New interface approaches for telemedicine

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Introduction

Over the past several decades, computer interface technology has had a huge impact on the medical profession. Electronic patient records are becoming mainstream, surgical training is being enhanced with virtual simulations and medical imaging is increasingly digital. Outside the medical profession computers are being used more and more for enhancing face-to-face and remote collaboration. Low-cost desktop video conferencing is common, as is using voice over IP long distance calling, and real time file and data sharing. These technologies are being used in a variety of Telemedical applications, and projects such as the Mobile Surgical Services bus* point to an exciting future of health care being provided anytime, anywhere.

However, current telemedical applications still provide a different experience from being in a real operating theatre, or in a face-to-face consultation. In a face-to-face meeting people share a wide range of verbal and non-verbal cues such as speech, gaze, gesture and body language, or even interacting with real objects as papers and anatomical models. There is a free and easy interchange of ideas and natural communication.

With current teleconferencing technology it is difficult to support this same rich experience. For example, with audio only conference calls and computer interfaces such as ThunderWire,[1] participants are unable to exchange non-verbal cues, while with desktop video conferencing there is often a lack of spatial cues.[2] Even in high end immersive virtual environments such as GreenSpace,[3] remote users are represented as low resolution virtual avatars that cannot display all the nuances of face-to-face communication.

At the Human Interface Technology Laboratory New Zealand (HIT Lab NZ) at the University of Canterbury, in co-operation with the University of Otago in Dunedin, we are developing new interface technologies that could transform how telemedicine is performed in the future. In this article we talk about two of our research efforts; *Tangible Teleconferencing* and *'Carpeno'*. These are currently research prototypes, but they show ideas that may enter the mainstream in the near future.

Tangible Teleconferencing

In a face-to-face meeting, real objects and interactions with the real world play an important role. People use the resources of the real world to establish shared understanding. Real objects are constituents of collaborative activity, creating reference frames for communication and altering the dynamics of interaction.[4] However, with current technology it is difficult to bring elements of the real world into a remote communication space. In most video conferencing applications users cannot share real documents, or manipulate tangible objects.

* Mobile Surgical Services website: http://www.mobilesurgical.co.nz/

The goal with the Tangible Teleconferencing project is to develop technology that would enable users to easily bring representations of real documents and objects into screen-based collaborative virtual environments.[5]

Our work is an enhancement of the cAR/PE! desktop collaborative virtual environment.[6] This is software that runs on a desktop computer with a web camera attached to show a three dimensional virtual conference room environment (see Figure 1). In the cAR/PE! virtual room, there is a virtual presentation wall intended for application sharing and presentation slide display and in the centre of the room is a table on which virtual models can be placed. Remote users are shown as virtual avatars in the conferencing space with live video texturing onto their virtual representations (see Figure 2). So unlike most desktop conferencing systems, users get the impression that they are in a shared conference room. Using a mouse and keyboard they can move their virtual bodies around the space, turn to talk to each other and convey a range of natural spatial cues.

For the Tangible Teleconferencing application two web-cameras are connected to a desktop PC running the cAR/PE! conferencing application (see Figure 3). The first camera is used for capturing the user's face, while the second is used for taking high resolution snapshots of real documents and for detecting tangible interaction objects placed underneath it.

The second camera is used to introduce virtual objects into the conferencing space and also allow real documents to be easily shared. Each of the virtual models that can be loaded into the conference spaces is associated with a real cardboard marker. This marker can be seen as a tangible placeholder for the virtual objects and therefore eases the interaction with the virtual content. Placing the marker under the camera causes the model to appear on the table in the conferencing space. When different model markers are in view of the camera the individual virtual models associated with them are loaded onto the table in the conferencing space. Thus the markers allow users to easily load a variety of different virtual models.

Once models have been loaded into the conferencing space they can be manipulated using a set of physical tools. A translation tool (Figure 4) can be used to move a model along all three axes in space. The tool consists of a visual marker attached to a handle. If a user wants to translate a model in the cAR/PE! environment, this marker is moved under the camera and its motion is mapped to the motion of the virtual object. There is a separate Rotation tool (Figure 5) that can be used to rotate a model about its x- y- or z-axis in space. The tool consists of three markers that are arranged around a triangular tool. Once one of the three markers is shown to the camera, rotation about the corresponding axis begins. The rotation speed and direction can be controlled by the dis-

Figure 1. cAR/PE! Virtual Conference Room

Figure 2. Avatar with live video texture

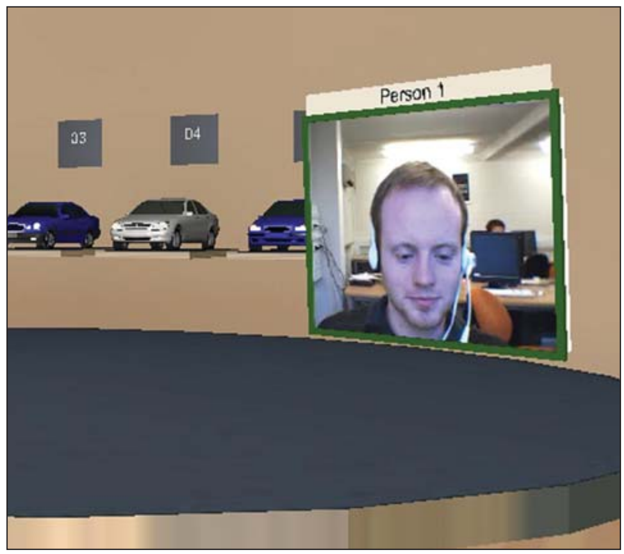


Figure 3. Tangible Conferencing hardware setup

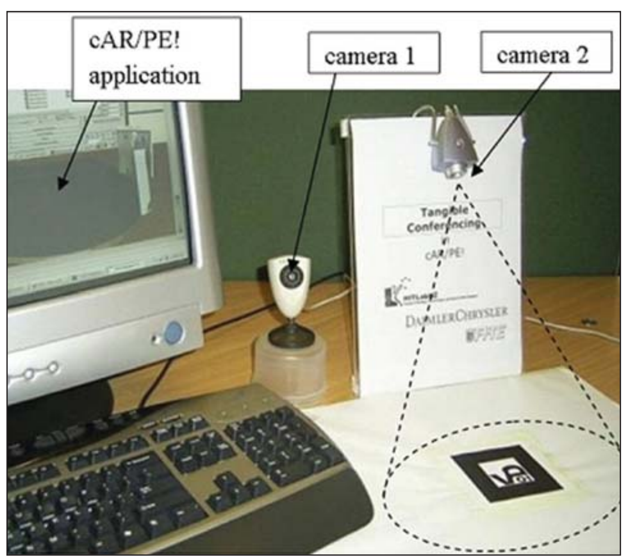


Figure 4. Model Translation using the translation tool

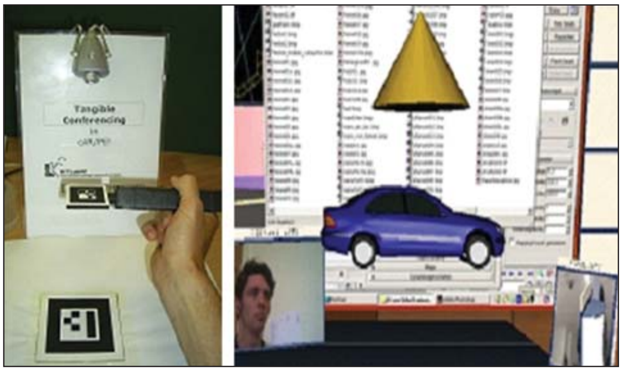
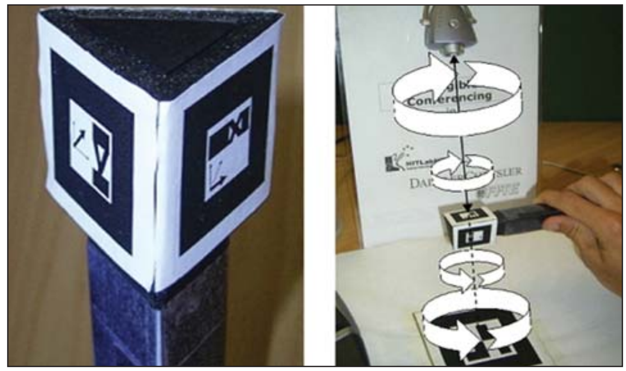


Figure 5. Rotation tool



tance of the tool to camera. Model scaling is achieved by using a third physical tool shaped like a magnifying glass. Moving it closer to the camera or further away scales the virtual model.

We can also bring real documents into the conferencing environment. The document we want to capture is placed inside a folder with a marker on the cover (Figure 6). If the closed folder is brought into the tangible interaction space, the marker is detected and a virtual model of the document pops up on the virtual table. After the document model is loaded into the scene the user is able to take a high resolution snapshot of the real document and display this as a texture map on the surface of the virtual document model. When the real folder is opened the cover marker is no longer visible and our software knows to take a picture of the document and texture map it onto the virtual model. This allows the user to share charts, text or pictures that can be found on any real document with another remote person.

Our software also allows the user to immediately add physical annotations and sketches to the shared document view with conventional pens and highlighters. This feature is ideal for creative collaboration tasks where a fast and easy visualisation of new ideas is crucial. To update the image snapshot all the user has to do is close and reopen the document folder. So the user can write on the document and in a few seconds have those annotations appear in the cAR\PE! environment (Figure 7). The document can also be scaled and zoomed with the lens magnifying tool.

So, unlike other conferencing tools the Tangible Teleconferencing interface allows real tools to be used to interact with virtual content, and real documents to be brought into the conferencing space. The first application area that we have developed this interface for is engineering design, but the same tool could be used in the medical arena for remote consultations and sharing of three dimensional medical data. Our first steps into a requirements analysis for medical applications have already shown the demanding needs and quality expectations in that field. Fortunately technologies available today in research and on the market can be integrated into our demonstration prototypes enhancing the overall quality of the system while maintaining the easiness of the interfaces developed.

Figure 6. Loading a document into the conferencing space

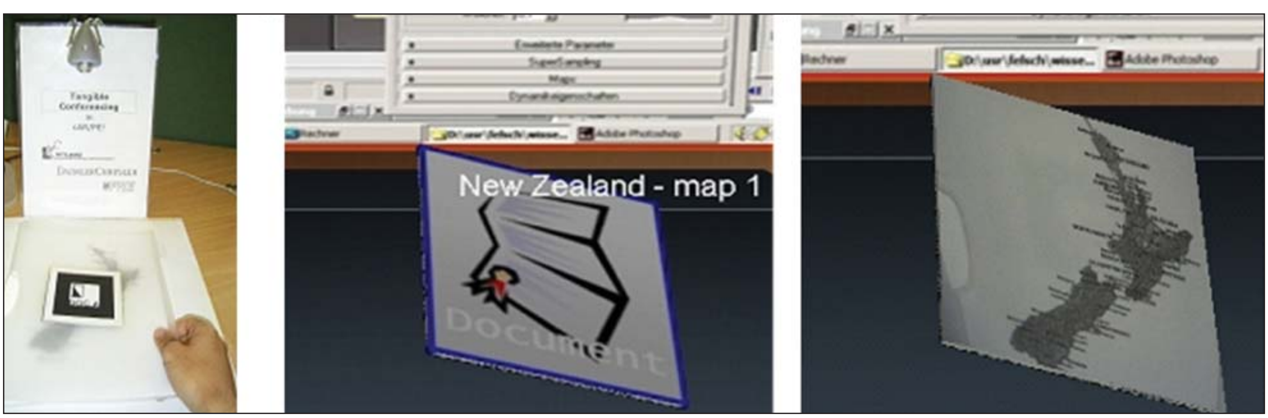


Figure 7. Annotating a document

Carpeno: Using multiple displays for remote collaboration

The Carpeno project is another teleconferencing interface that extends the cAR/PE! conferencing space by combing it with the Coeno collaborative interface.[7] In this case we use multiple displays to create the illusion that several remote people are really around the same real table. One display is a vertical screen, while the other is a large touch enabled plasma display placed on a tabletop (Figure 8)

The Carpeno system combines the two displays into a single system with seamless borders allowing for simultaneous co-located and remote collaboration around a common, interactive table. Users can sit at the table and bring their own laptop or tablet PC computers that can be wireless connected to the display server. So there are three display spaces:

Private Space: The user's laptop screen, only visible to them.

Task Space: The shared table surface, only visible to those sitting around the table.

Communication Space: The wall display, visible to all the people in the room, and showing the remote virtual conferencing space.

We use a simple hyperdragging metaphor that allows people to move data easily between the spaces. A user can use their mouse to select an image on their laptop screen (private space) and drag it towards the tabletop display. When the selected image reaches the end of the physical laptop screen then it will appear on the tabletop display, where it can also be dragging into the remote virtual conferencing space.

The shared table surface is also touch enabled using touch screen technology from NextWindow.[†] This allows users to select, scale and manipulate images using natural gestures, and naturally enhances the face-to-face collaboration. The images also appear on the cAR/PE! vir-

Figure 8a. Carpeno concept

Figure 8b. Prototype implementation

[†] Next Window website: http://www.nextwindow.com/

tual table and if the remote collaborator is pointing to a picture a virtual hand icon appears on the real interactive table surface, showing the image they are interested in. Their video texture is also automatically rotated to look at the image, providing an additional spatial cue.

The Carpeno project is an early attempt to allow remote people to come together around a conference table and be more than talking heads. By having a shared interactive surface face-to-face and remote collaborators can view and interact with the same shared medical image data in a natural and intuitive manner.

We are currently performing user studies with the Carpeno interface, but early indications are that users enjoy being able to interact with data using the touch screen, and that seeing their collaborators in a virtual conferencing space connected to the real space increases the sense of remote presence. Rather than talking at each other users feel that they are engaged with each other in a shared task.

By having a shared interactive surface face-to-face and remote collaborators can view and interact with the same shared medical image data in a natural and intuitive manner

Conclusion

In the future, greater computer processing power and communications bandwidth will allow more natural computer interfaces for remote telemedicine. This article has shown two prototype interfaces being developed at NZ institutions. The first, Tangible Teleconferencing, attempts to remove the barrier between the real world and virtual conferencing space by using tangible interface metaphors. The second, Carpeno, seamlessly connects several displays to provide an enhanced face-to-face and remote collaborative experience. These prototypes are currently just technology demonstrations but they show several possible directions that future telemedical interfaces could take.

Competing interests

None Declared

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