An Intelligent Digital Assistant for Clinical Operating Rooms

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Abstract

We present an Intelligent Digital Assistant for Clinical Operating Rooms (IDACO), providing the surgeon assistance in many different situations before and during an ongoing surgery using natural spoken language. The speech interface enables the surgeon to focus on the operation while controlling the technical environment at the same time, without taking care of how to interact with the system. Furthermore, the system monitors the context of the surgery and controls several devices autonomously at the appropriate time.

1 Introduction

With the emergence of new technologies, the surgical working environment becomes increasingly complex and comprises many medical devices which have to be monitored and controlled. However, the operating personnel cannot be extended infinitely, which is why new strategies are needed for keeping the working environment manageable. Our goal is to develop an intelligent assistant for clinical operating rooms which allows speech-based interaction as speech is the modality used by the surgeon to communicate with their staff and therefore does not pose an additional mental burden if it is used to control surgical devices.

2 Functionalities

In order to increase productivity and reduce the workload for the operating staff, our system acts active-cooperatively and supports the surgeon autonomously during the surgery. IDACO escorts the surgery team throughout the entire procedure and provides assistance where necessary. The main functionalities of the presented speech-based assistant for a clinical operation room (OR) include:

- Providing data about surgery type, operating team, general patient data, pre-diseases, medical treatment and laboratory data
- Saving preferred device settings for each surgeon, reading and changing the pre-settings as well as transmitting the parameters to the OR devices (e.g. OR table, room light, insufflator, suction and irrigation unit)
- Automatically controlling surgical devices (e.g. starting the insufflator, increasing the gas insufflation, turning off and on the light, tilting the table)
- Tracking the usage of surgical material (e.g. trocars, different types of clips, suturing material) and warning if the usage differs from the predicted surgical workflow
- Emergency mode for unforeseen incidents during a surgery, which includes a ”silent option” to prevent further distractions by the system

3 Challenges

Enabling an intelligent operating assistance system to follow a surgery and control surgical devices automatically bears several challenges.

For keeping track of the procedure and automatically controlling surgical devices, the system needs to know when to perform which action on which device and when to stay in the background. Therefore, it has to be aware of the whole context of the surgery, i.e. the current point of the procedure and all past and future actions. This means that a reliable method for tracking the course of the surgery needs to be developed, thus allowing

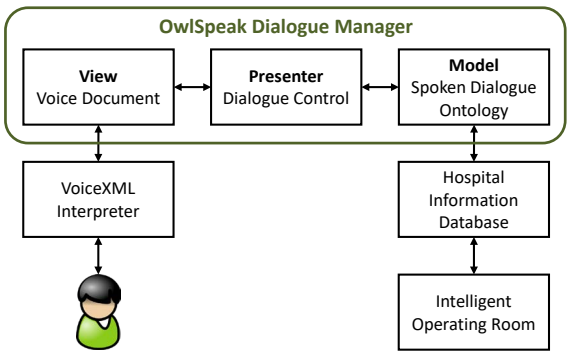

Figure 1: The overall architecture of IDACO comprising OwlSpeak, a VoiceXML interpreter and the connection to the clinical operating room.

to detect unscheduled events. Moreover, it has to be clearly defined how the system is supposed to react in tenuous situations. For this purpose, standardized surgeries need to be modelled in detail, allowing the system to compare the actual course of the procedure to the schedule (Feußner and Wilhelm, 2016). Using this medical domain knowledge, exact models of the complex surgery structure need to be created which are then applied to the voice interaction system. Additionally, an interface needs to be designed and implemented which allows intercommunication between the voice interaction system and the surgical devices as well as the clinical information system.

4 Implementation

For the implementation of our Intelligent Digital Assistant, we used the ontology-based Dialogue Management System OwlSpeak developed by Heinroth et al. (2010) and further extended by Ultes and Minker (2014). The overall architecture can be seen in Figure 1. As OwlSpeak provides a new VoiceXML document at each turn, a VoiceXML interpreter by Voxeo[1] has been integrated. Moreover, OwlSpeak has been connected to the Hospital Information Database which acts as the interface between the Dialogue Manager and the Intelligent Operating Room, thus allowing OwlSpeak to access necessary data and to control surgical devices.

As a first prototype, we modelled a laparoscopic cholecystectomy. Keeping track of the surgery is done by tracking the tool usage. Therefore, we introduced variables for all kinds of instruments and assistance actions. The system listens to each of the surgeon's instructions and increments the variables after each user utterance corresponding to its specific purpose. The workflow and hence the current part of the operation are then derived from the history of used tools at any point of the surgical intervention. The observed course of the procedure is compared to the surgery schedule which has been modelled in the Spoken Dialogue Ontology used by OwlSpeak. In case of a deviation from the schedule, the system reacts proactively and utters a warning. The surgeon can then correct the amount of used material or tell the system that the expected usage has to be adapted for the rest of the procedure. For the emergency mode, we introduced an Agenda[2] without any system move and only one possible user move which is the user giving the command to deactivate this mode.

5 Conclusion

We presented a speech-based assistant for clinical operating rooms allowing the surgeon to focus on the surgery while controlling the OR devices at the same time. The system monitors the usage of surgical material, infers the current part of the ongoing operation and escorts the surgery team throughout the procedure. Moreover, IDACO acts proactively and supports the surgeon autonomously during the surgery. This reduces the workload for the surgical team in order to allow them to fully focus on the actual surgical procedure as well as the amount of staff needed to assist during an operation and promises to lessen the rate of avoidable incidents caused by human error.

References

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Stefan Ultes and Wolfgang Minker. 2014. Managing adaptive spoken dialogue for intelligent environments. *Journal of Ambient Intelligence and Smart Environments*, 6(5):523–539.

[1] https://evolution.voxeo.com/

[2] Concept used by OwlSpeak to bundle several moves that belong to a specific dialogue turn (Ultes and Minker, 2014).