Inventing the Future Down Under: The Human Interface Technology Laboratory New Zealand (HIT Lab NZ)

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Introduction

As computers become invisible, the interface between human and machine is increasingly important. The proliferation of computing and communication devices with improved capabilities creates a wealth of opportunities for new types of human computer interaction. However many companies have little experience in building intuitive interfaces. Thus there is a need for research organizations that can develop next generation computer interfaces.

The Human Interface Technology Laboratory New Zealand (HIT Lab NZ) is an advanced research and development laboratory created to explore innovation in interface design. It was founded in April 2002 and is located at the University of Canterbury, in Christchurch, New Zealand. It is a daughter of the long established HIT Lab US [4] based at the University of Washington in Seattle.

The HIT Lab NZ has a three-fold mission:

- **Teaching:** Providing a multidisciplinary learning environment for students.
- **Research:** Building a world-class centre for interface research
- **Commercialisation:** Commercialising interface technologies

Corresponding to this three-fold mission, the main outcomes are: students able to conduct world-class interface research, unique intellectual property and academic publications and commercial products and/or spin out companies.

Although only three years old, the HIT Lab NZ has nearly 40 staff and students from a wide range of backgrounds. Students from around the world come to conduct research and study, creating a truly multi-national multi-disciplinary environment. It is not unusual to see computer scientists working side by side with artists and psychologists on the same project, or to have Germans and Swedes writing software with New Zealand students.

One of the unique aspects of the HIT Lab NZ is that it exists as a bridge between academia and industry. The lab is supported by an industrial consortium of 26 companies that engage in applied research projects. In addition, there are 15 universities from around the world that are academic partners. Many of the projects are tied to the needs of industry and involve other academic partners.

Research Focus

The WIMP (windows, icon, menus, pointers) metaphor is one of the most successful user interface paradigms ever developed. Even though the mouse was invented nearly 40 years ago, it is still the dominant tool for computer interaction. However, exponential advances in computer processing, graphics, networking and storage have enabled a wide range of other user interface techniques and devices. We are now entering a post-WIMP era where interface designers have a wide range of approaches to choose from. This is especially true with new types of interactive experiences.

Interactive interfaces are being influenced by three important trends in user interfaces: augmented reality (AR) [2], perceptual user interfaces (PUI) [10] and tangible user interfaces (TUI) [5]. AR interfaces superimpose virtual imagery over the real world, so that both reality and virtual reality are seamlessly blended together. PUI use cameras and other sensing devices to give computers some of the same perceptual capabilities of humans. Finally, TUI bridge the worlds of bits and atoms by enabling the user to interact with digital information by manipulating real objects.

These three fields are related. In the broadest sense AR interfaces are concerned with output and display of virtual imagery. Tangible user interfaces are primarily involved with input and coupling computer interfaces to physical devices. Finally the most novel aspect of perceptual user interfaces is middleware and software that tries to make sense of the input from the various sensing devices.

In order to have a point of difference both in New Zealand and globally, the HIT Lab NZ has adopted a unique research focus. While there are many other research groups working in the fields of AR, TUI and PUI, the HIT Lab NZ is conducting work at the convergence of these three areas (see Figure 1). The research also has an application focus; namely exploring how these three enabling technologies can be used to enhance collaboration between people.

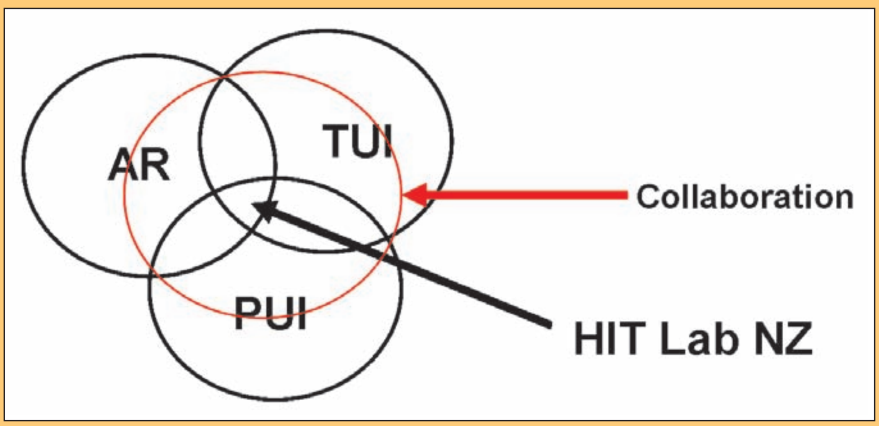

Figure 1: *The HIT Lab NZ research focus.*

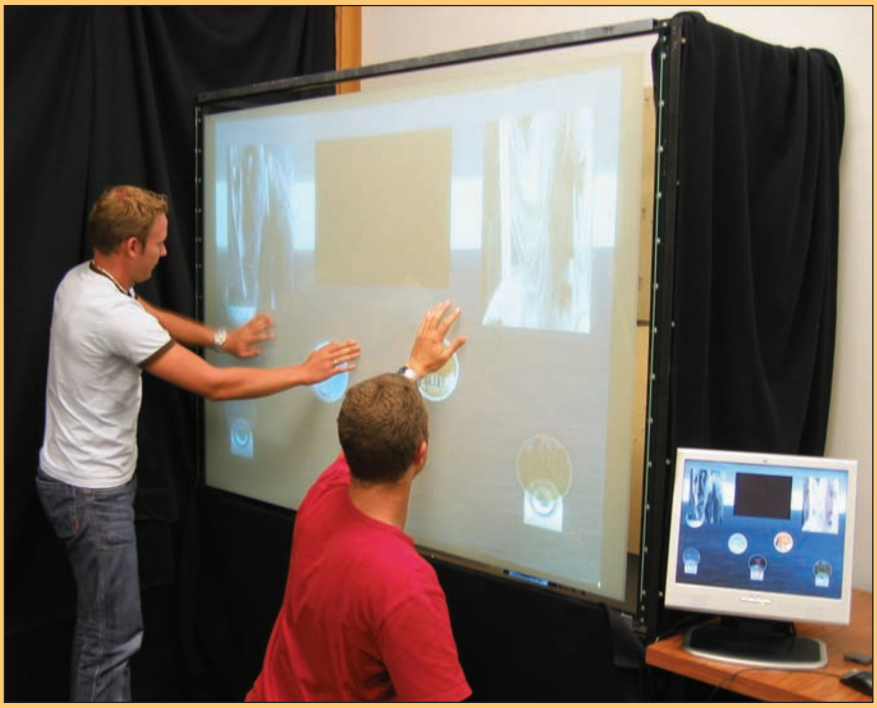

Figure 2: *The SmartScreen multi-touch display.*

Thus the HIT Lab NZ's main research focus is:

"To develop interfaces that support face to face and remote collaboration using augmented environments, sensing technologies and tangible interactions"

Sample Projects

At any particular time there are more than a dozen active projects in the HIT Lab NZ typically involving three to four people each. Some are applied research projects for partner companies while others are longer-term projects that address more fundamental research issues. Most work involves AR, TUI and PUI technologies and the overlap between these three fields. In this section, we review a sampling of projects to show the range of work being undertaken.

SmartScreen

The SmartScreen project is an example of an applied research project being done for a partner consortium company (in this case, Story Inc!) The goal is to develop touch screen technology that enables several people at a time to interact with digital data on a projection screen. Based on Matsushita's Holowall [6], the SmartScreen is a rear-projected screen that uses infrared lights and a camera to track users' hand positions as they touch the screen. Unlike most other touch screens, the SmartScreen is able to track many hands on the surface simultaneously. In this way it is able to naturally support groups of people collaborating together at a projection screen (see Figure 2).

This technology is currently being used in the New Zealand pavilion at the World Expo in Aichi, Japan. In this case, five SmartScreens are tiled together to provide a 10-meter by 1.5-meter interactive touch screen. Icons are projected onto the screen showing various aspects of New Zealand life. Users can grab these icons and drag them down to regions of the screen where they will cause still images to appear or movie clips to play. Opened in March 2005, over 4,000 people a day are using the technology. The response has been overwhelmingly positive as friends and families can play together, using just their natural hand gestures.

Lord of the Rings Motion Capture

Another perceptual user interface is a low cost motion capture system for museum exhibits. First developed for Story Inc! as part of the Boston Museum of Science's Lord of the Rings exhibit, our system uses a stereo camera, computer and green screen. The user stands in front of the screen and holds a yellow and red ball in their left and right hands. Projected on a screen in front of them they see a live video feed from the camera and a virtual character that mimics what the person is doing (see Figure 3). As the person waves their arms around the Gondorian Warrior on the screen copies them in real time.

The system works by using sophisticated computer vision techniques to find the user and then create a virtual character that approximates their body position. First, the user's body outline can be background subtracted from the green screen. Tracking the red and yellow balls enables the hands to be found and the stereo depth information from both cameras can be used to form a three-dimensional point cloud of the body pose. These features are used to control key points on a digital skeleton onto which the virtual body parts are drawn.

This system was shown for four months at the Boston Museum of Science while the Lord of the Rings exhibit was open. During that time over 70,000 people experienced the technology. Although not as accurate as a professional motion capture system, the interface was considerably cheaper and did not require a person to wear special clothing, or a motion capture suit. Users loved the fact that they could pick up a fake sword, walk in front of a screen and immediately be turned into an Orc or an Elf for a few minutes. The most important thing was that the users were able to understand the key point of motion capture – that their real body motion could drive a digital character.

Figure 3: *Lord of the Rings motion capture.*

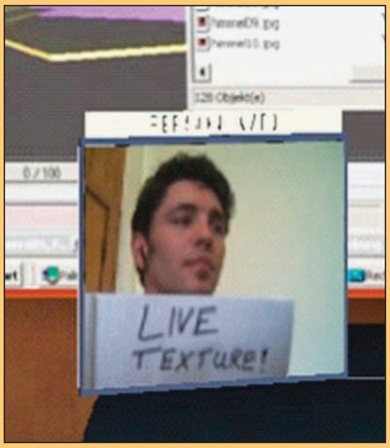

Figure 4: *Avatar with live video texture.*

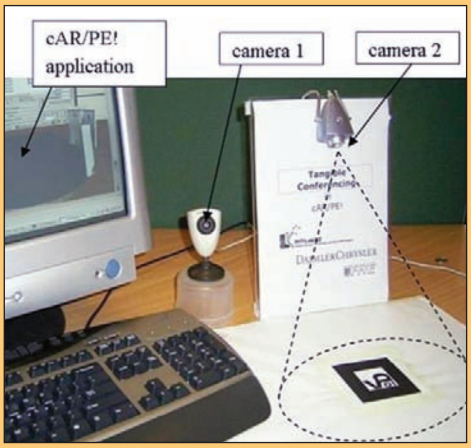

Figure 5: *Tangible conferencing hardware.*

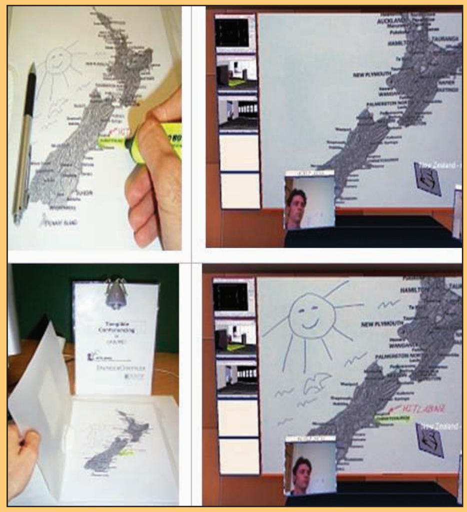

Figure 7: *Drawing on a real document.*

Figure 6: *Loading a real document.*

Tangible Teleconferencing

The Tangible Teleconferencing project explores how tangible user interface techniques can be used to overcome the limitations of traditional desktop video conferencing. In current desktop video conferencing the richness of face-to-face communication is often reduced to viewing small video windows that have reduced spatial cues and no support for interaction with real objects. Our goal with this project is to develop technology that would enable users to easily bring representations of real documents and objects into screen-based collaborative virtual environments. In order to achieve this, we blended research from the fields of tangible user interfaces, and desktop teleconferencing.

Our work is an enhancement of the cAR/PE! desktop collaborative virtual environment [8]. This is software that runs on a desktop computer with a web camera attached, and on-screen shows a three dimensional virtual conference room environment (see Figure 4). Remote users are shown as virtual avatars in the conferencing space with live video texturing on their representations.

Although the cAR/PE! interface supports intuitive spatial conferencing it still creates an artificial separation between the real and virtual worlds. Our research has extended this conferencing application to allow real documents and objects to be used at the interface. Specifically, we wanted to support the following:

- The use of real objects to load three-dimensional virtual content
- The use of real objects to manipulate virtual content
- Allowing users to bring real documents into the conferencing space

To support this we have a second camera facing down onto the user's desktop (see Figure 5). Real objects brought in front of the camera are used to interact with virtual objects on the screen, or to introduce content into the virtual space.

For example, to load a document a real folder is placed in front of the camera with a tracking marker attached to it. When the camera recognizes the marker, an electronic copy of the same document is placed on the virtual conference table (see Figure 6). The cAR/PE! environment also has a shared presentation screen in the virtual conference room. By pushing the document across the table to the screen, it will appear on the screen. The camera image of the document is used to create a virtual texture map of the document pages. This is updated continually so that the user can draw on the real page and have the new annotations appearing in the virtual communication space (see Figure 7).

We also support the use of real objects for manipulating virtual content. The cAR/PE! conferencing space was developed for virtual design review meetings. Several people can gather around the table and look at virtual models together. In our version a user can manipulate the model with a real input device. When a real interaction paddle is placed under the desktop camera, the camera tracks the paddle and maps its motion onto the virtual model. A user can translate the model simply by moving the paddle up or down (see Figure 8).

Figure 8: *Moving a virtual car using real paddle input.*

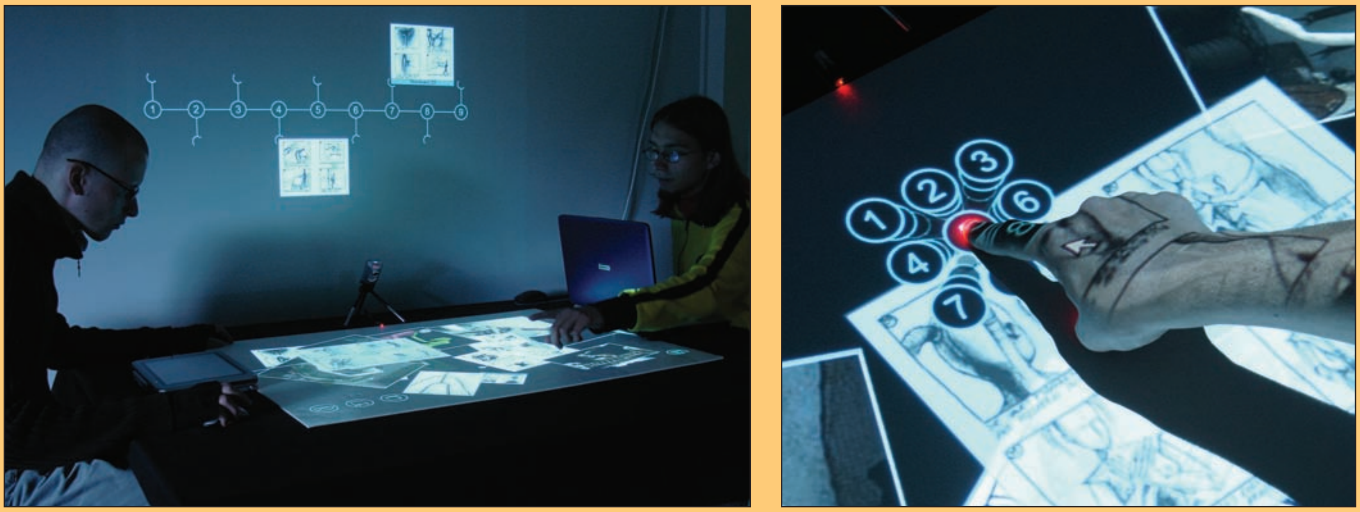

Figure 9: Using the Office of the Future.

This work aims to make teleconferencing much more natural by using easy to understand interface objects and metaphors. Another benefit is the ability to bring real documents into the conferencing environment, so we have an interface which seamlessly blends elements of the real world with shared digital content. Currently we are conducting studies to explore how usable the environment.

Office of the Future

The Office of the Future is a project conducted with our partners at the Upper Austria University of Applied Sciences. It is a next generation face-to-face collaboration tool that uses multiple projectors to move digital content from the desktop into the real world. Users can sit around a table and see virtual imagery projected on the table between them (see Figure 9).

Tables provide a convenient environment for people to meet, discuss, look over prepared documents and to present ideas that require face-to-face collaboration. However, digital data is commonly used in single user desktop environments and handheld devices. We want to combine both the usage of a table for a better communication with mobile devices (e.g. laptops, Tablet PCs etc.) to achieve the best infrastructure for a successful presentation and discussion environment.

In the Office of the Future, users can place a laptop on the table and then use a mouse to drag content from the laptop screen and have it appear projected on the real table. This is similar to the augmented surfaces approach of Rekimoto [9], but we have extended this with the addition of novel interaction techniques and a focus on developing an extensible architecture that can be used for a variety of collaborative applications.

One of the challenges with an interface like this is how to support intuitive input on the table surface. However it is natural to interact with projected digital data by using hand gestures. We support this through a novel laser input technique. A wide-angle low-powered laser shines across the surface of the table with a camera mounted above it. When the user touches the table, the beam casts a red spot on their figure that can be tracked by the camera. In this way, any portion of the table can be used for touch input. Multiple fingers can also be tracked allowing for more novel input techniques. Collaborators can use free hand input in a very natural way to drag digital content around on the table surface.

Informal user studies have shown that people enjoy working together in this setting, because they can both see each other and the data with which they're interacting. They enjoy having access to a private space (their laptop screen), a shared workspace (the table surface) and a public presentation area (the wall display). They also find the free hand input natural and simple to use.

Figure 10: Collaborative AR gaming using mobile phones.

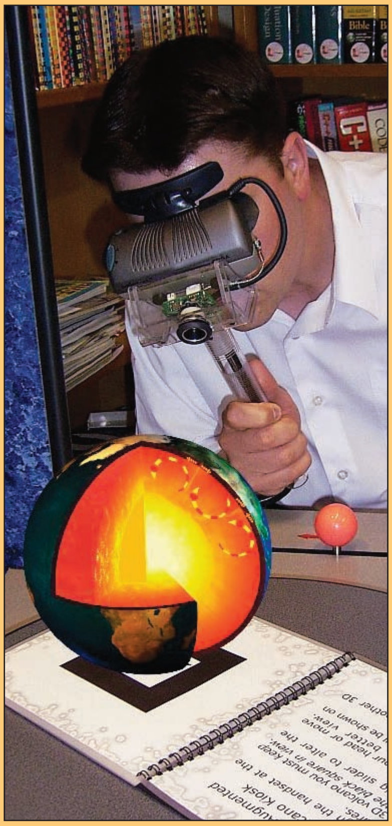

Figure 11: *Using the AR Volcano.*

Handheld Augmented Reality

In recent years mobile phones have developed into an ideal platform for augmented reality. Current phones have full colour displays, integrated cameras, fast processors and even dedicated 3D graphics chips. Henrysson [3] and Bimber [7] have shown how mobile phones can be used for simple single user AR applications. In their work, they create custom computer vision libraries that allow developers to build video see-through AR applications that run on a mobile phone.

The HIT Lab NZ, in collaboration with the Australasian CRC for Interaction Design [1], is conducting research on the types of AR applications that are ideally suited to mobile phones and user interface guidelines for developing these applications. The widespread adoption of mobile phones means that this platform could be the dominant platform for AR applications in the near future.

One particularly interesting area is mobile phone based collaborative AR applications. We have developed a simple AR tennis game that allows two players to play against each other in a face-to-face setting. In the game, when each player looks through the screen of their phone at a paper-tracking marker placed on the table, they see a virtual tennis court and ball (see Figure 10). They can take turns swinging with their mobile phone at the virtual ball and if they hit they hear the sound of racket on ball and feel the phone vibrate. Bluetooth is used to provide a peer-to-peer network connection to exchange data about the ball position, enabling players to play against each other.

Unlike normal computer games, this game moves the interaction from the screen space into the real world and effortlessly supports face-to-face collaboration. The players can easily see each other while playing together and can interact with the virtual graphics simply by using the real camera motion.

AR Museum Exhibits

The HIT Lab NZ has worked on several augmented reality installations for museums since it opened three years ago. AR technology is ideal for a museum because it enables educational virtual images to be shown in the real world and people can intuitively interact with the content using real objects.

For example, the AR Volcano Kiosk is an exhibit that teaches people about volcanoes, including details on tectonic plates, subduction, rifts, the Ring of Fire, volcano formation and eruptions. To use the kiosk, a person picks up a handheld display and looks through the display at the pages of a real book. The display has a camera on it and when the camera captures a tracking pattern on the page of the book, image processing software can calculate exactly where the view is looking from and draw a virtual image that appears to pop out of the real book page. Figure 11 shows a person using the AR Volcano kiosk and the virtual imagery they can see.

Each page of the book has different virtual content corresponding to different geological processes. The user can turn the book, walk around it or lean in close to see the virtual models from different points of view and so more clearly understand the content being shown. In addition, there is a real slider mounted by the book. Moving this will cause various animations to happen, such as the flow of magma down the side of a volcano or Mount St. Helens to erupt. Each book page also has printed text and spoken audio that further explains what the user is seeing, enhancing the educational experience.

The MagiPlanet exhibit is another AR museum exhibit that teaches people the position of each planet in the solar system. Unlike the AR volcano, the MagiPlanet is a shared AR experience. Two users each have a handheld display and when they look on the top of a table, they can see virtual planets attached to nine real wooden blocks (Figure 12).

The users can then work together picking up the virtual planets and arranging them in correct order around the sun. Interacting with the graphics is easy; to move a virtual planet, the user just has to pick up the real block the planet is attached to. In this way, blocks can be rotated and examined up close to see details such as the spot on Jupiter or Saturn's rings. The surface of each planet is highly detailed and based on accurate satellite imagery. Once all nine planets have been placed correctly, the planets begin to move around the sun, showing the relative speed of their orbital motion.

The AR Volcano and MagiPlanet kiosks have been placed in several museums and the response has been very positive. Children love seeing computer graphics magically appearing out of the pages of a real book and find it very natural to see different parts of the virtual model simple by walking around it. The interactive activity is entertaining and highly educational.

The MagicBook Project: Transitional Interfaces

The technology used in the AR Volcano project is also the basis of a deeper research focus inside of the HIT Lab NZ – exploring transitional interfaces. We are working on technology that allows a user to see augmented reality images popping out of the pages of a real book and then fly inside the content to experience it as an immersive

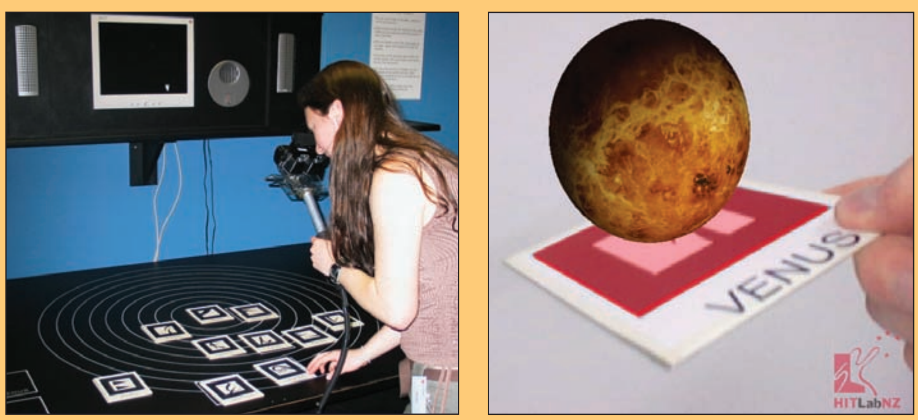

Figure 12: *The MagiPlanet virtual solar system.*

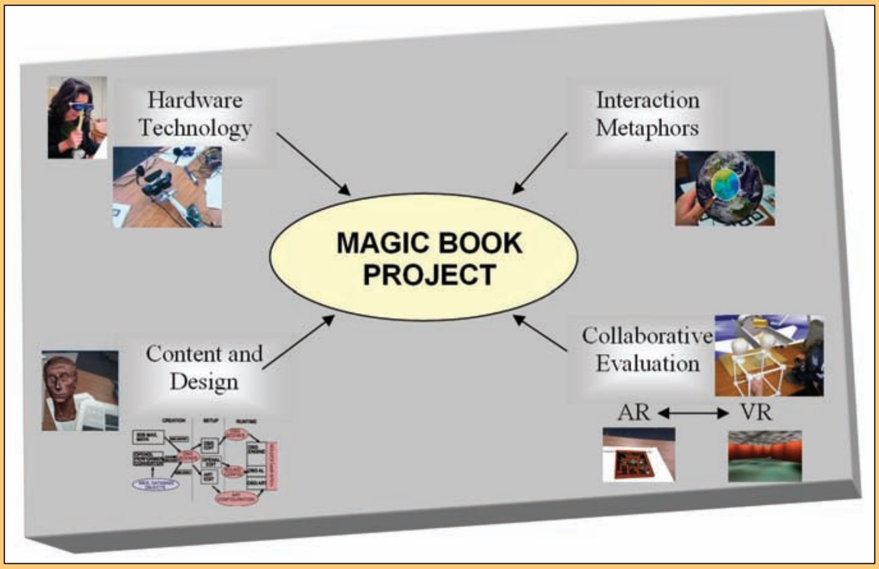

***Figure 13:** The MagicBook Project.*

virtual reality. First demonstrated during SIGGRAPH 2001, the MagicBook interface can provide a transitional interface to immersive virtual worlds.

We are currently conducting formal evaluations related to the collaborative aspects of interaction in transitional interfaces such as this. There are a number of interesting aspects to be researched such as how to maintain effective collaboration between a user immersed in the virtual world and one viewing them from an AR perspective. The use of multi-scale collaborative interfaces has many possible applications. For example, we have developed an interface space shuttle tele-robotic manipulation where using a combination of VR and AR views can improve the efficiency of the task.

There also needs to be new work conducted in appropriate interaction metaphors for transitional interfaces and methods for developing the content for the applications. One student at the HIT Lab NZ has been exploring the use of a lens-based interaction technique in which a virtual lens is used to view and select data in a very intuitive way. We are also collaborating with traditional artists and book illustrators to develop a range of tools that can be used by non-programmers to build augmented reality books. Figure 13 shows the related research concepts that make up the MagicBook project.

Conclusion

In this article we have given an overview of the HIT Lab NZ, its research focus and some of the current projects. A common theme running through this work is developing interfaces that make interaction with the computer more transparent and enhance face-to-face and remote collaboration.

As mentioned at the beginning of the article, the HIT Lab NZ bridges between academia and industry. As such we are activity looking for partners in universities and companies that would like to invent the future with us.

More information about the HIT Lab NZ can be found at **http://www.hitlabnz.org/**.

Acknowledgments

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