Model driven design of workflow schemata for the operating room of the future

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Abstract: Many assistance systems are available in modern operating rooms. These systems are poorly interconnected to each other and therefore cannot provide their information in a context sensitive manner. Those systems need to be considered as distributed systems when targeting the development of an workflow management systems to pilot the control flow between surgical assist systems. To achieve the best possible interaction between the systems the workflow management engine needs a reliable description of the underlying process. Because of the high variability of the surgical process a top-down approach cannot be used. In this article we describe a model driven approach to create a workflow schema out of a Surgical Process Model (SPM).

1 Introduction

In modern operating rooms a high variety of technical devices can be found. Each of these devices is made to assist the surgeon during his work by reducing complexity, operating with minimal invasive techniques, or to reduce the overall cost of the intervention. Most of these Systems are stand alone systems developed to provide specific functionality at a specific point in time or during a certain phase of the surgery. Therefore it is hardly possible to combine information from these systems on a single central display and in addition a redundancy of functionality could occur.

A common cooperation or the exchange of information between those systems is hardly realizable because of the lack of standardized interfaces or the missing overall coordination of the single devices [Gl05] [Cl05]. Surgical workflow management systems may support the surgeon by the means of requesting and displaying relevant information from other systems needed in the current work step.

In contrast to the administrative business world, were workflow management is highly established, the achievement of standardized business processes is not possible. This originates from the high variability of surgical processes due to patient individual characteristics, surgical skills, and the use of different surgical intervention techniques [Ne09]. This high variability eliminates the possibility of a top down modelling of the process such as is common in administrative business or rather leads to a process description on a rough detail level [JB08].

This article describes a method to inductively model a surgical process by using protocols of many patient individual surgical process models (SPM) of the same intervention.

Figure 1: Computer based assistance systems inside the OR

2 Model driven design of surgical workflow schemata

2.1 Recording of patient individual surgical process models

Models of surgical procedures courses were obtained by trained medical observers with the use of the Surgical Workflow Editor of the s.w.an-Suite[1], a software tool for the structured modelling of surgical processes. The Surgical Workflow Editor is a software tool for the structured acquisition of SPM data and was operated on a tablet PC by the observer. The workflow editor allows the user the creation of a detailed observation protocol by selecting relevant anatomical structure, surgical actions performed at the structure, involved resources, and the person who is carrying out the action (Figure 2). The accuracy of this method was validated in [Ne09]. It was shown that the result of the observation leads to accurate patient individual Surgical Process Models (iSPM).

[1] SWAN - Scientific Workflow Analysis GmbH; http://www.scientific-analysis.com

Figure 2: Surgical workflow editor interface

2.2 Generating generalized SPM from iSPMs

A sample of patient individual Surgical Process Models is used to create a generic Surgical Process Model (gSPM). To create a gSPM, the activities of the iSPMs are registered to each other. Subsequently, predecessor-successor relationships between activities are calculated as transitions, quantified and probabilities for subsequent activities are computed for each activity. The gSPM therefore is a statistically averaged model of many observations of the surgical intervention (cp. Figure 3).

Due to the inductive creation of a gSPM it is possible to face the high variability of surgical processes. The gSPM itself is a flowchart of all possible transitions between the process steps. With the use of a filter which cuts out the transition below a defined filter level it is possible to get a simplified, more generally accepted model of the surgical intervention. It has been shown in previous works that this cleanup can be performed and the resulting models still fulfill the requirements of the clinical guidelines of the intervention.

2.3 Transforming gSPM into workflow schemata

The availability of a valid gSPM is the main requirement for the successful generation of a workflow schema. A workflow schema is the representation of a process in a form that is process able by the underlying workflow management system [Aa03]. The workflow schema is required to control the workflow.

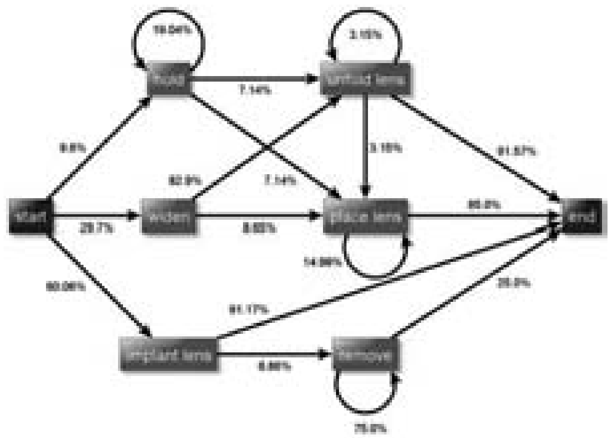

Figure 3: Example of a generic surgical process model

In our case the YAWL system[2] [Aa04] [AH05] was used as workflow management system. The gSPM resulting from the previous step is transformed in the petri-net based YAWL workflow language by converting the elements of the gSPM into the elements of the YAWL language. While petri-nets cover already quite a lot workflow patterns they lack of support for cancelation, XOR, or multiple instance patterns. YAWL was developed with the purpose to covering all available workflow patterns.

Subsequently the schema is loaded into the YAWL engine where a consistency check is performed. Figure 4 shows the workflow schema representation of the gSPM from Figure 3.

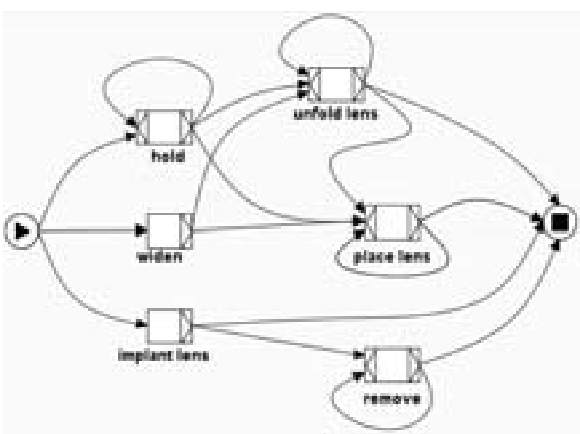

Figure 4: Example of a workflow schema for YAWL

[2] Yet Another Workflow Language

3. Summary and Outlook

To ensure a better quality in patient treatment and to increase the surgical efficiency in the context of increasing amount and complexity of computer based surgical assistance, workflow control could be the key technology to support the surgeon. The control has to be context sensitive and needs to consider the high variability of surgical interventions. A workflow management system that is located in the logical center of a distributed system design sets up the central theme of the intervention for all the other systems.

In future system design decisions the use of workflow management system, based on the modeling of workflow schemata described in this article, will be considered. The use of gSPM model as described in this article allocates a language neutral description of surgical processes. These descriptions can easily be transformed in almost any runtime language used by a workflow management system which was shown in example for YAWL.

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