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A Toolchain for Big Data Analyses in the Intelligent Cognitive Operating Room

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Abstract. This project aims to evaluate existing big data infrastructures for their applicability in the operating room to support medical staff with context-sensitive systems. Requirements for the system design were generated. The project compares different data mining technologies, interfaces, and software system infrastructures with a focus on their usefulness in the peri-operative setting. The lambda architecture was chosen for the proposed system design, which will provide data for both postoperative analysis and real-time support during surgery.

Keywords. Context-aware operating room, surgical data science, cognitive OR

1. Introduction

Supporting medical staff in the intraoperative area is one of the objectives of computer-assisted surgery. Context-sensitive systems record the current situation in the operating room and can thus provide specific information to support the actors in an operating room in a targeted manner. To provide information, various data must be collected, stored, and managed. There is no common information systems infrastructure available to support such context-aware systems regarding data management and data processing.

The goal of this project is to evaluate existing big data infrastructures regarding their applicability in the operating room. The data management system shall support a situation recognition pipeline [1] and thus enable a context-aware operating room.

2. Methods

We first did literature research on intraoperative context-aware systems to generate the requirements for the system design and interviewed the researchers who built the existing context-aware system at Reutlingen University. Based on the derived requirements, we performed systematic literature research on data mining technologies, interfaces in the medical domain, and software system infrastructures with a focus on their applicability in a peri-operative setting.

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As architectural patterns, we analyzed the lambda and kappa architecture [2] which are dedicated to big data applications. As data storage, we compared data lakes and data warehouse architectures. Data processing frameworks like Map-Reduce [3], Spark, Flink, and others [4] as well as six NoSQL databases were analyzed regarding their applicability.

From those building blocks, a system design proposal was generated.

3. Results

High-level use cases are a) providing data for postoperative analysis (e.g. for surgical data science or for machine learning) and b) providing near-real-time data intra-operatively for context-aware support. Data will be provided via the standards DICOM (imaging), HL7, FHIR (patient data), or SDC (ieee 11073, surgical device data).

Due to the fact that it can be important in the intraoperative area to ensure both real-time data processing and the storage of a master data set, the lambda architecture was chosen. For our prototype, we selected the Apache Hadoop[2] framework, and data storage was realized as a data lake. Figure 1 shows, how surgical device data, e.g. an event generated by the OR light, will be transferred to the data management system.

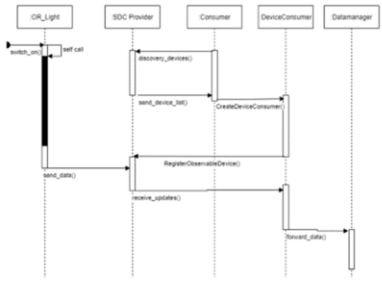

Figure 1. Sequence flow depicting how SDC data is transferred to the data management system (left) and mock operating room testbed for the system at Reutlingen University (right).

4. Discussion and Conclusion

We propose a system for the storage of peri-operative data for context-aware surgical assist systems. The next project step will be the evaluation in a real clinical setting after a successful evaluation in our mock operating room.

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