Through walls communication for medical emergency services

Bruce H. Thomas, Gerald Quirchmayr, Wayne Piekarski
Wearable Computer Laboratory
School of Computer and Information Science
University of South Australia
Mawson Lakes, SA, 5095, Australia
{thomas, quirchmayr, wayne}@cs.unisa.edu.au

Abstract

This paper presents a proposal for an outdoor wearable augmented reality computer system to support collaboration. A key attribute of this system is its ability to use all four time-space configurations for collaboration systems: same time - same place, same time – different place, different time - same place, and different time - different place. The proposed main form of user interaction is the use of hand and head gestures. The seamless movement of information across different display devices, such as head mounted display, PDA, laptop, data walls, and desktop is critical to allow this form of collaboration to be integrated with adaptive context aware work environments based on workflow management systems. A scenario of a medical emergency task is described to illustrate the functionality of this form of collaboration system.

1 Introduction

Augmented reality systems, in order to meet growing expectations, will have to be integrated with backbone systems that can offer the necessary computational power and storage capacities for providing elaborate context aware environments and improved information access. In the world of information systems, business process engineering and workflow management systems have been integrated and are properly linked to databases [1]. In desktop and notebook-based environments, the full benefits of this integration can already be used for delivering high-level portals and services. This paper presents a proposal for an outdoor wearable augmented reality computer system to support collaboration, and the particular application domain we are exploring is medical emergencies.

The approach discussed in this paper focuses on bringing the power of these advanced environments to mobile users. We therefore investigate adaptive context aware work environments and their possible linkage with a user through augmented reality interfaces operating on mobile equipment. Our goal is to identify a way of improving access to information, supporting teamwork, and facilitating communications. By linking advanced control rooms to mobile users, the centralised parts of the system can get access to on site information to improve the decision making process. The availability of this information also means that we can also support the building of domain-specific corporate memories (for a process model based view on organisational learning see [2]). The focus of this paper is however not on the decision support component, which is amply dealt with in the artificial intelligence and expert systems literature, but on the improvement of augmented reality approaches through integration with advanced control room concepts. As this requires a high degree of flexibility, we base our approach on adaptive context aware work environments.

To demonstrate the practical relevance of the concept, we introduce a scenario for supporting medical emergency services with an *outdoor wearable augmented reality collaboration system* (OWARCS). We believe a wearable computer with an augmented reality (AR) [3] user interface allows for exciting new collaborative applications to be deployed in an outdoor environment. In Thomas, 2001 [4] a description of how an OWARCS relates with existing collaboration systems is presented in the context of a time - place taxonomy [5]. The time - place taxonomy is defined by the position of the users (same or different) and the time of operation of the collaborative system (same or different). A distinctive quality of activities accessing an OWARCS is the ability to use all four time-space configurations, where many existing collaboration systems only support activities in one or two configurations. An OWARCS would seamlessly cross the four time-space configurations to support a task such as a medical emergency. The key to making an OWARCS useful is extending the user interfaces of existing outdoor augmented reality systems [6].

This paper starts with a medical emergency scenario to present the overall structure of our proposed system in operation. The next section describes the issues of supporting collaboration for users operating an OWARCS. The process communication through workflow management systems is presented subsequently, and how these feature in the application scenario. Our concept of an advanced control room – an adaptive context aware work environment, is then presented. Finally a description of the input devices and usability of the OWARCS is explained. The paper is then finished with some concluding remarks.

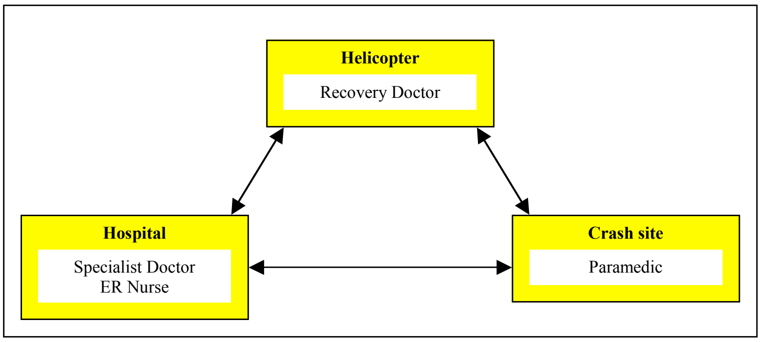

Figure 1 - Personnel for the scenario

2 Scenario

To place the augmented reality user interface in context of the emergency medical domain, we present a scenario of an automobile crash at a remote site. The reader should be aware that this contribution is a proposed augmented reality user interface, and that not all elements of the interface have been developed. Those portions that have been developed are described later in the paper. Figure 1 depicts the placement and titles of the personnel who are described in the scenario. There are two methodologies for treating patients in an emergency situation, "swoop and scoop" and "stay and play." As their names imply "swoop and scoop" attempts to extract the patient as fast as possible, and "stay and play" requires the paramedic to perform more medical treatment on site. The scenario presented here attempts to portray an example that fits both situations, and makes no assumptions on the preferred methodology.

The police call a local ambulance service and ask for the closet hospital helicopter to be placed on standby. The hospital is a three hour drive or an ½ hour helicopter flight from the crash site. The paramedic arrives and requests the helicopter to be sent to the crash site. The communication with the specialist doctor, the recovery doctor, and the paramedic is composed of audio, video, and augmented reality information. During this initial phase, the collaboration is a same time – different place configuration. The paramedic starts by preforming an initial diagnostics of the patient's injuries. The paramedic wears a light wearable computer and views data via a see-through HMD (head mounted display), while the specialist doctor is operating a traditional office workstation, and the recovery doctor is operating a notebook computer. All three are communicating via a wireless network.

Either doctor can advise the paramedic about procedures while the paramedic is tending the patient. The doctors can view a region of interest via digital video images displayed on their office workstation or notebook computer while the paramedic concurrently views the patient through their HMD. A doctor may indicate regions on the patient's body for further investigation by drawing augmented reality lines over the video image. An example is shown in Figure 2, where one of the doctors has indicated a region. These augmented reality line drawings are registered to the patient's body. Locale tracking infrastructure such as fiducial markers or radio beacons may be placed on the patient to improve such registration. Tracking articulated limbs of the human body in an outdoor setting is an open research question, and requires further investigation. The specialist doctor then directs the paramedic to check a particular vital sign of the patient. The specialist doctor can show examples of normal cases digital images or as 3D models, for example, to highlight a particular location of treatment. Both parties may make use of augmented reality information added to the other persons view to improve communication.

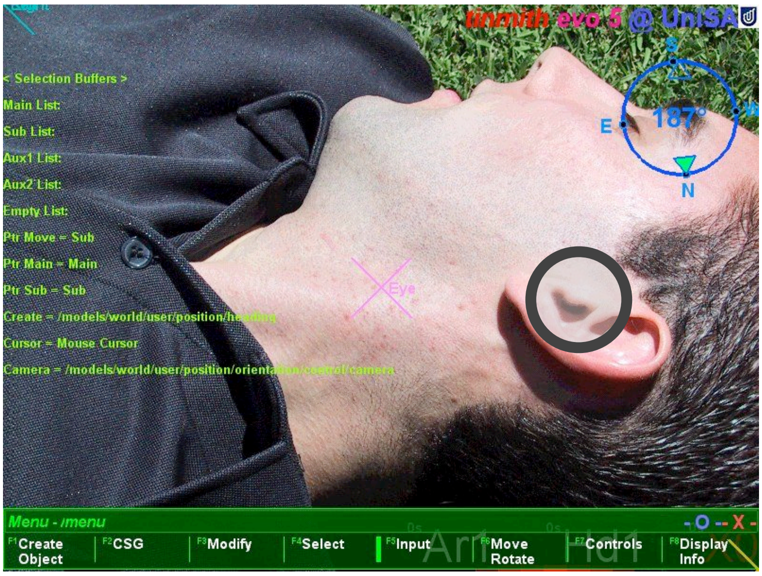

Figure 2 - Example AR overlay

While the paramedic is performing the diagnostics and treatment, they can place augmented reality information stickers on the patient's body. These stickers represent a record of the paramedic's case notes. This is a different time – different place configuration, as these stickers are reviewed by personal, such an ER nurse, at a later date in the hospital. The way we envision the paramedic to place the place augmented reality information stickers on the patient's body is via an eye cursor [7]. The eye cursor is fixed to the centre of the HMD, and is controlled by the user rotating their head to point to different positions on the patient's body. We have found the eye cursor to be very useful for our outdoor modelling applications [7, 8]. The paramedic points the eye cursor at a region of interest, for example the knee, indicates the priority, and speaks into a microphone to record an audio memo. The different priorities could be designated by colour, icon, or fill pattern. The priority is indicated either by voice recognition or binary switches placed on the paramedics clothing. Figure 3 depicts how a set of information stickers might appear through an HMD. Issues of colour when compared with background image, occlusion of normal vision, and ease of understanding are paramount in designing a proper augmented reality user interfaces. This simple example clearly demonstrates these issues, and is an issue for further investigation.

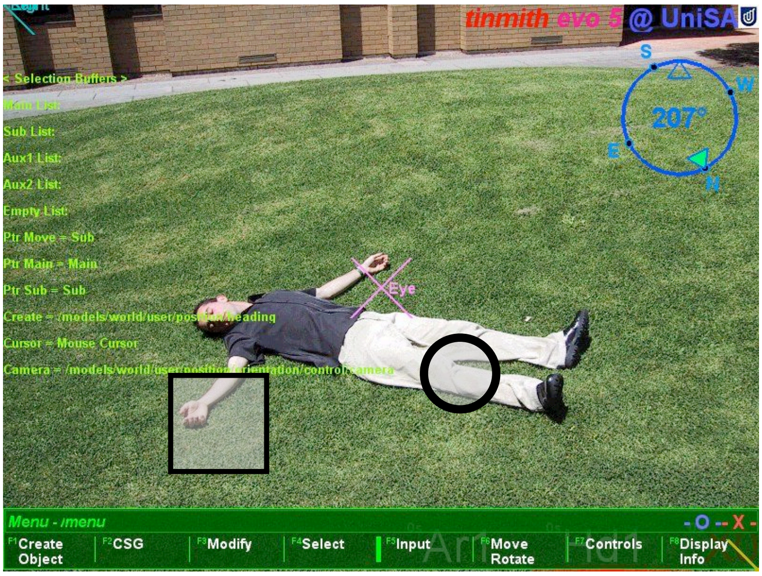

Figure 3 - Example set of augmented reality information stickers

Once the recovery doctor arrives at the crash site, the recovery doctor dons a wearable computer system and the configuration changes to a same time – same place configuration between the recovery doctor and the paramedic. To assess the current situation, the recovery doctor views the patient's medical records as screen relative information and the augmented reality information stickers as world relative information. Figure 4 depicts a prototype view of these two forms of information for the recovery doctor. We have been investigating the use of the augmented reality for patient record reviewing [9], and we found this to be useful for high-level information requiring a small amount of text. The paramedic indicates to the recovery doctor the current vital signals for the patient. The two can plan the best strategies for the patient. This interaction is happening simultaneously with the specialist doctor operating in a same time – different place configuration.

The paramedic is then called away to a different emergency. Now the recovery doctor uses all the information the paramedic has recorded for the patient, in a different time – same place configuration. A novel aspect of this system is the ability for the personnel to switch roles in the collaboration environment. When the recovery doctor communicates with the paramedic, the paramedic will now be the remote operator and the recovery doctor is the one in close proximity to the patient.

Figure 4 - Screen relative information

The patient is loaded onto the helicopter and flown to the hospital; treatment is continuing during the flight [10]. While the patient is being treated in the hospital, many different people will be examining the patient at different times and reviewing and changing the augmented reality stickers. This is now a different time – different place configuration. Issues of information security and easy understanding of the symbology are critical. Only the relevant information should be presented to the user, for example the ER nurse. The ER nurse makes use of the spatial symbolic information to quickly assess how to move the patient, what conditions require immediate attention, and a near future treatment plan for the patient. Unrelated patient information is not required and may be unethical for all medical staff to view.

3 Collaboration with an OWARCS

Collaboration technology facilitates multiple users accomplishing a large group task. There is a number of ways in which technology may help these users: combine or merge the work of multiple users, prevent and/or inform users when a data item is being modified by more than one user, and track the activities of multiple users. One major function of collaborative technology is to help people communicate ideas; collaborative electronic whiteboards are a good example of how collaboration technology may help multiple users to communicate, for example the Teamboard system [11].

Like other researchers, we are taking the use of AR from the indoor setting and placing it in the outdoor environment. There have been a number of systems for outdoor augmented reality such as the MARS Touring machine [12], NRL BARS system [6], previous UniSA Tinmith navigation systems [13, 14], and UniSA ARQuake [15]. A number of researchers are investigating how to remotely monitor and treat patients with wearable computer technology [16, 17]. Although these technologies may be incorporated into our proposed system, this form of wearable computer is not the thrust of our investigation.

The use of hand-held computing devices communicating via a wireless network has been investigated as a means to facilitate collaboration by Fagrell et al. [18]. Their architecture FieldWise is based on two application domains: first, mobile and distributed service electricians; and second, mobile news journalists. Munger purposes the use of pen-based computing as a means of improving emergency care [19]. An alternative to hand-held computing, wearable computers leave the hands free when the user is not interacting with computer but still allows the user to view data in the privacy of an HMD. Garshnek and Burkle [20] describe the use of wearable computer with this hands free nature as one of the next future steps in telemedicine. Pavlopoulos *et al.* [21] have developed a mobile telemedicine system AMBULANCE, which supports remote video, biosignals, and an archiving system. AMBULANCE successfully demonstrated the usefulness of mobile telemedicine systems.

A major research issue is the interaction techniques for users to control and manipulate augmented reality information in the field [22]. We propose the use of augmented reality in the field (outdoors) as a fundamental collaboration tool that may be used across a number of application domains, such as medical, maintenance, military, search and rescue, and GIS visualisation. A number of researchers are investigating augmented reality with wearable computers for distributive collaboration systems [23, 24], but we are proposing an overall framework to integrate augmented reality into a traditional workflow. Pazos *et al.* [25] proposed an integrated computer-based system for medical assistance in emergencies, but their focus was based on expert systems.

As previously mentioned, collaboration technology facilitates multi-user interactions to achieve a common goal. As with collaborative systems such as distributed white boards and remote video conferencing systems, the main aim of OWARCS is to improve communication between the multiple users to attain their common goal. Overlaying contextually aware information on the physical world is a powerful cuing mechanism to highlight or present relevant information. This ability to view the physical world and augmented virtual information in place between multiple actors is the key feature to this form of collaboration technology. A key difference with this form of collaboration is the artefact the users are manipulating. This artefact can be characterised by the following features: firstly, it corresponds to the physical world; secondly, the size of the information space reflects physical objects in a large area; and thirdly, the users are able to physically walk within the information space and the physical world simultaneously. This form of collaboration is similar to distributive virtual environment collaboration systems. Both have manipulable 3D models and the position of the users affects their vantage point. The significant differences are that the distances the users are allowed to physically move are larger and there is a one-to-one correspondence with the physical world.

4 Process communication through workflow management systems

There are several apporaches of structuring the communication between mobile devices and an advanced control room. As one of the major problems is synchronisation, not only of the communication, but also of the processes in both environments, workflow management systems are an appropriate tool for handling these coordination tasks, which can reach a very high complexity. As access to information must be provided in a very efficient and non-obstructing way, the actual information gathering process must be implemented as fully automated background process. The rendering process will consist of two parts, the delivery and the actual display of information. It has to be distinguished between knowledge (rules and conclusions) that is accessed and temporal and spatial data that has to be integrated with relevant background information from a database. An additional problem is that this information is in a legal sense highly sensitive patient data and therefore has to be protected by appropriate security mechanisms. As these mechanisms slow down the communication and performance of the system, the amount of security that can be provided is limited. The more efficient way in an emergency situation is to protocol access to data and audit the access in a later stage. Services for identification and authentication can be provided by wearable equipment and the advanced control room usually is secure. This means that for practical reasons, the real problem is the communication link. As the amount of data passed via this link has to be minimized for transport and display efficiency, the slowdown through encryption and decryption can also be kept minimal.

The most complex task will be to coordinate the processes running in parallel and making sure that at each process step the relevant information is available, preferably provided in a fully automated way. As it cannot be assumed that communication remains stable throughout a whole operation, several resynchronisation points have to be defined in the processes.

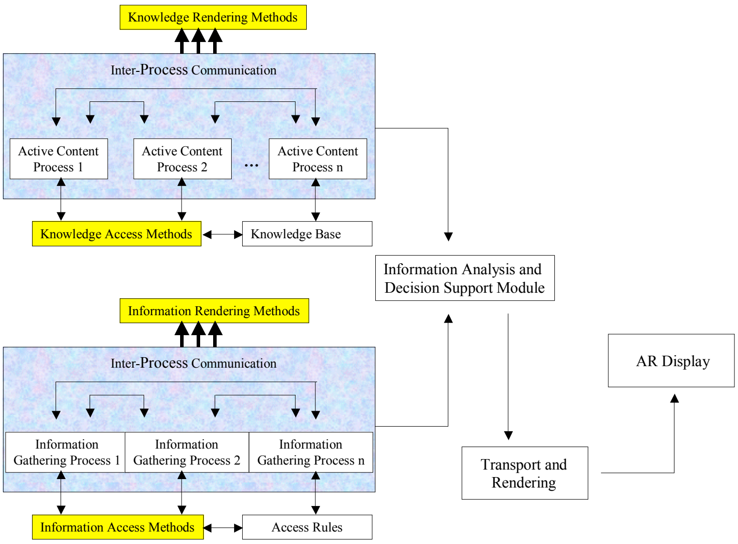

Figure 5 - Process communication

A proven way for implementing the middleware layer driving the infrastructure are workflow management systems (for an evaluation of the functionality of leading workflow management systems see [26], for WfMC standards see www.aiai.ed.ac.uk/WfMC). They can coordinate the execution of processes, inter-process communication and provide interfaces through which databases can be accessed. As workflow management systems are themselves only a component in an adaptive context aware work environment, communication can be implemented in a very robust form via message passing through an enterprise bus.

5 The application scenario from the process communication view

Medical emergency services are a very typical representative of the high complexity inherent to all types of emergency services planning and operations. Due to the extremely high technological level of medical equipment and the requirement to make especially diagnostic equipment remotely accessible as much as possible, medical emergency services come with a special challenge: the most efficient use of very expensive and limited human and material resources. Scenarios are reaching from the transport of patients with only minor injuries to first aid situations in which almost every second counts. Having to deal with natural and industrial disasters, such as storm, flooding, and fire, are the most demanding scenarios. The need to often coordinate an operation with other emergency services adds enormously to the involved complexity.

Once medical emergency services are called in, a good assessment of the situation, even before a unit arrives, is essential. Bringing the right resources to the right location at the right time is critical is for success. The crew on board the closest ambulance vehicle usually are the first to arrive at the scene. In today’s setting this ambulance has to analyse a given situation and deal with it with the resources available on site. Some advanced settings do already allow for the transmission of selected critical data via mobile phones, such as the heartbeat of a patient. A cardiologist based in a hospital with advanced analysis equipment can then give the necessary advice. This is an excellent example of how on site resources can be complemented with remote services. The major problem is that advanced communication facilities are not yet the standard equipment in either ambulance cars or hospitals. Life saving information and equipment do therefore remain unused in most situations. The basic facilities, namely radio, mobile phones and GPS, are already in place and can form the basis for an advanced infrastructure. Providing expert advise to remote medical emergencies is deemed an important and necessary step to improving emergency medical treatment [20, 27-29].

In this paper we look at a scenario in which research carried out in the fields of augmented reality, advanced control rooms, visualisation, process management and workflow management systems can be brought together to create such an advanced support environment.

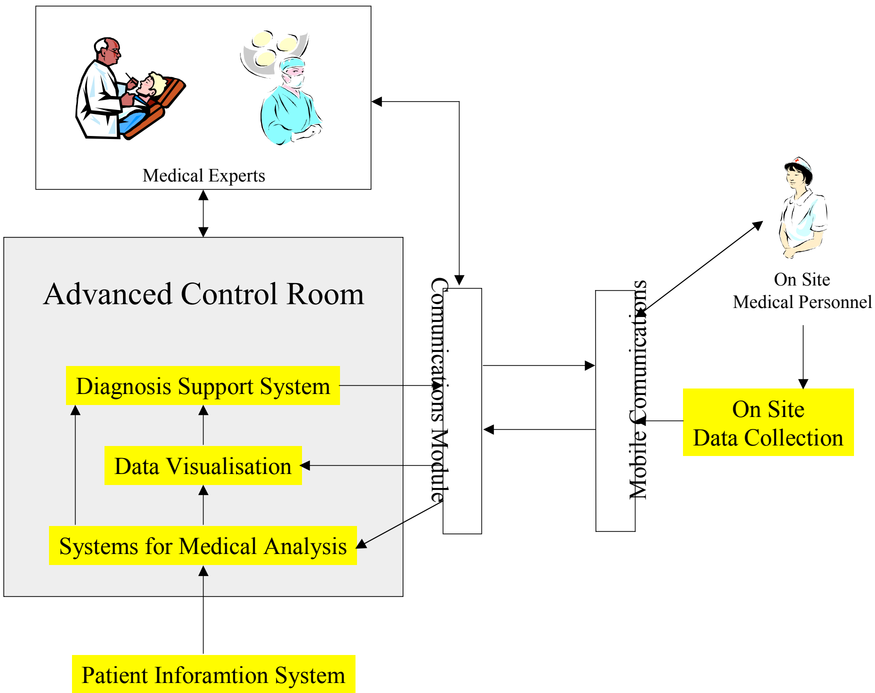

Figure 6 - Concept for Remote Support through an Advanced Control Room

Support for the on site analysis of a situation and linking this picture to a larger pattern is where the need for a direct link with an advanced control room first comes in. Unlike today, the assessment given by phone or radio communications should only be the first source of information, which is then complemented by video and medical data from the scene and by data provided through patient and diagnostic information systems. This data, usually available in hospitals only, will fundamentally change the situation for emergency personnel on the ground. It means that a remote expert can access, integrate and analyse it and give feedback and guidance to the emergency team. Instead of having to assess the situation with very limited data and equipment available, the emergency team can now be supported by an advanced control room.

The key components for an efficient use of an advanced control room will be the integration of incoming data from different sources, patient data being transferred online, information uploaded from databases, videos, and the oral assessment of the situation by the emergency team on the ground. Incoming patient data and other information about a situation must be collected with a minimum effort of the emergency team and definitely without obstructing their work. That is why video and sensoric input, unless it is medical data that has to be gathered through specialised instruments, are best collected from sensors mounted on emergency vehicles or through wearable equipment.

For an efficient process, effective data visualisation, directly feeding the incoming data into diagnostic systems, and efficiently guiding the medical expert through a diagnosis workflow are essential. This leads to a new approach towards medical diagnosis, with the need for an advanced analysis room being in place, similar to advanced control rooms being used in disaster management, spaceflight and military operations.

The use of the advanced control room concept described in the above figure is geared to support emergency situations, but not limited to it. The successful handling of emergency situations requires planning, training and simulation. The advantage of the approach is that by recording actual situations, realistic training scenarios can be created. As all control room functionality apart from rendering, which is dependent on the availability of appropriate rendering facilities, can be implemented in software, this approach is highly portable. If implemented in a scalable way, screens can replace advanced video walls where these are not available. The logical consequence is that such a control room can be deployed easily, if the right communications infrastructure is in place, which is a strong argument for basing it on GSM and GPS, which are almost ubiquitous, with radio as fallback for remote areas without GSM coverage. With such a demand, rapid configuration and a large number of adaptive elements become essential, to be able to get the system running on a wide range of different configurations. The workflow engine on which the process executions are based, must also be extremely robust.

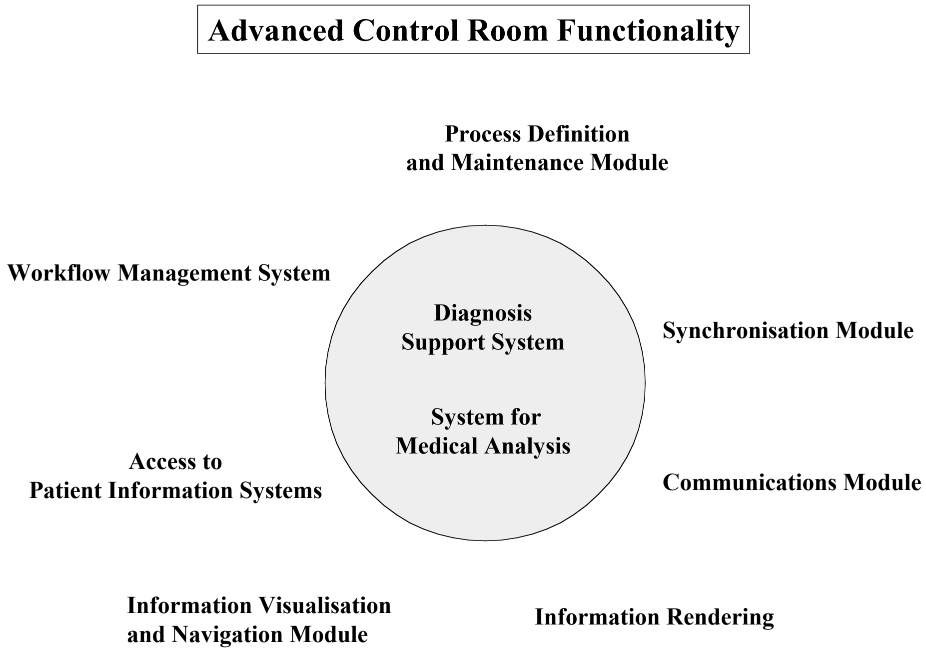

Figure 7 - Advanced Control Room Functionality

6 The advanced control room – an adaptive context aware work environment

For setting up such an advanced environment, a new approach has to be taken towards the system architecture. In traditional IT environments the system architecture is stable, in environments like the one described, the architecture must be flexible and even rapid configuration on demand is no exception. Context awareness and high adaptability are therefore essential. The greatest challenge is the integration of two live spaces, that of the control room and that of the emergency team on site, both of them being work environments. A combination of adaptive context aware work environments and augmented reality is a basis for solving this problem. On site support can best be given by adding useful information, i.e. augmenting the reality in which the emergency team is operating. The advanced control room concept should be based on the ACAWE concept proposed by the authors in an earlier technical report.

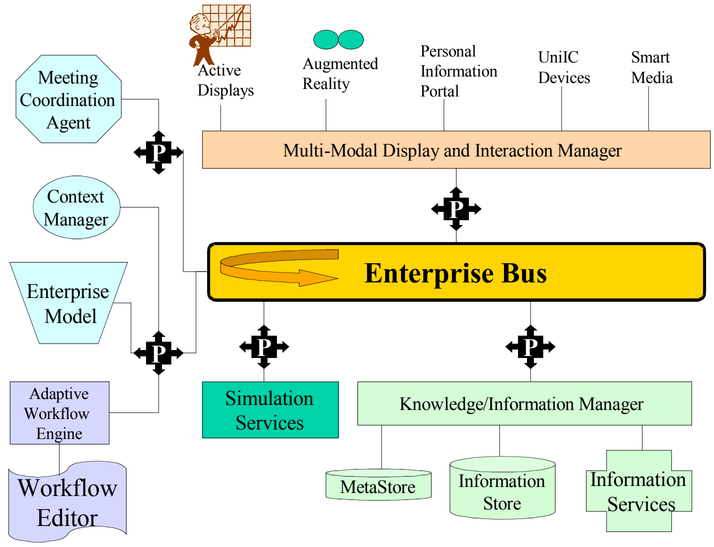

Figure 8 - Adaptive Context Aware Work Environment

The high flexibility of this concept, implemented by using DSTC's ODSI integrator and the underlying Elvin bus, makes it possible to synchronize the advanced control room with the on site activities. As communication and synchronisation are achieved through message passing, a high level of robustness is guaranteed. If a workflow is waiting for input, a human operator can be notified and can in the worst case, i.e. if no input becomes available, continue the workflow operation without this data or by entering an approximation or by instructing the system to use a pre-defined default.

7 Input devices for an OWARCS

Many traditional input devices such as mice and keyboards are not suitable for mobile work outdoors, as they require a level flat surface to operate. A second difficulty is the well-known registration problem. The field of virtual reality (VR) also suffers from the lack of proper input devices and sub-optimal tracking systems, and as a result, new input devices, interfaces, and trackers are continuing to be developed in an attempt to solve these problems. However, many of these devices require fixed infrastructure and are not useable in mobile outdoor environments. Two excellent papers by Azuma [3, 30] explain the problems of working outdoors, and the various technologies that are currently available.

The problem of registering virtual images with the user's view of the physical world is a main focus of current AR research. However, there is little previous work in the area of user interfaces for controlling AR systems in an outdoor setting, which is one of the focuses of this paper. Two major issues for the development of these user interfaces are as follows: firstly, registration errors will make it difficult for a user to point at or select small details in the augmentation and secondly, pointing and selecting at a distance are known problems in virtual and augmented reality applications (compounded by the fact the user is outdoors with less than optimal six degree of freedom tracking of their head and hands).

Therefore, new user interaction techniques are required for an OWARCS, and to state the obvious, the input techniques the users are required to use will have a large impact on the usability of an OWARCS. A key element of the new user interactions is that the augmented reality systems have a varying number of coordinate systems (physical world, augmented world, body relative and screen relative) within which the user must work. In an outdoor application the registration errors of objects at a distance amplify the differences between the physical and augmented world coordinate systems. In the medical emergency example, the problem of selecting the patient's knee becomes more difficult the further away the user stands while performing the selection task.

8 Usability of the OWARCS

The previously mentioned scenario described a number of different modes of operation to accomplish the given task: single user in the field using a wearable computer; single user in an office using a traditional desktop computer; two users, one in the field - one in an office; two users, both in the field with wearable computers. These different modes of operation suggest the need for seamless movement of information across different display devices. During the operation of the wearable computer, a user may require the display of information on a more standard display device, for reasons of readability of text, details of diagrams, or ability to concentrate on the data.

An HMD may not be the optimal display technology, and as such the transition between the use of the HMD and other devices must be simple to use. We are proposing the use of a vast range of display and computing devices to be deployed. The following are a number of possible examples:

1. Standard desktop computers for office centric work,
2. Wall projectors to produce a data wall for group and ambient interfaces,
3. Notebook computers connected to LAN's or by remote wireless, and
4. Hand-held computers connected by remote wireless.
5. Wearable computers with see-through HMD's connected by remote wireless.

Each of these configurations requires a different user interface for the user. The screen size and input device selection is different for each of configuration. The social protocols protecting sensitive information are different for each of the configurations. We propose all of these configurations can use for the same information and protocols for information transfer between users and their different information system.

To extend the task of the recovery doctor viewing the patient records, the recovery doctor could have a hand-held computer (in a similar configuration as described in [12]) to display more detailed information, instead of the patients medical record displayed as a screen overlay on their HMD. When the recovery doctor returns to the helicopter, an easier interface for reviewing the records could be provided by the notebook computer with a wireless communication link. These two forms of computers offer access to more traditional input devices and easier to read display devices. A second option would be to attach these traditional input devices and portable display devices to the wearable computer platform.

As one different example, data walls allow for information displayed on a standard computer screen to be shown in a larger format, for example on the order of 2.0 meters by 1.5 meters. This enables many people to view the information simultaneously. By have a number of people viewing the information; the information can facilitate group activities such as meetings and discussions. Data walls provide a useful ambient interface for a large work area. Ambient interfaces present information to users in such a way as to not dominate their immediate action. The classic example is a person can tell the passage of time from the changing of light levels coming through their office window. This information processing to determine the passage of time is a background activity for the user's cognitive system. By having a data wall present overall contextual information in a large community area (in our example the data wall could be placed in areas of the hospital personnel congregate, such as central hallways or tearooms), users are able understand key overall concepts of the workflow by working near the information, walking past the information, or occasionally popping in to see what is on the wall.

The privacy issues of such a device are clear, but there should be automatic mechanisms to display the appropriate information. The user interface demands are vastly different to a standard desktop configuration. Data walls are information presentation oriented, and input devices currently employed are traditionally a video remote control like device or driven from a standard desktop computer.

8.1 Collaboration user interface tasks

We believe the use of hand and head gestures are key to making collaborative systems usable. This section presents a number of augmented reality user interface mechanisms we designed and implemented in our Tinmith-Hand system for an OWARCS to support logistics applications [31].

The Tinmith-Hand provides navigation cues to the user to retrieve parts in the warehouse, by the use of virtual signposts, virtual line markings on the floor, and augmented reality information stickers. Figure 9 is the user’s view of two different navigation cues. There are three virtual signposts in the user's view in the figure, "Machine Shop", "Paint Shop", and "N000". The "Machine Shop" and "Paint Shop" virtual signposts indicate entrances to those facilities. The "N000" virtual signpost indicates a compass heading of due north; there are virtual signposts for the eight points of the compass. On the floor there is a red arrow headed thick line providing a virtual walking path for the user. (The greyscale images obviously do not reflect the red.) This virtual information is automatically generated.

Figure 9 - Augmented reality navigation cues

Tinmith-Hand supports a number of different forms of information stickers, such as: text, line drawings, and 3D graphical objects. In the future we will be adding new media types, such as audio, voice, digital images, and digital video. The augmented reality information stickers must be designed to be viewed from a number of directions and distances. Figure 10 shows two different forms of multimedia augmented reality information stickers. There is text label "Box sn00…." attached to the container in the right side of the diagram. The container on the left side of the diagram has a 3D graphical model depicting the part. This information may be placed in world coordinates (as is the instance in Figure 10) or in screen coordinates (as is the case in Figure 11). In the case of viewing 3D graphical objects, we support direct manipulation of the objects as well as a second useful camera control model, orbital mode, as described in [32].

Tinmith-Hand supports screen relative text boxes, such as patient medical records or the manifests of containers, as shown in Figure 11. As a container comes into the user's view, an augmented reality text label is attached to the container. A screen relative text box depicts the different manifests for each of the containers currently in the view of the user. A total manifest for the contents of a truck may also be viewed in a text box with appropriate scrolling and paging.

Figure 10 - Multimedia augmented reality sticker

Figure 11 - Manifests of each of the containers

In the medical emergency example, both users were required to indicate features in the physical world. Hand and head gestures are an intuitive means for indicating features in the physical world or on the 3D models. For example, one user may wish to indicate a particular feature by using a laser beam from the tip of their thumb (Figure 12). The laser beam technique uses a traditional virtual reality laser beam/ray casting selection cursor. The length of the laser beam is fixed, and this example it is set to two meters. In our laser beam example, the line is a cone and the direction and location is specified with the six degree of freedom tracking of the user's thumb. Once an object is selected, this is then highlighted on the desktop display and/or the HMD to provide additional visual cues to the user. For the HMD users, control of the selected region could be transferred to the head-tracking device for gross movements and the hands (using a magic lens interaction technique for example) may perform finer control. We believe the ability to quickly change input devices and coordinate systems is a key to making this form of interaction feasible.

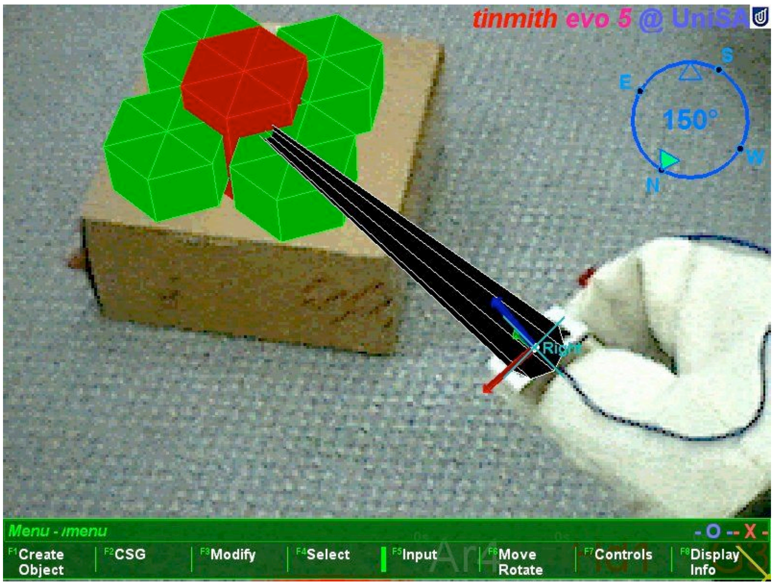

Figure 12 - Laser beam

9 Conclusion

The aim of our paper was to present a model for bringing the coordination power of workflow management systems to AR systems. We have shown how mobile equipment can be integrated with adaptive context aware work environments and indicated the benefits of such integration in a realistic scenario. We have designed appropriate information stickers that allow us to support data collection in medical emergency scenarios in an advanced form through a hands free user interface for medical personnel.

The interesting user interface technology we have proposed to be investigated includes multimedia, augmented reality information stickers, and the allocation of patient medical records to identified locations of the human body. We have also demonstrated how the access to relevant information can be improved for users in the mobile environment as well as for those in the advanced control room. An additional advantage is the automatic recording of on site data, which helps to build the medical record of a patient without interfering with the work of the emergency team.

10 References

[1] S. Rathnam, "ACM SIGOIS Bulletin, Special issue: business process reengineering," vol. 16:1: ACM, 1995,

[2] E. Ellmer, D. Merkl, G. Quirchmayr, and A. Tjoa, "Process model reuse to promote organizational learning in software development," presented at COMPSAC '96 - 20th International Computer Software and Applications Conference, 1996.

[3] R. T. Azuma, "Survey of Augmented Reality," *Presence: Teleoperators and Virtual Environments*, vol. 6, 1997.

[4] B. H. Thomas, " Using augmented reality to support collaboration in an outdoor environmen," presented at Special Session Augmented Reality: Usability and Collaborative Work in the HCI International, New Orleans, LA, 2001.

[5] C. Ellis, S. Gibbs, and G. Rein, "Groupware - Some Issues and Experiences," *Commication of the ACM*, vol. 34, pp. 9-28, 1991.

[6] S. Julier, Y. Baillot, M. Lanzagorta, D. Brown, and L. Rosenblum, "Bars: Battlefield augmented reality system," presented at NATO Symposium on Information Processing Techniques for Military Systems, Istanbul, Turkey, 2000.

[7] W. Piekarski and B. Thomas, "The Tinmith System - Demonstrating New Techniques for Mobile Augmented Reality Modelling," presented at Australasian User Interface Conference, Melbourne, 2002.

[8] W. Piekarski and B. H. Thomas, "Tinmith-Metro: New Outdoor Techniques for Creating City Models with an Augmented Reality Wearable Computer," presented at Fifth International Symposium on Wearable Computers, Zurich, 2001.

[9] S. Barretto, M. Chu, K. Hickey, M. Tu, G. Hooper, B. Thomas, and J. Warren, "Augmented Reality Interfaces for Single- and Multi-Party Viewing of Multimedia Electronic Medical Records," presented at Proceedings of the 8th National Health Informatics Conference, Adelaide, 2000.

[10] P. Felleiter, "Data Processing In Emergency Medicine And During Transportation Of Patients," presented at Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1992.

[11] TeamBoard Inc., "TeamBoard," 2001, 300 Hanlan Road, Woodbridge, Ontario, Canada L4L 3P6.

[12] S. Feiner, B. MacIntyre, T. Hollerer, and A. Webster, "A Touring Machine: Prototyping 3D Mobile Augmented Reality Systems for Exploring the Urban Environment," in *nternational Symposium on Wearable Computers*: IEEE, 1997, pp. 74-81.

[13] W. Piekarski, B. H. Thomas, D. Hepworth, B. Gunther, and V. Demczuk, "An Architecture for Outdoor Wearable Computers to Support Augmented Reality and Multimedia Applications," in

Proceedings of the Third International Conference on Knowledge-Based Intelligent Information Engineering Systems. Adelaide: IEEE, 1999.

[14] B. H. Thomas, V. Demczuk, W. Piekarski, D. Hepworth, and B. Gunther, "A wearable computer system with augmented reality to support terrestrial navigation," presented at In Second International Symposium on Wearable Computers, Pittsburgh, 1998.

[15] B. Thomas, B. Close, J. Donoghue, J. Squires, P. DeBondi, M. Morris, and W. Piekarski, "ARQuake: An outdoor/indoor augmented reality first person application," presented at Fourth International Symposium on WearableComputers, Atlanta, GA, 2000.

[16] C. Altieri, "Introduction of a fully portable, body-mounted emergency medical information system," presented at National Forum Research, Practice, and Opportunities, 1996.

[17] T. Martin, E. Jovanov, and D. Raskovic, "Issues in wearable computing for medical monitoring applications: a case study of a wearable ECG monitoring device," presented at The Fourth International Symposium on Wearable Computers, 2000.

[18] H. Fagrell, K. Forsberg, and J. Sanneblad, "Fieldwise: a mobile knowledge management architecture," presented at Conference on Computer supported cooperative work, Philadelphia, 2000.

[19] R. Munger, "Lights, sirens, and computers: how pen-based computing is changing the way emergency care is conducted and communicated," presented at Communication Jazz: Improvising the New International Communication Culture, 1999.

[20] V. Garshnek and F. B. Jr., "Telemedicine applied to disaster medicine and humanitarian response: history and future," presented at 32nd Annual Hawaii International Conference on Systems Sciences, 1999.

[21] S. Pavlopoulos, E. Kyriacou, A. Berler, S. Dembeyiotis, and D. Koutsouris, "A novel emergency telemedicine system based on wireless communication technology-AMBULANCE," *IEEE Transactions on Information Technology in Biomedicine*, vol. 2, pp. 261-267, 1998.

[22] B. Thomas, K. Grimmer, D. Makovec, J. Zucco, and B. Gunther, "Determination of placement of a body-attached mouse as a pointing input device for wearable computers," presented at International Symposium on Wearable Computers, San Francisco, CA, 1999.

[23] M. Bauer, G. Kortuem, and Z. Segall, ""Where are you pointing at?" A study of remote collaboration in a wearable videoconference system," presented at International Symposium on Wearable Computers, San Francisco, CA, 1999.

[24] M. Billinghurst, J. Bowskill, M. Jessop, and J. Morphett, "A wearable spatial conferencing space," presented at Second International Symposium on Wearable Computers, Pittsburgh, 1998.

[25] A. Pazos, V. Maojo, F. Martin, J. Barreiro, and A. Hernando, "Integrated Computer-based System For Medical Assistance In Emergencies," presented at Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1991.

[26] M. Berger, E. Ellmer, G. Quirchmayr, and A. Zeitlinger, "Evaluating workflow management systems," presented at Eighth International Workshop on Database and Expert Systems Applications, 1997.

[27] V. Prijatelj and A. Vuckovic, "Telemedicine-opportunity for improving survival likelihood during emergency medical services," presented at 11th IEEE Symposium on Computer-Based Medical Systems, 1998.

[28] H. W. Silver, "Wireless transmission of emergency medical care data," presented at Northcon/98 Conference, 1998.

[29] P. Stamford, T. Bickford, H. Hsiao, and W. Mattern, "The significance of telemedicine in a rural emergency department," *IEEE Engineering in Medicine and Biology Magazine*, vol. 18, pp. 45-52, 1999.

[30] R. T. Azuma, "The Challenge of Making Augmented Reality Work Outdoors," presented at First International Symposium on Mixed Reality (ISMR '99, Yokohama, Japan, 1999.

[31] B. Thomas and W. Piekarski, "User Interaction Techniques for Augmented Reality Supporting Collaboration in an Outdoor Environment," *Virtual Reality: Research, Development, and Applications*, pp. Under Review, 2002.

[32] D. R. Koller, M. R. Mine, and S. E. Hudson, "Head-Tracked Orbital Viewing: An Interaction Technique for Immersive Virtual Environments," presented at 9th Int'l Symposium on User Interface Software Technology, Seattle, Wa, 1996.