Large Interactive Displays in Hospitals – Motivation, Examples, and Challenges

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ABSTRACT

In this paper we reflect on our research into the design and deployment of large interactive displays in hospitals. First, we introduce lessons from studies of the use of large displays to coordinate hospital work in a hectic and critical work environment. Then we present some of our current research, especially focusing on our current design of large displays at an operating ward in a large Danish hospital. Finally, based on our research and experiences we discuss some of the challenges that we find in the design and deployment of large interactive displays in hospitals.

1. LARGE DISPLAY SURFACES IN HOSPITALS

Large display surfaces, like whiteboards and notice boards, are absolutely crucial in achieving work in a modern hospital [1, 8, 7, 9, 2]. In a recent interview, the managing physician of a large Danish hospital stated that the best way to make a modern hospital come to a complete halt is to remove all whiteboards – then everything would be chaotic. In light of these observations, it is particular interesting to observe that the deploying of electronic health records (EHRs) and scheduling and booking systems in Denmark and other countries has the consequence that what once used to be large visible information, displayed on large whiteboards is now being restricted to 17 inch monitors. Are we in the process of fulfilling the prophecy of the hospital manager?

Whiteboards in hospitals play a core coordinative role. For example, in an operating ward the operating schedule is often displayed on a large whiteboard which is clearly visible for all personnel (see figure 1[1]). Some of the core roles of such large display surfaces in hospitals can be summarized to:

Visibility – the main reason for using e.g. whiteboards and other large wall mounted boards in hospitals is clearly their visibility to relevant personnel. They are situated in places where clinicians often come by and where information related to the information shown on the display is available. The typical whiteboard for operation scheduling (e.g. the one in figure 1) is situated in the so-called

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[1]The picture and the work setting is further described in [1].

Figure 1: The operation schedule on a large operating ward. The schedule contains information on operation room number, scheduled time, ward, patient name and social security number, type of operation, involved personnel, and notes.

'coordination room' which is located central on most operating wards. This is the central hub of coordination while the operations in the different operating rooms are executed and all involved personnel, from orderlies, assistants, operating nurses, and surgeons, constantly enter this room in order to coordinate their work with others.

Overview – large displays at hospital is designed to provide an overview of the flow of work. Detailed information is often extracted, summarized, and abbreviated in the transfer from information sources to the boards. This means that these boards often contain a concentrated distillation of highly detailed information. In figure 1 the surgical procedure, names, notes, and status information is highly condensed and it takes a skilled clinicians to read and interpret the boards.

Status – the displays are designed to reveal important status information concerning the flow of work. This status information is, however, often very subtle and not visible to the trained eye. In figure 1, for example, status information is revealed by small marking on the left-hand side of the board, using signs like '–', '!', 'X', 'O', and similar symbols (see also [1, 9]).

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Coordination – Status information is central in order to ensure a smooth flow of work in hospitals – a common observation is that all personnel rely on these status markers by peeping into the coordination room, checking the status, drawing their own conclusion with regard to their own work, and silently carry on. For example, the surgeon will regularly monitor the board to look for the sign indicating that the patient is asleep and ready for the surgical procedure. Often the surgeon will not enter the operating room before this status has been marked at the board.

Communication – In addition to the silent kind of coordination described above, boards in hospitals are also used for more explicit communication. In these instances, the boards are used as message or bulletin boards. However, it is important to realize that most boards in hospitals are not general purpose bulletin boards (even though they of course also exist) but are specialized boards (like the operating schedule in figure 1) where short, concise messages are written or attached to specific items on the boards. Hence, communication is tightly linked to a specific clinical context like a surgical procedure on a specific patient.

Contingency management – Finally, in a critical environment like a hospital, the large display boards are used for handling acute situations, crises, and general contingencies occurring during e.g. surgical procedures. Even though clinicians prepare very carefully for each procedure, and much effort is made to foresee any kind of potential problems, problems and acute situations do occur. Clinicians know this and they are always prepared for handling such situations. Large boards often play an important role in conveying information to others that a crisis has occurred, that surgical procedures are delayed and the reason why, and who is in charge of solving the problem. Often information on a whiteboard is re-arranged to reflect the management of such contingent situations. In figure 1, for example, crisis situations are made with special signs and acute patients are highlighted using a special color code.

The presentation above only gives a glimpse of the complexity of the use of large displays and boards in hospitals, but we hope that we have been able to provide the reader with a minimal understanding of the core role that these displays play in a hospital - an understanding which is crucial in our design of computer technology for hospitals, which we shall turn to now.

2. AWAREMEDIA

AwareMedia is a combined media space and scheduling application which is designed to help clinicians coordinate work at a surgical department. More specifically, AwareMedia has two overall design goals:

- To provide all personnel involved in operations in the ward with a social awareness of each other, an awareness of the activity taking place in the different operating rooms, and an awareness of the individual operations taking place in them. We call this the *spatial overview*

because it is tied to the operating room as a place.

- To provide a schedule of the expected unfolding of the work on the operating ward much like the one illustrated in figure 1. We call this the *temporal overview* because it is tied to the unfolding of activities in time, i.e. the operation schedule.

The main design hypothesis is that the combined overview of place and time will help clinicians be more efficient in the coordination of work, including handling contingent and critical situations. Especially, we want to get information stored in clinical booking and scheduling systems 'back on the wall' by designing a large interactive display technology which pay due respect to our research findings as discussed above.

AwareMedia is build on top of the AWARE architecture [3] and the user interface of AwareMedia is illustrated in figure 2. The right-hand frame contains an overview of an operating room. The top part gives the spatial overview by showing a video link into the room, a status indication, and a list of personnel currently in the room. Below this there is a operation room chat used for communication. Further below the operation schedule provides the temporal overview by showing past, ongoing, and scheduled operations with assigned personnel. The current location and activity of each scheduled personnel is also revealed, which provided an overview 'into the future'. The left-hand frame provides a spatial overview of the coordination room and the coffee room. The lower frames on the left provides an overview of all personnel at work.

The AwareMedia is a working prototype that is currently being deployed in a three month pilot study in the operating ward a local hospital.

3. CHALLENGES

Based on our design and deployment of large interactive surfaces in hospitals we are facing a number of challenges which we shortly want to address and discuss in the remainder of this position paper. Some of these challenges may be specific to hospitals, but we think that many of them also may apply to other application domains, and we hope that this may help span a fruitful discussion at the workshop.

3.1 Privacy in Public Displays

The whole purpose of making public displays is to make information publicly available. However, patient data and e.g. surgical procedures are highly sensitive data where privacy concerns are important. Furthermore, when using video streams from an operating room, we are exposing patients in the most vulnerable situation you can imagine. Hence, privacy is an important issue. There is, however, an inherent contradiction at stake here – how can we make private data publicly available? We cannot provide one answer to this challenge and we believe that it to a large degree depends on the concrete application and its deployment conditions. For example, in our current deployment of AwareMedia, the large displays are only visible from inside the coordination room which is only accessible by authorized personnel, and not by e.g. patients, relatives, or visitors. Furthermore, we do not broad-
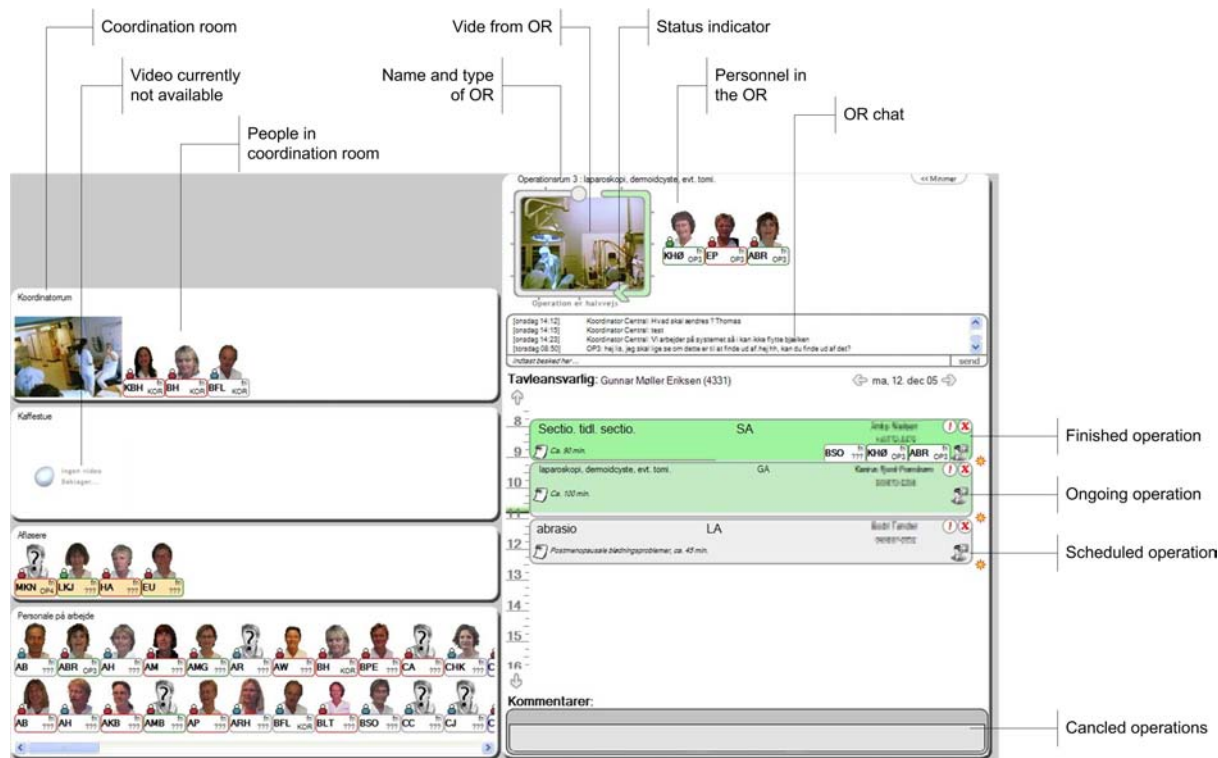
Figure 2: AwareMedia showing video connection between the different operating rooms, status information for an operation, and the operation schedule.

cast video outside the operation ward. However, we suspect that the rather primitive privacy mechanisms are insufficient and we hope to learn much more about how to design privacy mechanisms for public displays during our deployment. One idea currently being investigated is to allow for a *privacy token*, i.e. a small radio beacon, carried by a clinician or a patient, that sets a certain 'privacy level', like video on/off.

3.2 User Authentication and Accountability

According to Danish – and as far as we know international – legislation, personal user authentication is required to all clinical systems. This is to protect patients from having unauthorized personnel viewing their medical record and problems. The mundane example is that you can have a nosy neighbour who happens to be a medical doctor. This apply for both reading and changing medical data. In this respect, our current design of AwareMedia does not comply with the law. Neither does all the existing whiteboards on all hospitals around the world for that matter. Nevertheless, a core challenge in the design of large display surfaces in hospitals is to design a user authentication mechanism that does not compromise the core requirement of having information and data publicly visible. How can we know who is reading information off of the AwareMedia displays? One could imagine several solutions. Currently the AwareMedia uses location information and with a more accurate location tracking system we may be able to track and record who is within reading distance of the AwareMedia displays. This, however, seems like a poor solution since an adversary interesting in looking at information he or she is not authorized

to look at would just avoid using his or her location badge. Furthermore, this solution would not prevent unauthorized personnel to look at the information – the information is still visible. Other solutions like proximity-based user authentication [**?**] may be used to log in a person when approaching the display. Then, however, the whole idea of having central coordination information publicly available at all time, suddenly seems to disappear. So far, our best solution is to do like the analogue whiteboards today – to not comply exactly with the legislation.

3.3 Multiple users and shared awareness displays

Being aware of something is a highly active process involving selection awareness information relevant for the tasks at hand [5, 4]. Building representations and displays shared by many users either at the same time or at different time involves a negotiation of what information is displayed on this display, how it is displayed, and who is allowed to interact with it. For example, the surgeons need one kind of awareness information (awareness information about when the patient is anaesthetized), the nurses working at the bed wards need to know when to prepare the next patient, and other groups want to include the cleaning of the operating theatre on the display to raise the overall awareness of this activity. In the current version of the system we have experimented with a compromise between different views by using user interface components to make the display easy to read by different professions. We have chosen an optimistic approach to editing the information which allow everyone to actually change the information on the display, but expect

social convention to regulate who actually change the information. However, building shared displays available to multiple users with different information needs is a challenge we hope to explore in greater details with AwareMedia.

3.4 Untouchable Interaction

Most available interactive displays and surfaces rely on touch technology. For example, SMART Technologies, Mimio pens, and the DiamondTable. However, in many clinical situations you cannot touch anything. Much effort is taking place at hospitals to prevent germs and bacteria to flourish, and they often try to avoid touching too many things during their work. Furthermore, surgeons and operating nurses need to be sterile and cannot touch anything – it would also leave a rather nasty display if they touched it during an operation. Therefore, new kinds of non-touch based interaction mechanisms are needed for large displays in hospitals, especially the ones located inside an operating room. We are currently investigating the use of multi-modal interaction combining speech, gestures, and other modalities into an interface for e.g. surgeons using large displays while operating [Reference to UbiComp, ActiveTheatre ?]. However, this is not at all trivial, and much research are needed in this direction in order to make such large public displays workable in daily clinical work where there is little time or mental surplus for interacting with computers. We would most certainly welcome any suggestions and discussion of research in this area at the workshop.

3.5 Supporting the Web of Artefacts

It is evident that large visible surfaces, like whiteboards, are central for the coordination of work in hospitals as already discussed above. In another paper [2] we have, however, argued that it is important to understand that these surfaces do not exist in isolation but are inherently bound up in a web of a wide range of auxiliary artefacts, like personal notes, the medical record, and post-it notes. Therefore, providing an overview at a large interactive display has to be designed with this web in mind, which often means that the information that is displayed at the larger surfaces reflects information coming from other sources, and that this information need to be accessible in other places as well.

In the AwareMedia setup we are yet to address these challenges more specifically. At the moment we do not integrate with the booking and scheduling system already in place at the hospital, which clearly is a prerequisite for real use. One thing we did, however, was to provide access to some of the awareness information using the AwarePhone [3] which means that the clinician can get access to the operation schedule and the awareness information about the individual operations and person via his mobile phone. This is one examples of extending AwareMedia into the web of artefacts in the hospital, but more is needed. Especially proving Aware-Media with a link to the electronic health record would be beneficial.

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