# Focus shift analysis in the operating theatre

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**ABSTRACT**
In this paper I will describe my findings from studying during last year the use of information technology in operating theatres. Based on these findings I will present focus shift analysis as a method for analyzing complex interaction, and discuss how the use of speech commands within the operating theatre are able to address some of the breakdown found with the focus shift analysis.

**Author Keywords**
Focus shift analysis, operating theatre, speech commands, pervasive computing.

**ACM Classification Keywords**
H.5.3 Group and Organization Interfaces

**INTRODUCTION**
When you first enter an operating theatre you will realize that you have indeed entered into a pervasive computing environment filled with monitors, computers and electronic black boxes showing different displays. Some hard constraints are imposed on the interaction with this pervasive environment. The central person in this setting is the main surgeon and s/he has to remain sterile during the whole operation, close to the patient and sometimes the interaction is life critical.

Based on a large set of observations within the operating theatre I have found that the devices in the operating theatre are subdivided into three main regions and that the main surgeon is only able to interact with a small subset of these devices. I will use focus shift analyse to analyse the interaction and suggest that small breakdown can be the reason for the lack of interaction between the surgeon and the many devices present. Finally I will show how speech commands can be used to address some of the issues brought up by the focus shift analysis.

**FIELD STUDIES**
Last year I carried out field studies at different hospital departments in Denmark. In total, I followed doctors and nurses around for more than 20 full days and observed more than 15 operations at different departments such as plastic surgery, orthopedic surgery and obstetric surgery. I focused on two things. First of all I wanted to study interruptions and cooperation amongst clinicians [1], and secondly I wanted to study interaction with technology within the operating theatre.

Many studies have been conducted within the operating theatre studying the social interaction between the different actors present [6, 10]. However, in my studies I wanted to focus on the interaction with the different technologies used in the operating theatre.

I was surprised to se the huge amount of technology present in the operating theatre, and at the same time lack of use of information technology during the operation. I was curious about the reason for this observation, and I started to address it by first looking at the layout of the operating theatre.

**Layout of the operating theatre**
The operating theatres I studied were full of displays, controls and buttons to operate different machineries distributed around the space. In the following I divide the different interfaces according to how they were situated and used within the space.

**Figure 1. The main control wall**

First of all, what I will call *the main control wall* was situated on one of the walls in the operating theatre. This wall typically consisted of a computer running the electronic patient record (or the patient record in paper

format where no electronic record was implemented), different phones, a backlighted display to show x-ray images and a lot of papers containing different procedures and phone numbers. The people present during the operations I studied were; a non-sterile nurse, a sterile nurse, an anaesthetist, a surgeon and in many cases also an assisting surgeon. Of these people only the non-sterile nurse used *the main control wall*. In one case, the surgeon moved from the operating table to *the main control wall* to inspect an x-ray image brought by a colleague and in some cases the anaesthetist moved from the patient to the main control wall to enter some information in the electronic patient record. However, in both cases the surgeon and the anaesthetist mentioned the problem of moving away from the patient. Figure 1 shows the *main control wall.*

**Figure 2. The control screen**

The second interface group, I will call *the control screen,* was a set of controls and displays all placed around the anaesthetist. The displays showed life critical data about the patient, like blood pressure and the amount of air inhaled and exhaled. The controls allowed the anaesthetist to e.g. adjust the mixture of gas given to the patient. The control screen was only used by the anaesthetist. *The control screen* is shown in figure 2.

**Figure 3. The mobile control setting**

The third and last kind of interface group, I call *the mobile control setting,* consisted of a lot of displays and controls positioned around the surgeon that allowed the surgeon to view the displays without having to move away from the patient. The surgeon was also able to interact with this mobile control setting by using a foot pedal or a special sterile handle e.g. placed on the operating lamp. However, in most cases the surgeon had to ask the non-sterile nurse to operate the controls. Mainly the surgeons, and sometimes the sterile nurse, used the information on the displays. However, the non-sterile nurse was almost the only person who was able to interact with these displays.

*The mobile control setting* differed a lot from operation to operation; examples are displays showing pictures from endoscopic operation; devices for controlling the burner used to burn blood vessels; and in some cases manuals about how to use a specific advanced instrument. *The mobile control setting* was placed during the pre-operating phase [10].

The interaction within the operating theatre seemed to be divided into the above three interaction groups. The main surgeon used almost only the information displayed at the mobile control setting and s/he was not able to interact with the information here without the help of the non-sterile nurse. The lack of an easy way for the surgeon to interact with the different devices present seemed to be a hindrance for the use of information technology in the operating theatre. One of the big problems seemed to be that each time the surgeon interacted with a device s/he had to move her/his focus. To further investigate this proposal I started recording which area the surgeon focused on.

## FOCUS ANALYSIS

Bødker has previously used focus shifts to analyse the interaction with desktop application [4]. Bødker's main interest was, based on activity theory, to identify focus shifts and evaluate if they were intended or if the shifts were the result of a breakdown. I wanted to pursue the same method and identify if some of the focus shifts in the operating theatre were the results of breakdown.

To further analyse focus shifts Lafon's notion of 'degree of indirection' was used [2]. Lafon analyzed desktop interfaces, and he used the 'degree of indirection' to describe the distance between the object of interest and the instrument used to manipulate the object of interest. He distinguished between temporal and spatial offset. That is, he made a distinction between distance in time and distance in space between the interaction instrument and the object of interest.

Inspired by the term 'degree of indirection' I used the same division between temporal and spatial offset to analyze the interaction in the operating theatre. How long did it take from the moment the surgeon wanted to carry out a command until it was actually done? How far did the surgeon have to move his focus to find the information s/he was interested in? In some of the observed situation the surgeon had to move away from the patient to focus on a new area. To take these cases into account I will subdivide the spatial offset into *the focus spatial offset* and *the movement spatial offset*. If the surgeon is able to see the new focus area by moving his eyes or his head I will talk about *the focus spatial offset.* However, if the surgeon has to move his/her body to get to the new focus area I will call it *the movement spatial offset*.

Law and others have used eye tracking to look at the difference in focus shifting between novices and experts when doing laparoscopic surgery [7]. Boedker used video to analyze focus shifts in different applications. I was not allowed to use video during the operations I observed so instead I started recording the areas the main surgeon focused at. Figure 4 shows a simplified overview of some of the focus area found in the operating theatre.

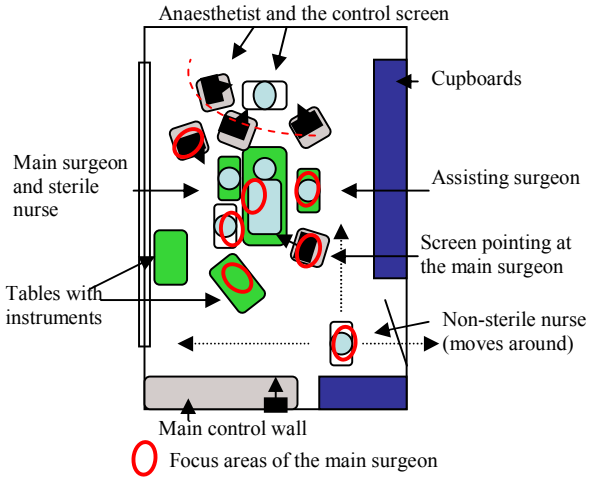


**Figure 4. Focus areas within the operating theatre**

When operating the surgeon's focus was on the object s/he was operating on. However, during the operation s/he had to use a lot of different tools, and sometimes the object s/he was operating on was only visible on a screen, if for instance the operation was endoscopic (done through a telescope). The sterile nurse was responsible for finding the right instrument and giving it to the surgeon, thereby preventing the surgeon to switch focus from the area of the operation to the table with the instruments.

If the sterile nurse and the surgeon had been working together for a while the sterile nurse was able to hand the right instruments to the surgeon without the surgeon even having to ask. This greatly reduce the spatial focus offset, however in some cases the surgeon did switch focus to either the nurse or the table with the instruments on to check for instance which instruments were available.

The situation was however different with electric instruments because a lot of parameters were adjustable. These parameters were adjusted by pressing different buttons. Only the non-sterile nurse was able to push these buttons as they were not sterile. The non-sterile nurse also had other responsibilities like entering information into the patient record, fetching new supplies of instruments. This meant that s/he moved around in the operating theatre during the operation.

The result was that each time a surgeon needed to adjust an electric instrument s/he first had to locate the non-sterile nurse in the operating theatre before giving the command to the nurse. This resulted often in a large both focus spatial offset and temporal offset in trying to locate the nurse. And sometimes the nurse was not even in the operating theatre which further increased the temporal offset.

A lot of other focus shifts were observed e.g. when the surgeon tried to relocate the foot pedal under the operating table, or when s/he had to look at displays not situated in front of her/him. The biggest shift in focus however, was observed in situations where the surgeon had to move from his position by the operating table to *the main control wall* to, for instance, inspect some x-ray pictures. In this case there were a movement spatial offset between the surgeon and the x-ray pictures.

In the cases where either the temporal offset or the focus spatial offset were large a breakdown in the surgeon's task could be identified. It was especially clear in the cases where there were a movement spatial offset.

In following I will discuss how the use of different interaction techniques can address some of the breakdown observed with focus shift analysis. Several researches have done experiments with digital overlays superimposed on the patients [5, 9]. I will argue that these techniques reduced the focus spatial offset. In the following I will however discuss how the use of speech navigation also can be used to reduce both the spatial and the temporal offset.

## SPEECH COMMANDS

A hospital in Denmark had recently introduced a new system in some of their operating theatres that allowed the main surgeon to control different devices with speech commands. It was possible to use speech to control e.g. the speed of the electronic knife, different cameras and other equipment. I went to this hospital and studied several operations conducted in this operating theatre and interviewed the main surgeon.

Speech interfaces are discussed by Mynatt, who argues for constructing explicit hierarchical models for navigation [11]. However others have argued for a more relaxed version where all the commands are not necessarily hierarchically structured [8]. In the operating theatre I studied all commands were hierarchically structured. The surgeon we observed was experienced in using the system and was able to really fast navigate to the right command.

One of my findings during these studies was that speech greatly reduced both the focus spatial offset and the temporal offset. The surgeon I interviewed said that with speech navigation he did not have to look around the operation theatre to locate the non-sterile nurse, which was a huge advantage because he could keep his focus on the operation.

Bellotti discusses some issues concerning sensor interfaces like speech, for instance how to address the system and how to know you have the system's attention [3]. With the system I studied a keyword was used to address the system,

and feedback about the system's state was given as an overlay on the screen right in front of the surgeon. By giving the feedback from the system either as computer generated speech or as layout on the screen the focus spatial offset was reduced and some of the challenges put forward by Bellotti addressed.

## CONCLUSIONS AND FUTURE WORK

Studies of the operating theatres have shown a space full of pervasive computers. I have divided this space into three distinct regions: *The control wall*, *the control screen* and *the mobile control setting* and addressed some issues with this division. I have used focus analysis to identify possible breakdown in the interaction between the main surgeon and some of the devices present in the operating theatre. Based on the observed breakdown I have studied the use of speech navigation and suggested that some of the breakdown observed can be addressed with speech technology.

One of the issues I would like to explore further is the large movement spatial offset that exists between the surgeon and the control wall. The control wall was used for documenting the operation and communicating with people outside the operating room. In the speech enabling operating theatre the surgeon used speech to take pictures and hereby document the operation. I would like to explore if more of the control wall's functions can be made available to the main surgeon.


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