Social acceptance of Augmented Reality in a hospital setting

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Key words: Augmented Reality, Mixed Reality, Usability, Acceptance, user-centred design

Summary
This paper is a report on the results of a usability study where Augmented Reality (AR) was used for giving instructions on how to start up a diathermy apparatus (DA). The main question in focus was if the AR system would be accepted as part of the technological support by a user group consisting of professional medical personnel. It was found that all users but one could solve the task at hand when aided by the instructions given in the AR system. The interviewed responded that they preferred personal instructions from an experienced user, sometimes in combination with short, written instructions, but also that they appreciated the objective instructions given by the AR system. Despite the reported problems, the users were positive towards AR systems as a technology and as a tool for instructions in this setting. This indicates that AR could be part of a future training resource for new staff, which does not demand the time of a trained professional.

Introduction
Today, public healthcare in Sweden faces many challenges with ever increasing demand on a limited number of resources in the form of time, people and monetary resources. One demanding task in hospitals, and most other work places, is the training of new staff which can be a time, and people, consuming task. One way to approach this problem is to introduce new ways of training and giving instructions to new staff. The field of Mixed Reality (MR) technology (including Virtual Reality, VR, and Augmented Reality, AR) has the ability to allow for training and exercise in a less resource allocating manner. This paper discusses the use of an AR application for giving instructions in a hospital setting.

Avoiding decomposition – a joint systems perspective on usability
The field of AR differs from standard desktop applications in one crucial respect; it is intended to be used as a mediator or amplifier of human action in direct physical interaction with the surroundings. This implies that it is necessary to address usability issues in such systems from a different angle than traditional HCI. Originat-

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ing from cognitive psychology and information science, ‘traditional’ HCI has adapted a decomposed view of human and machines, separating the user from the tool he or she uses. A basic assumption in the information processing approach is that cognition is studied as something isolated in the mind. A problematic consequence with this approach is that most basic studies are/were performed in a laboratory setting, aiming at investigating the internal structures of cognition, not focusing on human action in an actual work context (Dekker & Hollnagel, 2004). The starting point has thus been issues of human perception, and cognitive abilities and limitations rather than the study of purposeful behaviour.

An approach suggested by Hollnagel & Woods, influenced by cybernetics, is ‘Cognitive systems engineering’ (CSE) (Hollnagel & Woods 1983, 2005). CSE even goes a step further and suggests that cognition should be defined from a functional perspective:

“Cognition is not defined as a psychological process, unique to humans, but as a characteristic of system performance, namely the ability to maintain control. Any system that can maintain control is therefore potentially cognitive or has cognition” (Hollnagel & Woods 2005).

According to this definition, the cognitive system can be comprised of a human and a computer, a human, a computer, a telephone and another human and so forth, where the human brings in the ‘natural cognition’ to the system and artefacts or technological systems may have ‘artificial cognition’. Hollnagel & Woods uses the notion “Joint Cognitive System” (JCS) to describe systems comprised of both human and technological components that strives to achieve certain goals or complete certain tasks (ibid.). A CSE approach to humans and the tools they use thus focus rather on what such a system does (function) rather than what is (structure). An important consequence of that perspective is that users should be studied when they perform meaningful tasks in their natural environments, meaning that the focus of a usability study should be user performance with a system rather than the interaction between the user and a system. A design should thus be evaluated based both on how users actually perform with a specific artefact, but also how they experience that they can solve the task with or without the artefact under study.

**Augmented Reality**

Azuma (1997) mentions three criteria that have to be fulfilled for a system to be classified as an AR system: they all combine the real and the virtual, they are supposedly interactive in real time (meaning that the user can interact with the system and get response from it without delay), and they are registered and aligned in three dimensions. AR applications can be found in diverse domains, such as medicine, military applications, entertainment and infotainment, technical support and industry applications, distance operation and geographic applications.

Technically, there are two principally different solutions for merging reality and virtuality in real time today – video see-through and optic see-through (Azuma
Optical see through is where the user has a head mounted see through optical display which allows the user to see the real world as if through a glass lens (see figure 1). The virtual information is then overlaid on the see-through display. This technique causes some problems since the virtual information has to compete with the surrounding light, which places great demands on the display capabilities (it can be compared with having to work with a computer screen in direct sunlight).

Fig 1: To the left, schematic picture of a video-see-through and to the right, a video see-through AR system (Gustafsson 2004, Nilsson and Johansson, 2006)

A way to overcome the problems with optic see through is by using a camera in front of the users’ eyes, and then projecting the camera image on a small display in front of the users’ eyes (Azuma 1997, Kiyokawa 2007). The virtual images are added to the real image before it is projected which solves the surrounding light problem as well as gives control over where the virtual objects are placed (see figure 1). This puts other demands on the system, as the transferring of the real image suffers from the lag determined by the camera image update frequency. The lag can have effect on the user experience of the system, such as simulator sickness.

Case study

To investigate user acceptance of an AR system a case study was conducted at a hospital. The focus of the case study was the user experience and acceptance of an AR system providing instructions on how to prepare a medical device for operation, a diathermy apparatus (DA). The study was conducted on site at a university hospital and involved eight participants, all employed at the hospital. Four of them had previous experience with the DA, and four did not. First the participants were interviewed about their experience and attitudes towards new technology and instructions for use. Then they were observed using the AR system, receiving instructions on how to start up the DA. After the task was completed they were again interviewed about the experience. The interviews, as well as the observation were digitally recorded and the participants’ view through the video-see-through AR system was also logged.
Equipment

The AR system in the study (see figure 3) includes a computer (Fujitsu Siemens Tablet™), a helmet mounted display (Sony Glasstron™) with a fire wire camera (Point Grey Research, Dragonfly™). A numpad (Targus™) was used for the interaction with the user. The AR system uses a hybrid tracking technology based on marker tracking (Nilsson and Johansson, 2006). The software includes an integrated set of software tools such as software for camera image capture, fiducial marker detection, computer graphics software and also software developed specifically for MR-application scenarios.

As stated above, the users were given instructions on how to activate a surgical diathermy apparatus, ERBE ICC-350 with associated instruments and electrodes. In general, diathermy is a physical therapy for deep heating of tissues with high frequency electrical current. The ERBE ICC 350™ diathermy apparatus is used for mono- or bipolar cutting and coagulating during invasive medical procedures (it can be seen in figure 4). The instructions were divided into two main steps; first status verification of the patient, secondly start up of the DA.

Figure 3: A participant in the study interacting with the DA through the helmet-mounted AR system.

Results and changes of the system

It was found that all users but one could solve the task at hand when aided by the instructions given in the AR system. The interviewed responded that they usually prefer personal instructions from an experienced user, sometimes in combination with short, written instructions, but also that they appreciated the objective instructions given by the AR system. The problems users reported on related both to the instructions given by the AR system and to the AR technology, such as problems with an unstable image etc. Despite the reported problems, the users were positive towards AR systems as a technology and as a tool for instructions in this setting. A
new hand-held AR system and a new head mounted AR system have been developed based on the comments from this study (see figure 4).

Figure 4: The head-mounted AR system currently used.

Discussion – Designing AR systems for real world applications

One aspect of the system is of course its physical appearance and bulkiness largely originating from its first application domain, namely military systems. Effects of the physical intrusion of the system upon the user’s normal task should not be ignored. Even if the system is lightweight and non-intrusive, it still may change the task and how it is performed.

One useful aspect of the technology is that the AR system first prompts the user to answer a set of important questions (about patient status). The user cannot go to the next set of instructions before these questions are answered which ensures that the user at least has had to think about the patient status before preparing the DA for operation. This kind of “forced” instructions is not possible with paper based manuals where the user simply can turn the page and ignore or overlook important questions. This issue illustrates an interesting aspect of the AR system, where responsibility for the welfare of the patient to some extent actually can be built in the system, helping the user/nurse to remember important questions that could have severe consequences should they be overlooked. However, the AR system, as reported above, in some sense replaces the interaction with peers, potentially disturbing an important part of the interactivity in the learning process. The interactivity is also reduced compared to interacting with a human; the system can only respond to a pre-defined set of situations. We therefore believe that AR should be seen as a complement to traditional, peer-based learning rather than as a replacement.

User acceptance and the importance of field tests

The social aspects play a vital role in the way a system is used and perceived. In the study described above, the AR system used was originally designed for military applications and not for hospital settings. As a result the helmet was experienced as not only clumsy, but also as something very foreign to the hospital staff. This naturally affect the way a user perceives and interacts with a system and is a good example of why we cannot simply take solutions from one context and expect them
to work in another. Even small user studies in actual work settings, like the one described above, are rare in the field of AR and it is the belief of the authors that this largely can be ascribed to the design methods commonly used within the field. Confronting a design for a new technology with tasks from real work rather than laboratory settings allow problems that otherwise would remain unknown to emerge. A product like the DA represents an actual tool used for a high-risk task by skilled professionals and is clearly a case where improved functionality in terms of instructions is beneficial. Testing the concept of providing AR instructions together with such an apparatus in real-world settings thus reveal the pros and cons of a design. The system, regardless of appearance, does affect the social context of the task simply by being introduced as a new element. However, this may not be a problem in the long run – if the system has a positive influence on the task, user and context, it will with time and experience grow to be a part of the task. This should be true for AR as it has been true for other technologies; for instance the use of computers for writing papers – few students and researchers today can image writing papers without the cut-and-paste functionalities of word processors. In the same way, instructions through AR technology have the potential to become a natural part of everyday life in many domains. Cognitive Systems Engineering provides a way to study and think about AR systems as joint cognitive systems acting in a goal oriented and adaptive way in the world. These fundamental aspects are lacking in most other perspectives where interaction mostly is studied on a micro-level.

**Literature**


