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"Augmented Reality as a tool to achieve common ground for network based operations"

Topics: Cognitive and Social Issues, Collaborate Technologies for Network-Centric Operations, Civil-Military Endeavors, Multinational Endeavors

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Augmented Reality as a Tool to Achieve Common Ground for Network based Operations

Abstract

In complex collaborative situations, such as crisis management, actors from different domains and organizations must work together. This is especially evident in network based operations where virtually anyone in an organization should be able to contact someone else. However, collaborative work across organizational borders is not simple and confusion regarding use of terminology is not rare. This position paper presents a multi-user Augmented Reality (AR) application, where AR is used as a tool to aid cross-cultural communication in networked operations. AR is a technique that merges real and virtual information and presents it in the field of view of the user. An individual can thus look at a physical object at the same time as the AR-system overlays that particular object with a digital image, literally replacing its appearance with something else. Other objects such as text can also be placed in the field of vision. Earlier research has shown that humans normally have to spend significant effort at establishing a shared understanding, a common ground, when entering a collaborative activity. The larger the cultural differences and the competence level of the involved is, the more effort is needed. In future, network-based, operations, it is highly likely that people from different organizations, backgrounds or even countries will have to cooperate in ad-hoc situations. This paper suggests a way of using AR as a tool for enabling cooperation between users with different backgrounds by presenting personalized representations of for example map objects in a command center. By doing so, valuable time that normally would be spent on debating the meaning of an object, like when a military commander has to explain a military symbol to a civilian decision maker, can be reduced. Even differences in language could to some extent be bridged. The paper explains the potential of AR in a collaborative scenario and suggests a design for a simple experiment to test the assumptions described.

Keywords: Augmented Reality, Computer Supported Cooperative Work, Joint Operations

Introduction

During the last twenty to thirty years, a great interest and effort has been taken into designing and introducing information systems in crisis management and military operations. Especially in the domain of military command and control (C2) (Alberts et al., 2000; Johnson and Libicki, 1995; Rochlin and Demchak, 1991; van Creveld, 1985), there has been a focus on developing new information systems and decision support systems. A common argument for introducing new information systems in this area is to increase the speed and precision by which an organization can act. The focus on this topic probably comes from the influential theories presented by Boyd (Hammond, 2001). Boyd worked as a fighter pilot for the US during the Korean conflict, and later as a trainer and

advisor for the US Air Force. The fundament of his theory was the Observation, Orientation, Decision, Action-loop (OODA, see figure 1), which describes the task of a fighter pilot arranged in the form of a loop. His conclusion was that in a fight between two pilots in equal fighter planes, the one that is able to execute his OODA-loop faster will be the winner. This thinking has later been adopted by other military thinkers and translated to fit into an organizational perspective.

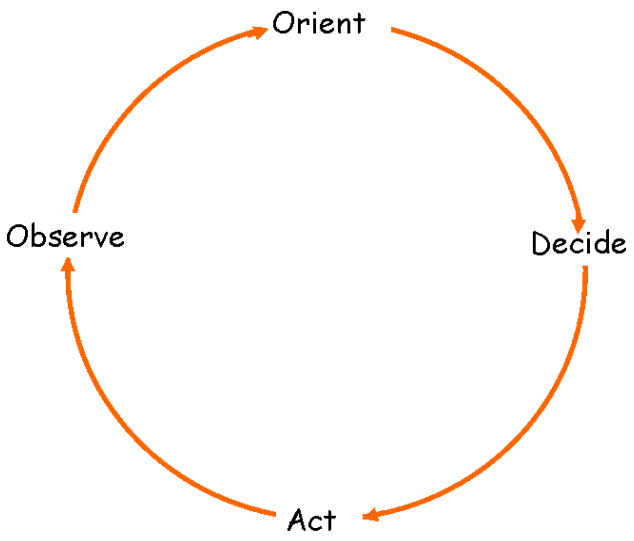

Figure 1. Boyd's OODA-loop. Adapted from (Hammond 2001).

A common argument that is based on the Boyd theory is that the mere improvement in gathering information from the surroundings could speed up the "Observe" and "Orient" parts of the OODA-loop, and this has had a great impact on the view of information technology. In combination with the swift development of the internet and computing capacity in general, several ideas about networked organizations for crisis management and warfare have emerged, described in the military community as a 'Revolution in Military Affairs'(Cebrowski and Gartska, 1998). The success of the coalition in the first Gulf War has also 'confirmed' that these approaches are promising (Rochlin and Demchak, 1991; Sundin and Friman, 2000), and several countries have now stated that they will transform their armed forces into 'networked' forces or that they intend to do this. The rapid technical development within the area of information technology has changed a lot of areas of activity like stock trading, logistics, telecommunications, etc, it is assumed that similar gains can be achieved within the military command and control. With satellites, UAV[1]:s and GPS[2]-support, it is possible to gather high-resolution

[1] Unmanned Arial Vehicle. Small recognisance aircraft used to gather information in dangerous areas.

[2] Global Positioning System. Satellite-based navigation systems which makes it possible to position objects with high precision.

representation of the battlefield, usually refereed to as the *digitized battlefield* (Ibid.). An important question in the development of new Command and Control Concepts is how the information from the digitized battlefield should be presented to the users of the system in order to improve (speed up) the *observe* and *orient* components of the OODA-loop. Various innovative forms of presentation have been proposed in different projects like 3D and other interfaces specialized in spatial presentation.

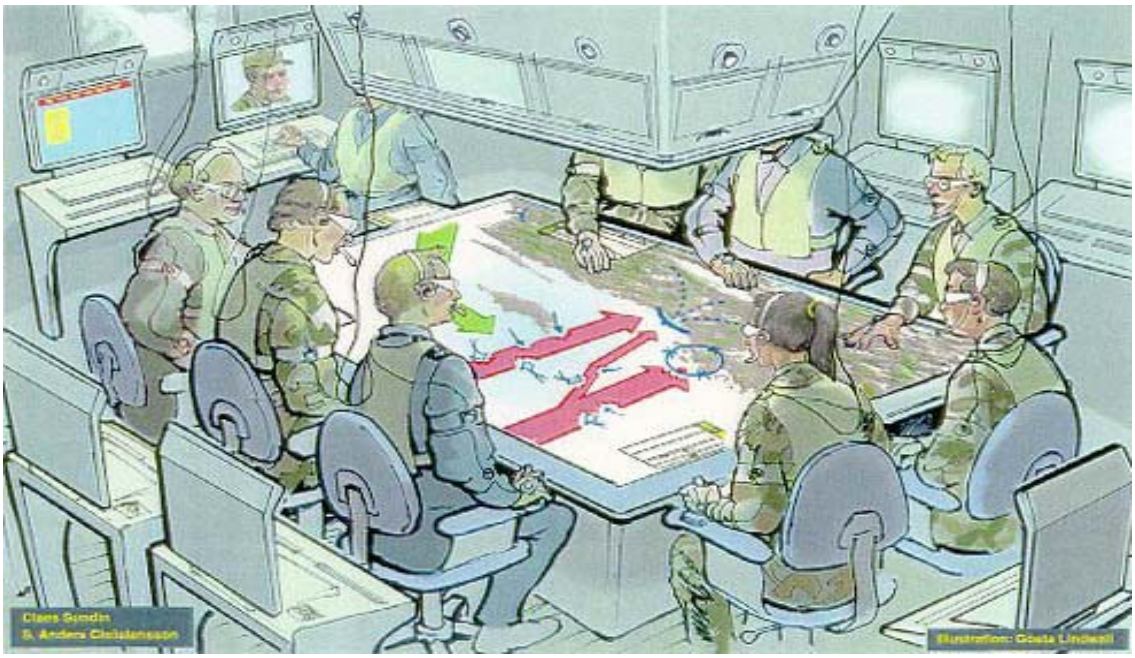

Figure 2. The Aquarium in ROLF (from Sundin and Friman, 2000) The commanders are gathered around the Visioscope™

A common assumption today is that commanders are to work together in a high-tech environment, manipulating shared database views while developing new orders and goals for the own organization. A large effort was initiated in Sweden during the late nineties, called ROLF (a Swedish acronym for Joint Mobile Command and Control Concept, see figure 2). In projects like ROLF, technical solutions are presented that should enhance the ability to work and communicate around situations. It is also suggested that by sharing the same view of situations, decision-makers should be supported in their effort of maintaining the current state of the joint activity. There are several potential problem areas that have to be conquered if cooperation should be efficient in an environment like this, such as training, cultural differences, organizational practices and so forth. The design based on the idea of a shared focus on a map is however easily recognized from 'traditional' command centers and poses the same difficulties as always. The essential difference lies in the idea that decision-makes from different branches and even organizations should cooperate in the same environment, sharing the same map. This means that for at least a foreseeable future, problems concerning communication and negotiation will arise due to the differences in background pointed out above. The coupling between the use of language and objects in a shared space is the initial obstacle

that has to be overcome. Below, we present and discuss how augmented reality can be used to do that.

Augmented Reality

One way to approach the problem of merging two different understandings of a situation and different language and object use is to use Augmented Reality. AR is a technology that merges real and virtual information in the field of view of the user, often in a head-mounted display (see figure 3, Kiyokawa, 2007).

Figure 3. A head mounted display with camera for video see through AR.

There are two principally different solutions for merging reality and virtuality in real time today – video see-through and optic see-through (Azuma, 1997; Azuma et al., 2001; Gustafsson et al., 2004; 2005).

Optic see-through systems

In optic see through AR systems 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. 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). There are also some problems with placement of the information in relation to the surroundings since

the depth of the display in this constellation is fixed whereas in reality objects are perceived in different focal planes (Gustafsson, et al, 2004).

Video see-through systems

A way to overcome the problems with optic see through is by using a camera to capture the real world image and then projecting this image on a small display in front of the users' eyes (Azuma, 1997; Gustafsson, 2004). 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 4).

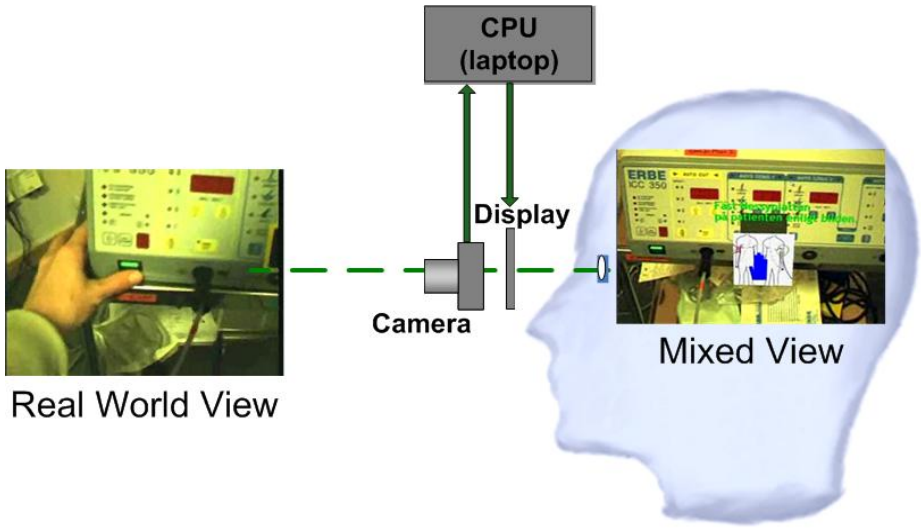

Figure 4: Video see through MR

In turn, this puts other demands on the system, as the transferring of the real image suffers from the lag determined by the cameras image update frequency. The difference between the perceived image and motion, and the real physical motion can also have effect on the user experience of the system, causing motion sickness. To conclude there is a trade-off between the two different solutions and the choice of solution is often determined by the available resources. Video-see-through AR gives complete control over the presented image and therefore is easier to use in scenarios such as the ones described in this paper.

AR applications

AR applications can be found in a variety of domains including the medical, military and industrial (Azuma et al, 2001). Although most AR applications to date are single user systems there are some examples of using AR for collaborative work. In 2002 Billinghurst and Kato merged the area of Computer Supported Collaborative Work (CSCW) and AR, allowing several users to interact with the same virtual information in a face-to-face situation (Billinghurst and Kato, 2002; Billinghurst et al, 2003). Using this

technology may improve the ability to work with and communicate about virtual information between several users with different backgrounds. This in turn will facilitate inter-organizational cooperation in that the AR technology allows users from different backgrounds to receive information relevant to them and to receive it in their own terminology (see figure 5).

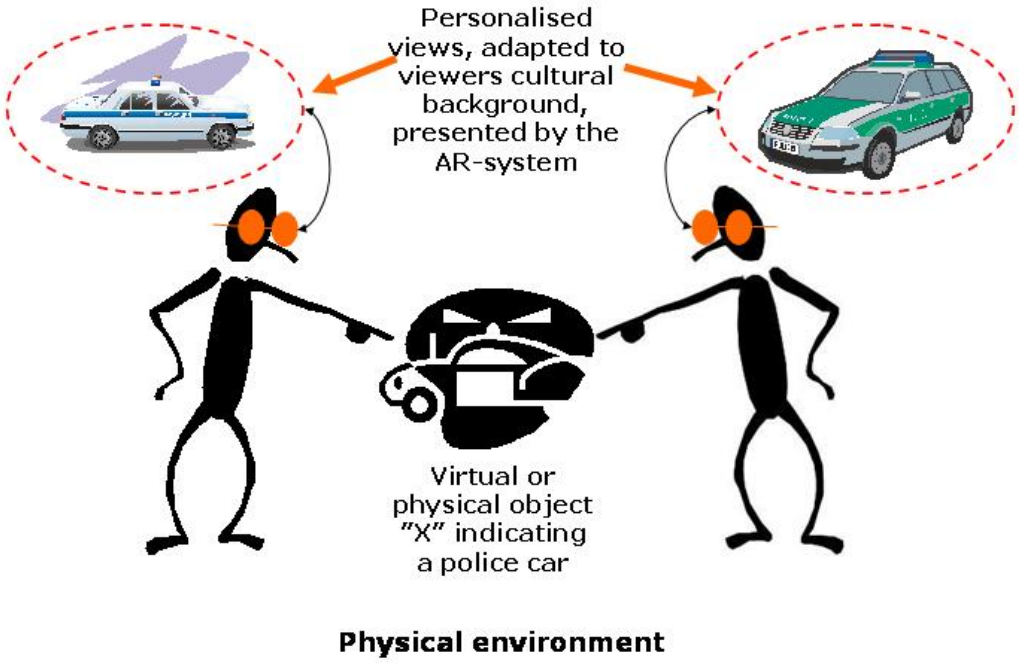

Figure 5. An example of how AR could be used to facilitate communication and improve understanding in a collaborative situation.

Sharing situational understanding in a co-located environment

Many studies have been performed concerning how we perceive objects and how we are able to manipulate representations of objects in imagery. Researchers like Heath and Hindmarsh (2000) have made extensive work-place studies examining how team-members in command and control environments communicate with each other about different objects in their environment. They address questions like how action is configured in an object, how a team member makes an object 'noticeable', and also how mediated communication hampers these abilities. Another important finding from their research is that the meaning of an object (such as a unit symbol on a map) does not remain fixed or static in any way; it is rather a product of the ever ongoing negotiation of meaning that the participants are conducted in.

Physical co-presence is an essential component in this process and bridging initial differences in understanding of a situation in collaborative work is still a challenge. It is important to view symbols in shared spaces as shared constructs, and not only as representations or abstractions of situations or objects outside of the command and control environment. A question that arises from this is how we should approach the design of future shared artifacts? The information that reaches the decision-maker will always be a condensed, and limited, interpretation of reality. The medium chosen for this purpose will therefore have great impact on the interpretation that the decision-maker can/will do. In addition, we have a number of persons with various backgrounds interpreting the information. This will undoubtedly create a situation where the meaning of input will need to be negotiated and 'translated' between the participants in order to achieve a shared understanding. This comes from the fact that the shared understanding at least initially is likely to be low in situations that demand inter-organizational cooperation. Will a police commander interpret the situation in the same way as a military commander? This is where the use of AR technology could assist the creation of common ground or a joint situational understanding by providing personalized views of objects and events.

Overcoming the obstacle of establishing a initial shared understanding

AR, as suggested above, could in theory allow the commanders to interact without spending effort on negotiating what things are, or mean. It can for example be achieved by 'translation' of map symbols so that one commander sees one type representation of an object, while another commander in the same situation sees another representation that is meaningful to him/her (see figure 5 above). By utilizing AR, it could be possible to mix in tailored representations of objects, while at the same time allowing the involved persons to refer to physical objects, something that is pointed out as highly important in collaborative situations. If we look to how action is embedded in an object, it comes from the way that a participant (publicly) is behaving in regard to this object. If person A reacts in a certain way when confronted with an object, and person B sees this, this action will be embedded into this object in the sense that person A:s reaction will be coupled to it. If commander C expresses concern when a new symbol is projected on a map, his subordinates are likely to find the new symbol of greater importance than other, less emotionally coupled symbols. It is thus not only the representation and spoken expressions that configure action to objects, but also how persons physically relate to them. AR is a tool that has the potential to allow users to move freely in the physical environment while at the same time manipulating and personalizing their view of the same environment.

Testing the hypothesis – a suggestion for a study

In order to evaluate the possible benefits of using AR to support a shared understanding, we suggest an experimental study where two conditions are compared. The design of the experiment is founded on having access to members from at least two different organizations, which are presented with a time-critical scenario that demands cooperation in form of collaborative command and control in order to be managed. As a basis, the

commanders will have access to a map with a number of symbols from either organization on it. The task is thus to collaboratively cope with a problem by utilizing units from both organizations in a coordinated fashion. In the first condition, the commanders have no support for solving the task. In the second condition, they are supported by an AR system that 'translates' symbols from the respective organizations to the other organizations symbolic language. It should also be possible to interact with the AR system to get additional information if needed.

Suggested design

This boils down to a between groups design with one factor: a.) joint command teams supported with an AR system, and b.) joint command teams without the AR support. Currently, participants from the police, rescue services and military commanders are expected to take part in the experiment. Rogalski (1999) has shown the need for having 'professional' participants in experimental studies, since outcome and ecological validity is greatly affected by the usage of novice participants.

How well AR actually supports the commanders can be evaluated both in terms of objective measures, like the time needed to complete the task, or in subjective measures of experienced support of the AR system, using queries. These measures should also be complemented with interviews and/or focus groups in order to gain a deeper understanding of how the participants in the experiment experienced the AR system.

Conclusion

Little research has been conducted concerning the possibilities of using AR to support cooperation in joint operations. Even less research exists regarding the use of AR as a support for improving the pre-conditions for communication between personnel from different organizations. This concept paper includes a proposal to a study that have the potential to improve understanding on how AR technology can be used in joint operations. Improving shared understanding between commanders has the potential to speed up coordination work, something that may prove to be an important enabler of success in many real-world situations.

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