize scanned documents if there is no other option. Still, the end goal is clear for Tom Lee: "But the result that we try to get to is APIs, bulk downloads, and open formats that anyone can use." Tom Lee is fully aware of their role as intermediary and sees this as a big part of many CSOs' strategies. He says that they "target journalists, activists, and others who are mediating institutions that can amplify the power of that data to the audience they have already organized".

Altogether, civil society representatives, government officials, and domain experts agree on the role of civil society actors as an intermediary. Andrew Turner puts it like this:

> Civil society then is the one that can help bridge the gap between that raw data and put it into relevant information depending on different communities. They can represent the individual interest of local citizens, specific interests groups, different thematic areas [...] they can essentially be those kinds of ambassadors of this data to those individuals. —*Andrew Turner*

10.3. Civil Society as a Watchdog

Another important task of civil society, once a government has pronounced a first OG strategy, is that of controlling the implementation and realization processes as a kind of *watchdog*.

Civil society actors can monitor and advise the implementation of OGD whether by providing technical knowledge, acting as a consultant, or performing the function of a supervisor—keeping track of the implementation process. As explained in chapter 6 that discusses key concepts, OGD and OG are still relatively unexplored, and uncharted fields and best practices or guidelines are just emerging. This fact makes it even more necessary to monitor the implementation process and its compliance, for example, to check whether the published OGD is adhering to commonly shared principles (see section 6.2). Actors from civil society can contribute to preventing misuse, depict technical shortcomings, fight for removing barriers that restricted access and "close the gap between strong open government policy commitments and a slow or weak implementation of them" [121, p. 10].

Tom Lee pointed out the fact that governments—even if they provide OGD—often lack the willingness to "face actual consequences that are attached to this data" referring to privacy issues, incomplete data sets or technical provision.

> With that said it becomes really important for people in civil society to be pushing and demanding more from them. It is not enough to just count on government to pursue this agenda on their own. —*Tom Lee*

A prominent example for a CSO performing the role of a watchdog as regards the implementation of OGD in the USA is the Sunlight Foundation that Tom Lee is part of. Founded in 2006 and based in Washington D.C, the Sunlight Foundation it is a nonpartisan and nonprofit organization which focuses on government transparency and accountability through the usage of the internet as a catalyzer. Besides acting as a motor of OGD it is engaged in "shining light" on shortcomings and setbacks in the implementation of OGD in the USA. To do so, the

Sunlight Foundation is in steady contact with state authorities. Jean Holm stated that civil society plays an important role in improving OGD and that they keep the government "honest".

Besides, and probably most importantly, civil society can take up a crucial role with a view to the risk of OGD being exploited for facade reforms by governments pretending to be more open than they are, as described in section 7.2. In its function as a watchdog, civil society actors can pressure governments to provide meaningful data which is politically relevant and enhances transparency and accountability in the sense of OG. According to the guidelines of the United Nations for OGD, governments should identify civil society stakeholders early on to allow them to be actively involved in the policy-making and implementation process [10, p. 48f].

10.4. Civil Society as a User of OGD

Last but not least, civil society next to private enterprises or individuals performs the role of a user in the sense of beneficiary or target group of OGD. As the evangelist for Data.gov, Jean Holm highlights this role of civil society actors besides their role as watchdogs: There are also "those who just, you know, take what we have got and move forward to do civil good with it or civic good". These groups range from individual activists, movements to highly specialized NGOs. All of these groups may be able to benefit from OGD for their objectives and missions—regardless if they are directly working in the field of transparency or others such as education, environment or health.

Robinson *et al.* [194] state in an article on OGD and civic engagement that, "when government puts data online, someone, somewhere, will do something innovative and valuable with it" [194, p. 86], and civil society can play an important part in this process. Similarly to private enterprises CSOs can take advantage of information and official data to justify and better illustrate their goals. Furthermore, they can reduce formerly existing information differences without the need to make individual inquiries to public administrations for each potentially interesting dataset, and they can benefit from entering into dialogues with the help of OGD portals [61, p. 58ff].

Most obviously, OGD helps organizations dedicated to transparency and government accountability through empowering them to highlight their criticism and marshal pressure on governments based on their data. Furthermore, CSOs not directly concerned with government transparency or OGD can equally benefit from government data to better achieve their goals. Examples may be environmental NGOs using OGD provided on dwindling forest resources or infrastructure projects to raise public attention for their goals, migrants' organizations backing up their work with facts and figures on migration patterns or women's organizations denouncing gender inequality based on up-to-date data.

Altogether, it is important to note that the boundaries between these roles civil society actors perform usually blur. For instance, CSOs dedicated to OGD and transparency often perform multiple tasks. These range from raising public awareness of the topic, identifying implementation errors to processing raw data. In the context of this thesis, this means that AIGs need to be designed with functions to support these different roles of civil society actors. For example, if a CSO acts as watchdog or driving force for OGD, aspects such as data provenance, linking data or comparing visualizations of OGD might be more important to illustrate a certain view than communication functions. On the other hand, if a CSO acts an intermediary, communication functions such as user profiles, notifications or integrated wikis might be more valuable to mobilize an audience.

A concrete example for the different roles of civil society in the promotion of OGD are the annually organized and global Open Data Days.[6] Civil society actors often (co-)organize the event, give and attend workshops and presentations, and engage with government officials to work on concrete problems. The goal is not to produce solutions or concepts—but instead to create and raise engagement by including people without prior knowledge, to network with like-minded individuals, and to have fun while doing civic good.

[6] See http://opendataday.org/, accessed April 11, 2016.

11 Providing Geospatial Open Government Data

Providing OGD is mainly a practical task that requires a solid understanding of data management and the domain of the OGD to be published. Recently, several OGD portals have emerged on national, federal or local levels. While the goal of freely usable, modifiable and shareable government data is clear, the necessary processes to publish OGD differ and depend on the particular case and context. As of yet, standards and best practices are just emerging as the OG community and data providers are sensitized for appearing issues.

This chapter provides an overview of best practices for providing geospatial OGD, answering GQ3 in the process. As this thesis is part of HCI research, the considerations do not focus on technical details such as metadata mappings, nor are they a step-by-step guide to include geospatial data in OGD portals. Rather, the provided considerations are user-centered and focus on the end users of OGD portals. Through this lens, challenges and potential solutions are described with a focus on the German situation. Nevertheless, the recommendations apply to the EU, albeit some would probably need some adjustments due to the slightly different implementations of INSPIRE in the member states.

This chapter is organized into three sections. Section 11.1 describes the initial situation outlining similarities and differences of INSPIRE and OGD. In total, six recommendations are made in the next two sections that deal with publishing OGD and aiding users in finding and using OGD, see sections 11.2 and 11.3. The recommendations for publishing geospatial OGD deal with aspects of metadata, licenses, and data formats while the recommendations for aiding users consider searching, previewing, and monitoring geospatial OGD.

Method. GQ3 is mainly answered using an ethnographic research approach as outlined and discussed in chapter 4. The author had the opportunity to work with two public administrations that publish OGD in the role of a participating observer in the workplace. As such, the gained insights are based on practical experiences and public feedback as both projects provide feedback mechanisms. Additionally, the EDP development process can be classified as participatory design, as civil servants and the public were involved in the development. Both projects and settings are described in more detail in the following.

Procedure. As participating observer in the work-place the presented best practices are based on a corroboration of several sources from an iterative process. For example, several personal meetings, group discussions, and e-mail exchanges provided the opportunity to interact and discuss the provision of geospatial OGD with civil servants. As both projects involved publishing and maintaining actual geospatial OGD practical experience could be gained. These lead to adjustments in the publication process to address newly emerging challenges. In essence, this chapter is the comprehensive summary of theoretical considerations that have been tested and improved due to their practical application in actual OGD portals.

Projects. Both projects that are detailed in the following were commissioned by public administrations and several civil servants were involved in various roles in both projects. The publication of OGD requires a joint effort of several departments or institutions, as such civil servants fill out several roles. For example, they act as data providers, domain experts for technical or legal questions, infrastructure providers or reformers that are tasked with the realization of OGD. Additionally, civil servants are expected to strike a delicate balance in the process between promoting the public interest and managing public institutions, see section 7.1.

European Data Portal. The European Data Portal (EDP)[1] is a project of the European Commission (EC) and federates OGD of the European Union (EU) member states, European Free Trade Association (ETFA) countries, and countries involved in the EU's neighbourhood policy. An international consortium of eight companies and institutions received the contract to realize the EDP in a three-year project. The author of this thesis was the lead technical designer and coordinator for all geospatial components of the EDP. The realization of the EDP relies on an iterative approach featuring several releases, close coordination with civil servants from the EC, and includes public feedback. As such, the software development method can be classified as participatory design. At the time of writing, the project is in its second year, and intermittent releases are performed in preparation for a larger major release that includes new functions and features that were identified based on (public) feedback.

Open.NRW. Open.NRW is the OGI of the federal state of NRW and so far the only comprehensive OG strategy with a vision beyond publishing OGD in Germany (see section 6.5). The "CIO-Stabsstelle" of the Ministry of the Interior and Communal Affairs of NRW is responsible for Open.NRW and the author of this thesis co-authored a feasibility study for Open.NRW. In essence, the goal of the feasibility study was to outline the overall process of publishing geospatial OGD and to identify challenges and solutions how existing geospatial data from the Geoportal NRW[2] could be published as OGD in Open.NRW. Similar to the EDP, several civil servants were involved in the project in various roles and provided insights and feedback for the feasibility study. At the time of writing, the author is involved in a follow-up project with Open.NRW to facilitate and sustain the use of OGD in NRW.

[1]See http://www.europeandataportal.eu/, accessed April 13, 2016.
[2]See https://www.geoportal.nrw.de, accessed April 13, 2016.

11.1. Initial Situation

OGD and INSPIRE are complementary efforts, and geospatial data is in high demand from re-users. However, as both fields originated from different contexts, different philosophies, goals, and practicalities have to be matched. In practice, both fields deal with similar organizational, technical, and legal issues that have to be considered before publishing data. While the INSPIRE community talks and thinks about interoperable services that are based on a set of complex standards, the OGD community emphasizes open data and open processes that emerge from a shared understanding, see section 6.2.

The “publish-find-bind” pattern that structures the data provision in the INSPIRE process [195] resembles the OGD counterpart: OGD is also published, harvested or federated by different catalogs, and discoverable through dedicated portals. In both cases, the data is downloadable or “bindable” through APIs, albeit these APIs are called services in INSPIRE and are limited to a set of standards.

Most OGD portals are pure catalogs that only contain metadata describing OGD, these catalogs only link to the OGD that is hosted elsewhere. As such, these catalogs are very similar to INSPIRE catalogs that do the same. While INSPIRE catalogs are limited to be pure catalogs due to their standardization, OGD catalogs can do more. One of the most popular OGD catalog implementations—OKFN’s CKAN—allows to upload and host OGD as well.

These examples illustrate that both efforts, OGD and INSPIRE, have many similarities in their intent: data is published, made discoverable, and usable for users. However, the INSPIRE process is highly standardized, and the standards are legally binding while the publication of OGD is “fine” with de facto standards or unstandardized approaches, as long as they are “open”.

Unstandardized approaches facilitate more rapid innovation and adoption of the latest technological advances, but they also create problems regarding maintenance, scalability, and interoperability. As more OGD portals are emerging and federated in several portals, these issues become apparent. The original developers of GovData—Fraunhofer

Fokus—reported on such issues in a development blog post in April 2013. They stated that some “minor tricks” had to be used as they started federating other OGD portals. According to them, metadata elements are not consistently used or present, for example, even titles and keywords need to be supplemented. Furthermore, the meaning of the metadata elements sometimes differs and needs to be carefully considered.[3] Since these early days, a shared understanding regarding the metadata schema seems to be emerging as the federal portals consider and factor in GovData’s metadata schema, following Klessmann *et al.* ’s [61, p. 176] recommendation. While this emerging shared understanding alleviates the issues of custom metadata mappings, workarounds, and semantic inconsistencies still pose problems that need to be considered.

In comparison, the standardized metadata schemas and interfaces of INSPIRE try to ensure interoperability and easy exchange of metadata through the EU. Albeit, the critique can be leveraged that INSPIRE standards are over-engineered—leading to poor use and confusion in their practical application. This critique is best illustrated with the official technical guidelines for the INSPIRE metadata implementation rules that are based on ISO 19115 and ISO 19119:

> The conformance of an ISO 19115 metadata set to the ISO 19115 Core does not guarantee the conformance to INSPIRE; [...] full conformance to ISO 19115 implies the provision of additional metadata elements which are not required by the INSPIRE Implementing Rule on Metadata. Additional metadata elements are required by the INSPIRE Implementing Rules [...]. Over the structural requirements formalised through the mappings, the conformance to INSPIRE is also a matter of semantic of the information provided. —*INSPIRE Metadata Implementing Rules* [69, p. 13]

In summary, the INSPIRE metadata guideline explains that one should follow the ISO standards, but that certain ISO metadata elements are

[3] See http://open-data.fokus.fraunhofer.de/en/ernten-und-geerntet-werden-erfahrungen-beim-govdata-de-harvesting/; accessed April 04, 2016.

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not needed, some new elements need to be added, and that certain elements have other meanings [69].

In essence, the issue of incomplete, lacking or wrongly used metadata is a general one and not limited to INSPIRE or the OGD movement. To support the use of OGD data providers need to take great care in the publication and maintenance of the data and the metadata as both are important. After all, if the metadata that describes the published OGD is lacking it hinders the discovery and subsequent use of OGD.

11.2. Publishing Geospatial OGD

From a user-centered perspective, the publication of existing geospatial data from INSPIRE sources as OGD requires paying special attention to data formats, license information, and general metadata elements that enhance the ease of use and finding geospatial OGD: First, users need to know under which license the data is published, e.g., if an attribution is necessary and whom to attribute. Second, the data format needs to be known and technically open—meaning that the format should be non-proprietary and free/open-source software needs to be present that allows processing and modification of the data. Third, general issues that relate to metadata such as storing the geospatial coverage or duplicate identification need consideration. For example, as the data is geospatial the ability to search for or limit search results to a specific geographic coverage helps the discovery of OGD.

While INSPIRE services are based on technically open standards and license information is present, the license can be restrictive and the published data is not necessarily "raw" or completely processable. As such, INSPIRE data can not be published straight away from a geospatial catalog and metadata elements need to be considered carefully. The following subsections address these aspects and provide best practices that are emerging in Germany or the EU.

Readers that are interested in a general overview about publishing OGD should refer to Klessmann *et al.* 's [61] study on OGD in Germany and the "Open Data Goldbook for Data Managers and Data Holders" [196] of the EDP as they provide a more holistic view. For example, they discuss Davies [197] "open data engagement model" and Tim Berners-Lee's five star model for linked open data[4]. Additionally, they provide general recommendations such as a public ticket or comment systems for datasets, stress the need to highlight OGD success stories, and give pointers on how to create and sustain OGD communities.

11.2.1. Metadata

Recommendation 1: Geospatial data providers should ensure that the unique identifier that accompanies every INSPIRE compliant dataset is harvested to enable duplicate detection and updates of the metadata. Similarly, they should ensure that the geographical coverage is expressed as geometry (e.g. a bounding-box) that is always present for geospatial OGD to facilitate the discovery of geospatial datasets with spatial filter and search functions.

Several considerations and publications are available that deal with metadata for data portals in from different angels. For example, the World Wide Web Consortium (W3C) has formulated best practices[5], the EU created a metadata schema called DCAT-AP [198] that is based on the W3Cs recommendations, the metadata conventions of the German Geodateninfrastruktur Deutschland (GDI-DE) [199] are based on the INSPIRE metadata standards [69], and Klessmann *et al.* 's [61] study on OGD in Germany contains a section on metadata as well.

Creating and maintaining metadata is a complex topic. As such, the following recommendations address only specific aspects that are visible to the user and handled differently in the publication of OGD and INSPIRE. General aspects of metadata schemas that are shared and required in both fields such as date of publication, contact point, title, and description are omitted as these work reasonably well and are described exhaustively in the previously mentioned publications.

[4] See https://www.w3.org/DesignIssues/LinkedData.html, accessed April 21, 2016.
[5] See https://www.w3.org/TR/dwbp/, accessed April 19, 2016.

From a user-centered and geospatial perspective, the most obvious differences in the metadata schema of INSPIRE and GovData are present in elements that describe the geographic coverage and uniquely identify the resource—licenses are discussed separately. INSPIRE mandates that the geographical coverage is expressed with a bounding box, and that a unique resource identifier is present [69, p. 10f] while both metadata elements are considered optional in GovData's schema.

GovData's metadata schema offers several optional elements to described the geographic coverage or a location. For example, they can be expressed via a textual representation, e.g., in the Nomenclature of Territorial Units for Statistics (NUTS) or as free text. The option to provide the coverage as a polygon (that can be a bounding-box) is available as well, and geospatial data providers should use it to enable a spatial search via a geo-visual interface.

While it is reasonable that GovData's metadata schema does not require to express the geographic coverage for every dataset as not every dataset is geospatial, every geospatial dataset should be described with one in a consistent way. Due to the option to use multiple elements, complex post-processing of the metadata is necessary to enable search functions in the OGD portal that use the geographic coverage. Such a post-processing needs to account for that fact the geographic coverage may be expressed as free text that requires a potential error prone geocoding process while other fields such as the NUTS-Code would allow an accurate processing. As there are several non-mandatory options present to express geographic coverage with varying levels of quality, the user experience of searching geospatial data via a geo-visual interface is severely limited. As such, geospatial data publishers should always describe the geographical coverage with a bounding box using the appropriate metadata element of GovData as INSPIRE mandates a bounding box as well.

The second metadata element that is considered optional in GovData's metadata schema is a unique resource identifier (e.g. a Universally Unique Identifier (UUID)) that is provided by the original data providers. A unique identifier is persistent, replicated if the metadata is harvested into another catalog, and never changed even if the metadata is updated.

While these unique identifiers are less important in strict "bottom up" harvesting hierarchies they are critical in organizational forms where decentralized, cyclical harvesting can occur. As OGD is openly available, everybody can harvest data from multiple OGD catalogs into local or federal portals. These portals may have different scopes and aggregate OGD for various purposes, but may contain OGD that is not yet present in the other portals. The lack of such a unique identifier has a substantial impact on the users of the OGD portal as they allow a consistent identification of duplicates and allow to apply updates on the metadata in combination with a datestamp. To consistently identify duplicates in cyclical structures where only subsets of the entire catalog are "new", unique resource identifiers are crucial.

The original developers of GovData published an article based on their experience with harvesting activities for GovData during its initial development. Marienfeld *et al.* [200] conclude "that several routes exist for a piece of metadata to get from the origin via transformation steps to an aggregation portal" [200, p. 5]. They continue to describe that metadata quality is an issue, necessitating a strong quality assurance on several levels, for example, checking and probing referenced links, validating the harvested metadata schemas and trying to harmonize semantic inconsistencies.

As such, geospatial metadata providers should always use the optional metadata element for the "original metadata identifier" in GovData's metadata schema to persist the INSPIRE mandated UUID and follow the Geodateninfrastruktur Deutschland (GDI-DE) conventions that stress that a unique identifier needs to be always present. While this will not solve the general issue of duplicates for all OGD datasets, at least the duplicates of geospatial datasets can be avoided.

Data providers should note that the metadata schema of GovData is under revision. The revision will include public feedback[6] and will likely consider the newly developed metadata standard DCAT-AP of the EU that features a specific extension for geospatial data that is compatible with INSPIRE. DCAT-AP [198] and GeoDCAT-AP [201] are Resource

[6] See https://www.govdata.de/web/guest/metadatenschema, accessed April 15, 2016.

Description Framework (RDF) vocabularies that are based on the Data Catalog Vocabulary (DCAT) to enable cross-data searches for public sector datasets. The European Data Portal (EDP) implements DCAT-AP for harmonizing the metadata of the national OGD portals of the member states.

11.2.2. License

Recommendation 2: Geospatial data providers should use an open, well-known license and provide necessary details like name, attribution, identifier, and link to the full license text in a structured and consistent way. In Germany, geospatial data providers should follow GDI-DE's conventions as they ensure that the metadata is properly federated and reflected in geoportals and OGD portals.

License information is a particular piece of metadata and especially important for OGD and therefore discussed independently. In contrast to OGD, data that is released due to the INSPIRE process does not require open licenses. In fact, licenses for INSPIRE compliant data are often very restrictive or can even be unknown. License information is not limited to a set of well-known and recognizable licenses, and it can be provided as free text in the native language of the data providers [69, p. 51ff]. Even if the license is open (see section 6.2) users would need to read and understand each legal text. In the worst case scenario, each dataset would feature different licenses, making the discovery and use of the datasets very cumbersome or even impossible for non-experts. Marienfeld *et al.* [200] noted that this is an issue for OGD if it originates from the INSPIRE process as well.

To circumvent this problem, GovData's current metadata schema has a short list of well-known licenses that are considered "open". Licenses that are not present or recognized are classified as "restrictive" and users can limit their search results in GovData to exclude these datasets. As such, the data that originates from INSPIRE sources needs to be licensed under one of the listed licenses. Otherwise, GovData will not recognize the dataset as open.

Due to the need for standardization in the INSPIRE process, the German "GDI-DE" formulated a set of conventions how license information should be provided in the metadata of INSPIRE compliant datasets [199, p. 20ff]. The GDI-DE conventions require an id for the license, the name for the license, a link to the complete license, and the attribution/source. Data providers are urged to use one of the existing licenses that are maintained by GovData. Additionally, the conventions specify how this information should be structured in the metadata. Data providers should never only change the license in the metadata for OGD portals as the portals usually link back. Conflicting licensing information was one of the reasons why the launch of GovData was met with harsh critique—it made the published data practically unusable, see section 6.5.

11.2.3. Data Format

Recommendation 3: Geospatial data providers should publish the geospatial data in multiple formats and consider if community standards such as GeoJSON[7] can be supported. "Raw" or vector data should be provided, especially alongside existing INSPIRE View Services to foster the use of the data.

Releasing data in multiple formats is a common and good practice in the OGD community. As explained earlier, the published data needs to be technically open and open/free software programs need to be available that allow processing and modification. Releasing OGD in multiple formats simplifies the use as users have multiple options and do not need to be familiar with one specific data format or software. These issues can be addressed by supporting and providing OGD in community standards such as GeoJSON.

In the context of INSPIRE, all standards for INSPIRE services are publicly available. Several free/open software projects exist that can consume or process the services that contain or expose the geospatial data. For example, QGIS[8] is a free and open source GIS that is ca-

[7] See http://geojson.org/, accessed April 19, 2016.
[8] See http://www.qgis.org/, accessed May 03, 2016.

pable of handling INSPIRE compliant services such as View [202] or Download [203] Services that may be implemented based on the Open Geospatial Consortium (OGC) Web Mapping Service (WMS) and Web Feature Service (WFS) standards.

However, OGD data should be “raw” data meaning that unnecessary pre-processing steps are to be avoided to maximize the use. For INSPIRE compliant data the principle of “raw” data has a direct consequence: View Services, e.g., an INSPIRE compliant WMS is sometimes not the best format to publish data. As the name suggests these services are intended to view data, not to allow modification or complex processing. While a WMS allows some level of modification by, for example, applying different styles that allow changing the appearance, the data format is mostly inert as a WMS delivers static image tiles, raster data.

If the source data is raster data, this delivery is certainly appropriate, but if the source data is vector based the vector data needs to be published alongside the rasterized INSPIRE View Service. For larger quantities of vector data with large file sizes, spatial extraction, transform, and load processes can be (re-)used as these are commonly used internally in public administrations already. To give an example:

If a user is interested in using the official street network or plot boundaries downloading the entire dataset for a federal state or city might not be required or is even counterproductive. By allowing the user to specify a spatial extent and limiting the download to that particular area, large quantities of geospatial data can be made available. The necessary processes might require asynchronous processing and a separate notification of the user when the process finishes, but these processes can be used to handle large quantities of vector and raster data (e.g. orthoimages) alike. If data providers do not provide the data in its raw form but instead in inert formats, they are at risk to pretend to be “open” while they are not. Users could get the impression that data providers are trying to prevent and protect “their” data and interpretation of it [6, 141]. Besides, civil society projects such as OpenStreetMap (OSM) provide exactly this kind of functionality as well. Users can view rasterized and pre-processed images, but have the option to download the entire raw dataset or specific areas. Nevertheless, it is a good first step to publish

INSPIRE View Services as they are very common and readily available. The OKFN encourages to start out small with data and formats that are available, but starting out small is not an excuse to not publish the source data subsequently, see section 7.2.

Providing the option to download vector or raster data is also in the best interests of data providers, allowing users to process, modify, and host the data on their infrastructure. If only the services are published, these services are open to being used in any context or application that OGD users might create. As such, the potential load on the service infrastructure can drastically increase, affecting the cost of providing it. Users' expectations regarding availability, scalability, and performance might differ considerably in comparison to the original requirements for INSPIRE services.

By providing the option to download the data, data providers remain data providers and can reasonably state that they do not need to concern themselves with issues such as availability, scalability, and performance beyond the INSPIRE requirements, as everybody can use, copy, and host the raw data. If they only offer INSPIRE compliant services as OGD and no option to download, data providers are turning into service providers in an environment without clear requirements.

11.3. Finding and Presenting Geospatial OGD

Based on the (ongoing) experiences with the EDP and Open.NRW that include public feedback three recommendations can be made to help users to find and decide whether they want to use the published geospatial OGD. While the following recommendations are often encountered in geoportals they are equally applicable for OGD portals as they help users to find geospatial OGD:

First, OGD portals should allow users to apply simple geospatial filtering functions to narrow down or base their searches on geographical coverage or locations. Second, previewing functions for geospatial data should be included to allow users to get a first impression of the dataset. Third, monitoring systems should be established and users should be informed if issues with the published OGD are present, including geospatial and non-geospatial data alike.

11.3.1. Faceted Search

Recommendation 4: Spatial search facets should be included to aid the discovery of geospatial OGD as they allow users to focus or limit their searches to a certain geographic area or location. A spatial search facet facilitates the discovery of available OGD for certain regions without the need to know which public administrations might offer OGD for a particular topic in a particular region. Additionally, the spatial search facet should facilitate searches for placenames via a Gazetteer to assist users further.

Faceted searches are commonly encountered in portals that need to structure and expose their (meta)data. They are a combination of directed searches via keywords and filters that allow narrowing down the search results based on various aspects. Kules *et al.* [204] findings suggest that facets play an important role in exploratory search processes, even more so than the direct query. As such, most OGD portals have facets for data formats, licenses, categories, and tags that can be derived from the metadata and allow a direct search for keywords. As geospatial coverage is part of the metadata, including a spatial search facet is straightforward, e.g., with a simple geo-visual interface that allows to specific an area via a bounding-box.[9]

Spatial search facets allow users to limit the search results to a specific area and may reveal results that users might not have found otherwise. See figure 11.1 for the spatial search facet of the EDP with a concrete example: A user searched for "continental conservation areas", and specified a bounding box that covers northern Germany and parts of Denmark. The search result yields data from several national catalogs, e.g., Germany, the United Kingdom, Denmark, and Sweden as they provide data that (partially) covers or intersect with the specified bounding

[9] For example, CKAN offers a spatial search extension, see https://github.com/ckan/ckanext-spatial/, accessed April 23, 2016.

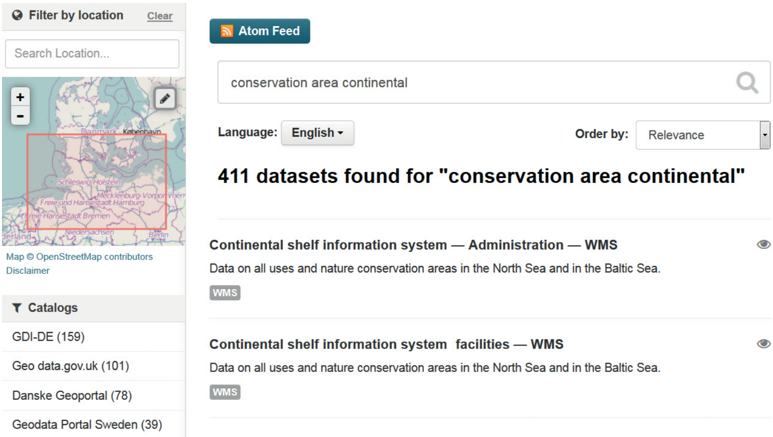


Figure 11.1.: Spatial search facet implementation in the EDP with an active bounding box for nothern Germany and parts of Denmark. Users can also search for a placename in the spatial search facet, accessed April 24, 2016.

box and meets the direct search query as well. The user could have searched for German data only by limiting the originating catalog to the German GDI-DE—but this would exclude the data from the other catalogs although they contain data for the region of interest.

An additional function that is helpful for spatial searches is a placename or geographical name search via a Gazetteer. The placename search in the EDP assists users to search and find cities if they are only known by their name without the exact knowledge of their location. Also, the EDP's placename search helps to disambiguate between cities that share the same name and supports multilingualism as it includes Exonyms (placenames are different in different languages) from GeoNames.org, a public and worldwide placename database.[10]

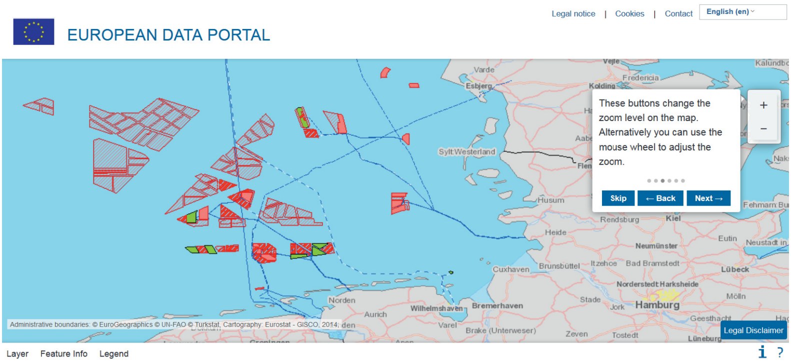
[10]See http://www.geonames.org/, accessed April 25, 2016.

11.3.2. Preview Function

Recommendation 5: OGD portals should include a simple geo-visual preview function to allow users to get a first impression of the dataset. Preview functions allow users to explore the dataset and decide whether it fits their needs, eliminating the need to download or check every potentially relevant dataset in an external program.

A simple geo-visual preview function helps users to check the offered dataset quickly while they explore the offered OGD in the portal. While users can obtain a first impression via the offered metadata of the dataset, this first impression depends directly on the quality and expressiveness of the metadata. As most OGD portals are federating OGD from various data providers, the quality and level of detail of the metadata is likely to vary. Preview functions are even more important when the provided OGD is only accessible via specialized data formats or services that require a solid understanding as it is the case with INSPIRE compliant data. While several free/open software projects exist that can process and view INSPIRE data, the services or formats are not as common as, e.g., Comma Separated Values (CSV) files and require familiarization.

If the metadata descriptions are lacking or not detailed enough, users might simply ignore the published datasets due to "rational ignorance" as the cost of using data in an unfamiliar format and program can outweigh the potential gain [137]. As such, a preview function does not need to support processing or manipulation of the dataset, but the preview should allow users make a first assessment, enabling them to make an informed decision. By simplifying access to the dataset user interest can be sparked and a potentially cumbersome search or exploration process improved. Another useful preview function for users is to visualize the geographical coverage in the metadata, as the textual representation of a bounding-box is unlikely to be understandable for non-experts. See figure 11.2 for an examples of a geo-visual preview function for the actual dataset (11.2a) and how the geographic coverage is visualized (11.2b).



(a) A simple geo-visual preview displays geospatial OGD to allow users a first assessment of the dataset. This dataset displays offshore wind turbines sites and high voltage cables in the North Sea. Additionally, an interactive tutorial is active explaining the available functions of the geo-visual preview.

(b) The detailed view of a dataset in the portal visualizes the geographic coverage of the dataset to give users a quick overview.

Figure 11.2.: Examples for the geo-visual preview function and geographical coverage display of the EDP that allows user to quickly check the available data; accessed April 24, 2016.

11.3.3. Automatic Data Monitoring

Recommendation 6: OGD portals should include an automatic monitoring component that generates public reports and indicates found issues at the published dataset to manage user expectations and data quality.

For a sustainable OGD strategy the lifecycle of OGD has to be considered. After collecting, preparing, and publishing OGD needs to be maintained [196]. Automatic monitoring systems can help to handle large quantities of published OGD as they can identify outdated metadata, account for common technical errors, and do so on a regular and consistent basis.

If users frequently encounter outdated or broken OGD in the portal, interest and use are likely to drop, and users are left with a negative impression. Similarly to inert data formats, users may get the impression that data providers pretend to be open while they are not and that the publication of the data was a one-time effort. Even if the OGD is hosted in the OGD portal the data is offered by different providers that are affected by, for example, changing organizational structures, personnel changes or shifting priorities. Monitoring published OGD is a requirement for portal operators, as more (meta)data is accumulated over time and mechanisms are needed to help to maintain data quality.

Such monitoring systems are particularly helpful if OGD is published via APIs that serve the data as it is the case with INSPIRE compliant data. In comparison to files that can be downloaded via a file server, INSPIRE services rely on a more complex technical infrastructure as every API does. While the data providers are clearly responsible for maintaining their APIs, it is in the best interest of OGD portal owners to ensure that the data they are offering is accessible.

Transparent data monitoring and reporting mechanisms can help OGD portal operators to manage user expectations if the monitoring is public. For example, if a linked dataset is consistently unavailable the portal operators can contact the data provider, ask them for the cause, and try to fix the problem. The status of the monitoring process can be publicly displayed at each dataset, informing every user if an issue is

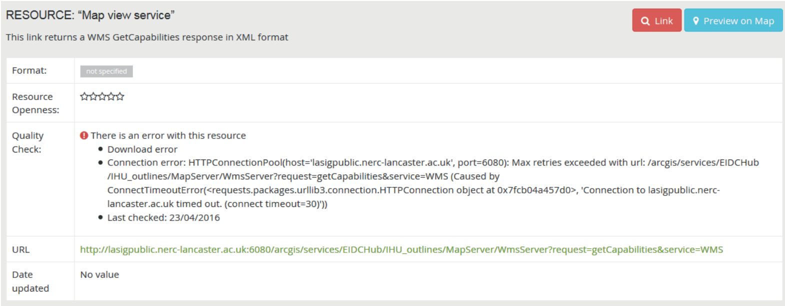


Figure 11.3.: Detailed monitoring report for a dataset from the UK's OGD portal allowing users to get (technical) information for an identified issue, accessed April 26, 2016.

present and how it is taken care of. If users can access the monitoring results, they can decide if they want to check the dataset at a later date, open a support ticket or comment on it to demonstrate interest, or look for another dataset.

Some portals already include such public monitoring systems. For instance, the EDP has a monitoring component that checks the published metadata periodically, identifies metadata schema violations, and reports on technical issues such as timeouts. Results are visualized in several ways and users have full access to them. The OGD portal of the United Kingdom (UK) has a similar monitoring and probes metadata for broken links.[11] Additionally, the UK's portal informs users via a small icon at the dataset for each file format if an issue is detected. Users can get more information about the issues by clicking on the symbol, accessing the report and underlying cause, see figure 11.3.

[11]See http://www.europeandataportal.eu/mqa-service/ and https://data.gov.uk/data/report/broken-links, both websites were accessed on April 26, 2016.

12 Geo-visualizations for Citizen Engagement

This chapter is based on publications P3–P5. Section 12.1 corresponds to P3 "Facilitating Citizen Engagement in Situ: Assessing the Impact of Pro-active Geofenced Notifications" by Thore Fechner, Dominik Schlarmann, and Christian Kray. Section 12.2 corresponds to P4 "Presenting Citizen Engagement Opportunities Online: the Relevancy of Spatial Visualization" by Thore Fechner and Christian Kray. The third and last section 12.3 corresponds to P5 "Ethermap—Real-time Collaborative Map Editing" by Thore Fechner, Dennis Wilhelm, and Christian Kray. Please refer to the list of publications for the complete citations.

This chapter presents the three developed AIG prototypes and their accompanying evaluations. Each prototype is described individually in one of three sections. Together, the three prototypes and their evaluations provide answers for GQ4 that investigates the effects of specific instances of Augmented Interactive Geo-visualizations (AIGs) for certain citizen engagement levels and activities. Every section for a prototype starts with an introduction motivating the use and links the prototype to the established design space for AIGs (see chapter 9). The evaluation methodology and results are described in detail for each prototype. The results and limitations of all prototypes are discussed together as part of the reflections in chapter 14.

The first section 12.1 investigates how AIGs can help to inform citizens. Realized as a smartphone application, the first prototype pro-actively informs citizens about engagement opportunities based on space, time, and custom user preferences as they move through the city. Section 12.2 presents the second prototype called "Dialog Map" that looks into the citizen engagement levels of consulting and involving citizens. Dialog

Map offers a tightly coupled spatial and textual view, and allows to exchange ideas, ask questions or start dialogs facilitated by the combined spatial and textual view. The last and third prototype is called "Ethermap" and is presented in section 12.3. Ethermap is an AIG for distributed real-time collaboration. Ethermap investigates how to support creating, editing, updating or deleting geospatial data at the same time in a "shared" virtual work environment with multiple collaborators.

12.1. Geofencing Engagement Opportunities

> Likewise, some of the research into participation does pay attention to the question whether citizens have been informed properly and can have access to the information they need to participate but, again, this is the exception rather than the rule. —Meijer *et al.* [19, p. 11f]

Conceptually, the first prototype is located on the level of informing citizens. The application pro-activley notifies citizens about engagement opportunities but citizens can not enter into a direct exchange with the information provider or the engagement opportunity using the appliaction. Still, Arnstein [71] notes that "informing citizen of their rights, responsibilities, and options can be the most important step toward legitimate citizen participation" [71, p. 219]. Similarly, Meijer *et al.* [19] stress that citizens have to be informed properly before any meaningful engagement can happen.

Information about engagement opportunities usually includes details about the actual topic, why citizens should engage, as well as when, and where to contribute. In the commonly encountered communication forms such as newspapers, flyers, posts on social media networks or dedicated websites, location and time are part of the communication but do not affect to whom the information is provided or how it is triggered.

Hence, the first AIG prototype applies the notion of a geofenced Location Based Services (LBSs) for informing citizens about potential engagement opportunities. The prototype is motivated by the fact that spatial vicinity helps citizens to connect and identify with the processes that affect their personal lives [13, 14, 149, 205]. Existing applications that are used for similar purposes in e-commerce [206], tourism [153] or enhancing community awareness for local heritage through situated storytelling [148] informed the design of the prototype.

Therefore, a notification application for smartphones was developed and evaluated that provides citizens with information about nearby engagement opportunities. The main function of the app is an automatic notification service that triggers notifications on the user's smartphone if an engagement opportunity is in the immediate vicinity. By applying virtual spatial barriers (geofences) around citizen engagement opportunities, the notification service can trigger notifications once users enter or leave the area. Users are directly informed in their current spatial context, e.g., near the location of a meeting that will be held or an affected area. Also, users can customize the notification service by selecting only certain engagement categories (e.g. children and youth, sustainability, culture) and by specifying a spatial extent to only receive notifications in certain parts of their city.

Overall, the notification application includes the following functions from the AIG design space in chapter 9 that are loosely clustered to the level of informing citizens: The triggered notifications are a *communication* function that does not require user input. This communication function rather relies on an indirect action that users perform—moving through the city. Additionally, a simple like/star system allows users to express interests in an engagement opportunity. *Data* about engagement opportunities is used by the notification application but also linked as users are pointed to additional information about the engagement opportunities on the respective website. Users can interactively *explore* the engagement opportunities and customize the notification triggers using spatial and content filters. Two different linked *visualization* forms are present. A simpel geo-visualization displays the geofences of the engagement opportunities and allows users to zoom, pan, and obtain information about the displayed engagement opportunities spatially. A textual view shows engagement opportunity "cards" and allows users to linearly explore all present engagement opportunities. As such, functions from all four aspects of an AIG are present in the first prototype.

As the related work for this prototype was discussed in subsection 7.5.1 the following details the approach and continues to provide a short overview of the application as well as its implementation. Afterward, the results of the two conducted user studies are presented in detail.

12.1.1. Triggering Notifications Implicitly

As spatially enabled notification service, the application uses the following interaction idea: *The act of moving through the city is used as an implicit interaction with the notification application leading to an explicit interaction with the application.* An action of the application, a notification, is triggered *implicitly* if certain spatial, temporal, and individual user conditions are met. After perceiving the notification, users *explicitly* interact by investigating the notification obtaining additional information or by dismissing or ignoring the notification, choosing to disregard it. The use-case is based on the premise that citizens might be additionally motivated and engaged if they find spatial connections and relations between their daily lives and engagement opportunities. Approach and resulting interactions are best described with an actual engagement opportunity example from the field study.

An urban planning project in the city of Münster aims to restructure a large vacant space in the city—the "Oxford Barracks" that are not used anymore. The organizers desire a high involvement of the population in the planning process as multiple repurposing options are available, e.g., living quarters and/or a recreational space are to be discussed. A series of participation workshops is planned, and the organizers reach out to the population. They provide information via newspaper, a broadcast by the radio station, and flyers. Additionally, the same information is entered into the managing component of the notification application. The only difference is that the places and times of the participatory workshops are entered spatially via a map interface as simple points while the vacant area is represented by its actual bounds. Spatial representations are extended (buffered) automatically by the application to cover the immediate vicinity such as sidewalks or the other side of the road. Temporal information, such as the estimated duration of the entire project and workshop dates, are used by the notification service to only trigger notifications about engagement opportunities that have not already taken place.

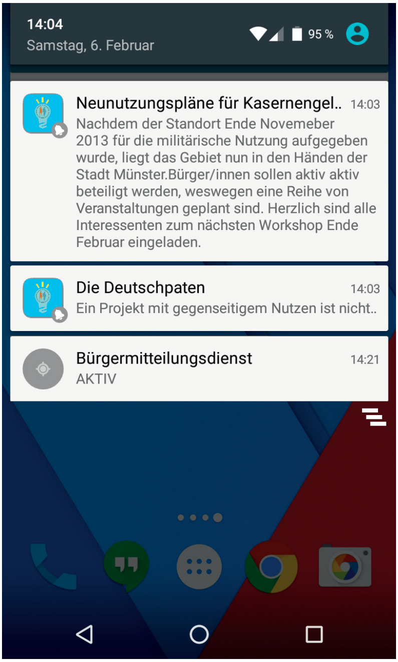
Citizens who have installed the notification app on their smartphone will receive an automatic notification if they are near one of the workshops locations or the Oxford Barracks. This is an *implicit interaction* with the notification application, no user input is required. Citizens are informed as they move through the city during their regular activities like commuting to work, casual walks or sportive activities. Space, time, and individual user preferences that were specified beforehand affect if a notification is triggered. Spatial and temporal information about the engagement opportunities are set in the managing component of the notification service. They are provided by the organizers of the engagement opportunity alongside additional information as textual descriptions, the category of the engagement case, and an image illustrating the case. Refer to figure 12.1 for the representation of the information in a triggered notification and the card-view for the given example—the Oxford Barracks.

The developed notification application follows four of the seven principles of persuasive technology that were recommended by B.J. Fogg [207]. It *reduces* the complex act of finding engagement opportunities based on the simple premise that they "pop up" as one moves through the city caring about the daily business. A citizen can *tailor* the received notifications by using spatial and content customization options. Citizens are also guided or *tunneled* through a series of simple steps if they want to obtain more information about an engagement opportunity. They can click on a notification, read a short description, and are guided to the website of an engagement opportunity if they want to know more. The application provides *suggestions* to citizens which they can read at an opportune time of their choosing, either right now at the moment that it is provided in situ or later on if they have finished their current activity that takes precedence, e.g., rushing to work. The principles of self-monitoring, surveillance, and conditioning are left for future work as the application aims only to inform citizens instead of nudging them towards a particular behavior.

Figures 12.1, 12.2, and 12.3 depict the concrete realization of the functions. Sub-figure 12.1a shows two triggered notifications in the notification center of an Android smartphone. The top entry is expanded (this can be achieved by swiping down) while the second entry is collapsed. The entry below both notifications indicates that the notification application's movement tracking function is active. Sub-figure 12.1b displays an engagement opportunity card that is opened if the user clicks on a notification: it offers textual descriptions about the engagement opportunity, a small picture, and contact information. Users can visit the website of the engagement opportunity or display the geofenced area/location of the engagement opportunity on a map alongside their position via two buttons. The option to like/star engagement opportunities is present to allow a simple expression of interest from citizens. Additionally, liking/starring an engagement opportunity can act as reminder, another function of the app allows citizens to display all liked engagement opportunities. Citizens also have the option to suppress notifications about this particular engagement opportunity in the future.

Also, users of the notification app can customize it to only trigger notifications that are likely to be more relevant for them. They can apply a spatial filter to limit notifications to a certain part of the city and subscribe to certain engagement categories, e.g., children and youth, infrastructure or culture. Notifications are then only triggered for the subscribed categories and spatial extent, see sub-figures 12.2a and 12.2b for these spatial and content customization options.

Aside from these functions, the notification application offers a set of other explicit interaction options. As notifications are only generated by entering a geofenced area, some citizens may never receive them if they do not move through the city or only through parts that do not offer any engagement options. Citizens might also be interested in getting a quick overview of all available engagement opportunities. Therefore, two exploration views are present, see figure 12.3. Citizens can show all cases via simple spatial and textual overviews in the application. A map displays all engagement opportunities with their corresponding geofenced areas, while a list of all engagement opportunity "cards" shows them linearly in a scrollable textual overview. The spatial and



(a) Two notifications are shown: the first notification for the Oxford barracks is expanded and another notification collapsed. Additionally, a status indicator shows that the notification application is active.

(b) Card view for the Oxford barracks: image, textual description and contact information are shown. Users can like the engagement opportunity, dismiss it, go to its website or show the location on a map.

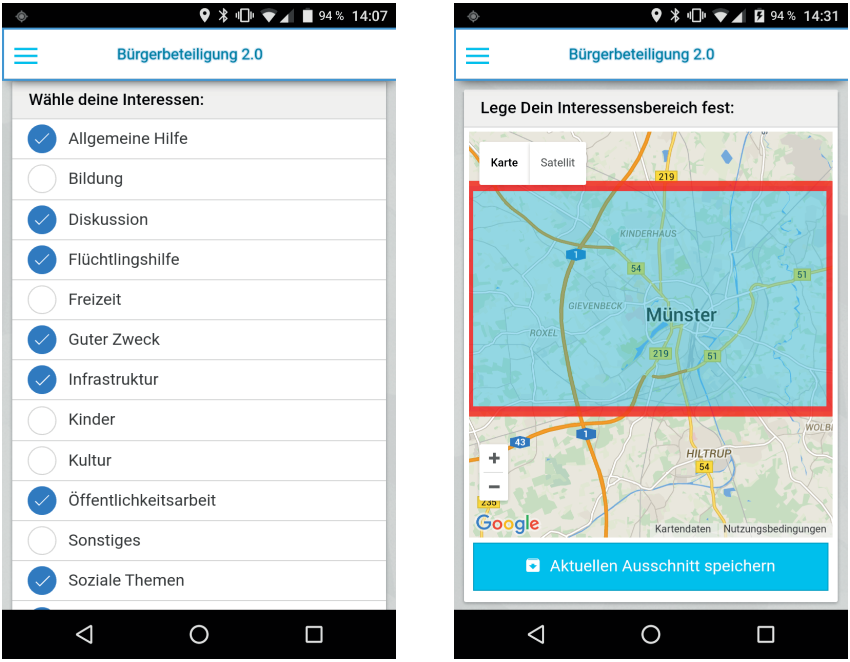
Figure 12.1.: Triggered notifications in the notification center of a smartphone and notification card view in the app.

textual overviews are linked in the sense that they are equally affected by the customization options and users can switch between them to explore the engagement opportunities. Category, textual, and temporal filters and can be applied in both views to reduce and specify the shown engagement opportunities. The last filter that can be applied shows only previously “liked” engagement opportunities, essentially allowing user to manage favorites.

A step-by-step interactive tutorial helps citizen to set up the notification application. Users are guided through all of the available functions via interactive overlays that highlight functions and explain their use. Starting the application for the first time initiates the tutorial. Individual steps can be skipped, returned to or the entire tutorial can be canceled at any time. The tutorial remains accessible via the app’s main menu, which also provides access to the necessary disclaimers for the research and basic settings for the application.

After starting the application, users are informed that their movement is tracked and how their location data is anonymized and processed. The movement tracking function needs to be explicitly started in the main menu with a large button. Stopping movement tracking is possible at any point with the same button. An indicator that the movement tracking function is active is displayed in the notification center at all times (refer to sub-figure 12.1a). If users disable the movement tracking function, textual and spatial exploration overviews remain functional, albeit no notifications can be provided. The settings menu offers the option to play a special audio cue if a notification was triggered to be independent of the general notification settings that apply per default as recommended by Chang and Tang [208]. Further settings allow an automatic start of the application including the movement tracking after a reboot of the smartphone.

The entire client of the notification application is based on Cordova and Ionic as they allow cross-platform development. Although the notification app was only realized for Android 4.4 devices both frameworks allow to include additional platforms in the future. Cordova was used to access hardware-related functions to locate the smartphone’s position. All user interface elements were realized with Ionic as it provides several interface elements that follow the Android Design Guidelines. The used technology stack is based on HTML5, AngularJS, and SASS. Server side components contain the necessary logic for triggering notifications



(a) Content customization: users can subscribe to only receive notification about certain topics.

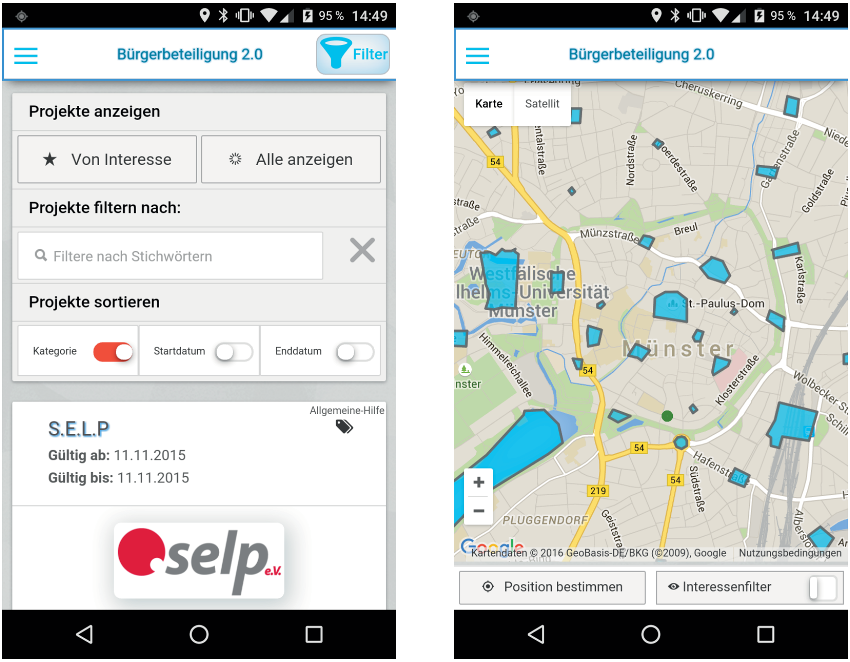
(b) Spatial customization: users can specify to only receive notifications for a certain area of their city.

Figure 12.2.: Notification application customization options.

and are based on ESRI's ArcGIS Server and the Geo-Event Extension.[1] Custom implemented server side processes regulate the geofencing mechanisms for the spatial and temporal dimension, and the individual user preferences that each user can specify.

For example, these server side processes ensure that notifications are only triggered once a citizen enters a geofence, rapid leaving or re-entering do not repeat the notification. These effects need to be

[1]See https://cordova.apache.org/, http://www.ionicframework.com/, https://www.w3.org/TR/html5/, https://angularjs.org/, http://sass-lang.com/, and http://www.esri.com/software/arcgis/arcgisserver, all website were accessed May 11, 2016.



(a) Linear, textual overview of the engagement opportunity cards with expanded filter options.

(b) Spatial overview of all engagement opportunities displaying their geofences on an interactive map.

Figure 12.3.: Notification application views.

accounted for as they can occur due to the shape of geofences (they do not have to be convex polygons) or as the tracked movements accuracy can vary widely resulting in “jumps”. All processing intensive operations are performed on the server side to save battery life on citizen’s smartphones. ESRI’s ArcGIS Server offers several of the necessary processing options out of the box and was therefore chosen. By implementing the notification application in an agile approach, the prototype was tested using rapid deployments in different iterations with a small group of users that provided feedback.

12.1.2. Evaluation

Two user studies were carried out to test the approach and the developed notification application. Overall, the goal was to test how participants used spatially triggered notifications and if they value a smartphone application with such functions. The first study is field-based focusing on usage patterns and motivational aspects of the in situ discovery of engagement opportunities. An official citizen engagement website of the city of Münster was compared to the notification application in a lab-based setting in the second user study. The comparison investigated the pragmatic and hedonistic qualities of the notification application and whether participants would find it more attractive compared to the more common form of representing citizen engagement opportunities via a website.

Field Study

To assess the usefulness of the application for citizens in their daily lives a field-based study "in-the-wild" was conducted. The field study took place in Münster, Germany during a ten day period in October 2015. Before conducting the field-based study, a pre-study tested the application and all individual elements of the apparatus with seven participants. Pre-study participants were not included in the final field study, and the results are omitted as the pre-study was only conducted to ensure that all technical components were working. The notification application was not changed or updated technically, but additional engagement opportunities were added.

Participants. 37 participants (14 female and 23 male) were recruited by word of mouth, e-mail lists, a blog-post, and university campus with diverse backgrounds. Participants' age ranged from 18 to 51 years, with an average age of 25.6 years. All participants owned an Android smartphone. Study participants could invite other participants themselves to the study to gain a wider reach. All necessary consent forms and disclaimers were available digitally in the smartphone application and had to be filled out before the application could be used.

Procedure and Apparatus. Participants could access and download the notification application through Google's PlayStore for Android devices that use version 4.4 or above. The application featured 55 actual engagement opportunities that were distributed evenly throughout Münster with a focus on the city center. All engagement opportunities were obtained from the city's official website, called "Gutes Morgen Münster".[2] For the study, 16 engagement categories were established and all opportunities included that would happen in the future. During the recruitment phase of the user study participants were asked to fill out the first of two questionnaires to establish baseline parameters like age and gender. Participants also indicated if they had previous experiences with citizen engagement opportunities. The first questionnaire featured additional preformulated statements that participants could agree or disagree with using a five point Likert Scale ranging from strongly disagree (1) to strongly agree (5). These statements asked participants about their preferred channels to inform themselves about engagement opportunities (e.g. newspapers, flyers, e-mails, citizen apps), general aspects of the information provision (e.g. actuality), and which features they value in the digital provision such as chatting with other users or playfulness.

A custom built event-driven framework logged participants' interactions with the notification application. Every user interaction such as accessing a notification or accessing a certain view generated an event with a unique identifier that described the interaction and included a participant's location. The custom logging allows to describe the app use in general, to identify the most used features, and where participants interacted with the application in the city in relation to the engagement opportunities. After the ten-day deployment period, users were prompted to fill out the second

[2] See http://www.gutes-morgen.ms/, accessed February 10, 2016.

questionnaire via e-mail. The second questionnaire consisted of the System Usability Scale (SUS) [47], five additional pre-defined statements, and a free text field for general responses. Participants rated whether they felt engaged while using the application, which features they found most useful, and if they had concerns regarding their privacy. 30 of the 37 participants are considered for the analysis of the results, as seven participants did not fill out the second questionnaire or did not use the application at all by generating a notification.

Field Study Results

Based on the results from the questionnaires and logged data, the results indicate that individualization options and suggestions were useful for the participants. Participants were valuing spatial notifications and the resulting suggestions, but the interaction with the triggered notifications do not necessarily occur in situ. The following paragraphs describe how these conclusions were drawn.

The participants' responses to the first questionnaire indicate that they primarily would use a "citizen app", social media networks such as Facebook, local media like radio shows or newspapers for information provision about citizen engagement opportunities. 72% agreed or strongly agreed to use a mobile application (mean=4.0, SD=1.3) while 66% also agreed or strongly agreed to use social media networks such as Facebook (mean=3.7, SD=1.3). However, there is also a strong desire for information about engagement options in traditional channels. Local media such as newspapers or radio shows were most valued by the participants. All of them agreed or strongly agreed to use them and no one disagreed (mean=4.4, SD=0.8). With an average of less than 2.3, participants disagreed on using flyers (SD=1.4) or e-mail newsletters (mean=2.2, SD=1.1). Cities' websites were similarly disfavored with a mean of 1.9 and SD of 1.1. Most important for all participants was "up-to-date" information provision (mean=4.8, SD=0.4). Ten of the participants (33%) had previous experiences with public polls, discussions, online-based surveys or demonstrations.

If information about engagement opportunities is provided digitally, participants rated the option to inform themselves based on individual interests as most important. 47% of all persons strongly agreed and 40% agreed to use individualization options (mean=4.3, SD=0.7). This factor seems to be particularly important for smartphones as all participants strongly agreed or agreed on individualization options for smartphones (mean=4.6, SD=0.5). Suggestions about potential engagement opportunities seem to be useful for digital channels as well. With a mean of 4.1 (SD=1.0), participants agreed to suggestions in general for digital media. Location-based suggestions for smartphones were also agreed on with a mean of 4.1 (SD=0.9). Other functions such as an integrated chat for communication with other citizens were deemed as rather unimportant (mean=2.6, SD=1.3), and concepts for playful entertainment like badges or banners even more unimportant (mean=1.9, SD=1.1).

The logged data, see table 12.1, of the field study underpin the participants' responses regarding individualization options and usefullness of (spatial) suggestions. Almost every participant customized the notification triggers (27, 90%) by subscribing to certain topics and 22 (73%) set a spatial extent for notifications. A total amount of 345 notifications were triggered during the field study. 230 notification were accessed (67%) and 115 were dismissed (33%). This equals a two to one ratio, indicating that suggestions were not perceived as an unnecessary distraction. Another indicator for the usefulness of the suggestions is that out of the 230 accessed notifications 166 (72%) lead to a direct referral to the websites of an engagement opportunity. Almost three out of four accessed notifications started a direct subsequent information retrieval outside of the application at the homepage of the provider.

However, participants did not necessarily interact with the triggered notifications in situ. In fact, of the 345 triggered notifications 215 (62%) were dismissed or accessed outside the immediate vicinity of the engagement opportunity and 130 interactions (38%) took place in situ. Additionally, no change is visible in terms of accessed or dismissed notifications based on the location of the interaction. Interactions in situ and outside of the immediate vicinity have almost the same access to dismiss ratio: 89 (26%) of all triggered notifications were accessed

Table 12.1.: Logged interactions with the notification application during field study. Results are clustered according to notification, notification trigger customization and general data.

Notifications	
average per user	11.5 (SD=8.3, max=29, min=2)
triggered	345 notifications were triggered for 43 out of 55 engagement opportunities
interactions	230 notifications (67%) were accessed, 115 dismissed (33%)
referrals to websites	166 referrals (61%) to show engagement opportunities websites occurred due to a notification (273 total)
show location on map	220 clicks (73%) to show an engagement opportunity location on the map occurred due to a notification (311 total)
deactivations	78 times, 11% of the participants deactivated notifications for specific opportunities after they were received
Trigger customization	
topic customization	27 participants (90%) subscribed to topics of interest, only receiving notifications for these (total of 45 times)
spatial extent customization	22 participants (73%) applied a spatial filter, only receiving notifications for this part of the city (total of 26 times)
General	
likes/stars	161 likes on engagement opportunities were logged; 93% of participants used this function
filter functions	21 participants (70%) used the filter functions in the exploration and spatial overview 89 times
navigation distribution	HomeView (textual descriptions): 325 times (47%); MapView (spatial overview): 221 times (35%); Settings: 98 times (15%); Help: 34 times (3%)

and 41 (12%) were dismissed in situ, almost a two to one access to dismiss ratio. Outside the immediate vicinity, 141 notifications (41% of all notifications) were accessed, while 74 (21%) were dismissed. Again, almost a two to one access to dismiss ratio.

By analyzing individual participant's interactions it is possible to look for specific user types or patterns. The analysis shows that only six participants (20%) interacted with 80% of their triggered notification in situ. 16 participants (53%) interacted with 80% of their notification outside of an engagement opportunity's geofence. The remaining eight interacted in situ and outside of engagement opportunities falling into neither category. Figure 12.4 provides a complete overview as a bar chart of the per participant spatial interaction distribution. The plot uses absolute values to show the total number of triggered notifications per user. The six participants that consistently interacted in situ (labeled "Group Inside") have almost the same average number of notifications (11.8, SD=6.08) as all 30 participants overall (mean=11.5, SD=8.3).

There are also no strong differences regarding accessed to dismissed notifications between the three user groups. The first group that acted primarily in situ accessed 81% and dismissed 19% of notifications while being in situ. Outside the immediate vicinity, they accessed and dismissed notifications evenly. The second group (primarily interacting outside of the geofence) accessed 72% and dismissed 28% of the notifications while they were in situ. Similarly, they accessed 73% outside of the context and dismissed 27% of the notifications. The last and third group without a clear preference accessed 64% of notifications in situ and dismissed 36%. This group accessed 61% of the notification while they were further away, dismissing 39%. Therefore, no clear behavior seems to be present regarding accessed or dismissed notifications concerning the spatial location. In general, the majority of the participants interacted outside of a citizen engagement's geofence with the triggered notifications and not in situ.

Still, the results of the second questionnaire that participants completed after the deployment shows that spatially triggered notifications were well received: 26 participants (86%) liked the feature (16 strong agreements, 10 agreements) and four participants disliked it (3 partici-

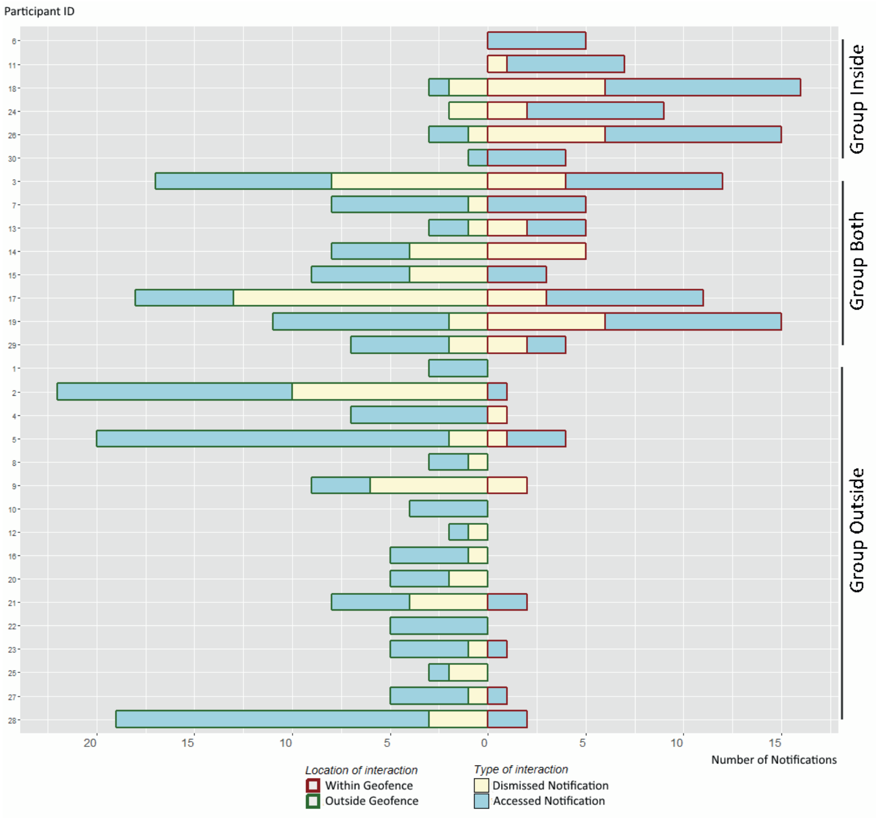


Figure 12.4.: This bar chart depicts absolute values for accessed and dismissed notifications based on the location of interaction for each participant. Bars to the right show the amount of notifications interacted with inside the geofence (in situ). Bars to the left display the amount of notifications that were interacted with outside of the geofence. Participants are ordered according to the three identified groups: participants that primarily interacted with notifications inside of a geofence, both inside and outside of a geofence, and primarily outside of a geofence.

pants disliked it, one participant strongly). Participants that disliked the spatial notifications did so due to privacy concerns, as they want to avoid providing a third party with location sensitive information. Additionally, they could not see any benefit of spatial notifications (mean=1.3, SD=0.5) and they found notifications to be disturbing (mean=1.3, SD=0.5). The 26 participants that liked or strongly liked the spatial notifications described them as interesting (mean=4.2, SD=0.7), motivating for an actual participation (mean=3.7, SD=1.1), supporting the information provision about engagement opportunities (mean=4.5, SD=0.8), and practical (mean=4.3, SD=0.7).

The open responses from the free text field were categorized and coded: 26 participants mentioned the overall design and layout with phrases such as “easy usage”, “understandable, modern, and pretty” or “clear and well structured”. These free text statements are backed up by the overall SUS score of 85.5 (minimum=55, maximum=97.5, SD=10.4) that suggests a good usability. The spatial notification function was mentioned explicitly by 20 participants with positives phrases liking the “continuously and automatic character” based on the “individual interests and own needs”. Six users mentioned improvements to the user interface. They would have liked a less “plain or flat” interface and 15 participants would have liked to see technical improvements regarding performance and stability of the notification application.

Comparison Study

For the lab-based comparision study, 20 participants were recruited directly after the field study ended. The study compared the official website of the city that informs citizens about engagement opportunities with the notification application. By comparing the application to a regular website that offers similar functions insights into the perceived pragmatic and hedonistic qualities of the website and the notification application can be obtained. Both qualities are important as the medium that citizens use to inform themselves about engagement opportunities needs to be appealing and useful to facilitate a prolonged use. These aspects need to be considered carefully in citizen engagement scenarios as engagement often originates from intrinsic motivations linked to citizens' convictions, values, and needs.

Participants and Apparatus. For the comparison study, 20 participants (twelve male and eight female) were recruited from the pool of users who had participated in the previous field study. Ages of the recruited participants ranged between 22 and 32 (mean=26, SD=3). To ensure that participants had experienced the notification application for a prolonged time, they were recruited from the field study. While the use of a website can be assessed without moving, the notification application and its approach are very dependent on actually moving through the city during one's daily business—something that is hard to simulate in a lab-based setting.

The official website of the city, Gutes Morgen Münster, features the same engagement opportunities that were used for the field study plus a large number of additional initiatives. All engagement opportunities that are featured on the website were collected via a crowd-sourcing process during a contest to raise awareness about existing initiatives in the city. The website was created for the contest and offered functions and design follow modern standards. Citizens can obtain information about all projects via a simple spatial overview that locates all projects on an interactive map. Alternatively, all projects are displayed in a gridded mosaic-view that shows a picture, a short title, and a description. Both functions have counterparts in the notification application that features a spatial and textual overview as well (see figure 12.3).

To compare the website and the notification application, the "AttrakDiff2" questionnaire [50] was used. Hassenzahl *et al.* [50] developed it specifically to compare the pragmatic and hedonic qualities of two systems or products. Hedonic aspects refer to the human need for stimulation and the human desire for a positive attitude towards artifacts they interact with. In contrast, the pragmatic quality measures usability and effectiveness. The questionnaire consists of 28 word pairs that each represent the opposite end of a continuum [49, 50]. Participants are asked to indicate on a seven point scale for each word pair, where the used system is located with respect to the two words. The 28 word pairs belong to four dimensions with seven word pairs each and the four dimensions describe the pragmatic quality (PQ), hedonistic stimulus (HQS), hedonistic identity (HQI), and attractiveness (ATT). By explicitly targeting the subjective view of participants, the questionnaire compares the satisfaction of participants between two systems or products [50]. As the participants were native German speakers, the German version of the AttrakDiff[3] was used to exclude errors due to language. However, the results are provided here in English using the official translation of the AttrakDiff to make them more accessible to a wider audience.

Task and Procedure. Before starting, topic, procedure, and task were explained for five minutes for each participant. Participants received necessary consent forms and signed them before proceeding with the study. The instructions explained that the participants should explore and use the official website of the city to obtain information about engagement opportunities. Identical instructions were given for the notification application; additionally, participants were asked to recall the usage of the notification application. All participants stated that they could remember the usage well, as the comparison study was conducted immediately after the field study ended.

For each of the two tasks participants had up to 15 minutes and they were informed when that time was over. Participants could finish their exploration of each system and switch to the other condition if they felt they had used the website or application sufficiently. Order of exposure of the website and notification application was randomized. After completing both tasks, participants filled out the AttrakDiff questionnaire online. Participants used a desktop computer with a keyboard, mouse and 23 inch

[3] http://www.attrakdiff.de, accessed February 10, 2016.

screen for the website and filling out the online questionnaire. For the notification application, participants used their smartphone as they did before in the field study. No further instructions regarding the questionnaire were provided as it aims to capture and investigate participants' first subjective responses.

Comparison Study Results

AttrakDiff provides three results for assessing the comparison. The first is a plot displaying average scores for the four dimensions (figure 12.5), the second plot depicts individual scores assigned to the 28 word pairs (figure 12.6) and the third plot is matrix that compares the general characteristics of the two systems or products (figure 12.7).

In summary, the notification application received higher average values for all dimensions, see figure 12.5. The largest difference is present in the perceived hedonistic stimulus. Although the notification application is perceived to be more demanding than the website, participants rated

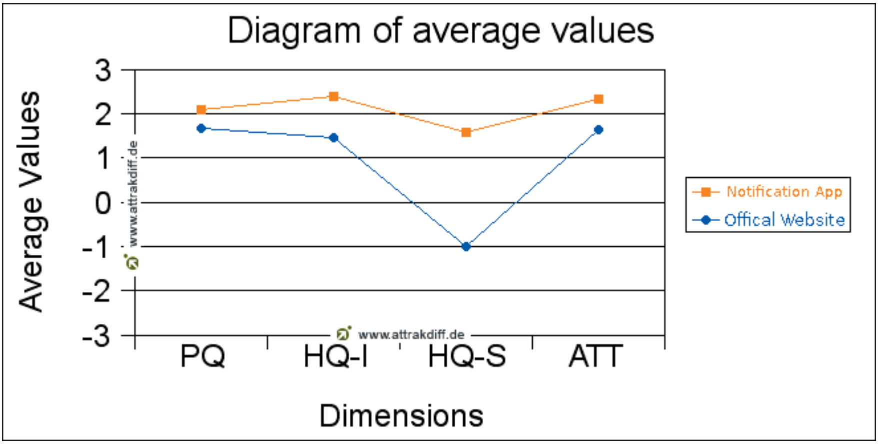


Figure 12.5.: Average values for both systems in the dimensions of pragmatic quality (PQ), hedonistic stimulus (HQS), hedonistic identity (HQI) and attractiveness (ATT).

it as more innovative, novel, and captivating. This is probably due to the nature of the spatially triggered notifications as this is a new and innovative function that needs to be understood first. Scores for the attractiveness (ATT) and pragmatic quality (PQ) are similar for website and application, indicating that both systems were perceived overall as well designed and usable by the participants.

A closer look at the scores of the individual word pairs reveals that participants consistently assigned higher scores for the notification application for 26 of the 28 word pairs, see figure 12.6. Participants deemed the notification application to be more unpredictable and more demanding compared to the website, albeit the assigned values do not differ largely. The largest individual difference can be found for the word pairs that describe novelty and innovation potential. This is unsurprising as the concept of spatially triggered notifications about engagement opportunities was under investigation. Still, as participants assigned very high scores for the hedonistic identity (HQI) this indicates that participants could identify with it, finding it stylish, presentable, and integrating. Nevertheless, the scores for the website are certainly good as well. Equal or close to equal scores were assigned for general manageability, presentation, and level of professionalism.

Both systems were found to be pragmatic and attractive, while the notification application scored higher regarding the hedonistic stimulus and identity. Figure 12.7 depicts the general comparison in a matrix. The computed confidence rectangles are small, which means the participants have the same opinion in general. Differences between the developed mobile application and the official website are statistically significant for the hedonic as well as pragmatic quality as the confidence rectangles are not overlapping in either dimension.

Overall, the findings of this prototype can inform designers of mobile "citizen apps". They provide evidence that citizens value in situ notification systems that create a spatial relation to the citizen engagement opportunity, although citizens do not necessarily interact straight away "in place" with the notification.

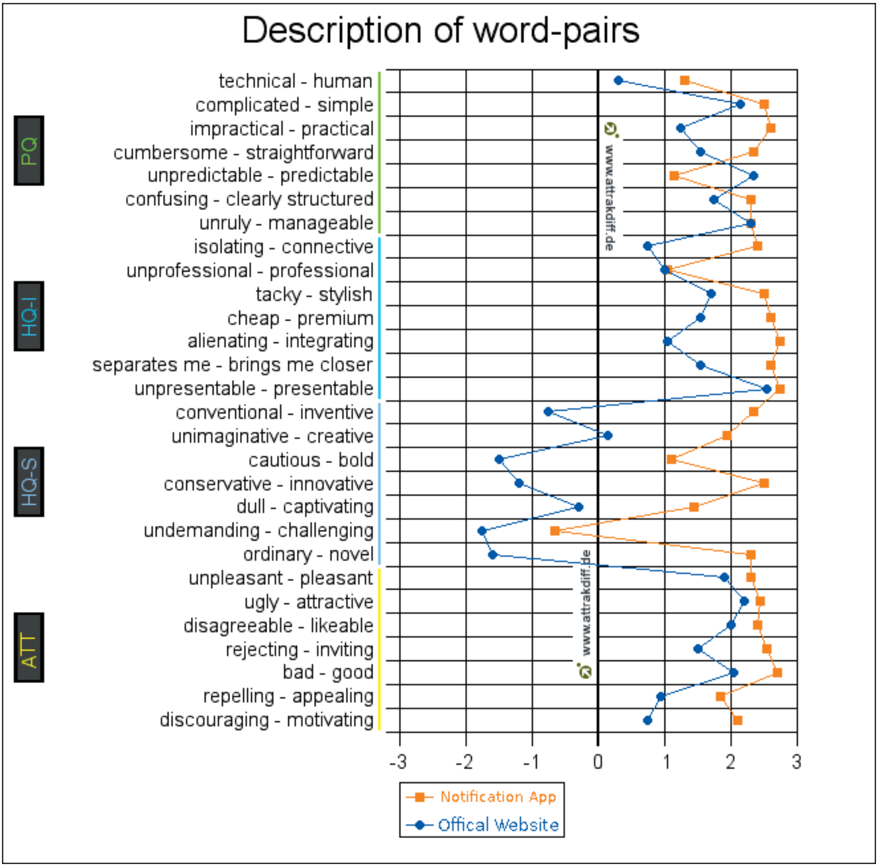


Figure 12.6.: Detailed plot of the assigned scores for the individual AttrakDiff wordpairs. Both applications received high scores, but overall the notification application was rated consistently higher or equal in some cases. An exception are the word pairs describing predictability, and undemanding or challenging use.

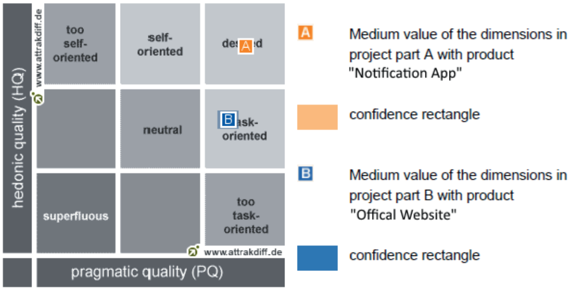


Figure 12.7.: Matrix displaying the overall results of AttrakDiff in terms of hedonic and pragmatic quality. Both systems are suitable for obtaining information, but users found the notification application to be more desirable.

The next section presents the second prototype called "Dialog Map" that intertwines textual and spatial representations for the citizen engagement levels of consulting or involving citizens.

12.2. Dialog Map

Dialog Map, the second prototype, investigates the citizen engagement levels of consulting and involving citizens. Citizen consultations usually only collect public feedback or comments, reflect on it and acknowledge that is was received. If citizens are involved their influence on the process and outcomes is stronger. Citizens are included directly throughout the process, and their aspirations and concerns are considered consistently. As both citizen engagement levels rely on an ongoing exchange, Dialog Map is inspired by and revisits Rinner's [162] concept of an Argumentation Map that allows linking textual arguments to a location.

Dialog Map extends the idea of an Argumentation Map as it tightly couples and synchronizes spatial and textual representation in a highly interactive and responsive User Interface (UI). Furthermore, Dialog Map was developed in cooperation with a local CSO and evaluated "in-the-wild" in an extensive field study with the partnering CSO as evaluations for Argumentation Maps with actual citizens seem to be scarce. Rinner *et al.* 's [168] evaluation from 2009 is one of the only ones that is available, but it only features a rather small set of participants (16) and evaluates Keßler *et al.* 's [167] prototype from 2005, see the discussion of related work in subsection 7.5.2. As such, the second prototype, Dialog Map, aimed to modernize and revisit the idea in the OG context with a larger evaluation.

Dialog Map includes the following functions from the AIG design space and implements several features that are loosely clustered to the levels of consulting or involving citizens: Users can create and exchange spatially referenced comments, arguments or feedback as part of the *communication* process in the citizen engagement case. Simple user profiles allow networking activities, and users can use existing accounts from social networks or create new and independent profiles for Dialog Map. As part of the communication process, users create and edit *data*, e.g., spatial references or written texts such as comments and can link and reference them to each other or external data. Dialog Map's interface *visualizes* the spatial dimension with simple polygons, lines or markers but intertwines them with the textual dimension in a tightly coupled and responsive interface that reacts to input in either dimension updating both. Standard *exploration* functions such as zooming or panning are present for the spatial dimension, but Dialog Map features additional filter functions such as a full-text search for the textual dimension as well. Almost every interaction in either dimension is reflected immediately and updates in the entire AIG to facilitate the exploration process.

The partnering CSO for the development and evaluation of Dialog Map was the "Stiftung Bürger für Münster (SBM)", a local CSO in the city of Münster. A focus of the SBM is to act as umbrella and networking organization for other local CSOs.[4] Dialog Map was developed and evaluated with the SBM as real world partner that provided valuable insights in the process—following MacEachren *et al.* 's [81] recommendation to not just build a system but rather activley engage with users. Furthermore, Gaventa *et al.* 's [104] recommendation was also followed

[4]See http://www.buergerstiftung-muenster.de/, accessed May 06, 2016.

to actively include CSOs for the in-the-wild study as citizen engagement does not occur automatically.

The following subsections detail the approach and application. Subsequently, the evaluation and the results are described. Limitations and results are discussed in chapter 14 alongside the other prototypes.

12.2.1. Synchronizing Spatial and Textual Dimension

The concept of Dialog Map is applicable for several citizen engagement cases, for example, an urban planning project that aims to restructure an area or an environmental conservation project that looks at wind-farming planning sites and their impact. However, the collaboration with the SBM lead to a focus on presenting and exchanging about existing citizen engagement cases in the city of Münster as one of the SBM's major focuses is networking. As such, the following descriptions exemplify the approach of synchronizing spatial and textual dimension for this particular use-case.

The UI of Dialog Map intertwines spatial representation of engagement opportunities with their textual descriptions in real-time. This results in the entire exploration process becoming highly responsive, and it allows for different strategies of exploration, and to seamless switch between them. Similar to an Argumentation Map, users can also provide feedback, or start discussing and link written statements to editable spatial representations in the geo-visualization that they can create. Figure 12.8 shows the interface while the mouse pointer is hovering over a textual description of an engagement opportunity.

The largest portion of the interface is a map-view displaying the locations or affected areas of citizen engagement opportunities. A vertical sidebar shows textual information and images about the available opportunities. Selecting any citizen engagement opportunity in the textual or spatial representation automatically selects or highlights the corresponding entities in the other view. Spatial references within the textual descriptions are directly linked to the map-view and visually emphasized in the text. Non-spatial filtering capabilities such as instant full-text search or filtering through preferences are also available.

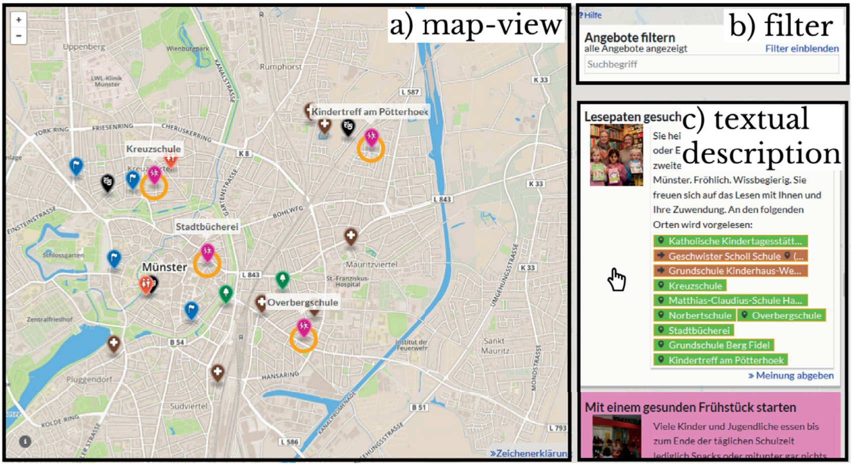


Figure 12.8.: The interactive interface consists out of an interactive map-view (a), a sidebar featuring non-spatial filters like a full-text search (b) and textual descriptions with images of the engagement opportunities (c). User interactions in any of the parts automatically update the entire interface.

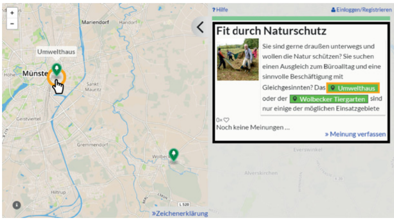
A hovering cursor over a textual description of an engagement opportunity automatically results in highlighting the corresponding locations that are currently within the viewport of the map-view. The spatial references in the textual description are also emphasized. As mouse hovering over textual descriptions frequently occurs, the spatial extent is not updated to encompass all spatial references that are linked to the textual description, as this would result in too many updates in the map-view. This highlighting and linking is one example of the intertwining of textual components and the spatial dimension.

The map view supports standard operations like zooming, panning, and hovering over spatial references. Interacting with the map view affects the textual description of the engagement opportunities in the sidebar: hovering over a spatial reference in the map-view highlights that particular reference and shows its title over the marker. At the same time, the sidebar will display the corresponding textual content or images of the equal citizen engagement opportunity. However, zooming and panning the map-view do not automatically update the sidebar to only display descriptions of engagement opportunities that are currently shown in the map-view. This behavior would result in rapid and unexpected changes and could thus irritate users. Refer to figure 12.9 for an illustration of some of the functions.

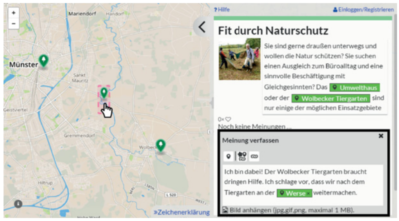
A click on a spatial reference or a textual description updates the map-view and triggers the expanded, “detailed-view” of that particular engagement opportunity in the sidebar. Expanded content is then displayed on its own in the map-view and sidebar. Users can now leave comments, ask a question or voice an opinion that relates to the selected engagement opportunity. Enriching comments is possible by linking to existing spatial reference or uploaded materials. The implementation also enables users to create new engagement opportunities or to create activities for a given period. However, these features were disabled in this case. The focus of the campaign was on recruiting volunteers for *existing initiatives* rather than creating new ones.

The user interface provides two further functions: an instant full-text search and filters for citizen engagement preferences. Preference filters are collapsed by default and can be expanded on demand. The full-text search enables users to search for an individual or combined search terms. Results are shown immediately after the user typed the first two characters and search results update continuously while users type to provide matches.

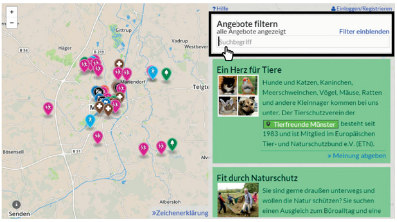
Search terms filter the textual descriptions, and sidebar and map-view update to display matches. This behavior creates a highly interactive experience driven by user input. As users type search terms, the search space is reduced, and only matches are displayed both in the sidebar and the map-view. Hence, users can assess search results rapidly from a spatial and textual point of view. Filtering for citizen engagement preferences (e.g. children and youth, supporting the elderly or sustainability) is straightforward and works identically. All functions work in



(a) The detailed-view shows one particular engagement initiative.



(b) The detailed-view with opened feedback function and a referenced location.



(c) Without a search term, the textual search interface displays all content.

(d) As soon as users type, the textual immediatley displays matches and updates the geo-visualization.

Figure 12.9.: Some functions of Dialog Map: detailed-view, detailed-view with opened feedback function, and the textual search that updates displayed content immediately.

combination, granting users the power to easily and quickly explore the available engagement opportunities.

Colors and icons are consistently used across the entire UI to provide additional clues and to tie the different UI elements together. Specific colors indicate different preferences of engagement opportunities. The background color of the textual descriptions in the sidebar corresponds to the color of their depictions on the map.

12.2.2. Evaluation

Dialog Map was used and evaluated in a campaign of the partnering Stiftung Bürger für Münster (SBM) to raise citizen engagement in the city of Münster, Germany. The SBM is a foundation aiming to cultivate and support citizen engagement and backed up by 260 private and corporate donors. Dialog Map was evaluated in a campaign to raise citizen engagement in Münster as the SBM recruited several established local NGOs that address several topics (e.g. sustainability, elderly, children and youth). The goal was to test Dialog Map in an actual setting with multiple local NGOs that can act as multiplicators. In this setup, the idea was that citizens would start an active exchange using Dialog Map about the opportunities and become active in the process.

The two and a half month campaign was called "1000 Stunden für Münster" which translates to "a thousand hours for Münster" and was a joint undertaking of non-governmental partners from the city. Citizens should be made aware of the various citizen engagement opportunities that are available across town and incentivized to partake. Total preparation time of the campaign was a year, and it took place from mid-January to end of March in 2015. Two research institutes, a professional graphic artist, a journalist, and 25 NGOs participated in the campaign. The campaign was conducted as an SBM survey revealed that a portion of the population did not feel sufficiently informed about existing citizen engagement opportunities.

Although the claim of the campaign was "a thousand hours for Münster", the cooperation partners knew that reaching this bar would not be likely and hard to measure. Nonetheless, the claim was used as it was catchy. Münster has roughly 300 000 inhabitants, a high student density, and active civic community with various NGOs.

The use-case allowed gaining new insights, as the targeted user base is diverse and in an actual citizen engagement context. Therefore, the study is not controlled in the sense of lab-based research. It was performed out "in-the-wild" with real citizens, granting insights into their preferences and usage patterns.

The research goal was to evaluate the relevance of spatial visualization and interaction while testing whether citizens would use Dialog Map's built-in spatial commenting or feedback mechanisms to exchange ideas or make suggestions.

Citizen Information Portal. Dialog Map was embedded in a citizen information portal that was specifically developed for the campaign and study. The basis of the citizen information portal was a content management system featuring general information about the campaign and partners. Its primary function was to allow citizens to inform themselves online about the offered engagement opportunities. Two possibilities were present for that: The first option was the mosaic-view, a visualization form frequently encountered in citizen engagement portals. Such mosaic-views are quick to realize and mimic a content organization form that is usually found in non-digital media, e.g., booklets that present their content structured through categories or some other linear representation. The second option was Dialog Map that intertwined the spatial dimension of the citizen engagement opportunities with their textual descriptions. While both options could be used individually, they were also linked. Users could click on a link in the details page of the mosaic-view opening up the same detailed-view in Dialog Map, or go back to the mosaic-view via the header of the website.

The mosaic-view displayed 25 engaging images of the offered activities in a grid, see figure 12.10. Engagement opportunities were clustered linearly by preference in the grid and color coded. Each picture showed the title of the engagement activity below the image. A short description would be displayed on top of an image if a user hovered over the picture with the mouse. Detailed-views could be reached via a mouse click, providing descriptions about the initiative, who was organizing it, where it would take place, and when. Dialog Map was not placed prominently compared to the gridded mosaic-view. The header of the information portal displayed seven entries in this order: A clickable logo to return to the landing page, "1000 Hours" with general information, "25 Offers" displaying the engagement opportunities in the mosaic-view, "News," "Map" offering Dialog Map, "Partners", and "SBM."

The mosaic-view would open up if a user clicked on the second tab while Dialog Map was accessible via the fourth tab. Due to the ordering of the navigation bar, it was likely that the mosaic-view would receive more clicks. This assumption was confirmed later by the logging system. The SBM insisted on this order to display the pictures and slightly longer textual descriptions prominently in the mosaic view.

Data Logging. An automated logging system captured user actions. Google Analytics provided a baseline and was complemented by an event-driven custom logging framework to capture individual user interactions in the browser. Individual users of the citizen information portal were identified via browser fingerprinting (refer to section 4.2 for details). The custom logging frameworks allowed to capture interactions such as zooming, panning, hovering, and typing as Google Analytics does not support these actions.

Participants. No information about age or gender can be given as Dialog Map was evaluated as part of an actual campaign to raise citizen engagement "in-the-wild". No questionnaires had to be filled out before citizens could use the information portal to avoid alienating interested citizens. To raise attention for the campaign and reach out, ten thousand glossy DIN A6 booklets with 48 pages were printed. 9250 booklets were distributed in the first two weeks. Booklets described engagement opportunities and included some additional material about the partners. The booklets were disseminated equally in the city through publicly available spots like grocery stores, pharmacies, neighborhood town halls or downtown information booths. The SBM sent some booklets (1400) to partner organizations by mail. Additionally, citizens were informed via 25 posters in university buildings, theaters, and exhibition halls. The campaign was featured once in the local newspaper and dur-

(a) Overview of the mosaic-view displaying all engagement opportunities in a grid with images.

(b) Detailed information (what, who, when, where) in the mosaic-view.

Figure 12.10.: Main view for the mosaic-view and a detailed-view for the mosaic-view.

ing a broadcast of the local radio station. Online advertisement included Facebook posts, university-wide newsletters, blog posts and a 50 second YouTube video that was distributed via social networks.[5] All materials included a link to the portal.

Results

In the following, the findings of the evaluation are presented. They start with logged data from the citizen information portal, look at interactions in the mosaic-view and geo-visualization, and present a user-flow analysis that identifies usage patterns. The evaluation focuses on the comparison of the mosaic-view and Dialog Map, as the comment and feedback functions that Dialog Map offers were not used.

Citizen Information Portal

The initial assumption that the ordering of the navigation bar affects the clicks on the corresponding sub-pages holds true, see table 12.2 for a compilation of the general data from the website. As the second entry, the sub-page that displayed the engagement opportunities in the gridded mosaic-view entitled “25 Offers” was accessed 10.3 (51.3%) times as often as the entry “Map” (5.0%) that offered access to the Dialog Map.

For the following analysis, 468 out of 713 individual users are considered as active users, as several users left the citizen information portal after glancing at it. 223 active users accessed the geo-visualization—roughly every second active user (47,76%). Considering all users, 227 of the 713 users accessed the geo-visualization (31.83%), every third user. These access numbers of the geo-visualization are comparatively high because the entry in the navigation bar was accessed ten times less than the entry for the mosaic-view concerning pageviews. The fact that still 47.76% of all active users accessed the geo-visualization can be attributed to the link “display on a map”, which was present on each detailed-page of the engagement opportunities in the mosaic-view. Active users who

[5] See https://youtu.be/sz2aeA1OzxA or https://www.facebook.com/buergerstiftung.muenster/videos/631837113611103/ for the video, accessed May 27, 2016.

Table 12.2.: Aggregated data about website usage from January, 15th to March, 31st 2015.

unique users	713 total users; 245 user left after displaying the landing page.
user acquisition	47.90% via direct URL; 43.19% via referals from other websites; 8.91% via social networks or search engines
visitors	70.9% new visitors; 29.1% returning visitors
geo-ip	97,74% of visits originated in Germany, 92% of these visits originated from the federal state in which the city is located.
total pageviews	6627
number of sessions	998 total; 654 these occurred in the first month
dropped sessions	26,82% were dropped after displaying the fist page and 7.51% after displaying two pages.
average session time	03:34 minutes
click distribution on navigation entries	Landing Page: 17.0%, 1000 Hours: 13.7%, 25 Offers: 51.3%, News: 6.5%, Map: 5.0%, Partners: 3.1%, SBM: 2.9%, Imprint: 0.6%

did not access the geo-visualization (245) viewed on average 5.6 sub-pages in the citizen information portal before leaving. The interactions with the mosaic-view were limited as well as those 245 users opened up 2.4 engagement opportunities on average during their stay on the site. Users that accessed the geo-visualization were more active overall as they viewed on average 11 sub-pages and 3.1 engagement opportunities within the mosaic-view.

Interactions Mosaic-view and Geo-visualization

The mosaic-view was accessed in 45% of all sessions with the first interaction, probably due to its placement the navigation bar. The geo-visualization was only accessed in 1.7% of all sessions with the first interaction. Still, 47.76% of all active users accessed it during their stay on the citizen information portal. Users accessed various citizen engagement opportunities in the mosaic-view and looked at the detailed-page, switching back and forth between the overview and the detailed pages. Most views in the mosaic-view were accumulated by engagement opportunities that are already known in the city in the area of children and youth work, international activities that organize meet-ups, or environment and sustainability initiatives.

The amount of performed actions in each of the areas of the geo-visualization can serve as an indicator to gain a first insight into their importance. 4476 interactions (78,83%) (zooming, panning, hovering, and clicking) occurred in the map-view, and 1141 interactions (20.10%) happened in the textual descriptions of the sidebar (hovering over textual spatial references, clicks to access the detailed view, scrolling). The least amount of interactions occurred in the textual filter function that was located on top of the sidebar. In total 61 interactions (1.07%) were performed with it.

Most of the interactions in the map-view were mouse hovers with 57.4%. Zooming and panning account for 39,9% of the interactions in the map-view. Clicks on markers to access the detailed-view with the interface for giving feedback add up to 2.7%. High numbers of mouse hovers are not surprising, as this is an interaction that only requires users to remain with the mouse cursor over a spatial reference on the map for a few milliseconds. Zooming and panning require a mouse click or scrolling, a more determined interaction in comparison to a mouse hover. 14 users accessed the filter functions and filters were toggled 20 times. Four users used the full-text search. Each of the four users searched for one search term individually, and all searches looked for one specific and well-known engagement opportunity in Münster that helps children to learn to read.

The feedback mechanism that could be accessed in the detailed-view in the Dialog Map were not used. No user wrote a comment, asked a question or referenced an additional area. Seven users clicked on the button to open the feedback form in the detailed-view, but no one wrote, referenced or linked anything. In total, the feedback form was opened for six different engagement opportunities.

Overall, 2527 interactions were recorded for the mosaic-view, while 5678 were registered for the geo-visualization. While both presentation forms offered interaction possibilities, the geo-visualization offered a wider variety of functions for interaction. Both values are hard to compare directly; still, the total interaction counts show that users engaged with the geo-visualization.

User Flow

User flow patterns were established for a direct comparison of the geo-visualization with the mosaic-view. A user flow pattern is the sequence of accessed sub-pages and interactions on each sub-page for each user. If a user accessed the site multiple times, the behavior that occurred during multiple sessions is aggregated. The evaluation reports on the predominant pattern for each user. Only active users that accessed the geo-visualization are considered for the user flow analysis. Active users that did not access the geo-visualization amount to 245 users. These users only looked at the mosaic-view and did not access the geo-visualization. They are not included in the user flow analysis as they accessed on average 5.6 sub-pages and on average 2.4 engagement opportunities directly in the mosaic-view. They are still counted as active users as they spent time and did access the mosaic-view, although they interacted overall in a relatively limited fashion with the citizen information portal. Active users that accessed the geo-visualization viewed on average 11 sub-pages and interacted with 3.1 engagement opportunities in the mosaic-view.

Four distinct user flow patterns for active users that used the geo-visualization could be identified. A semi-automatic classification process sorted and pre-classified all user interactions for all active users that accessed the geo-visualization. Based on the sequence of the interactions with the citizen information portal users were grouped and classified. The classification was verified manually in a subsequent step. Table 12.3 provides a breakdown for each pattern.

Table 12.3.: User flow categories were identified in a semi-automatic classification process for users that accessed the geo-visualization.

pattern	total users
1. mosaic-view → geo-visualization	114
2. mosaic-view ↔ geo-visualization	80
3. only geo-visualization	21
4. geo-visualization → mosaic-view	8
$\sum$	223

In the *first user flow pattern* with the largest amount of users, a user started to explore the engagement opportunities in the mosaic-view. At some point during the exploration, the user decided to either click on the link "display on a map" in the detailed-view or clicked on the "Map" entry in the header and started to use the geo-visualization to explore the engagement opportunities. In this pattern, users did not access the mosaic-view afterward again. A total amount of 114 users employed this pattern. Switching between mosaic-view and geo-visualization is the *second user flow pattern*. 80 users started to investigate engagement opportunities by accessing the mosaic-view and followed up to use the geo-visualization. Subsequently, they accessed the mosaic-view and geo-visualization again switching between them. In the *third user flow pattern* users only used the geo-visualization, without accessing the mosaic-view at all. Those users started by clicking on the "Map" entry in the navigation bar and used the geo-visualization exclusively—21 users are present in this pattern. The *fourth user flow pattern* is the reversed first pattern, but it does not occur often. Eight users started by investigating the geo-visualization first. After interacting with the geo-visualization, they followed up by investigating the mosaic-view.

Figure 12.11 displays patterns one and two for two selected users. Reoccurring interactions are clustered for the mosaic-view and the geo-visualization. Pattern one displays a user that switched from the mosaic-view to the geo-visualization and pattern two depicts a user that switched between mosaic-view and geo-visualization repeatedly. Interactions with the mosaic-view are in blue. Interactions are labeled with OM if they occurred in the overview of the mosaic-view while interactions in the detailed-view of the mosaic-view are labeled DM. Interactions in Dialog Map are in ochre and labeled with M and S for interactions with the map-view (M) and the sidebar (S). White boxes are general interactions on the citizen information portal. A last typical action of users before leaving was to open up the landing page or other general information like cooperating partners before they closed the site.

Additionally, dwelling times for the total amount of time spent on the geo-visualization and the mosaic-view were computed. However, the computed dwelling times can be incorrect as users can not be tracked directly. The capabilities of automated logging through a browser are limited. For example, not all browser indicate whether a tab is active, and even if it was, the logging software could not determine whether users spent time reading the displayed text or if they are doing something else entirely. Dwelling times for the mosaic-view are slightly higher compared to the geo-visualization. For 117 users (52.5%) the mosaic-view was displayed longer in the browser compared to the 106 users (47.5%) were the geo-visualization was active longer in the browser. The computed dwelling times for each presentation form account only for the presentation form, time on information pages (e.g., landing page, news) were not counted and excluded.

After the campaign had ended, the participating NGOs partners drew positive conclusions, albeit the SBM had hoped for a higher impact. Seven out of the 25 participating NGOs reported an increased number of volunteers, four NGOs did not report back, and 14 NGOs had no new visitors. Details about newly acquired volunteers like age or gender were not reported due to privacy concerns. All of the new volunteers stated that the campaign made them aware of the engagement opportunity. The SBM counted 30 new volunteers in total, and 15 confirmed that they would return to volunteer additional time. During the last meeting, the SBM and some partners reported their experience with similar campaigns and explained that wide-spread reception and mobilization

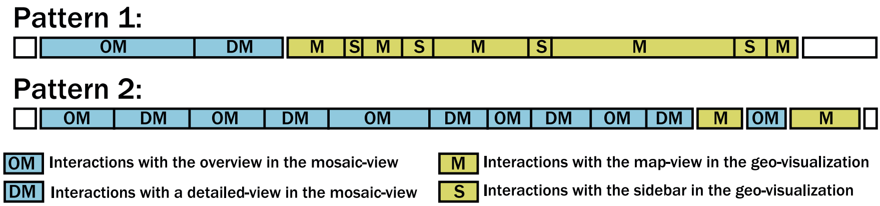


Figure 12.11.: Example of two user-flow patterns (one and two) that occurred most often, the patterns are based on two actual users.

of citizens takes time, and subsequent activities are needed. As such, the campaign will be repeated in the following years.

In summary, the results indicate that citizens seem to value spatial visualization that is tightly coupled with textual information in a direct comparison with a more traditional gridded mosaic-view presentation form. However, insights on obtaining feedback or comments from citizens in consultations or involving citizens can not be presented. In this particular case and setup, citizens did not use the offered feedback functions. The next section presents the third prototype called "Ethermap" that looks at real-time geospatial collaboration.

12.3. Ethermap

The third prototype is called Ethermap and looks into the citizen engagement level of collaboration and how *real-time geospatial collaboration* can be realized. With the rise of cloud-based computing, real-time collaboration has found its way into many web applications such as Google Docs, Cloud9 IDE, or Etherpad.[6]

In essence, real-time collaboration enables multiple users to simultaneously edit the same dataset while working on different devices and/or at different locations. Any changes in the shared workspace are im-

[6]See https://docs.google.com, https://c9.io, and http://etherpad.org, all websites accessed May 10, 2016.

mediately visible to all collaborators and can thus lead to increased efficiency compared to standard approaches [178]. By implementing user awareness features and inbuilt communication capabilities like textual chats, real-time collaborative editors try to mimic the dynamic of working together at the same place and time. Conflicting changes can be resolved in real-time in contrast to asynchronous approaches, e.g., classic version control systems. Version control systems are nevertheless important tools for collaboration, as they provide insights into data provenance and the history of the data. In addition, they allow for inspecting changes and reverting to older versions, for example, to remove errors or unwanted changes.

While some research on asynchronous geospatial collaboration is available [e.g. 183], work on real-time geospatial collaboration is comparatively scare, see section 7.5 for the discussion of related work. As such, Ethermap investigates how to extend the process of non-blocking real-time collaborative editing to geospatial data. While a collaboration between citizens and civil servants can take shape in many forms, Ethermap focuses on enabling multiple users to simultaneously map, comment or edit geospatial data in a virtual shared workspace as a web-based application. The design was informed by existing research in the area of multi-user collaboration environments [209, 210], single screen geocollaboration environments [166], and geo-conference tools [181].

Ethermap includes the following aspects of the design space for AIGs that are loosely clustered on the level of collaboration: it features several direct and indirect *communication* functions. For example, Ethermap's user-awareness features unobtrusively highlight collaborative user activities visually in the shared workspace using consistent color coding and provide a functionality to follow other users' movements. Additionally, Ethermap includes a chat that can directly reference geospatial objects. Collaborators can *explore* the map history that is enabled by a version control system. The map history allows a detailed inspection of changes over time, and to analyze data provenance as it lists collaborators and their changes and contributions in the history. Other exploration functions such as adding and removing layers, zooming and panning, and getting detailed feature information are present as well. As Ethermap is a real-time collaboration editor for geospatial *data*, users can create, edit or delete data collaboratively without the need for locking or restricting access. Due to the versioning system, it is also possible to filter or access specific geospatial objects and their history. Aside from the indirect user-awareness features that visualize user activities, Ethermap's *visualization* of geospatial data is straightforward and based on polygons, lines and markers as Ethermap focuses on mapping and editing geospatial data collaboratively. However, users have the option to style the created geometries using the "simple style specficitation"[7] that allows to render and style geospatial objects according to their attributes.

As the related work for Ethermap was already presented in subsection 7.5.3, the following subsection details the approach and implementation of Ethermap. Subsequently, the next subsection presents the two-tiered evaluation that consists of a user study and three semi-structured expert interviews. Equal to the previous two prototypes, the discussion of the results and limitations are presented in chapter 14.

12.3.1. Geospatial Real-Time Collaboration

Usually, mapping tools are asynchronous and blocking applications that require sequential interaction. In multi-user scenarios, it is frequently the case that "same place work models" or remote presence systems are used [181], where one user "drives" the system and the others are merely "passengers". The interaction possibilities of the latter group are limited, as they often can not interact with the data directly. They might also have to wait until a lock is released or a new version is made available. Real-time collaboration on maps removes these obstacles and thus challenges the very idea of what defines a map user, as every connected user can easily become a contributor at any time [26]. This collaboration type is essential in scenarios where every edit counts, e.g., in crowd-sourced disaster mapping or urban planning as duplicates or conflicts are reduced, queues are eliminated, and efficiency is raised.

[7] See https://github.com/mapbox/simplestyle-spec/, accessed May 10, 2016.

The overall goal of the approach is to facilitate this type of real-time collaborative map editing of geospatial data between distributed users. Ethermap is the prototypical implementation of this concept, which is designed around the idea of gathering, creating, and using geospatial data together—thereby improving the process of collaboratively working on geospatial data.

Real-time collaborative editing of geospatial data could further enable novel application scenarios such as “pair” mapping (as in extreme programming, where two programmers work closely together). This approach can be beneficial in several scenarios. For example, if awareness of other users is crucial, if collaborators are under time pressure, and in scenarios where universal and equal access is essential. Real-time collaborative editing can also help to resolve conflicts through implicit coordination and to avoid double work, as contributors do not have to wait for other collaborators to finish working on a specific object before editing it. Instead, collaborators can directly start working to update, create or enhance geospatial data.

The key challenge to overcome in realizing real-time collaboration on geospatial data results from the distinct properties of such data (compared to other data types such as text). Firstly, geospatial data is spatial and extends to at least two dimensions, which makes it harder to navigate and to track changes. For example, in texts, it may be feasible to show changes in-line with the old text being crossed out, this principle would not directly translate to geospatial data, as the location of an object carries meaning. Secondly, geospatial data is often layered to deal with different aspects related to a spatial area, and layers are superimposed. For example, the use-case may require combining different layers encapsulating buildings, height profiles, and water bodies to assess flood risks.

Thirdly, geospatial data is highly structured: in addition to spatial components, there is a (potentially large) number of non-spatial components, called attributes, which represent thematic aspects of a geo-object. For example, a two-dimensional polygon might represent a building, and several thematic attributes might describe its main use—its owner and value. Finally, geospatial data can be very complex and might require extensive navigation when working with just a single object: the geometry of a river may span multiple screens (depending on the zoom level) and contain thousands of points. The distinct properties of geospatial data thus require adjusting principles and interfaces in real-time collaboration and the design of new ones to support collaboration.

Conflict resolution is a further area, where geospatial data can pose significant challenges. Conflicts can arise easily when multiple users edit or map data, for example, in crowd-sourced projects dealing with geospatial data such as OpenStreetMap (OSM) or the Humanitarian OpenStreetMap Team (HOT). OSM is a project aiming at crowd-sourcing a map of the world, whereas HOT strives to support humanitarian actions and disaster response efforts. When conflicting versions appear in the system, OSM simply raises errors, while the "HOT OSM Tasking Manager" uses a soft locking mechanism that tries to focus work on a specific geographic area at a time.[8] However, conflicts can still arise as contributors can leave the assigned geographic area easily by zooming and panning and then edit geometries outside, which potentially results in invalid and conflicting states. These conflicts can prevent collaborators from contributing, create frustration, and can also significantly reduce efficiency and scalability. Time is often of the essence in scenarios requiring real-time collaboration, e.g., in disaster mapping or during participatory planning processes. Ethermap eliminates this problem by introducing real-time synchronization between all contributors.

To enable efficient real-time collaboration with geospatial data, a set of measures that account for the specific properties of geospatial data is applied. The approach is based on the principle of immediate and continuous real-time synchronization of all changes that are being made. Introduced measures focus on raising user awareness, facilitating communication, and the interactive exploration of changes. In the following paragraphs, these measures and their realization in Ethermap's prototypical implementation are described. Please refer to figure 12.12 for a picture of Ethermap's interface.

[8] See http://openstreetmap.org/, http://hot.openstreetmap.org/, and http://tasks.hotosm.org, all websites accessed May 10, 2016.

Real-time synchronization: The basic underlying principle is to enable users to create, edit, and delete simple geometries, such as points, lines, and polygons while working in the same workspace and on the same data. Every time a feature is created or edited, the changes are immediately distributed to all users. This synchronization is essential to enable all users to edit any object at any time and thus to facilitate real collaboration [179]. Conflicts are not managed automatically, but the conflict resolution process is supported via the measures described below. Ethermap achieves real-time synchronization via an optimized client-server architecture with push-based messaging to ensure that all users receive updates in real-time.

Raising user awareness: To make users aware of the work of other collaborators, Ethermap highlights certain aspects so that users can coordinate their activities. These include whether other people are currently focusing or working on a specific geo-object, who they are,

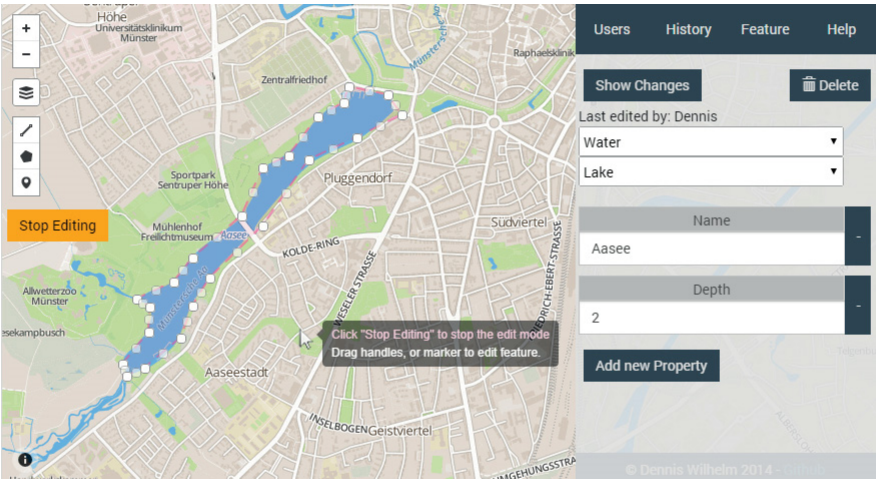


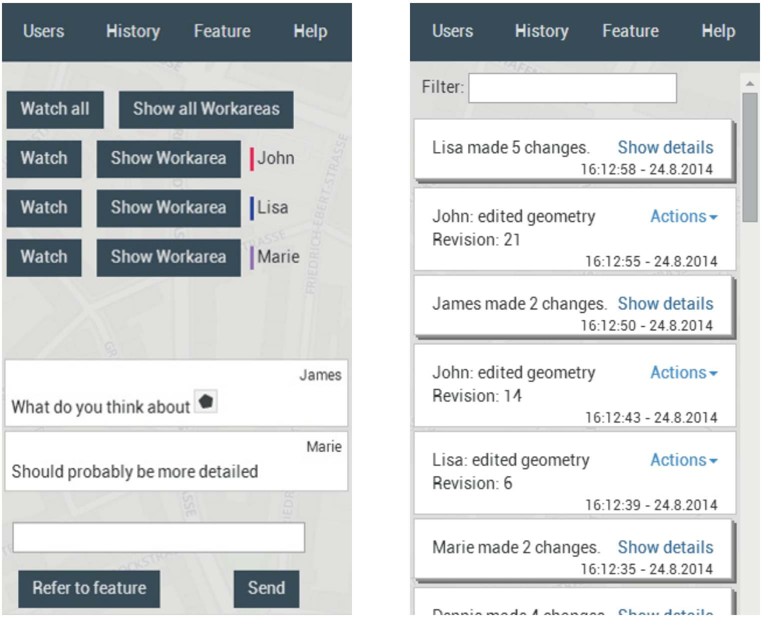
Figure 12.12.: Ethermap's main interface while a user edits a geospatial object. The menu on the right displays and allows to change or add attributes of the object.

what objects have been edited, and also which part of a potentially large map other users are working on at a particular time [211].

Ethermap realizes these functions in the following way: users are color-coded, and this color is used to highlight different actions they perform. When an object is updated, it is briefly highlighted in the color of the user who caused the change, and then it fades back to its original color. All information about currently connected users is displayed in a contextual menu (see figure 12.13a). This menu can also be used to indicate the current work area of a particular user: clicking on a user's name will briefly highlight the bounding box of their current work area. Also, it is possible to continuously "follow users around" by activating a "watch'" function. Unless disabled, the map view of one user will then automatically follow the view of another user. This can be beneficial, e.g., when working in pairs where one person edits the geospatial data while the other person checks if the changes are correct.

If an object is currently being edited by a user, other users will see a dashed outline in the color of the editing user. This function helps to reduce conflicts that might otherwise occur. If multiple users are editing the same geo-object at the same time, they are all displayed in the contextual menu.

Facilitating communication: Establishing means to communicate with collaborators is vital for collaboratively solving tasks [212]. While the presented ways to raise user awareness facilitate implicit communication, direct communication is needed as well. In Ethermap, an online chat tool enables users to explicitly discuss various aspects, to express opinions, and to ask questions. In the context of collaborative map editing, the domain of conversation is inherently spatial and complex (see the discussion at the beginning of this section). Also, only a subset of geo-objects usually has meaningful names, which makes it difficult to refer to them verbally. Thus, Ethermap's chat is extended with means to easily reference geo-objects and to navigate the potentially large map, which is known to improve communication [213]. Ethermap allows including cross-modal references to geo-objects in the chat. Sub-figure 12.13a shows a chat message that references a polygon. The reference shows the symbol for the type of the geo-object, in this case, a polygon. Users



(a) Users tab: shows who is online; provides means to chat, and to show users' workareas.

(b) Global map history: shows aggregated changes to avoid cluttering the list.

Figure 12.13.: Ethermap's users list and global map history menu.

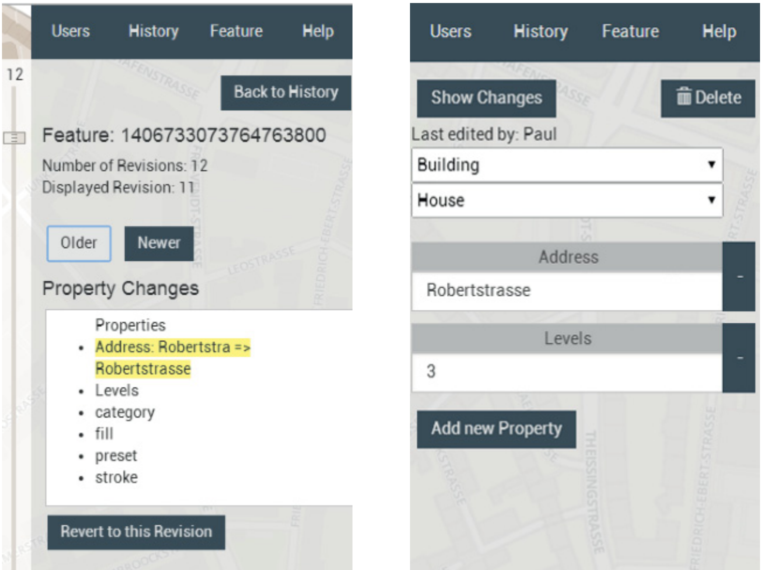
can easily insert such references in a message by clicking a button within the chat window and clicking the geo-object afterward. When a user clicks on a reference contained in a chat message, the map view centers on the location of the corresponding geo-object while setting the appropriate zoom level.

Exploration of changes: When multiple users collaborate, it is important to keep track of what is being done by whom and when, and to provide means to revert to earlier states of the work. For example, how things have changed over time can help understand work processes and provenance. In the case of geo-objects, it can also document how the world has changed over time (e.g., after a disaster struck). The exploration of changes is subject to similar constraints as the facilitation of communication. Due to the complex and spatial nature of the domain, it is necessary to extend the standard functionality of version control tools with means to easily reference and interact with geo-objects. Version control systems can be used in synchronous and asynchronous collaboration systems. Priedhorsky *et al.* [183] reported on an asynchronous version control system for geospatial data, and OSM also provides basic version control functionality.

Just like Cyclopath and OSM, Ethermap provides similar version control functions. However, Ethermap's features can be used synchronously: all version control features are fully integrated into the real-time editing process. Any actions performed on the version history are thus immediately visible to all collaborators. In Ethermap, a continuous history feed records all changes made to the map. The feed encodes whether geometries and/or attributes were added, changed or deleted in a list. Subsequent actions of individual users are aggregated to avoid a cluttering of the history, see sub-figure 12.13b. A click on an entry will center and zoom the map on the referenced geo-object. Additionally, users can access a more detailed overview for individual geo-objects. Different revisions can be visually inspected using either a simple interface or textually, see sub-figure 12.14a.

Changes are color-coded based on the type of the change to facilitate easy recognition. If attributes are added they are colored in green, changes are yellow, and deletions are displayed in red. Changes to the geometry of a geo-object are directly visible on the map. Geometry revisions are displayed in their original color (defined by the category of the geo-object). In addition to reviewing older versions, it is also possible to revert a geo-object to a previous revision.

Ethermap was developed as a web-based application to keep the entry barrier low since this is one of the main challenges for open collaboration [214]. Furthermore, various successful web-based mapping platforms exist, and the most common synchronous collaborative text editors are web-based as well. Ethermap was implemented in HTML5 and JavaScript. It uses well-known libraries and frameworks such as node.js for the server and socket.io for real-time messaging that is



(a) Geo-object history tab: supports browsing and reverting to revisions of a particular geo-object via slider or buttons.

(b) Attribute tab: shows the attributes of a geo-object and provides means to edit them.

Figure 12.14.: Ethermap's history menu for individual geo-objects and attribute editing menu.

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based on WebSockets. CouchDB is used as multi-version concurrency control database for storing JSON documents. The frontend (client) of Ethermap relies on AngularJS for easy modularization and Mapbox.js for map display and interaction.[9] The latter integrates the "simplestyle specification" that allows geo-objects to be rendered and styled according to their attributes. Data is exchanged and stored using the GeoJSON specification, a lightweight, and widely used community standard.

[9]See https://nodejs.org/, http://socket.io/, http://couchdb.apache.org/, https://angularjs.org/, and https://www.mapbox.com/mapbox.js/, all website accessed May 11, 2016.

Ethermap reuses the existing category system of OSM. Within this system, geo-objects can be classified and described according to informal standards. The visual appearance of an object in the geo-visualization (e.g., colors, line width) is automatically derived from its category. For example, polygons categorized as a "building" are colored in red by default. Ethermap also generates input fields for the appropriate attributes from these categories. For instance, buildings have an address and a number of levels, whereas roads have an attribute for the speed limit (see sub-figure 12.14b). Users can append custom attributes as key/value pairs to extend the default fields.

12.3.2. Evaluation

Neale *et al.* [215] and Pinelle *et al.* [216] recommend to evaluate real-time collaborative multi-user applications from several angles to assess their quality and usefulness. Ethermap's evaluation followed their recommendation, and the prototype was tested in a lab-based user study. Subsequently, three domain experts were interviewed after presenting Ethermap to them.

Before Ethermap was evaluated, informal user tests and a technical evaluation were conducted to assess the scalability and robustness of the approach to ensure a smooth evaluation. The controlled lab-based user study was conducted to investigate collaborative aspects, logging every user activity, and followed up with a detailed questionnaire. To gain additional insights into the usefulness and applicability of real-time collaborative map editing three semi-structured expert interviews were conducted with domain experts.

User Study

The goal of the user study was to gain insights into the usability of the approach, into usage patterns, and most used or valued functions of Ethermap. The scenario for the user study was disaster-mapping as this is a common geospatial collaboration task performed by citizens and supported by CSOs such as the HOT. In disaster-mapping, participants usually update an existing map according to changes introduced by a disaster, e.g., a flooding event. As such, official data from a flooding event in 2013 in Germany was included in the application and served as an actual scenario. Participants were tasked to collaboratively map flooded areas in an urban environment near the city of Dresden. Aerial images and OpenStreetMap data served as base data. Participants could overlay publicly available, and official near-infrared images of the flooded area as this helps to identify the areas in question.[10]

Participants. 39 participants were recruited from the university campus, and most were students taking an introductory course on GIS. 17 participants were female, 12 male, and ten did not to state their gender. Their age ranged from 18 to 26 (mean = 20.6, SD = 1.7). Thus, the participants had some initial familiarity with mapping software, but no use-case specific knowledge.

Procedure and Apparatus. Similar to the study by Butt *et al.* [181], a combination of logging user behavior with a custom build logging software and a questionnaire was used to gather the data for the analysis. The user study was performed with two groups consisting of 20 and 19 participants. After a ten minute introduction, participants were asked to start Ethermap by entering a user ID that had previously been assigned randomly to each participant. An interactive tutorial repeated the task participants had to perform and reminded them about the available tools. As all participants were in the same room, they were invited not to talk to each other to simulate working from distinct places. After 15 minutes of active mapping, Ethermap closed automatically and switched to the online questionnaire.

The first questions of the questionnaire captured demographic information and familiarity with mapping software as well as real-time synchronization. The questionnaire then focused on Ethermap's functionality and asked participants about real-time

[10] See https://geoportal.sachsen.de/cps/metadaten_seite.html?id=29a1ee58-9b39-49af-b05a-7a3460239fbe for the near-infrared imagery, accessed May 11, 2016.

synchronization, user awareness, and version control. 27 questions were present: 12 questions used a seven-point Likert scale (ranging from “strongly agree” to “strongly disagree”), eight were open questions (allowing for textual replies), and seven were yes-no questions. Free text answers were analyzed by categorizing and summarizing the responses based on the given statements. Questions based on the Likert scale were analyzed by calculating the frequency of the given responses. The seven-point Likert scale was simplified into a three-point Likert scale as recommended by Maurer *et al.* [217] due to the relatively small sample size.

User Study Results

The questionnaire started by asking the participants about their overall experience regarding GIS as well as previous usages of real-time synchronized editors. 49% rated their experience with low to no experience at all. 28% selected medium and the rest rated themselves with a good or expert experience (24%). Out of these participants, 69% had never used real-time synchronized editors before; 8% were unsure, and 23% had prior experience. Table 12.4 summarizes the participants’ replies to the main questions of the questionnaire.

Real-time synchronized map editing: Both groups created 268 geo-objects (93 lines, 10 markers, 141 polygons) with 972 revisions in total. The revisions consist of 268 geo-object creations, 24 geo-object deletions, 344 geometry edits, and 336 attribute edits of the geo-objects.

Figure 12.15 depicts the actions performed by the participants. Activity levels and dominant categories differed considerably between them, and distinct strategies are visible. Some users focused on editing geometries and properties while others created objects and did not edit geometries afterward. Four participants were particularly active: they performed over 55 actions (the average was 24.9 actions). Three users applied almost no changes to the map.

From the logged data, three main collaborative patterns can be identified. In the first pattern, one participant applies edits while at least one other participant monitors those edits. In the second pattern, multiple

Table 12.4.: Summary of Likert-scaled questions with answers ranging from 7 (strong agreement) to 1 (strong disagreement).

Question	Median	SD
I could easily recognize the presence of other collaborators.	6	1.54
I could easily detect changes by other users.	6	1.95
Different colors helped me identify which users had edited a geo-object.	4	1.64
Actions of other users did not interfere with my work.	4	1.64
I was satisfied with the speed of the editor.	7	1.61
A revision history is useful when jointly editing maps.	6	1.17
Real-time synchronization enabled me to complete the task more efficiently.	5	1.53

participants co-edit the same geo-object at the same time (within a few seconds). In the third pattern, multiple participants monitor the same geo-object at the same time without applying edits. In this context, "monitoring" refers to an active selection of a geo-object. A geo-object is selected by clicking on it, which enables users to inspect/edit its attributes or the geometry.

Pattern one occurred 31 times on 25 geo-objects. Active co-edits (pattern two) were more scarce with nine separate instances on six different geo-objects. Active co-edits are edits that occurred in quick succession (within a few seconds). The third pattern occurred 15 times on 13 geo-objects. In this particular pattern, it is likely that users checked if further refinements were needed and that the simultaneous monitoring happened co-incidentally.

In total, 29 geo-objects of the 268 were created and edited collaboratively by two or more people: two users edited 23 geo-objects, three users edited five geo-objects, and six users edited one. The results from the logging and the established patterns show that collaboration mostly

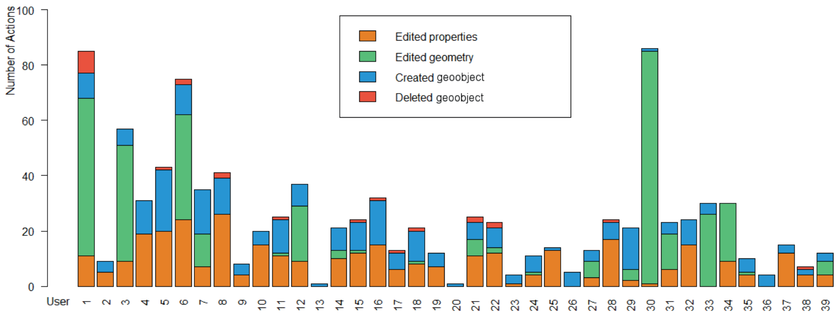

Figure 12.15.: Histogram summarizing the number of logged actions performed by each user. The actions are divided into four categories: edited properties, edited geometries, created, and deleted geo-objects.

occurred "side-by-side", meaning that user collaborated in mapping geo-objects in the same area. Nevertheless, some users refined and edited individual geo-objects simultaneously.

Figure 12.16 shows the timeline of 15 minutes for one particular geo-object, which was edited by six different participants. Blue segments indicate that a user was in edit mode, and red segments indicate when changes were applied. The diagram highlights the complex nature of collaboration with different users performing different actions at different times—both concurrently and sequentially. At one point, for example, users 49, 77, and 26 were concurrently editing the geo-object, while user 50 simply monitored the geo-object for a longer period without performing any actions.

41% of the participants stated that they stopped working on a geo-object when others applied edits, while 51% stated they did not. It is likely that most of the users who did not stop their edits were actually observing edits of others, as only 9% of the geo-objects were actually *edited* by multiple users. This assumption is backed up by the high amount of views (705) where no edits were applied to the inspected geo-object. Participants seemed to distribute the mapping tasks serendipitously

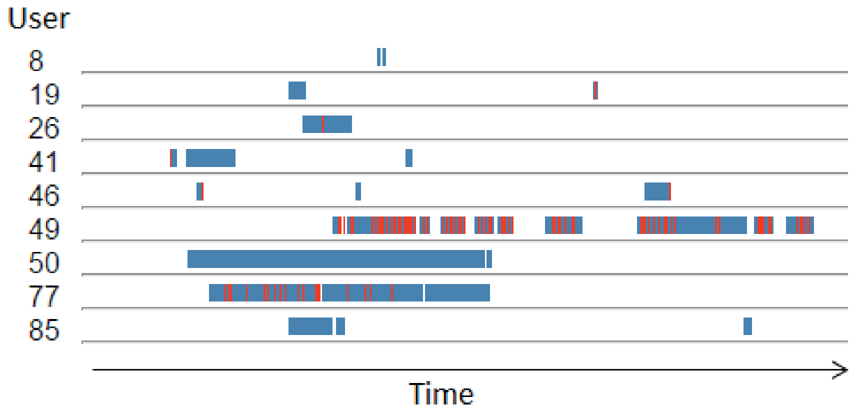

Figure 12.16.: Chart displaying the actions performed on a single geo-object by different users. Each row corresponds to specific participant. Blue bars indicate when the geo-object was in edit mode, red bars indicate an actual edit/change.

among themselves and changed the work of others only sparsely. Overall, these results indicate that real-time synchronization is applicable for geospatial map editors and that users can successfully collaborate. Based on the questionnaire results, participants thought that the task was performed more efficiently through the real-time collaboration.

User awareness: Ethermap's user awareness features were received well: 79% of the participants stated that they could recognize the presence of other collaborators well, 13% responded neutrally, while 8% responded negatively. 69% of the participants could easily detect changes, 28% could not, and 3% replied with a neutral answer. Participants stated which user awareness functionality helped most in a free text answer. The most frequently mentioned statements were (in this order): colored highlighting, direct appearance of geo-objects within the viewport, and through the history view. While the first two answers are directly linked and interdependent, the history view is a textual representation that is located in the context menu. Even though visual highlights seemed to be important, 38% had a neutral opinion about color coded user-identification. The remaining 62% were evenly distributed in agreeing and disagreeing to the color coded user-identification.

When asked whether the actions of other users interfered with their work, participants' answers were distributed evenly. 31% felt disturbed by the actions of other users, 33% had a neutral opinion, and 36% stated that other users' actions did not interfere with their work. The highlighting of geo-objects after changes was not perceived as particularly disturbing, though: 56% found it useful, 26% had a neutral opinion, and only 18% disliked this feature. Half of the participants (51%) continued work on a geo-object even when other users were also editing the same object, while 41% stopped working on an object when others were editing it at the same time. 8% of the participants were unsure whether they stopped or not. 69% agreed that real-time synchronization enabled them to complete the task more efficiently. 18% of the participants were unsure, and 13% disagreed.

In summary, users were thus able to recognize the presence of other collaborators, as well as changes others made to the map. The questionnaire revealed that 41% of the participants stopped editing a geo-object that was currently also edited by someone else, which also confirms people's awareness of other users' actions. The actual awareness seemed to result mostly from highlighting changed geo-objects as well as the direct updates of the geometries within the viewport. Asked about "Watch" and "Show Workarea" functions, most participants indicated that they did not use these functions to look at other users' activities. The functions to show the workarea of others or watch their actions were used sparsely (the "Watch" function was used 29 times in total; "Show all Workareas" was activated eleven times.). This might partially be because users received random user IDs to anonymize participants as well as due to the difficulty to distinguish between "unique" colors for 20 concurrently active users in the first group and 19 in the second group. Color coding and watch functionality might thus be more useful in scenarios with fewer participants and self-picked user names.

Communication: Another section of the questionnaire focused on the communication aspect of Ethermap. When asked why the chat was (not) used, the most common answer was that there was no need to communicate for the given task. Those who used the chat stated that it was used for asking or answering questions about the task. According to the questionnaire results, the “refer to geo-object” tool was used to ask questions about a specific geometry without having to textually describe it, and to spare collaborators the trouble of searching for the mentioned geo-object. Overall, 19 chat messages were sent by nine individual users. Four of those messages contained a reference to a geo-object within the map: three questions referenced a polygon asking if it marked a flooded area. One participant convinced other collaborators to edit existing geo-objects rather than creating new ones.

The last part of the questionnaire asked which features participants liked best/least. The real-time synchronization, the chat, and the simplicity/good usability of the editor received positive feedback. Negative comments pointed at too many collaborators working in the same area. Some people also found the history function too complicated. Overall, the user awareness and communication functions seem to have worked: online collaborators and status indicators for objects were successfully recognized by the users and informed user actions. Furthermore, communicating via chat messages and references to map geo-objects was received positively by the participants but rarely used in the study.

Version control: Even though the map history was only used moderately, about two times per user on average (85 times in total; the history of individual geo-objects was opened seven times), the questionnaire results showed that the map history was useful. The function to revert to previous states for individual geo-objects was not used. As participants started on an “empty” map they might have focused on adding data in order to cover the whole area affected by flooding rather than inspecting changes over time. As all participants were not familiar with disaster mapping, reviewing data and analyzing the mapping quality might also not have been as important to the users as creating new geo-objects. Other tasks, such as collaborating on planning processes could, therefore, result in different usage patterns.

Expert Interviews

While the user study focused on investigating usability, semi-structured expert interviews were used to gain insights into the subjective perspectives of domain experts [218]. The interviews focused on the general usefulness of the Ethermap concept and individual functions.

Method. Semi-structured interviews guidelines were prepared and tested according to Helfferich's [41] recommendations. The questions and guidelines provide enough space for open and detailed statements of the interviewed experts [218]. All interviews were recorded using a stereo recorder and transcribed based on Kuckartz [42, 43] transcription rules. The transcripts were analyzed in a process similar to Kuckartz's [43, p. 91ff] qualitative content analysis as it paraphrases, generalizes and reduces statements. Categories for the process were established based on the overall concept of Ethermap, interactive version control for geo-objects, and methods regarding user awareness.

Procedure and Interview Partners. All interview partners were met in person in a quiet setting. Before an interview started, Ethermap was demonstrated. Interviews lasted about 30-40 minutes. Interview partners were selected based on their background to capture different aspects such as innovative potential, usefulness in disaster management scenarios, and productive use of Ethermap. The first interview partner (I1) is the manager of a not-for-profit company working on open source software in the geospatial domain. He also serves as innovation manager for a large commercial company developing mapping software. The second interviewee (I2) is the executive director of a group of volunteers supporting disaster response, and she is very familiar with current disaster mapping systems. The third expert (I3) is the head of product management at a medium-sized software company building custom solutions in the geospatial realm.

Expert Interviews Results

Real-time synchronized map editing: All three interviewees reacted positively to the overall concept of a real-time, synchronized map editor. I2 responded that they would normally use screen-sharing for real-time collaboration, and only one person would be able to control the map. I2 further elaborated that real-time synchronization with a combined watch functionality is very useful, in particular for teaching purposes: "For teaching, there is certainly a huge benefit—on being able to edit in real-time. And also to better—working together". In an initial familiarization phase, new collaborators could watch how more experienced users work to learn from them in a process Panciera *et al.* [219] and others call "educational lurking".

When asked about the efficiency regarding working simultaneously together, I1 responded that given the right scenario, the concept of Ethermap would contribute to increasing the productivity of all collaborators. Nevertheless, both I1 and I3 agreed that this could be very dependent on the specific use case. I1 further stated that real-time collaboration is only meaningful if all persons "are in the same context and [...] have a similar understanding of what has to be done". I2 agreed that real-time synchronization allows users to work better together, as usually editors have to include other mechanisms to prevent users from colliding with each other, which often result in restricting users.

In addition to the given use case of disaster management, interviewees identified further areas that could benefit from real-time synchronization. They named teaching, planning, logistics, but also tourism, and helpdesk applications as promising application areas. When asked about the current functionality of Ethermap and the integration of more complex GIS capabilities, I1 and I3 agreed that this is very use case specific. I1 stated: "I think it's a very good idea to start with these simple features and then extend if necessary. So keep it simple as far as possible".

Still, the experts also pointed out that measuring (I1) or buffering tools (I2) could be helpful in discussions. Other feature requests were, for example, the need to get a quick overview of the existing attributes in the map. I2 reported: "One feature I think would be useful, would be some sort of spreadsheet to view the attributes available for the geo-objects in an area". Overall, I1 and I2 agreed that many functions of a collaborative editor would benefit a lot from spatial filters. Examples would be the map history, geo-object attributes (I2), but also the user list (I1), which could be filtered based on the current map viewport (I2).

User awareness and communication: Questions about user awareness also resulted in positive feedback. I1 mentioned the importance of knowing where other collaborators are currently working on a map, and how active they are. This could inform organizers of the current focus or interest of collaborators. I2 also stated the usefulness of the user awareness methods and compared them with positive collaboration experiences in GoogleDocs. I3 agreed that it is important for people to know that they are not working alone on a topic. Being able to see how many users are working on the same task would also impart a sense of relevancy (I3). In addition to methods to increase real-time user awareness, I1 also mentioned that reviewing the activity on a timeline could be beneficial to know how the focus of the work has changed over time, or how up-to-date data is.

However, allowing communication within the editor seemed to be one of the most important aspects for all interviewees. "[...] I thought chatting about a specific object was really cool as well. Because it is an easy way to point them at an object if you had specific questions about it" (I2). Even though I3 stated how important communication is, he explained that chatting is often only the first step, whereas a communication via voice would be even more beneficial.

Version control: Another aspect covered in the interview was the interactive version control. I2 reported on this subject that it was useful "especially when you have new editors. Having an easy way to go back, and one: show the mistakes, and two: correct mistakes instead of redoing the work, you could just go back in time". In addition to that, I3 stated that particularly in real-time scenarios where people are working under time pressure (e.g. disaster management), errors will occur. Having an "undo" tool is thus important. I1 also mentioned: "To see what has happened to a geo-object and to see how it was edited, if it was refined somehow, or when did it pop up?" is very important.

In summary, both evaluations show that real-time collaboration on geospatial data is feasible. Participants of the user study were quickly able to start mapping collaboratively and successfully completed a mapping task. Experts and users agreed that given the right scenario, the approach could benefit collaborators. Additionally, the interviewed experts came up with several potential scenarios, such as teaching, planning or helpdesk applications.

13 Summary

Part III of this thesis provides answers to the four guiding questions, and each chapter addresses one of them. Chapter 9 conceptualized the design space for Augmented Interactive Geo-visualizations (AIGs) and provides answers for GQ1. The design space details aspects that need consideration for different citizen engagement levels and explicitly links them to the reviewed related work. The identified aspects are visualization, exploration, communication, and data.

Chapter 10 looked at the target audience, civil society, and investigated the roles individual actors or CSOs might take on in the context of OGIs that primary deal with publishing OGD for the moment. Based on semi-structured interviews and the literature review, an answer is provided for GQ2. Four roles were identified: civil society can act as a driving force, as a watchdog, as an intermediary, and as a user. Most civil society actors in OGIs are "tech-savvy" and occupy multiple roles at the same time to reach their goals.

Best practices for providing geospatial OGD were investigated in chapter 11 that answers GQ3. Based on the author's (ongoing) involvement in the realization of the European Data Portal (EDP) and the OGI of the federal state of NRW (Open.NRW) six recommendations were formulated. The recommendations deal with publishing and finding OGD. Data providers that publish geospatial OGD based on INSPIRE compliant datasets should ensure that the metadata mappings properly transfer the fields for unique identifiers and geographical coverage. License information likely needs to be updated, and geospatial data providers should provide "raw data" where possible to adhere to the OG notion. Moreover, OG portal operators should consider to provide geospatial search and preview functionalities and establish transparent monitoring processes for the published OGD.

Chapter 12 looked at the effects of specific instances of AIGs for a selected subset of citizen engagement activities. Based on the design space for AIGs, three prototypes were implemented and evaluated that provide first insights for different levels of citizen engagement.

A notification application that provides information about citizen engagement opportunities on a user's smartphone was investigated with the first developed prototype. The act of moving through the city was used as an implicit interaction with the notification application that triggered notifications if certain spatial, temporal, and user preferences were met. The triggered notifications lead to an explicit interaction with the application that allowed users to obtain information about nearby engagement opportunities. Study participants valued the notification application and preferred it over an official website. However, the evaluation also revealed that participants do not necessarily interact "in place" with the notifications. The evaluation of the first prototype provides the following insights and contributions to GQ4.

Insight 1: Citizens seem to value a customizable and pro-active provision of notifications about citizen engagement opportunities based on space, time, and user preferences. After using the notification application, 86% of the participants described the triggered notifications as interesting, motivating, and practical.

Insight 2: Interactions with the triggered notifications do not necessarily occur in the immediate vicinity of the engagement opportunity, even though the notifications are triggered based on this factor. 20% of the participants consistently interacted with triggered notifications near the engagement opportunities, 53% consistently outside of the immediate vicinity, while 27% of users did not display a clear behavior.

Insight 3: There seems to be an untapped potential to provide information about engagement opportunities via smartphone applications. In a direct comparison with an official website that provides information about citizen engagement opportunities, participants rated the developed application to be more desirable than the compared website. However, website and the notification application received high scores for pragmatic quality revealing that both channels are suitable to inform citizens.

The second prototype, called Dialog Map, investigated whether citizens would use an AIG that tightly couples the spatial dimension with the textual dimension to provide feedback or comments. The evaluation was carried out in cooperation with a local CSO, the Stiftung Bürger für Münster (SBM), in a campaign to raise citizen engagement. Results indicate that citizens valued the spatial visualization of the engagement opportunities in comparison to a more traditional gridded mosaic-view. However, Dialog Map's feedback mechanisms were not used in the "in-the-wild" study. While this may be an artifact and limitation of the evaluation, it is clear that further studies are needed to better understand if or how AIGs can be used to obtain textual feedback from citizens. The evaluation of Dialog Map provides the following insights and contributions for GQ4.

Insight 4: Spatial interaction and visualization seem to be relevant for citizens to obtain information about engagement opportunities in citizen information portals. In a direct comparison with a gridded mosaic-view that presented the citizen engagement opportunities as well, 48% of the citizen information portal visitors accessed and used the AIG although it was not as prominently placed as the gridded-mosaic view.

Insight 5: The availability of functions that allow citizens to provide spatially enabled feedback does not necessarily imply that citizens use them in this context. Additional research is needed to fully understand and assess the potential impact of spatially enabled feedback functions for citizens. In this particular case and setup, visitors of the citizen information portal did not use them.

The third AIG prototype is called Ethermap and provides an approach and implementation that facilitates real-time collaborative mapping. In existing asynchronous geospatial collaboration environments one user usually “drives” the application and other users are mere “passengers” or have to wait until they can contribute. Ethermap enables actual real-time collaboration in a “base democratic” way by relying on ICT advances, and applying and extending user awareness and communication features to the geospatial domain. The evaluation revealed that users were quickly able to start collaborative mapping, and they successfully completed a disaster mapping task. Experts and users agreed that given the right scenario, the approach could benefit collaborators. Additionally, the interviewed experts came up with several potential scenarios, such as teaching, planning or helpdesk applications. The evaluation of Ethermap provides the following insights and contributions for GQ4.

Insight 6: The concept of a real-time synchronized map editor seems to facilitate geospatial collaboration. Interviewed experts reacted positively to the concept and 69% of the participants agreed to a statement that real-time synchronization enabled them to complete the task more efficiently after completing the user study. 18% of the participants were unsure and 13% disagreed.

Insight 7: Real-time geospatial collaboration seems to work without the need to define strategies or patterns explicitly beforehand for, e.g., conflict resolution or coordination of the collaboration. Three main collaboration patterns were identified in the evaluation: 1) one user applies edits while at least one other user monitors those edits; 2) multiple users co-edit the same geo-object at the same time; 3) multiple users monitor the same geo-object.

Insight 8: However, users seem to prefer to avoid interfering with actions that other collaborators currently perform. Only some collaborators refined and edited individual geo-objects simultaneously. Rather, most of the collaboration occurred “side-by-side”, meaning participants mapped or edited geo-objects within the same area.

The following part reflects on the presented research and discusses the obtained results, pointing out limitations and potential directions for future work.

IV

Reflections

14 Discussion

This chapter is based on publications P2–P5. It integrates the discussions of the respective publications that are extended and adjusted for this thesis. Additional aspects are taken from publication P1 "Geo-referenced Open Data and Augmented Interactive Geo-visualizations as Catalyst for Citizen Engagement" by Thore Fechner and Christian Kray and from publication P6 "Natural Interaction with Video Environments Using Gestures and a Mirror Image Avatar" by Christian Kray, Dennis Wilhelm, Thore Fechner, and Morin Ostkamp.

The following sections of this chapter discuss the individual results of the guiding questions. Afterward, the individual discussions are combined in a corroboration to provide an answer to the overall research question that investigates the effect of Augmented Interactive Geo-visualizations (AIGs) on citizen engagement in Open Government Initiatives (OGIs).

First, the established AIG design space (GQ1) is discussed in section 14.1. The section focuses on inherent limitations of using AIGs in citizen engagement contexts and points out that the design space is just one potential conceptualization. Next, section (14.2) discusses the identified roles civil society actors might take on in OGIs (GQ2) and looks at limitations and challenges for civic activism. Subsequently, section 14.3 reflects on the best practices for providing OGD (GQ3) that were recommended based on the author's experiences in two projects with public administrations that publish OGD, the European Data Portal (EDP) and Open.NRW. The discussion looks at the importance of information quality and presentation for publishing OGD and briefly discusses privacy aspects that should be addressed by future work.

Section 14.4 reviews the evaluations of the three AIG prototypes individually (GQ4). The results and limitations of each prototype—the notification application, Dialog Map, and Ethermap—are discussed.

Next, section 14.5 corroborates and combines the obtained insights from each guiding question to answer the overall research question, looking at the direct and indirect effects AIGs have on citizen engagement in OGIs from a HCI perspective. In closing, the identified effects are briefly summarized in section 14.6.

14.1. AIG and AIG Design Space

This section discusses the answer of Guiding Question 1: *What are aspects that Augmented Interactive Geo-visualizations should support to facilitate citizen engagement?*

Based on the literature review, four distinct aspects were identified as important for using AIGs in citizen engagement cases: visualization, exploration, communication, and data (see chapter 9). For each aspect, examples and functions were given and loosely clustered to a citizen engagement level, illustrating their meaning.

However, Rittel *et al.* 's [187] statement about the complexities of public policy and citizen engagement directly applies to the idea of AIGs and the established AIG design space. They challenge the perspective that every problem can simply be analyzed in a goal-driven and step-by-step manner resulting in an optimal solution. As already stated in chapter 9, the conceptualized AIG design space is one initial conceptualization of how AIGs can be applied to citizen engagement cases. The intention is to highlight aspects that need to be considered, but the design space does not "solve" citizen engagement by using AIGs. It lays the foundation for a shared understanding of the topic, but it does not represent the only possible view nor does it claim to do so. Similar to other conceptualizations, e.g., MacEachren *et al.* 's [81] map use cube, the design space will likely need to be updated as time passes and new insights are gathered. The design space was applied in the creation of the three AIG prototypes, but newly developed AIGs might lead to adjustments in the future.

Overall, AIGs and the AIG design space are subject to certain inherent limitations due to the approach while other limitations arise due to the scope of this thesis. For example, a well-known and inherent limitation of ICTs in citizen engagement contexts is the digital divide that was already discussed as part of the related work for OG in general and geo-visualization in particular—see sections 7.1 and 7.4.

Unequal access to ICT systems and applications due to, e.g., financial, spatial or educational reasons can exclude parts of the population [144] while the dissemination medium, the Internet, is prone to exploitation if the disseminated content is not handled neutrally by favoring or suppressing certain views [138]. Furthermore, online communities are at risk to create information bubbles, and gated communities can easily avoid views of other social groups [103].

Other reasons that can hinder parts of the population to engage with AIGs might seem mundane to technology-affine citizens, but are nonetheless equally important: not every citizen wants to rely on modern ICT such as smartphone applications or websites for citizen engagement.

Media and formats have to be diverse, and OGIs have to carefully adjust their activities to avoid over-reliance on ICT for citizen engagement and to truly establish a culture of governance that transcends them (see section 6.1). While these limitations apply to all ICT- based citizen engagement approaches, additional aspects need to be considered when AIGs are used in citizen engagement. While AIGs offer a window to the world, contextualize spatial information, allow reasoning, and foster exploration, they do require a certain level of map literacy [147].

Geo-visualizations, maps or GIS functionality can be misused or misinterpreted, and citizens need to be aware of this fact. Not every map-based visualization they see is a "map" in the traditional sense that depicts stored spatial knowledge. Citizens need to be aware of the fact that AIGs are seen as tools of knowledge construction and emphasize this aspect.The primary function of AIGs is to foster interactive exploration in a sense-making activity and they are not a finished product like a map (see section 6.4). Additionally, almost all web-based maps or geo-visualizations are biased as they heavily distort sizes and assume a spherical earth, which leads to misrepresented relations. Projections are a general challenge for every geo-visualization or map as they unfold a three-dimensional object to a two-dimensional plane. There are no "correct" projections, only approximations that work well for a certain case and context. As such, the geo-visualizations that are produced or used in citizen engagement cases represent one possible view that is influenced by the specific perception of the discussion partners. This makes them valuable, but everyone involved has to be aware of it.

Another limitation of the approach is that not everything can or should be displayed with a geo-visualization. While an impressive amount of OGD has a geospatial relation, is available in an inherently geospatial file format or service, OGD from certain domains such as financial or legal data might best be presented in other forms.

Some limitations of the AIG design space arise due to the scope of this thesis: The presented examples for the aspects of visualization, exploration, communication, and data are neither complete nor strictly ordered, but only loosely clustered to a particular citizen level. As every citizen engagement case is unique, and requires careful consideration and customized approaches, the given examples are not a definite answer, but rather serve as inspiration.

A concrete example is the visualization aspect of the design space. In its current state, all examples are derived from standard cartographic practices and only consider two-dimensional representations. However, hybrid or blended approaches are equally possible and could be applied in citizen engagement cases. For example, P6 describes initial work that was conducted to investigate a hybrid approach: The proposed idea looked into merging panoramic videos with three-dimensional virtual objects and a mirror image avatar in a larger installation that could be deployed in public spaces. The installation is an immersive video environment that allows users to interact with the blended panoramic videos and virtual objects that are injected or overlayed into the scene. In the installation, several large screens encompass a user's view completely, and users are filmed and placed virtually in the hybrid scene as a mirror image avatar that can interact and manipulate the virtual objects using gestures. The process creates a highly immersive feeling but allows quicker prototyping compared to full three-dimensional representations that are required for virtual reality as panoramic videos can be captured faster and require less post processing.

While advances in computer graphics allow to create very convincing visual representations and will continue to improve further, blended panoramic videos still offer a higher visual fidelity as they capture reality directly. However, the interactions in blended approaches are more limited compared to fully three-dimensional models as the source material is easier to manipulate. Still, by blending and augmenting the video with virtual objects, users can interact and manipulate with the scene without the need for a full three-dimensional representation.

In summary, the presented AIG design space can serve as a foundation for using and designing AIGs for citizen engagement cases. Still, it is not a complete description of all conceivable AIGs and advances in ICTs will certainly lead to new and novel forms of visualization, exploration, and communication that can be applied to AIGs.

14.2. Civil Society Activism in OGIs

This section discusses the answer of Guiding Question 2: *What roles do civil society actors have in Open Government Initiatives?*

Based on six semi-structured interviews and backed up by the literature review four roles were identified that civil society actors could take on in the field of OGD and OGIs in general (see chapter 10): civil society actors can be a driving force for the proliferation of OGIs, can act as a watchdog supervising the implementation, can fulfill the role of an intermediary that processes, expands, and mobilize a broader user group, and civil society actors can act as a user or beneficiary.

The roles of civil society were investigated in order to design AIGs that are useful for civil society actors and citizens. For example, if civil society actors would primarily fulfill the role of *users* in OGIs the emphasis for AIGs would need to be placed differently, e.g., by focusing on exploration and visualization aspects. However, as civil society actors also take on roles such as an *intermediary*, *watchdog*, and *driving force*, a broader scope is required: aspects such as communication, data provenance, or creating and using data are similarly important. Nevertheless, every concrete implementation of an AIG needs input from the users of that particular citizen engagement case to maximize its use. Still, the generalized understanding of the potential roles of civil society actors suffices as the first step for this thesis to inform the selection of the developed AIG prototypes.

While Bates's [40] recommendation was followed to include established actors, local individuals, and domain experts to avoid biased or one-sided views, only six interviews were conducted. The sample size is limited due to research practicalities to fit in the overall scope of this thesis. Still, the identified roles are backed up by the examples from the literature and the domain. Apart from expanding and refining the roles civil society actors take on in OGIs, future research could investigate motivations, challenges or typical processes to deepen the understanding of their needs regarding geospatial ICTs.

As explained in chapter 10, interview partners were recruited from Washington D.C. in the USA as civil society actors had more time to adopt and take up different roles compared to German actors. Still, the identified roles from civil society actors in the USA are applicable in Germany as actors and the general field are very similar on a cultural and technological level. For example, the "Code for America" initiative has a German counterpart that is called "Code for Germany" and both projects were initiated by non-profit organizations to build applications for citizens that use open data.[1] A technical example is OKFN's CKAN, as it was used in Germany and the USA to create the national (and several other) OGD portals. In both countries, civil society actors use CKAN's API to access OGD on a technical level. Similarly, the OKFN's OpenDefition and the Sunlight Foundation's ten principles for open data are the basis and benchmark for published OGD (see section 6.2). Furthermore, events such as the worldwide annual Open Data Days foster cross-border exchange between civil society actors.[2] Software is often co-developed across country borders by collaborators on social coding websites such as GitHub, and some national governments share their source code of developed applications openly to foster exchange.

[1]See https://www.codeforamerica.org/ and http://codefor.de/, accessed May 14, 2016.
[2]See http://opendataday.org/, accessed May 14, 2016.

For example, the code for the OGD portals from the UK, Germany, the USA, and the EDP is publicly available.[3] Hence, the processes and circumstances in both countries are similar and share several cultural and political traits.

Another aspect that needs to be discussed with regards to the roles civil society actors take on in OGIs are challenges and risks related to their involvement from the point of view of democratic theory. A strong role and involvement of civil society in the implementation and use of OGD can be considered problematic regarding the commensurate representation of interests and influence.

After all, civil society is not one homogeneous entity but reflects the plural and diverse interests existing in a society. Insufficient expertise of different civil society actors to handle data may intensify differences between organizations as OGD favors only those who are technically capable and trained for working with it. Processing and using OGD requires resources, even though it is published openly and freely. As such, equal use and participation of different civil society groups may be difficult to guarantee. Differences in access, resources, technical expertise, and manpower will lead to an imbalance between involved actors so that the power and responsibility attributed to civil society may end up concentrated in the hands of a few powerful groups.

Offe [220] postulated that the power and capacity of organizations or interest groups depend on societal resources, which normally are very unevenly distributed. This imbalance undermines the promise of equality associated with liberal democracy. Practically, it will be easier for powerful, old, and already established actors to benefit more from the mere disclosure of OGD. These actors would be able to uphold and advance their interests as they have the required resources and expertise to process and use the information, while smaller or marginal groups would be left by the wayside. Accordingly, the provision of OGD to the general public may consolidate some organizations' supremacy

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[3] See https://github.com/fraunhoferfokus/GovData/, https://github.com/GSA/data.gov/, https://github.com/datagovuk/ckanext-dgu/, and https://gitlab.com/groups/european-data-portal/, all websites accessed May 14, 2016.

as exclusive information sources and gatekeepers. Closely related to this argument are general doubts concerning the trustworthiness and benevolence of CSOs and their influence in government decisions that were already discussed in section 7.3. While a strong commitment of civil society is desirable and would further the proliferation and distribution of OGD, this does not relieve the state from its responsibility to secure access for all and prevent a concentration of power in the hands of the few well established actors.

Altogether, civil society is an interesting but yet understudied actor within the discussion on OGD and OGIs—concerning its multiple tasks and potentials as well as doubts and challenges. The identified roles indicate that civil society actors can create opportunities for a quicker proliferation, a better control of implementation standards, and the quality of OGIs. Still, questions concerning the (unequal) distribution of power among different civil society actors and interests need to be addressed in future work to avoid creating a vacuum that could be exploited by vested interests for private gain [40].

14.3. Providing Geospatial Open Government Data

This section discusses the results of Guiding Question 3: *What are best practices in the provision of geospatial Open Government Data?*

Chapter 11 presented and discussed six concrete recommendations for providing geospatial OGD that addressed the aspects of publishing, finding, and presenting geospatial OGD from a HCI point of view. The provided six recommendations originate from the author's involvement in two projects of public administrations (the EDP and Open.NRW) that publish OGD. The first three established recommendations deal with metadata, licenses as a special case of metadata, and data formats. They directly address standardization and fragmentation issues and provide recommendations to overcome them if INSPIRE compliant geospatial data is published as OGD.

The remaining recommendations deal with the process of finding and presenting geospatial OGD. The fourth and fifth recommendations are already realized in several specialized geoportals. Nevertheless, they are equally important for OGD portals that publish geospatial data. Spatial search facets help users to limit their searches to a certain geographic region and should include a placename search. Spatial preview functions should be included to allow users to get a first impression of the search results, without the need for external tools. The last recommendation is to establish an automatic data monitoring component that informs users about the status of the published OGD. Such a monitoring component is important for OGD portals as publishing OGD is only the first step. User expectations and data quality need to be managed carefully, especially as the amount of data grows and users need to be informed about known problems and how these are dealt with.

All recommendations are made to deal with the potential rational ignorance of users [137]. If citizens are alienated by the OGD portal due to, for example, poor presentation, an obscure interface, outdated or outright broken OGD that can not be accessed, citizens will probably ignore the portal and in turn the published OGD. If the cost of learning or coping with the OGD portal is too high and the potential gain (OGD of varying quality) is limited citizens might turn away. Janssen *et al.* 's [108] general assessment and list of issues regarding the publication of OGD from 2012 describes the current situation aptly.

> As with most data sets, the quality of information is not automatically guaranteed, and insight is needed in this before the information can be used for certain purposes. Data might be simply incorrect, but also essential information about the data sets might be missing, such as the time period in which the data was collected. Finally, there are number of technical barriers, ranging from the unavailability of a supporting infrastructure to the lack of standards, fragmentation, and legacy. —Janssen *et al.* [108, p. 263]

OGD portal operators seem to follow OKFN's recommendation to start out small and apply improvements in iterations, considering public and community feedback in the process. However, this approach requires a prolonged commitment and patience from all involved parties as everybody is “learning on the job”. Standards and best practices are emerging in Germany and the EU as data publishers and the OG community learn and gather insights throughout the process. Still, it is crucial for the success of OGD that a prolonged commitment and development is present as OGD is a new phenomenon. To improve the provision and the respective portals users and data publishers need to work together in a user-centered design approach.

The users need to be included first and foremost. If users are not asked what kind of data should be published, what their needs in terms of presentation are, and how they can be better supported to use the published data, OGD is likely to fail. As such, the identified best practices by this thesis (that include public feedback) help geospatial data providers to avoid issues that were already experienced in previous OGD portals and iterations. Thus, the best practices contribute to the development of robust guidelines for publishing geospatial OGD.

The formulated recommendations originated from the author’s involvement in two projects of public administrations, they are thus limited in their scope: diverse legal and cultural backgrounds have to be considered in different countries, and the provided best practices particularly consider the German perspective. Still, as the INSPIRE process applies to the entire EU with some slight difference regarding its implementation, they can also inform geospatial OGD providers in other countries. In Germany, OGD is federated from local to federal and then the national level, while the EDP provides the supra-national level. Hence, (meta)data heterogeneity, quality, and challenges in the maintenance of OGD affect all levels.

Future research on OGD should investigate privacy issues that arise if large amounts of data are published openly and evaluate and apply existing concepts to ensure anonymity. While some initial privacy considerations are present in the EDP’s Open Data Goldbook [196, p. 24f] that point to a one-page factsheet for “Data protection in the re-use of PSI" they are only initial considerations and a starting point.[4] No clear guidelines or processes are available, and the fact sheet is rather vague. It states, for example, that personally identifiable information needs to be "reasonably protected" or that personal data must be proportionally collected or used, but does not provide any further insights into possible techniques to accomplish these goals.

At the moment, each data provider is responsible for deciding what is deemed as personally identifiable information and a holistic view and investigation of the published OGD seems to be missing. Past research demonstrated that the combination of different sources or combination of attributes can lead to the re-identification of anonymized datasets. For example, by combining zip code, date of birth, and sex, researchers were able to re-identify previously anonymized data [221–223]. Similarly, research is available that deals with privacy issues of geospatial data [224, 225]. For example, home or work locations can be used in automatic processes to deanonymize data and to re-identify individuals, while human inference attacks are equally possible. Readers with an interest in automatic processes that attack or preserve location privacy should refer to Krumm's [224] survey while previous work by the author provides first insights into human inference attacks on location privacy [225].

14.4. Geo-visualizations for Citizen Engagement

This section discusses the results of Guiding Question 4: *What effects do specific instances of Augmented Interactive Geo-visualizations have on a selected subset of citizen engagement activities?*

The following subsections discuss each developed prototype and the corresponding evaluations (chapter 12) and insights (chapter 13) individually. First, the notification application and the approach of geofencing engagement opportunities are discussed. Second, the Dialog Map prototype and the idea of intertwining textual and spatial dimension are looked at, and reasons considered why the spatial feedback and

[4] See http://www.europeandataportal.eu/sites/default/files/data-protection-in-re-use-psi.pdf, accessed May 20, 2016.

comment functions were not used in this particular case and setup. The discussion of the prototypes concludes with reflections about the last prototype, Ethermap.

14.4.1. Geofencing Engagement Opportunities

Designers or initiators of citizen engagement opportunities should consider to complement their digital media with additional channels, especially if they rely only on websites. The questionnaire of the first study revealed that all of the participants found articles in newspapers or radio broadcasts to be crucial while smartphone applications were the second highest rated channel the participants agreed on using. Cities' websites were deemed rather unimportant compared to social media networks and smartphone applications, an indication which was further investigated with the second comparison study. In the direct comparison of the second study, participants found the developed notification application to be more desirable compared to an official website that offers a set of similar functions.

Overall, the results from the first prototype indicate that there is an untapped potential in digital channels with regards to "citizen apps". While the official website received similar scores for pragmatic qualities, the notification application was found to be more appealing and innovative. As the participants' average age was 25.6 years for the field study and 26 years for the comparison study, the results do not apply to the entire population. While younger generations may find smartphone applications natural and useful, attitudes of older citizens might differ considerably. As the notification application is ICT-based, general considerations regarding the digital divide and access to technology apply as well. Only four of the participants expressed privacy concerns, even though their movement was tracked. This might be an artifact of the study. Participants knew they were part of a research project and had full control of the tracking function, which they could enable or disable at any time during the evaluation.

In summary, participants valued the smartphone application to obtain information about engagement opportunities. Participants liked implicitly triggered engagement notifications that are based on space, time, and individual user preferences. However, an important finding is that most of the participants (53%) consistently interacted with the triggered notification *outside* of the immediate vicinity of an engagement opportunity. Only 20% consistently interacted with them in situ, in the immediate vicinity of an engagement opportunity, within the geofence. 27% of the participants displayed no clear preference as they interacted either in situ or outside the immediate vicinity.

Notifications seemed to be considered useful and motivating: 67% of the triggered notifications were accessed, and 72% of the accessed notifications lead to an immediate exploration of the corresponding website of engagement opportunity. The results of the accompanying questionnaires corroborate these findings; participants agreed that location-based suggestions are useful, and 86% still liked the feature after they used the notification application for ten days (ten strong agreements, ten agreements). Furthermore, almost all participants liked and used the individualization options that customize the notification triggers.

A finding of the conducted evaluation is that no clear differences were present in the ratio of accessed to dismissed notifications depending on the location. Potential reasons that influence whether participants access a notification or not could be content, available time or presentation. A subsequent study could include a short poll in the application after a user accessed or dismissed a notification to sample users' experiences. While these kinds of polls disrupt regular use, the insights gained in this way could help identifying the underlying reasons. Additionally, user activities and context could be provided to clearer establish types of use patterns. Furthermore, users could indicate if the notification was received too early or too late, as the engagement opportunity might only take place in the near future. Such issues could potentially be accounted for by introducing additional customization options.

The field study that was conducted did not yield insights into why most of the participants interacted outside of the immediate vicinity of the citizen engagement. Reasons for this may be found in the general usage of smartphones. Notifications are only checked in bursts by some users [226] or notifications might be disabled entirely to avoid distractions [208]. Certainly, further studies are needed to understand the effect of spatially triggered notifications for citizen engagement.

Reasons for dismissing notifications are equally important, as some users already receive many messages on their smartphones [227]. They may thus just dismiss them reflexively to avoid being overloaded. The developed notification application prototype offers a mechanism to suppress re-occurring notifications to avoid overloading users, but longer studies are needed to investigate if such functions affect users' behavior and the appeal of the triggered notifications over time.

The analysis of the spatial occurrence of interactions with the notifications is rather straightforward as it only considers two cases: interactions in situ (inside the geofence) and outside of it. A deeper analysis taking into account distance to the engagement opportunity and time passed since the notification was triggered could provide better insights. Dingler *et al.* [228] found that people are highly attentive to their mobile phones, and 75% of triggered notifications from communication applications are attended to within the first 12.5 minutes. 25% of the triggered notification are attended to within the first 12 seconds.

By considering traveled distance and passed time, more refined usage patterns might be identified, albeit several additional factors should be accounted for such as time of day or environmental conditions. Additionally, cases that prohibit the use of a smartphone, such as driving a car or riding a bike need consideration. For this kind of analysis considerably larger sample sizes and additional data are needed, preferably with more diverse participants.

14.4.2. Dialog Map

Users of the citizen engagement portal did not engage with the spatial discussion features in this particular citizen engagement case. One might argue that this is not surprising, as the campaign did not explicitly call on citizens to voice opinions and thus was not framed to incentivize feedback. Still, the total absence was unexpected and might indicate that the implementation of Dialog Map was too obscure or hidden away. Another potential reason is that it takes an active, organized civic community for this kind of engagement [104] and that volunteering time is an individual choice.

While the evaluation and development were closely coordinated with the SBM to engage citizens the feedback functions could have been advertised more. Although the SBM has a strong network with several partnering organizations, it is also only an umbrella organization with no direct access to the existing citizens that volunteer time in the partnering NGOs. A different case and setup with one CSO and its members might yield different results as access and motivation might differ if “your” organization calls for action instead of an umbrella organization that wants to recruit additional volunteers for the city in general.

In this case, citizens were apparently satisfied with obtaining information. They did not need to ask questions, exchange information or start a dialog. As already discussed in section 7.4, Krek [137] found that citizens sometimes neglect PPGIS with rational ignorance—as the cost to learn a PPGIS is too high and the potential gain too small. This idea of rational ignorance might be employed here as well. Users could just have wanted to obtain information and would need to spend additional time to *learn* the required functions to provide feedback, although they are quite similar to standard comment functions that are widely used on various websites. An extra point that might have hindered the use was that a login was needed. Although users could log in with social network accounts or create a custom account, this is another barrier that was knowingly introduced to be able to prevent misuse and a requirement of the SBM.

However, spatial visualization and interaction seem to be relevant for citizens while exploring engagement opportunities online. The first indicator for this conclusion is that the geo-visualization was accessed by roughly every second active user (47.76%)—even though it was only the fourth entry in the navigation menu. Regarding raw clicks, the second entry in the menu that lead to the mosaic-view was accessed 10.3 times more than the entry for the geo-visualization. This is probably an effect due to the ordering of the navigation menu. Nevertheless, a significant portion of the users accessed the geo-visualization, although the textual descriptions had all the needed information.

The second indicator is that the total amount of recorded interactions within the geo-visualization is higher than the number of recorded interactions in the mosaic-view. While both presentation forms were interactive, direct comparisons are tricky as different types of interactions were possible and needed. The geo-visualization allowed, for example, to zoom and pan within a map-view to find engagement opportunities. These are interactions that have no counterparts in the mosaic-view. In total, 5678 interactions occurred in the map-view and 2527 interactions in the mosaic-view.

The third indicator is that 114 out of 223 active users used the geo-visualization without accessing the mosaic-view again after they found it. These users from the first user-flow pattern started with the mosaic-view and did not return to it after discovering the geo-visualization. An additional 21 users interacted only with the geo-visualization, accessing the "Map" entry in the navigation bar directly, without accessing the mosaic-view at all. These users seem to value spatial visualization greatly. Another indicator that is worth considering is that 80 users repeatedly switched between views. One potential reason for this behavior is that they needed information from both presentation forms. The geo-visualization offered a better spatial overview, allowing users to find engagement opportunities quickly that are close to each other or located in a particular part of town. The mosaic-view offered slightly longer textual descriptions that were specified and provided by the partnering organizations. This has likely affected and promoted this user behavior and is a limitation of the study that should be accounted for in the future. Nonetheless, switching between presentation forms also indicates engagement with both presentation forms. Only eight users started with the geo-visualization and switched to the mosaic-view afterward.

The insights that can be obtained by the evaluation are limited as the study is not comparative in the sense of a within-subject design. For example, groups were not counterbalanced and learning effects are not accounted for as the study was conducted "in-the-wild". To take part in the campaign and to avoid losing potential volunteers both presentation forms were accessible while the mosaic-view was favored in its placement in the navigation bar as the SBM explicitly requested this ordering. Still, Dialog Map's in-the-wild evaluation extends the scare available body of knowledge regarding real-world evaluations of spatially enabled feedback and comment functions (see section 7.5.2).

The most obvious limitation is that no insights can be presented on why citizens did not use the offered feedback and comment functions. Additionally, the dwelling times should be considered carefully as there is no certainty of what the user did while the website was active. Two independent user logging systems were used to cross-validate the results. While the unique user count is identical, and session times and dwelling times are similar in both systems the user count is based on the used device. Multiple users can share a device, distorting the identified patterns, or one user might use different devices at home or work. Similarly, ad- and tracking blockers need consideration as well: technology-affine users that could have particular interaction preferences may have blocked the logging system entirely. Such effects can only be controlled in a lab-based environment. Therefore, further studies should involve a lab-based study with a refined system that also accounts for the discrepancies in the displayed content and functions: the mosaic-view could feature a similar sidebar as the geo-visualization and offer filter functions, and exactly the same content should be shown.

Furthermore, future studies should focus explicitly on the citizen engagement levels of consulting or involving citizens and the use of the feedback functions. In this setup, it is likely that the campaign did not incentivize citizens enough to provide feedback, views or opinions. The scenario of motivating citizens to volunteer time might not lend itself easily to discussions or there was no real need to use them. An evaluation in a scenario with controversial opinions or divergent views might yield different results. Moreover, the logging revealed that there is an amount of users that felt the need to switch between mosaic-views and geo-visualization, but reasons for this behavior could not be identified. Future evaluations of the concept should consider including methods such as semi-structured interviews or questionnaires to capture additional data, even if the study is conducted in-the-wild with a real-world effort to raise citizen engagement to account for these limitations.

Insights regarding the overall impact of the online component for actually activating citizens to volunteer time are thus limited. The participating NGOs only reported back in general and expressed their interest in repeating the campaign as activating citizens takes time and routine. In total, the partnering NGOs reported that 30 new volunteers were acquired and that 15 would return to volunteer additional time. At the time of writing, the SBM was one of the winners of Google's 2016 Impact Challenge with the campaign "1000 Stunden für Münster"[5] and is in the process of repeating the campaign with the newly acquired funds. However, the discussions after the campaign also reaffirmed the confidence in the importance of physical and local activities. For example, the SBM will continue to periodically present initiatives and partners in a "citizen booth" in downtown Münster.

Overall, the participating NGOs were satisfied with the campaign, press coverage, and citizen information portal, but the insights for the citizen engagement levels of consulting or involving citizens with an AIG are severely limited. Nevertheless, the results of Dialog Map's evaluation show that citizen valued spatial visualization and engaged meaningfully with Dialog Map for this purpose.

14.4.3. Ethermap

Ethermap's evaluation aimed at assessing key aspects of real-time synchronized map editing: the general usability of the approach, emerging usage patterns and further aspects pertaining to its use (user study) as well as the overall usefulness of the approach and individual functions (expert interviews). Overall, the outcomes of the evaluation provided strong evidence that the concept is technically feasible with a low entry barrier. The participants of the user study could grasp the underlying principle and learn how to use Ethermap in a short amount of time, and the approach was perceived as useful by experts and non-experts alike. However, the participants were recruited from an introductory

[5] See https://impactchallenge.withgoogle.com/deutschland/charity/1000std_muenster, accessed May 25, 2016.

GIS course and might be biased, even though they were not experts in web mapping applications.

Usability and related aspects: Only three users did not map actively while 36 participants started mapping right after the introduction and tutorial. It is thus likely that the task of the study was easy to understand and to carry out using the prototypical application. Also, the basic concept of real-time synchronized map editing did not seem to pose a problem to participants. Though not all functions provided were used intensively: the version history and the chat, in particular, saw little use. Feedback from participants and experts about the concept and the functions provided by the prototypical application was predominately positive.

Usage patterns and collaboration: Usage patterns varied considerably across participants both regarding number and type of actions. Collaboration occurred mostly “side-by-side”, meaning geo-objects were mapped within the same area, rather than refining individual geo-objects collaboratively. Still, participants did collaborate on individual geo-objects as well. Figure 12.16 provides an example of a simultaneously collaborative refinement process. That only a couple of these simultaneously collaborative refinements occurred could be an artifact of the task and the limited amount of time: participants might have focused on covering the largest possible area in the available time rather than on correcting details of the created geo-objects.

Nevertheless, participants were aware of what their co-workers were doing and seemed to use this information to coordinate their work serendipitously. 51% of the participants did not stop working on a geo-object when others applied edits, though “working” most likely included monitoring an object according to the interactions logged during the study. These observations go along with some of the suggestions that were received in the questionnaire: participants proposed to assign specific roles such as “rough mapper”,“detailed mapper”, or “only applying edits” to further improve coordination of the work. Color coding users according to such a role might be more useful than individual color assignments in case of many collaborators.

Usefulness and application scenarios: Based on the questionnaire results participants thought that the task was performed more efficiently through real-time collaboration. During the interviews, the domain experts commented positively on the overall concept as well. More specifically, the experts saw the version control feature and the chat function with direct geo-references as being very useful for real-time collaborative mapping. They also highlighted the "Watch" functions as great tools in a teaching context or for presentation purposes. Suggested improvements included voice chat, measurement tools, buffering, and spatial filtering. Considering the large number of map movement/zooming (265 times per participant on average), the latter function, in particular, has a substantial potential for improving efficiency.

The experts also pointed out that realizing the benefits of real-time synchronized mapping depends on the specific use case. Besides disaster mapping, they identified teaching, planning, logistics, tourism, and helpdesk scenarios as promising application areas. All these applications benefit from the immediate visibility of actions performed by others' and from the non-blocking nature of the interaction, which is not afforded by asynchronous solutions. Also, real-time synchronized mapping opens up new ways of collaborating and coordinating work. For example, using this approach the work practices of extreme programming—one person programming, while their partner looks over their shoulder to check their code as they type—can be translated to the geo-realm.

The performed evaluation is subject to some limitations as the number of participants and tasks was limited. Additionally, the overall duration and execution time of the task was limited as well.

The user study was performed with students who had some background in cartography, but little experience in active mapping and less so in disaster mapping. The results for the communication aspects or "Watch" functionalities were limited by the type of the task and the study duration as well as by randomly assigned identifiers, which could have been an obstacle as they were not human readable and rather long. It is also unclear how different group sizes could affect the outcome of the study. While users reported that they were more efficient using Ethermap, a direct comparison study with an asynchronous system would be beneficial to validate these claims.

Furthermore, the evaluation of Ethermap focused on the actual collaborative process. The result of the task, the mapped flooded areas, were not assessed. While participants did complete the task to map flooded areas successfully, the study does not provide insights into the quality of the collaborative work or geospatial collaboration patterns besides mapping data, e.g., reasoning or assessing a situation in a group.

However, further studies could now investigate such aspects as the evaluation showed that the concept of real-time geospatial collaboration is feasible for mapping, and three main collaborative patterns were identified. Overall, participants and interviewed experts reacted positively to the concepts and the developed prototype. Real-time synchronization seems to facilitate geospatial collaboration and collaborators were able to distribute tasks serendipitously in the collaboration process without the need to define strategies beforehand. This effect could be particularly useful in collaborative citizen engagement scenarios that place an emphasis on a low entry barrier or ad hoc scenarios.

14.5. Effect of AIGs in OGIs

This thesis is exploratory in nature and investigates the effects of Augmented Interactive Geo-visualizations (AIGs) on citizen engagement in OGIs from a Human-Computer Interaction (HCI) perspective. The research question in chapter 3 that describes the objectives of this thesis was phrased as follows: *What are the effects of Augmented Interactive Geo-visualizations on citizen engagement in Open Government Initiatives?*

To investigate potential effects and to provide a comprehensive answer to the research question, it was approached from several angels: this thesis looked at aspects AIGs need to support citizen engagement, civil society as the target audience, best practices in the provision of OGD, and at specific effects of three AIGs prototypes for a limited set of citizen engagement activities.

Thus, the answer to the research question is the corroboration of the individual results and discussions that were previously presented. Also, the answer to the research question follows Meijer *et al.* 's [19] recommendation. They stress that "the evaluation and subsequent optimization of open government should acknowledge the variety in effects" [19, p. 25] and that there are various relationships between openness in informational terms (vision) and interactive terms (voice).

> Some researchers argue that openness does not have any effect if opportunities are not being used. This argument is too simple. Researchers should acknowledge that openness can have direct and indirect effects: opportunities for vision and voice may have effects even if nobody uses these opportunities. The fact that citizens can have access to information and decision-making may already influence government processes. —Meijer *et al.* [19, p. 25].

As such, the answer to the research questions of this thesis is not a simple binary statement but rather multifaceted and depending on the viewpoint. In summary, four effects can be observed based on the evaluations and obtained Insights 1–8 of the AIG prototypes from chapter 13 and the author's experiences in the domain:

Effect 1: Citizens value AIGs for exploring and obtaining information about engagement opportunities.

This first effect is observable in the notification application and the Dialog Map prototype. In case of the notification application, 86% of participants described the notifications as interesting, motivating, and practical (I1). The results of Dialog Map corroborate this finding. They show that citizens engaged with the AIG in a consistent manner to inform themselves about engagement opportunities in a direct comparison with a more traditional gridded mosaic-view (I4) in a setting where the AIG was placed less prominently compared to the gridded mosaic-view. The user flow analysis of Dialog Map shows that the largest group of active users switched from the gridded mosaic-view to the AIG and did not switch back—continuing and ending their exploration in this view. The second largest group of active users switched between the gridded mosaic-view and the AIG back and forth for exploring the engagement opportunities, indicating that both presentation forms presented information in a way citizens wanted to obtain or that something was missing in either form.

In combination with the results of the comparison study of the notification application, this illustrates that there is an untapped potential to offer citizens the option to explore and obtain information about citizen engagement cases with an AIG (I3, I4). In comparison, participants rated the notification application overall to be more desirable than the official website that had also a gridded mosaic-view (I3). Participants assigned similarly high scores for the official website regarding pragmatic quality. However, the official website was perceived to be more "task-oriented" and subsequently not as desirable.

As such, designers, organizers, and citizen engagement practitioners should consider extending existing information channels and presentation forms with AIGs to allow users to interact in different ways with the case at hand. "Augmented" and "interactive" need to be emphasized, as neither the notification application nor Dialog Map were straightforward geo-visualizations. Rather, both prototypes offered citizens multiple interactive and augmented functions such as implicitly triggered notifications or coupled textual and spatial dimensions to explore and obtain information about the citizen engagement case.

Effect 2: AIGs can facilitate distributed geospatial real-time collaboration for practical tasks.

Ethermap's evaluation suggests that real-time geospatial collaboration is a feasible concept and that an online editor for geospatial collaboration could help citizens in scenarios that focus on creating, editing, or handling geospatial data. Interviewed domain experts reacted positively to the developed prototype and 69% of the participants of the evaluation agreed that they completed a disaster mapping task more efficiently compared to asynchronous approaches after finishing it (I6). Besides identifying three emerging collaborative patterns that occurred without previously defining them (I7), the results suggest that most of the collaboration occurs "side-by-side", within the same area and not on the same geospatial objects (I8).

While this effect has only been demonstrated for a disaster mapping scenario, interviewed experts suggested additional application areas for real-time geospatial collaboration such as tourism, helpdesk or teaching applications. For long-term and non-time sensitive tasks, an asynchronous geospatial application might be equally suited. Nevertheless, synchronous geospatial collaboration can help distributed or co-located collaborators in activities such as joint knowledge construction, creative processes, or to avoid errors as not only one collaborator "drives" the system. Also, as every user of Ethermap can contribute right away, this form of real-time geospatial collaboration equalizes and empowers citizens.

Ethermap does not introduce artificial barriers due to technical constraints, but rather creates the opportunity of an "open space". While this unrestricted form of collaboration might be exploited by some collaborators if they constantly adjust or delete contributions of others to emphasize their contribution, Ethermap's data provenance system can be used to counter these actions. The complete history of all contributions is persistent with a version control system and users can revert to any previous revision or check the history to verify it. Another use of the data provenance system might be to identify contested areas that are often changed to start a mediation process between the collaborators.

Overall, for a focused task that deals with creating or editing geospatial data directly, AIGs seem to be able to facilitate collaboration. Future studies should investigate the concept and its application in real-world scenarios with more diverse participants. Nevertheless, the initial results are promising as participants were able to complete a disaster mapping task successfully in a flooding scenario that used actual and publicly available government data.

Effect 3: AIGs facilitate exchanges about OGD and OG.

This is a largely indirect effect that was observed by the author during this thesis but one that should not be underestimated for OGIs. As civil society actors are not only using OGD, but also act as intermediaries, watchdogs, and driving force (see chapter 10), civil servants are often interested in what happened with the published data. They also often rely on civil society actors and ask them about what data is missing for a particular application or what needs to be enhanced. Such exchanges often start during hackathons or other events that are (co-)organized by public administrations or civil society actors.

Hackathons frequently feature contests and honor the "best or most innovative" prototypes or ideas that were created. While the effect of starting an exchange is not limited to AIGs but also applies to all applications that use OGD, AIGs are often the condensation point or catalyst for such discussions as they contextualize and visualize OGD. For example, the author was part of a team that made second place in Open.NRW's first hackathon—the first place included a geo-visualization as well. Also, colleagues of the author won in two out of three categories with a geo-visualization at a national "data run" of the Federal Ministry of Transport and Digital Infrastructure.[6]

Another example of this indirect effect is that civil society actors prominently expose AIGs on their website that present their projects and work. For example, several labs of the "Code for Germany" initiative have developed dedicated AIGs for specific topics that expose OGD and address a topic that concerns them or they find interesting. The project pages of Code for Münster, Köln or Berlin feature several examples that range from simple geo-visualizations that depict geospatial OGD to complex services that include real-time data.[7]

(Non-)Effects: Being notified about an engagement opportunity in the immediate spatial vicinity of it or the option to provide feedback in an AIG do not necessarily imply that citizens use these functions straight away or at all.

[6] See https://open.nrw/de/content/nrwhackathon-war-ein-voller-erfolg for the first Open.NRW hackathon and https://www.bmvi.de/SharedDocs/DE/Pressemitteilungen/2015/128-gewinner-1st-bmvi-data-run.html for the data run, both websites were accessed May 22, 2016.

[7] See http://codeformuenster.org/, http://codefor.de/en/koeln/, or http://codefor.de/en/berlin/, all website were accessed June 29, 2016.

This observation is rather the absence of a direct effect or interaction in a certain way. As discussed previously, Dialog Map's spatial and textual feedback components were not used during the evaluation (I5). This non-use of the corresponding functions may be an artifact of the framing of the campaign, due to the implementation and exposition of the function or due to the concept itself. Still, Meijer *et al.* 's [19] argument that openness in interaction may have indirect effects needs to be considered—even if the provided interaction options were not used. In Dialog Map's case, the discussions after the campaign with the partnering NGOs and the SBM reaffirmed the view of the partners to continue to present partnering NGOs in a physical "citizen booth" downtown for direct exchange and contact. Also, the results verified previous experiences of the SBM that new brands and efforts require a prolonged effort, regardless of the medium.

Similarly, while the usage patterns of the notification application suggest that the majority of participants (53%) do not interact with the triggered notifications right away or in situ (I2) this does not mean that participants did not value this feature. On the contrary, 86% of the participants of the corresponding study described the spatially triggered notifications as interesting, motivating, and practical, and 20% of users did consistently interact with the triggered notifications in situ. Designers of notification applications or organizers of citizen engagement opportunities need to consider this behavior.

Overall, incentivizing and engaging citizens is a complex process and can be seen as a wicked problem [187]. Citizens seem to value AIG for exploring and obtaining information, but future work is needed to deepen the understanding of when and why citizens decide to deepen their engagement.

14.6. Summary

Summarized, the following effects of AIGs on citizen engagement were observed: Citizens seem to value AIGs for obtaining information and exploring citizen engagement cases. They engaged with the developed prototypes consistently and valued AIGs for exploring and obtaining information about engagement opportunities.

Real-time geospatial collaboration appears to facilitate collaboration without the need to explicitly define strategies between collaborators beforehand. Experts reacted positively to the concept as well and identified additional application areas. Additionally, AIGs seem to be a conversation starter between civil servants and OG activists.

However, the availability of spatially enabled feedback functions does not necessarily imply that citizens use them. These functions were not used by citizens in a "in-the-wild" evaluation that called on citizens to volunteer time. In this case, citizens might have been satisfied with obtaining information, the scenario of motivating citizens to volunteer time might not lend itself easily to discussion or there was no real need for feedback. Similarly, distance to an engagement case does not seem to affect citizens in their interactions with notifications that are triggered spatially. Nonetheless, participants valued the spatially triggered notifications and found the notification application to be more desirable than the compared official website.

It is important to stress that the presented results can only be generalized carefully. For example, a statement that only states that the participants did not often interact with the triggered notifications in situ implies that spatially triggered notifications seemed to be unimportant for participants. However, the results of the questionnaire show that 86% of the participants described the notifications as interesting, motivating, and practical and 72% of the accessed notifications lead to a subsequent exploration of the website of the corresponding engagement opportunity. Most of the interactions occurred outside of a geofence, and the reasons for this behavior are not yet known.

Similarly, one should not state that real-time geospatial collaboration is better than asynchronous geospatial collaboration. Ethermap's evaluation did not compare asynchronous and synchronous collaboration directly. However, Ethermap's evaluation suggests that the approach of synchronous geospatial collaboration is feasible, and 69% of the participants agreed with a statement that the real-time collaboration enabled them to complete the disaster mapping task more efficiently.

15 Conclusion

This final chapter summarizes the contributions of this thesis. Section 15.1 clusters them according to the research question and guiding questions that were established in chapter 3 and provides a tabular overview. Furthermore, section 15.2 outlines potential future work based on the presented research.

15.1. Contributions

As the title suggests, this thesis looked at the integration of Augmented Interactive Geo-visualizations (AIGs) and Open Government (OG). The main research questions investigated the effects AIGs have on citizen engagement in Open Government Initiatives (OGIs). To provide a comprehensive answer, the topic and domain were investigated from several angles with a Human-Computer Interaction (HCI) perspective. Four guiding questions were established as additional questions that inform the main research question describing the different phases of the integration of AIGs in OGIs.

Overall, this thesis provides five main contributions that inform OG practitioners, civil servants, citizens, and researchers. These contributions are summarized in table 15.1 and clustered to the research question and the guiding questions.

The first contribution is the answer to the research question. Four effects of AIGs on citizen engagement in OGIs could be identified and were described and discussed in chapter 14. Summed up, the results indicate that citizens value AIGs for obtaining information and exploring citizen engagement cases. AIGs seem to be able to facilitate real-time geospatial collaboration between distributed collaborators, visually grounding

Table 15.1.: Contributions (C1–C5) of this thesis clustered according to the research question (RQ) and guiding questions (GQ).

ID	Questions and Contributions
RQ	What are the effects of AIGs on citizen engagement in OGIs?
C1	Four effects were identified: i) citizens seem to value AIGs to explore and obtain information, ii) AIGs seem to be able to foster real-time geospatial collaboration, iii) AIGs seem to be a conversation starter in OGIs, iv) in situ notifications for citizen engagement opportunities and textual feedback functions in an AIG do not necessarily imply that citizens use the functions straight away or at all.
GQ1	What are aspects that AIGs should support to facilitate citizen engagement?
C2	The conceptualized AIG design space identifies four aspects that are important for AIGs. They are loosely clustered to a citizen engagement level and illustrated with examples and functionalities. The aspects are communication, data, exploration, and visualization.
GQ2	What roles do civil society actors have in OGIs?
C3	Four roles that civil society can take on were identified: i) civil society can act as driving force pushing the proliferation, ii) it can act as watchdog supervising the implementation, iii) fulfill the role of an intermediary that mobilizes an audience, iv) and civil society can act as user or beneficiary in OGIs.
GQ3	What are best practices in the provision of geospatial OGD?
C4	Six recommendations for publishing and presenting OGD were established that deal with metadata, licenses, data formats, spatial searches, preview functions, and automatic data monitoring.
GQ4	What effects do specific instances of AIGs have on a selected subset of citizen engagement activities?
C5	Based on C2, three AIG prototypes were developed and evaluated that investigated different levels of citizen engagement. The notification application looked at informing citizens in situ; Dialog Map provides initial insights for consulting or involving citizens; and Ethermap investigated geospatial real-time collaboration. The obtained insights informed C1.

the collaboration and allowing users to easily co-organise the process simultaneously. Also, AIGs seem to be a conversation starter in OGI as they contextualize and visualize OGD and foster an exchange about, for example, improvements of published OGD. However, the results also indicate that additional research is needed to better understand the role AIGs can potentially play for consulting or involving citizens in combination with textual feedback mechanisms. In the study, the coupled textual and spatial feedback mechanism was not used. Furthermore, notifications about engagement opportunities in their immediate spatial vicinity do not necessarily imply that citizens use these functions straight away while they are in situ. Still, citizens engaged with the AIGs nevertheless to explore the presented citizen engagement cases and to obtain information about them.

Contribution two is the proposed design space for AIGs that provides the basis for the three developed AIG prototypes, aiming to establish a shared understanding and combined view of the domain (see chapter 9). The design space is based on a comprehensive literature review of related work in the fields of geoinformatics, OG and OGD, and citizen engagement. Four aspects were identified as important for AIGs in citizen engagement: visualization, exploration, communication, and data. Examples or functions for each aspect were provided to illustrate their meaning and are loosely assigned to the citizen engagement levels. Rather than "solving" citizen engagement, which is unlikely as it can be seen as "wicked problem", the design space can serve as a discussion starter and can provide inspiration for designers and OG practitioners that provide citizen engagement opportunities.

A first understanding of the different roles civil society performs in OGIs was presented, see chapter 10. Based on six semi-structured interviews with local and established activists, domain experts, and public officials four roles were identified that are backed up by the emerging literature and real-life examples. These identified roles constitute contribution three: civil society can act as a driving force that pushes the proliferation of OGD and OGIs, can act as watchdog supervising its implementation, be an intermediary actor that broadens and mobilizes users or audience, and act as user or beneficiary. Given these roles, civil society is helping to realize the full potential of OG and OGD, by fostering administrative and democratic innovation. As such, these roles need to be kept in mind for designing and developing AIGs, as civil society actors do a lot more than just use or receive data—they are actively shaping citizen engagement processes.

AIGs require data for visualization, exploration, and communication, especially OGD. While several OGD portals are emerging in Germany and the EU, standards or best practices are sparse. Hence, contribution four of this thesis provides six concrete recommendations that serve as best practices for publishing geospatial OGD, see chapter 11. The recommendations originate from the author's involvement and gained experiences in two projects with public administrations that publish OGD. The first three recommendations deal with aspects of publishing geospatial data and deal with metadata, licenses as a special case of metadata, and data formats. They highlight aspects that geospatial OGD publishers should adhere to if they want to maximize the usefulness of their data, especially if the data is already present in an INSPIRE compliant form. The following three recommendations deal with presenting and finding geospatial OGD that OGD portal operators should provide to allow users to explore and identify the OGD they want to use. Spatial search facets that include a placename search enable users to find geospatial data based on the geographic region and a spatial preview function allows users to get a first impression of the search results. Also, portal operators should establish transparent monitoring processes that inform users about the status of the published OGD to manage expectations and data quality.

Based on contribution two, the conceptualized AIG design space, contribution five consists out of three AIG prototypes that were designed, developed, and evaluated in this thesis (see chapter 12). Based on the gained insights during their respective evaluations, the effects of AIGs on citizen engagement were described in the overall corroboration and reflections. The first prototype is a notification application for smartphones that informs citizens about engagement opportunities as they move through the city by applying geofences that surround the associated locations. By moving through the city, notifications are triggered that are based on user preferences, space, and time. The notifications prompt the user to explicitly interact with the application and obtain further information about the engagement opportunity. The second prototype, Dialog Map, intertwines the spatial and textual dimension and offers citizens the option to provide and exchange comments, ideas or feedback spatially and textually, revisiting the idea of the Argumentation Map (see subsection 7.5.2). The third prototype is Ethermap, an online web-mapping editor that facilitates geospatial real-time collaboration—applying the notion of non-blocking synchronized collaboration that is found in online text or coding editors to the geospatial domain.

Besides the five main contributions, several smaller contributions are also present in this thesis. For example, readers that are new to the domain might find chapter 6 useful as it describes key concepts. Researchers might view the presented related work section as a good starting point as it provides a comprehensive overview on OG, OGD, citizen engagement, civil society, geo-visualizations and ICT applications for citizen engagement. OG practitioners might draw inspiration from the presented arguments in the motivation (chapter 2) of this thesis. Others might appreciate the fact that they can re-use, modify or build upon two of the three developed AIG prototypes as they are publicly available with accompanying technical documentation.[1]

15.2. Future Work

While the five contributions of this thesis can help OG practitioners, civil servants, citizens, and researchers to obtain first insights on how to integrate AIGs in OGIs, future work could extend the presented work.

Subsequent work could expand the AIG design space by including three-dimensional visualizations. While the discussion of the AIG design space looked at hybrid or blended visualization approaches, three-

[1] Please refer to https://github.com/ubergesundheit/dialogmap/ for Dialog Map and https://github.com/dwilhelm89/Ethermap/ for Ethermap. The notification application will eventually be released, see http://schlomm.github.io/; all websites were accessed June 05, 2016.

dimensional visualizations could also be examined for AIGs. Virtual globes such as Google Earth or Nasa World Wind have become fairly common in recent years. They could allow citizens to obtain a better understanding and offer a better representation in citizen engagement cases that require large-scale depictions.

Other virtual three-dimensional representations such as city or building models are equally applicable for AIGs as research and technology progress. With the recent advent of virtual reality and the consumerization of the necessary devices such as the HTC Vive or the Oculus Rift, highly immersive and interactive representations might also prove to be useful and open up innovative AIG's for citizen engagement.[2] In virtual reality, citizens could fully explore and interact with different envisioned models in three dimensions, e.g., how a modern train station would fit into and "feel" in a historical city center.

While the four roles that civil society might take on in OGIs help to describe its involvement and to design AIGs, these roles are likely to change and shift as OGIs enter new phases. At the moment, most OGIs are establishing OGD portals and start to publish OGD. However, as the focus shifts towards citizen participation, the dynamic between civil society and civil servants might change, and new or more refined roles are likely to emerge.

Future work on the provision of geospatial OGD could investigate search and publication strategies or infrastructure concepts for vast quantities of geospatial data. With the realization of programs such as Copernicus that will openly provide enormous amounts of remote sensing data on a regular basis[3], current approaches will likely need to be extended or adjusted to allow users to find what they are looking for. Other work might take a closer look at synergistic effects of INSPIRE and OGD and investigate if both fields should be merged eventually.

As already discussed in section 14.3, privacy is an understudied and underrepresented topic in the provision of OGD. While some might

[2]See https://earth.google.com and http://worldwind.arc.nasa.gov/ for the virtual globes, and https://www.htcvive.com/ and https://www.oculus.com/ for the HTC Vive and Oculus Rift. All websites were accessed June 05, 2016.

[3]See http://www.copernicus.eu/main/data-access, accessed June 03, 2016.

feel that privacy is a trite issue, it is important nevertheless. This is especially the case in a field that emphasizes transparency, participation or collaboration to counter arguments that oppose privacy and transparency as mutually exclusive. Hence, the OG community should foster a discussion surrounding privacy issues to address privacy related fears, threats, and countermeasures. Research in the area could investigate if privacy and openness are necessarily exclusive in nature or if synergies can be found. For example, if data providers are aware that most data is published openly, privacy aspects might receive more attention as they need to carefully consider what kind of data needs to be collected.

Future work could also revisit the developed prototypes to include or improve functions based on the evaluation results. For example, Dialog Map could be enhanced by coupling the gridded-mosaic view with the geo-visualization and the textual descriptions, evaluating if the combination of engaging images, textual descriptions, and geo-visualization yields new insights. Furthermore, access to the feedback or commenting functions could be integrated tightly into existing social media channels or microblogging services to test if this would have an impact on feedback that is provided by citizens.

A future study of the notification application could sample users' experiences during the use of the smartphone application to gain insights into habits and patterns when and why users decide to interact with triggered notifications. Additional features might be included in the notification application as well. For example, Dialog Map, a social network, and the notification application could be combined. Such a combined platform would allow users to be notified about engagement opportunities, while they have the option to provide feedback on the case at hand via the social network that acts as a multiplicator. These evaluations could supply additional insights for the proposed AIG design space and provide additional data for its validation. Eventually, this could lead to the combination and evaluation of all three prototypes in one application to test the effects of seamless transitions between different citizen engagement levels.

V

Appendix

Bibliography

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Supplementary Material

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Disclosure and Consent

Disclosure about the conducted research for participants was provided during evaluations of this thesis. In case of electronic applications like the implemented prototypes disclosure was provided via the imprint or in a disclaimer. The disclosure contained information about the fact that website or app usage was tracked and standard disclaimers about the usage of cookies. Contact information was provided as well. If questionnaires were used, written disclosure was provided before the questionnaire started. Interview partners were informed verbally and with a written statement before the interview started.

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Student Theses and Repositories

The author of this thesis co-supervised several M.Sc. theses and B.Sc. theses as part of the Graduate School for Geoinformatics program. The following student theses contributed to this thesis. Additional information or program code is available and linked; all websites were accessed June 05, 2016.

René Unrau: B.Sc. Thesis, entitled: Entwicklung und Implementierung eines Parser für die OpenData Plattform GovData. Institute for Geoinformatics, WWU Münster; submitted July 17, 2014.

Dennis Wilhelm: M.Sc. Thesis, entitled: Collaborative, Version Controlled Map Editing. Institute for Geoinformatics, WWU Münster; submitted September 25, 2014. Repository: https://github.com/dwilhelm89/Ethermap/

Gerald Pape: M.Sc. Thesis, entitled: Supporting Public Deliberation Through Spatially Enhanced Dialogs. Institute for Geoinformatics, WWU Münster; submitted November 2, 2014. Repository: https://github.com/ubergesundheit/dialogmap/

Dominik Schlarmann: M.Sc. Thesis, entitled: Geofenced Location-Based Services for eParticipation. Institute for Geoinformatics, WWU Münster; submitted January 4, 2016. Website: http://schlomm.github.io/

Curriculum Vitae

Integrating Augmented Interactive Geo-visualizations and Open Government

High hopes are pinned to reshaping civic engagement in Open Government Initiatives that seek to open up governmental processes and data by using modern information and communication technologies. The aim is to facilitate citizen engagement through open interactions and access to data by emphasizing transparency, participation, and collaboration. However, a key need for Open Government Initiatives is to create and adopt information and communication technologies that are easily accessible and that reflect the envisioned cultural change. The intended cultural shift needs to be supported by the technical innovation, and existing approaches need to be rethought, renegotiated, and augmented.

This thesis formulates and evaluates an approach to facilitate citizen engagement with Augmented Interactive Geo-visualizations (AIGs) to address the need. AIGs use space and time as integrators that allow citizens to contextualize, visualize, and engage in different ways. The central research question of this thesis investigates the effects of AIGs on citizen engagement. Four guiding questions inform the research question and look at pre-requisites and challenges. First, a design space is conceptualized that identifies aspects that AIGs should support for different levels of citizen engagement. Second, potential roles of civil society actors in Open Government Initiatives are described to understand the target audience and their needs. Third, best practices for providing geospatial Open Government Data are established to facilitate subsequent use. Fourth, three AIG prototypes have been developed and evaluated for specific instances and levels of citizen engagement to investigate their effects.

Readers can use the contributions of this thesis, for example, to inform their Open Government strategy, consider the best practices to enhance the provision of Open Government Data, and adapt or draw inspiration from the AIG design space and the prototypes.