Living with a Virtual Agent: Seven Years with an Embodied Conversational Agent at the Heinz Nixdorf MuseumsForum

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Abstract
Since 2004 the virtual agent Max is living at the Heinz Nixdorf MuseumsForum – a computer science museum. He is welcoming and entertaining visitors ten hours a day, six days a week, for seven years. This article brings together the experiences made by the staff of the museum, the scientists who created and maintained the installation, the visitors and the agent himself. It provides insights about the installation's hard- and software and presents highlights of the agent's ontogenesis in terms of the features he has gained. A special focus is on the means Max uses to engage with visitors and the features which make him attractive.

1 Introduction

Today, virtual agents are much more common than ten years ago. There are, however, little of them continuously in action – not to say alive – for longer periods. One of the exceptions is the virtual agent Max who has a full-time job as a central exhibit at the Heinz Nixdorf MuseumsForum since 2004.

1.1 The Virtual Agent Max

The virtual agent Max marked the cutting edge of research in artificial intelligence and artificial life at the turn of the millennium. His ontogenesis has, however, never stopped and he is continuously updated. This kind of research can rarely be experienced in everyday life. As a layman it is hardly possible to appreciate or even use such technology. With Max the visitors can have lifelike experiences with an anthropomorphic "virtual life form" and interact with it using simple natural language input via a text console (see Fig. 1). During the dialogue with the agent many questions arise which go far beyond the exhibit itself: How manlike is the artificial human? Can his intelligence and his knowledge be compared to that of humans? How well are his mimics and gestures evolved? Interacting with the agent is like running a small Turing test, explicitly or implicitly run by every visitor – even by the naïve.

Doing so, visitors soon realize that in contrast to humans, artificial systems require a much more explicit use of language. Beyond this, the agent is the most colorful information system of the museum: similar to textual descriptions and multimedia terminals, the agent offers explanations and comments about the exhibits in his surroundings, about the museum, the city, Germany or about himself.

Max is self-explanatory in the true sense of the word; no manual is needed. He can elaborate on himself and the technologies which have been used to create him. When interacting with the agent, the visitor experiences individual aspects of computer science, such as logic, natural language processing or computer vision, in concert. This is a unique feature of this exhibit.

The agent has been developed by the A.I. (Artificial Intelligence) group at Bielefeld University starting in 1999 (Kopp and Jung, 2000). In 2004, the museum renewed the state-of-the-art area of its permanent exhibition. In this progress, the department "A.I. and robotics" was created and integrated into the exhibition. At that time, the agent already lived at the department of the A.I. group for five years (Jung and Kopp, 2003). Soon, the contact was made, the two groups met and the agent moved – or better: copied – to his new place (see Fig. 1). Since then, the agent's ontogenesis has been driven by a triangle of three forces: the scientific progress, the vision of the curator of the museum, Stefan Stein, and the needs of the visitors.

A contract between the museum and Bielefeld University's A.I. group ensures regular updates and the maintenance of the system, including security updates and new operating systems. In addition to that, the A.I. group also takes care of updating the knowledge base and provides new features.

Fig 1. The agent is a continuous attraction for the public and the local and national media.

1.2 The Heinz Nixdorf MuseumsForum

The Heinz Nixdorf MuseumsForum (HNF) in Paderborn/Westphalia, Germany, has been initiated in 1996 by the Westfalen Stiftung, a foundation established by the German computing pioneer Heinz Nixdorf. It is dedicated to the history of communication technology (Heinz Nixdorf MuseumsForum, 1999) and has been recognized by the Guinness Book of Records as the biggest computer museum in the world. Not just a museum for computer science, the HNF shows communication technology from the early beginnings to modern digital technology and its possible futures.

The agent Max is located on the second floor towards the end of the permanent exhibition and the course "A.I. and robotics". This location also marks the end of the full course through the museum: At the beginning, the visitors can play with a variety of intelligent systems, such as the best artificial chess player, systems for recognizing coins by their noise, logic games, or artificially generated cantata of Bach. The highlight at the end is then the small talk with a "real" virtual agent.

The agent Max stands for one of the museum's main principles: to show historical and concurrent technologies that can also be tested. The visitor can really interact with technology. In addition to the permanent exhibition, this principle is also motivation for several special exhibitions, for example the highly acclaimed Computer.Gehirn (Computer.Brain) exhibition in 2001 (Heinz Nixdorf MuseumsForum, 2001).

1.3 The A.I. Group at Bielefeld University

The A.I. group's research on virtual embodied agents began in 1995, when an agent was used to establish a frame of reference for spatial tasks in a virtual environment (Jörding and Wachsmuth, 1996). While at that time users already could interact with the virtual environment via natural language, the agent itself was used like a marionette. This changed in 1999 when work started on Max who later moved to the museum in 2004 (Kopp et al., 2005).

The A.I. group envisions virtual embodied agents as an important metaphor in human-machine interaction. When users are interacting with computers, one finds some anthropomorphism, but overall, the interaction often is in the fashion of a command-and-control interface. If done properly, a virtual agent of human-like appearance paired with adequate behaviors can elicit more natural human interactions. At the same time, creating such an agent requires very explicit models of human behavior, interaction skills and intelligence (Cassell et al., 2000). That is why understanding through construction is the driving scientific method of the group.

Scientific research in A.I. does not often leave the protecting walls of the laboratory. Also, the dominant user group testing research prototypes consists of students and scientists of computer science, which might not represent typical users. Consequently, putting a complex A.I. system such as an interactive virtual agent into a museum is a great opportunity: the system's environment is dynamically changing, there is no caring scientist around to provide immediate support, and there are many curious visitors testing

the system to the limit. There is a lot to learn and observe for A.I. researchers in such a context, and various studies have been conducted with the agent at the museum (Kopp et al., 2005; Kramer et al., 2007; Von der Putten et al., 2008).

So far, it has been argued that the opportunity to show the agent as an exhibit in a museum is very interesting to scientists. Yet there is an additional challenge: The visitors have to be interested in the agent, too. Otherwise there would not be much interaction to observe. The agent thus has to be both intelligent and interesting. One advantage is that the museum's theme is computer science and the agent – as a piece of advanced computer science – is interesting per se in such a context. To further provoke the curiosity of the visitors and please their needs, the agent has been designed to have several features:

- he has interesting content to tell
- he is a character (see description in 2.5)
- he proactively engages with visitors, and
- he shows emotions

In addition, the agent is continuously evolving, so that recurring visitors will have something new to discover on a regular basis.

The following section provides a description of the strategies which are followed to attract the attention of the visitors. Subsequently, Section 3 goes into details about the set-up of the installation, the agent's interaction capabilities and the necessary hardware. Section 4 then is dedicated to the visitor experiences and provides feedback from the museum staff. Finally, Section 5 concludes and discusses future work, which may involve the extension of the interaction capabilities of the agent to social media.

2 Strategies to Attract Attention and Facilitate Active Interaction

2.1 Be Engaging

The first thing to do is to get the attention of the visitors. The agent thereby is not just waiting for a visitor to start typing on the console. He is equipped with a video camera targeted at the hall just in front of him and monitors the area for passers-by. Using computer vision techniques, he continuously tries to detect human faces. As soon as he has recognized a human face, he turns his head and starts to address the visitor with a greeting and an invitation to talk to him. Sometimes, he also just states that he is bored and wants to play. This strategy is maintained throughout the dialog, i.e., the agent does not only react to sentences entered by the visitor, but also introduces new issues.

2.2 Be Informative

Once the agent has gotten the attention of the visitor, he starts with a formal greeting and an exchange of names. Right after that, he offers to give some presentations about the museum or the exhibition and demonstrates his willingness to provide answers to the visitor's questions. To this ends, the agent has been equipped with a knowledge base consisting of facts about the museum, the exhibition, the local area, a coarse knowledge about national politics and extensive knowledge about him and the technologies used to create him.

2.3 Be Witty

Joseph Weizenbaum's Eliza has led the way on how to create the illusion of an understanding interlocutor and to keep the dialog flowing (Weizenbaum, 1996). The agent adopts this approach by using a pattern matching system to detect specific keywords, but also to identify questions, requests or statements. Once a match is found, an associated rule specifies the reaction of the agent in terms of sentences to answer, sounds to play or animations to show. These reactions are designed in such a way that they are partly humorous, partly thoughtful and whenever possible, they are open, so that the flow of dialog can continue. These verbal reactions can also be accompanied by special effects. For example, when asked whether he is cool, the agent draws black sunglasses out of his pocket and keeps them up for some time. At one time or another he will later put the glasses down again, independently of the current topic of the conversation.

2.4 Be Surprising – Logic and Emotions

When interacting with an artificial intelligence, one would expect to be confronted with logics and very formal behavior. One probably would not anticipate perceiving a virtual agent displaying emotions. In a certain sense, the agent can be happy or be annoyed. Every perception registered by his sensors, the video camera or the console, is given a certain emotional value, which is sent as an impulse to an artificial emotion system (Becker et al., 2004). The same holds for internal events, such as registered failures in parsing or interpreting the input given by the visitors. If, for example, the agent is insulted, he gets angry and his voice gets tense. Also, his visual appearance changes and his mimics reflect his anger. Over time or when the visitors apologize, he calms down and his facial features get soft again. If he does not get any impulses over a long time, he even gets bored and it could be that he falls asleep.

2.5 Be a Character

The agent is not a shapeless piece of software. He is designed to be a plausible, interesting character. This can be best described by the following characterization, given by one of the museum's staff members:

The agent has been brought to live in 1999. He is non-smoker, single, knows little about his developers but nothing about family. He knows about national politicians, but nothing about local ones. He is into music except for pop, loves Kraftwerk[1], and knows at least one poem from Goethe. The agent knows how to sing and dance – at least occasionally. His favorite movie is "Star Wars". He prefers watching sports over being sporty. He knows that his eyes are blue, likes guessing games, and does not go to the movies but likes watching DVD. He is instantly offended when hearing the word "Pfannekuchen"[2] (pancake) and knows more or less that he does not need to eat or drink. He absolutely loves his job at the museum, where he also celebrated his 10th birthday (see Fig. 2).

[1] Kraftwerk is a famous German electric music band which is active since 1970.

[2] "Pfannekuchen" is used as a keyword to explicitly trigger emotional reactions for show during tours.

Fig 2. The agent's tenth anniversary has been celebrated with attention from several media. The people in the picture are Max, Stefan Stein, Stefan Kopp and Ipke Wachsmuth (from left to right).

2.6 Be Current

Every year, the agent is provided with a major update. While there have been purely technical updates, such as a migration from single-core to multi-core technology, most of them offer new functionalities that can be interactively explored by the visitors. This way, recurring visitors have always something new to find and thus have an additional reason to interact with the agent over and over again.

As the world is continuously changing, the knowledge of the agent is aging. This is particularly true for his knowledge about the weather, the exhibition or national politics. It is thus necessary to provide near-term knowledge updates. In case of the weather, the agent is enabled to query a WWW-weather forecast and verbalize the answer in natural language to the visitor. All other knowledge, including facts about the exhibition is updated manually (so far).

In 2007, the agent learned about mathematics and demonstrated his knowledge in the year of mathematics 2008. Since then, he not only knows about famous mathematicians or number theory, but also how to do calculations and to check prime numbers. He also learned some logic tricks and enjoyed playing games with the visitors. This made him so special, that a new instance of the agent had been created to be part of the temporal exhibition on mathematics. This special agent was at first distinct from the permanent agent – also, e.g., in terms of appearance to accentuate the difference visually. After the year of mathematics, however, most features were merged into the permanent agent.

Also in 2007, the former standalone system was migrated to a system driven by a Live-DVD and the agent became mobile. This feature had also been used for creating the special agent. This special agent was so successful that, starting in 2009, it toured through several museums as part of a smaller installation, only comprising the main system unit, a computer display, a sound system and a keyboard.

In 2010, the agent has been trained in photography and is now happy to take pictures of visitors, compose an electronic postcard and send this postcard with some greetings to an email address given by the user. This process is fully interactive and handled in a natural dialog. Considering the demonstrated interaction capabilities, this is the first time where the agent can interact with the visitors outside of the museum, beyond the direct face-to-camera interaction at the exhibit.

3 The Installation

3.1 Presentation and Interaction

The exhibit is located on the second floor of the museum, right at the end of the main course through the permanent exhibition. It is the area where many high-level computer systems, A.I. systems and robots are located. The main component of the installation is the large canvas where the agent is displayed using a front-projector mounted to the ceiling. The agent is target of many group interactions. This is considered by the installation by exposing the agent above ground and oversizing him a bit, so that everyone in the group has a good experience. Voice and other sounds are made audible by a set of speakers attached to the mount of the canvas.

Interaction with the agent is supported by two modalities: typing on a keyboard and visual interaction. The keyboard console is located right in front of the canvas, at about 1m distance. The console and keyboard is ruggedized and well suited for frequent visitor interactions. Special care has been taken to disallow the visitors to interact with the underlying operating system, thus special keys, key combinations and functions such as task switching have been deactivated. A mouse or touchpad interface is not required. Visual interaction is supported by a video camera which is mounted right beside the canvas to the left of the agent. It is focused on the area right in front of the console to take a close-up of the visitor interacting with the keyboard.

3.2 Software and Computer System

At the time being, the agent itself is hosted on a 2.66 GHz Quadcore system with 3 GB RAM, a NVIDIA Quadro FX 1700 and a Brooktree Bt878 framegrabber. This system is located in a server facility next to the exhibit. The computer system is running on Ubuntu Linux. The graphics are handled by SGI OpenGL Performer. Since 2004, the hardware has been completely exchanged once, in 2009, to migrate to the modern multi-core architecture, allowing for advanced computer vision techniques, which are the basis for recent feature additions.

The software pattern used to create the agent is a multi-agent system. Thus, the overall experience provided by the agent emerges from the collaboration of many software experts, which have been constructed to cooperate on this task. There are software experts to receive keyboard input, to parse natural language, to manage knowledge and the progress in dialog, to realize the visual appearance, to plan synchronized speech and gestures or to verbalize the generated utterances. The A.I. group has used this architecture for over 15 years – but it is more than ever up-to-date, because it scales well with the multi-core systems that are state of the art today.

3.3 Maintenance

Running a complex installation such as the virtual agent requires a robust strategy for update and maintenance. In the beginning, the success of the installation had not been foreseen and long-term maintenance had not been an issue in the design of the installation. Considering the fast progress in computer hardware and the high iterations of updates of operating systems, seven years are a long time in terms of computer technology. Thus, up to today, major changes happened regarding computing power, starting with single core systems and nearly non-programmable computer graphics cards in 2004, and are now definitely not in a finite state in 2011, where there are multi-core CPU architectures and graphic cards with hundreds of programmable cores. At the same time, the operating systems version number has changed from version 4.10 to 10.10. The changes in the operating system software included major changes in compiler technology, which directly affected the overall software installation.

In addition to these problems, over the last seven years several functionalities have been implemented to support maintenance regarding the functional part, the interaction with the visitors:

- A verbose logging system has been implemented to assess the interactive sessions after a failure has been detected.
- A log-file rotation scheme has been realized. Log-files are normally stored on the hard drive of the computer system. The insertion of a USB stick in the securely stored system triggers a process that copies the current log-files to the stick. This simplifies the on-site administration process. This feature was especially useful for the mobile installations, as they did not have a permanent connection to the internet.
- A remote administration service has been set-up, which allows the scientists from the A.I. group to access the system on-line in case of problems. This is the second alternative to copying the log-files as the most relevant source of analyzing system problems.
- Since 2010, the system also automatically composes emails with excerpts of the recent log-file activities in the case of unexpected failures and reboots. This simplifies the reaction scheme in the case of incidents and provides just-in-time reporting. The staff at the museum does no longer need to report every incident, but can provide elaborate feedback on the situation at the exhibit if unknown problems are encountered.
- The Live DVD system which has been installed in 2008 increases the robustness of the installation. By swapping the Live DVD, the staff at the museum is now able to exchange the hardware or to revert to a previous version of the agent known to work if a new feature shows teething problems.

With all of the aforementioned maintenance functions in place, controlling and administering the agent has become a lot easier for the scientists, who can now focus on solving problems and implementing new features.

4 Acceptance and Feedback

4.1 Qualitative Feedback of the Museum Guides

The museum employs freelancers as museum guides. They complete a specific training offered by the museum and successfully pass a control tour. Many of them have already given several hundred tours. For the following collection of qualitative feedback, the six most active guides have been interviewed and asked for their comments along a collection of questions regarding the acceptance of the system, the typical questions asked, anecdotes or the kind of visitors that are interested in Max. (Interestingly, one of the six reported that he deliberately does not include Max in his tour, but refrained to disclose his reasons.)

The overall acceptance of the system as perceived by the other museum guides is excellent. The agent is seen as one of the most popular attractions of the exhibition and receives a lot of attention, both from the young and the young at heart. The demand to challenge the artificial intelligence is great. As the agent is in most cases the final highlight of the guided tour, visitors often remain at the console over the end of the tour. Some were even reported to have missed their bus.

The guides are reporting that especially younger visitors approach the agent without reservations. They even address him via direct speech although they had been explained that he can only be talked to via the console just right beforehand. This can be interpreted as an immersion of younger visitors into the illusion that the agent is a real conversational partner and underlines his inherently consistent appearance. When talking to the agent, especially young pupils tend to ask embarrassing questions and use awkward formulations they would never try on their parents. The agent has been adjusted to this observed behavior and retorts accordingly. When the situation escalates, he protests and leaves the screen, only returning after a proper apology by the visitor.

Overall, visitors are perceived to be excited about the intelligence and the friendliness of the agent. However, the tour guides of the museum noticed a difference in the attitude towards the agent between adults and children. Children like chatting with the agent very much. The adults appear to be concerned about robots and agents replacing and surpassing humans. When interacting with the agent, though, they notice his bounded intelligence: he often gives wrong answers if he does not recognize words or has no knowledge about a topic. On the other hand, he is perfect at German grammar, which most visitors – be they national or international – are not. Yet if something is spelled incorrectly, he would not recognize it.

In the end, visitors are either surprised by the intelligence displayed by the agent, or they leave with a smile. Whether this is due to the witty character of the agent or to their relief that agents will not take over the world tomorrow the museum guides cannot tell.

The museum guides also report on many repeated visits. Often, some members of a group of visitors already know the agent and are happy to meet him again. There are also always some visitors who return to the agent at the end of a tour or walk there repeatedly during their stay. This is especially true for groups of seniors.

4.2 Questions Asked

The range of questions asked by visitors covers topics such as personal background, physical attributes, up to philosophical issues. Typical questions, which have been compiled by a museum guide, are:

- Do you have a girlfriend?
- How old are you?
- How tall you are?
- Do you like soccer?
- What's your mother's name?
- Where are you from?
- Why are you here?
- Are you a victim?
- Can we dance?
- What is the answer to the universe and all the rest?
- How's the weather tomorrow?
- Will you be a robot some day?

Interestingly, there are also questions about the price of such a system and whether it will be available for sale. In addition, visitors are interested in the use of such a system. One museum guide remembers a young pupil asking whether the agent is also good at doing homework. And sometimes, they even ask the agent to be their friend.

These are the questions posed by visitors which are aware of being observed by a museum guide or which are part of a group tour. The log-files, however, can tell a different story by revealing the questions asked when visitors are feeling unobserved. Groups or individuals which are not part of a tour often pose quite explicit questions, use vulgar expressions or exhibit a crude behavior towards the agent. Unfortunately the percentage of visitors showing this behavior is comparably high. Some are even undeterred by other visitors or officially guided tours.

4.3 Some Statistics from the Logfiles

The logfiles between November 2010 and January 2011 have been analyzed to generate some statistics about the interactions with Max. During the time of regard, the museum has been open on 75 days. On average, about 21 direct interactions were started by visitors a day by using the console. Of them, 53% (11.36) were conversations of appropriate form, including a formal greeting, exchange of names, several exchanges of small talk, game playing or presentations, and a farewell. The remaining interactions consisted only of one or two sentences. The mean number of inputs made during such conversation was about 23 sentences, the mean duration about 13 minutes. Note that typically a group of visitors has a conversation with the agent with interleaving inputs, so the number of visitors that interacted with Max is greater than the number of conversations.

These numbers have to be taken relatively to the numbers of visitors per day, which is on average about 390 (estimated on data from 2004 to 2010). And they have to be taken relatively to the number of about 2000 exhibits concurrently being presented in the permanent part of the exhibition, not counting temporary special exhibitions.

Each day, Max responded to about 387 sentences. In 75% (290) of the cases the agent was able to make an interpretation of the sentence, i.e. Max had an explicit rule matching the input.

In conversations (852 total in 75 days), Max made a direct offer to give a brief presentation about the exhibition in 61% (523 total) of the dialogues, which was accepted in 21% (110 total) of these cases. On average, he asked visitors to play a game with him in 32% (269 total) of the dialogues. This offer was accepted in 62% (168 total) of the cases.

Regarding the emotional system of Max, in about 6% (1806 total) of the cases the sentence entered had been an insult which provoked a negative emotional reaction. Only a bit less than 1% (281 total) of the sentences were interpreted as a compliment, which led to a positive emotional reaction.

To compare, De Angeli and Branham (2008) found in a similar analysis of logfiles from the online chatterbot Jabberwacky a typical conversation length of about 41 inputs. This is nearly twice as many as the 22.57 inputs found in conversations with Max. Interaction with Jabberwacky, however, happened online and interlocutors were probably sitting in front of their computers having a private chat. Also, interaction is purely based on text and answers from Jabberwacky are quick and short. In the museum, the users are standing in front of Max and his answers are spoken out loud. They are elaborate and span several sentences, as Max is primarily an information-giving agent. It can thus be assumed that the overall length of conversations in terms of time actually may have been longer with Max than with Jabberwacky, but timespans are not reported in their analysis. Regarding the insults and abuse of language, they come to similar, but slightly higher results, which might be attributed to the more private interaction with an online system as opposed to an interaction in public space where some responses from Max could have been overheard.

4.4 Anecdotes

The agent has seen some famous visitors, such as in 2005 the federal chancellor Gerhard Schröder (see Fig 3, right). In 2006, for another example, the federal president of Germany, Horst Köhler, visited the museum during summer (see Fig 3, left). Mrs. Köhler, who was joining him, addressed the agent with the question: “Is it not too hot for you?” and the agent answered: “Going to the swimming pool would be just the right thing to do today.” Given the formal circumstances, this bold answer caused quite a laughter.

As already mentioned, the agent’s 10^{th} birthday has also been celebrated officially at the museum. There has been a short speech, coffee and a marzipan cake for all of the participants of the A.I. conference held at the very same day and place. This event even has been taken up by the local media and it could have been the first official birthday party for a virtual agent.

Fig 3. The agent is well-known and has been visited by famous German politicians, such as Horst Köhler (federal president of Germany 2004 – 2010, to the left) with his wife Eva Köhler on July 11th, 2006 and Gerhard Schröder (federal chancellor of Germany 1998 – 2005, to the right) on July 5th 2005.

5 Discussion

5.1 Lessons Learned

Managing and maintaining a large software architecture such as that of the agent Max (see Section 3) is a challenge for a research group. In science, especially in A.I., one is primarily concerned with developing theories and creating software prototypes as a proof of concept. There normally is only a restricted group of users interacting with the systems and the scientists are always around to help and fix.

This is quite different from the situation at the museum. The installation has to be up and running six days a week for up to ten hours. There is no expert around if something breaks. The reason for a broken system is often found in unexpected clever or just lucky user input of visitors which are no longer around to ask what they have done. Consequently, the first two years have seen many incidents and some tense interactions between the staff of the museum and the A.I. group. However, both sides and especially the agent have learned a lot during this phase.

Reviewing the results of the logfile analysis, it is interesting to see that there are a lot of insults targeted at the agent. This could be explained as follows: The visitors are explicitly made aware of the fact that the agent shows emotion. It is thus quite natural that they try to test him by throwing insults at him, just to elicit his reactions and, for example, make him leave the screen or show some other interesting behaviors. Visitors could just be checking out his boundaries, just as children do. However, looking at the logfiles, one finds that often dialogs later leading to insults had started quite naturally. In most of the cases, it is only when the agent got something completely wrong that visitors turned to insulting him. This is a further motivation for the A.I. group to improve the dialog capabilities of the agent.

Still, this observation also shows the strengths of the strategies implemented in the agent: If it was not for the emotions, the visitors would probably just have dropped out of the dialog, as soon as they had lost the immersion and started to disbelieve in the intelligence of the agent. With the dynamics of the agent's emotional system, some myths still remain and keep up their interest.

5.2 Future Vision and Plans

Having a virtual agent living in a museum for seven years, one vision that repeatedly comes up is that of allowing the agent to make one step beyond his nice but narrow quarters. With the photo-postcards one first approach is taken were the agent is enabled to contact the external world. But this approach is very restricted. More interactive examples could, e.g., be used to enrich the presence of the museum enabling visitors to get a first glimpse of the system on the museums webpages. This would, however, require support for real-time 3D graphics and sounds on the client-side – technologies which are just in the progress of being taken up by the general public.

As the virtual agent is accepted as a human-like communication partner, he could also make use of other communication channels. One example is Facebook, where he could keep in contact with the visitors or announce upcoming events. As Max is an emotional being, he could also report on the visitor interactions he had each day: if there would have been a special event and many visitors would have interacted with him, he could, e.g., comment on the fun or the stress he had that day.

Finally, modeling the agent's real-world knowledge manually is a very time consuming task. The agent is therefore only equipped with a very restricted knowledge, as has been explained before. An interesting resource for common knowledge is collected by thousands of people in their work on wikipedia. Current research of the A.I. group is thus focussing on accessing this huge ressource and thus broadening the range of topics the agent is able to talk about.

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References

Becker, C., Kopp, S., and Wachsmuth, I. (2004), "Simulating the emotion dynamics of a multimodal conversational agent", in E. André et al. (Eds.): *Affective Dialogue Systems* (pp. 154-165). Berlin: Springer (LNAI 3068).

Cassell, J., Sullivan, J. and Churchill, E. (2000), *Embodied Conversational Agents*, MIT Press.

De Angeli, A. and Branham, S. (2008), "I hate you! Disinhibition with virtual partners", in *Interacting with Computers* Volume 20 Issue 3 (pp. 302 – 310).

Heinz Nixdorf MuseumsForum (2001), *Computer.Gehirn*, Paderborn: Schöningh.

Heinz Nixdorf MuseumsForum (1999), *Museum Guide*, Paderborn: Verlag HNF – Heinz Nixdorf MuseumsForum.

Jörding, T. and Wachsmuth, I. (1996), "An Anthropomorphic Agent for the Use of Spatial Language", *Proceedings of ECAI'96-Workshop Representation and Processing of Spatial Expressions* (pp. 41-53), Budapest.

Jung, B. and Kopp, S. (2003), "FlurMax: An Interactive Virtual Agent for Entertaining Visitors in a Hallway", in T. Rist et al (eds.): *Intelligent Virtual Agents. 4th International Workshop*, Springer, LNCS 2792.

Kramer, N., Simons, N. and Kopp, S. (2007), "The effects of an embodied conversational agent´s nonverbal behavior on user´s evaluation and behavioral mimicry", in *Proc. of Intelligent Virtual Agents 2007* (pp. 238-251), Berlin/Heidelberg: Springer-Verlag.

Kopp, S. and Jung, B. (2000), "An Anthropomorphic Assistant for Virtual Assembly: Max", *Working Notes Workshop Communicative Agents in Intelligent Virtual Environments*, Autonomous Agents 2000.

Kopp, S., Gesellensetter, L., Krämer, N., and Wachsmuth, I. (2005), "A conversational agent as museum guide – design and evaluation of a real-world application", in Panayiotopoulos et al. (eds.): *Intelligent Virtual Agents* (pp. 329-343), Berlin: Springer-Verlag (LNAI 3661).

Von der Putten, A., Reipen, C., Wiedmann, A., Kopp, S. and Kramer, N. (2008), "Comparing emotional vs. envelope feedback for ECAs", in *Proc. of Intelligent Virtual Agents 2008 (*pp. 550-551), Berlin/Heidelberg: Springer-Verlag.

Weizenbaum, J. (1996), "ELIZA: a computer program for the study of natural language communication between men and machines", *Communications of the ACM*, vol.9.