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A novel service-oriented software platform facilitating medical workflow assistance systems

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Newly developed imaging modalities, treatment strategies, and clinical instruments promise improved results and effectiveness but usually come at the cost of increased complexity with regard to the clinical workflow. Thus computer-assisted systems become increasingly important, providing support for the physician in its clinical research and routine. Researchers in the field of medical image processing are nowadays confronted with the task of tackling problems which require a wealth of software tools to be effectively worked on. Therefore, they rely heavily on software environments which allow to focus on the actual research task by providing commonly needed functionality like data handling and visualization. Due to the increased complexity of clinical workflows and related research problems, re-usability and interoperability of solutions in the form of software components becomes essential.

The main objective of this thesis was to design, implement, and evaluate a software platform which facilitates the creation of complex, workflow based assistance systems for clinical research.

In the following paragraphs, the main contributions of this thesis are summarized.

A novel service-oriented software platform

A requirements analysis and review of established technologies lead to the design and creation of the CTK Plugin Framework, a novel dynamic component system for C++ based on the OSGi specifications. It enables users to realize a service-oriented architecture and to create highly reusable software components, called bundles. In addition, two general purpose services were implemented. The Configuration Admin service handles persistent configuration data and the Event Admin service provides an publish-subscribe system to facilitate communication between otherwise unrelated services.

A rapid application development (RAD) framework

Based on the CTK Plugin Framework, a novel RAD framework called BlueBerry was introduced. It allows the creation of extensible application platforms, suitable for modeling clinical workflows.

A radio-frequency ablation assistance system

To evaluate the proposed platform with regard to creating assistance systems for complex clinical workflows, a radio-frequency ablation workflow assistance system was designed and implemented.

Performance tests showed that service operations using the novel C++ framework are equally or more efficient when compared to related Java implementations. The event handling system does not compare equally well but still provides more than enough performance for typically communication patterns in clinical workflows. Further, the dependency management system of versioned bundles inside the framework is not complete yet.

As an exemplary workflow, the radio-frequency ablation procedure was chosen. The realized assistance system for RFAs provides a simple interface but is nevertheless highly modular, adaptable, and extensible due to its service-oriented nature. It served as a proof-of-concept and evaluation tool for the introduced platform and at the same time is an example of best practices and design principles.

Designing individual workflow steps as reusable services demonstrated the dynamic and adaptable capabilities of the service-oriented approach. Usage of the Configuration Admin and Event Admin services allowed to keep the individual service interfaces simple and independent of each other.

In conclusion, the service-oriented platform presented in this thesis proved to be appropriate for mapping complex clinical workflows in extensible and flexible software-systems. Because of its open-source character, and thus its applicability for numerous future research projects the potential impact of the presented platform can be regarded as extremely high.