

Towards a Framework for Sensor-based Research and Development Platform for Critical, Socio-technical Systems

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1 Motivation

The complexity of critical systems, in which failures can either endanger human life or cause drastic economic losses, has dramatically increased over the last decades. More and more critical systems involve into so-called “socio-technical systems”: humans are integrated by providing and assessing information and by making decisions in otherwise semi-autonomous systems. Such systems depend heavily on situational awareness, which is obtained by processing data from multiple, heterogenous sensors: raw sensor data is cleansed and filtered to obtain features or events, which are combined, enriched and interpreted to reach higher semantical levels, relevant for system decisions.

Existing systems which use sensor data fusion often require an a-priori configuration which can not be changed while the system is running, or require a human intervention to adapt to changed sensor sources, and provide no run-time-extensibility for new sensor types [HT08]. In addition, analysis of data quality or query plan reliability is often not possible and management of recorded data frequently is done by hand.

Our goal is to support the research, development, evaluation, and demonstration of such systems. Thus, in the proposed talk we analyze requirements and challenges for the data management of sensor based research environments, and we propose a data stream based architecture which fulfills these requirements.

2 Challenges and Requirements

To support the research, development, test, and demonstration of sensor-based, critical applications, we plan to address the following challenges and requirements:

- Changing sensor configurations: during research and development, the sensor configuration might change often. In addition, when sensor data is delivered from moving objects, the available sensor sources may change during runtime.
- Information quality: since sensors do not deliver exact data, quality aspects needs to be considered at all levels of processing.

- Validation of data management: since the sensor data processing is a vital part of the system, it should be validatable and deterministic.
- Reproducibility of experiments and tests, intelligent archiving: in the process of research, development and test, application sensor-data and additional data for ground-truth (e.g., video-streams) needs to be archived and replayable.
- Integration with simulation environments: before such systems are deployed in the real, they need to be modeled and analyzed in various simulation tools. The transition from pure simulation to pure real-world execution should be easy.

In the project, we plan to address these challenges by a modular, extensible and comprehensive framework. While these challenges are similar to other data analysis and integration scenarios, they have to be addressed under the specific constraints of limited maritime communication channels and data standards.

The main contribution will be a combined solution that addresses these challenges in a unified framework. This is why we will base our work on the Odysseus [AGGM12] framework: it has a clear formal foundation based on [K08] and is designed for extensibility, using the OSGI service platform. Odysseus offers bundles for data integration, mining, storage and data quality representation, and allows installation and updates of bundles without restarting the system, which leads to a high flexibility and run-time adaptability. The framework will offer a unified sensor access and data fusion approach which allows a flexible use of the platform for the transition from simulation to real-world applications, reducing the expenditure of time for research and development.

3 Outlook

The framework will be used in two scenarios, which is a research port for analysis of sensor-based support for port navigation, and driver state observations for cooperative, semi-autonomous driving applications. Further, we plan to explore that approach in other projects, covering cooperative e-navigation and smart city applications.

References

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