The Cognitive Interaction Toolkit – Improving Reproducibility of Robotic Systems Experiments

CITEC COR-Lab

Florian Lier, Johannes Wienke, Arne Nordmann, Sven Wachsmuth and Sebastian Wrede

Online version of this poster including all video material

1 CURRENT STATE

- Research on autonomous robots achieved considerable progress over the recent years.
- Reported results are **typically** validated through experimental evaluation or demonstrated live at robotics competitions. [DARPA GRC, RoboCup, RockIn]
- Amongst other reasons, this is due to: „off-the-shelf" robots [NAO, iCub, Baxter] and vivid open source communities providing reusable building blocks, e.g. ROS, Orocos, OPRoS, ...
- Publicly available data sets are used to improve benchmarking procedures, i.e., Rawseeds Project. [1]

2 PROBLEM STATEMENT

»Numerous studies have been performed over the past 15 years, but one of the hallmarks of science has yet to be achieved: results at present are hardly ever reproducible by other research groups.« [2]

- Methodological issues that prevent reproducibility of robotic system experiments. [3]
- This includes the frequently neglected impact on experiments caused by the relationship between individual components and the whole system – in component-based systems for instance.
- Question: **how** do publications need to be **written** and **published** in order to improve reproducibility?

3 IDENTIFIED ISSUES

- **Information retrieval and aggregation:** artifacts are often distributed over different locations, thus already the discovery, identification and aggregation of all required artifacts is difficult.
- **Semantic relationships:** which specific versions (master or 1.33.7) of software components were in use for a particular study?
- **Software deployment:** Most current systems are realized using a component-based architecture. They do not necessarily use of the same build infrastructure CMake, Catkin, maven, etc., binary deployment mechanism and execution environment.
- **Experiment testing, execution and evaluation:** Advanced robotics experiments require significant efforts spent on system development, integration testing, execution, evaluation and preservation of results. This is particular costly if many of these tasks are carried out manually. Crucial run time parameters and component configurations are often omitted or not documented properly.

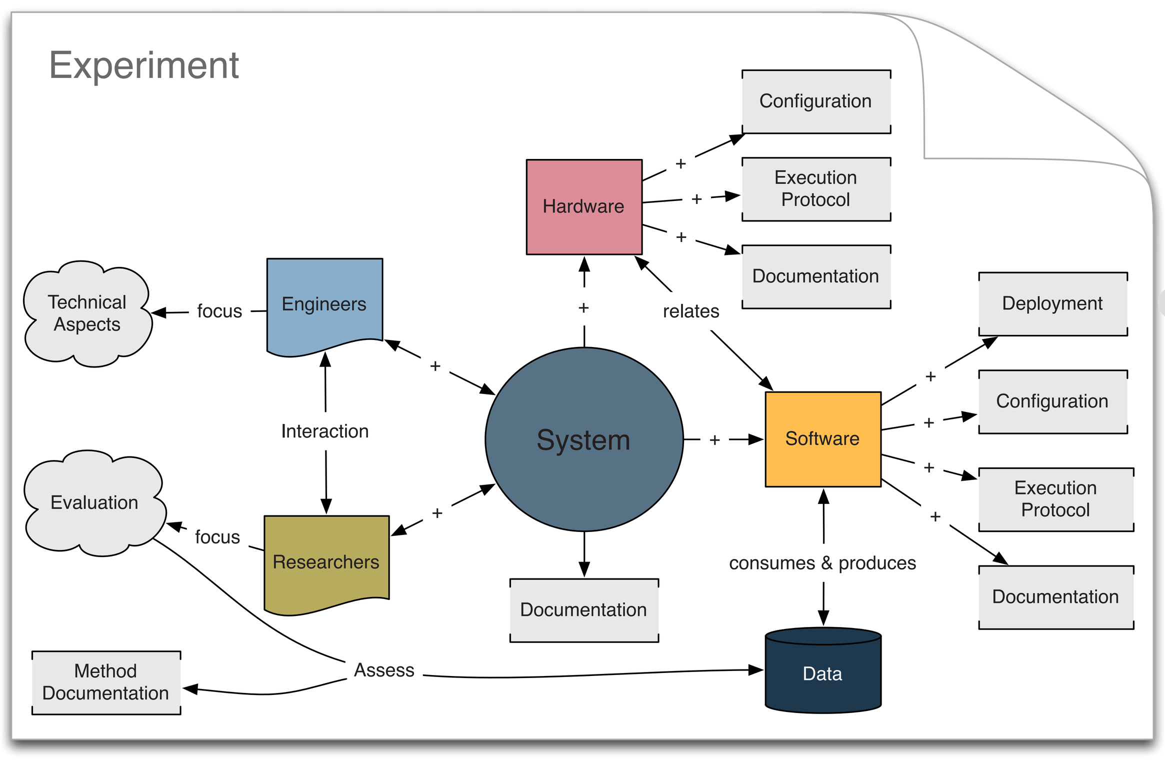
4 GOAL

To tackle these issues we introduce an approach for reproducible robotics experimentation based on an **integrated** software **toolchain** for system developers and experiment designers.

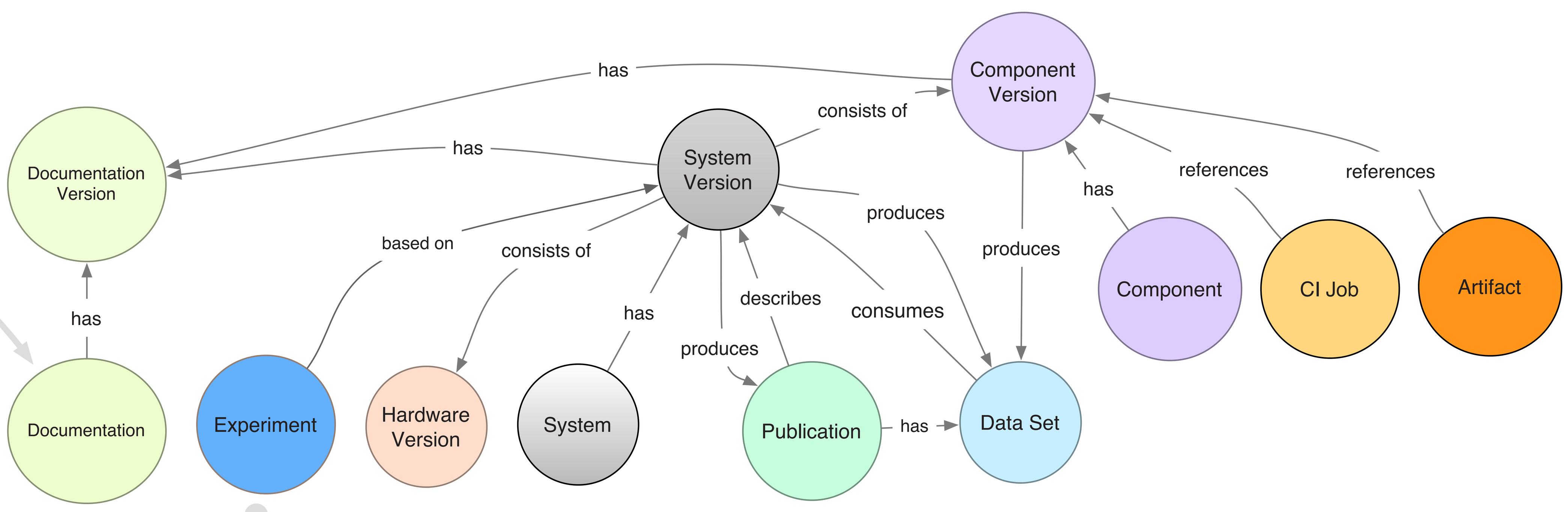
https://toolkit.cit-ec.uni-bielefeld.de

APPROACH:

5 IDENTIFY ARTIFACTS



6 DERIVE DATA MODEL



7 INFORMATION RETRIEVAL

- We developed a web-based **catalog** for robotics systems. It enables researchers to browse and search for software components or complete systems and their related artifacts like publications and provides them with the necessary information for experiment reproduction, it hence reflects our data model.
- The catalog provides information in human readable form (HTML) and machine interpretable form (RDF) and is entity-based.
- Catalog content can be either created manually through web forms or automatically using the REST **client API** written in Python.

8 SEMANTIC RELATIONSHIPS

- In the web-based catalog, according to our data model, systems are specifically modelled as **system versions.**
- All required artifact versions are **linked** to a specific system version (aggregation)
- Content (entities) in the catalog can be reused. Thus, a component version can be linked to multiple system versions, if applicable. This is also working with publications, data sets, documentation, tutorials, **experiments**, hardware, etc.
- The general approach for creating entities in the catalog is "rather importing than redundant manual creation". As an example, the "health" status of a software component is automatically retrieved from our Continuous Integration service.

9 SOFTWARE DEPLOYMENT

- While the data model of the web-based catalog already describes the composition of system components and related artifacts, it lacks information on how to **technically reproduce** a referenced version of a system.
- CITK addresses the aforementioned issues by applying a **generator-based** solution. A newly implemented generator uses minimalistic descriptions of the diverse software components that belong to a distribution and generates jobs for a **CI server**.
- From the descriptions, that augment our data model, and an automatic repository analysis the dependencies and required build steps are derived.
- As a result, we can use an established technology like the CI server for deploying **complete software systems** without knowledge duplication, which results in an improved maintainability.

10 EXPERIMENT TESTING AND EXECUTION

- Besides gathering information about a system and deploying it, a successful reproduction and interaction with the system also includes repeating tests and experiments.
- Unfortunately, experiment execution and testing are mostly carried out manually and are thus infrequent and prone to user induced errors.
- Thus, we suggest to convey the concept of an experiment protocol to the orchestration of software components involved in an experiment and to execute, test and evaluate software intensive experiments in an automated manner.
- For this purpose, we introduce FSMT, a software tool that implements the afore mentioned suggestions based on finite state machines that define the experiment execution. FSMT supports automated bootstrapping, evaluation and shutdown of a software system used in an experiment.

References

[1] A. Bonarini et al. RAWSEEDS: Robotics advancement through web- publishing of sensorial and elaborated extensive data sets. In IROS'06 Work- shop on Benchmarks in Robotics Research, volume 6, 2006.
[2] K. Dautenhahn. Methodology and themes of human-robot interaction: a growing research field. International Journal of Advanced Robotic Systems, 2007.
[3] F. Bonsignorio, J. Hallam, and A. del Pobil. Defining the requisites of a replicable robotics experiment. In RSS2009 Workshop on Good Experimental Methodologies in Robotics, 2009.

Affiliation

Florian Lier, Johannes Wienke, Arne Nordmann, Sven Wachsmuth and Sebastian Wrede are with Cognitive Interaction Technology — Center of Excellence, Bielefeld University (www.cit-ec.de)
Johannes Wienke, Arne Nordmann and Sebastian Wrede are also with
The Research Institute for Cognition and Robotics — CoR-Lab (www.cor-lab.de)