interaction | interfaces | invention

Future Training - Simulations, Virtual Reality, Serious Games and Augmented Reality

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Working Paper Series, Number 2, March 2017

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Future Training - Simulations, Virtual Reality, Serious Games and Augmented Reality

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ABSTRACT

As computer technologies continue to evolve so do the ways we interface with them. In this report I briefly review the past, present, and future of advanced computer interfaces. This includes a general introduction to the related technologies of simulation, virtual reality, computer games, and augmented reality. In particular, this introduction focuses on the application of these technologies to support training and decision-making tasks. As these topics are also a focus of current research in the i3Lab, this report also identifies a number of key research questions. A recurring theme of these research questions is the need to develop more objective measures for evaluating these technologies. Such measures will be critical for evaluating the efficacy of new 3D interfaces designed to support decision-making tasks. They will also provide objective measures of the training effects gained from simulation-based training.

NOTE: This report is adapted from a talk given by Keith Nesbitt at a public forum at the Royal Newcastle Lecture Theatre, JHH Hospital on Monday, 28th November 2016. This forum was organised by The Centre for Brain and Mental Health Research (CBMHR), in partnership with Hunter Medical Research Institute (HMRI).

i3 Lab

1 Introduction

For many people, their daily work involves some form of critical decision-making. Sometimes these decisions need to be made with insufficient data, or too much data, the wrong type of data, or even incorrect data. Usually in the modern world these decision-making tasks occur while interacting with complex computer interfaces. Therefore one important role of the interface designer is to develop systems that bring computers, data, and people together to undertake specific decision-making tasks.

While this objective is simple to state, the engineering of user interfaces is a complex field that needs to consider the capabilities and risks of a range of interface technologies and the associated cost constraints of any hardware and software required for implementing the interface. Furthermore, interfaces between humans and computers are constantly evolving as new technologies such as Simulation and Modelling, Virtual Reality, Serious Games and Augmented Reality enter into mainstream use (Southgate et al. 2016). This report introduces these technologies and provides background into how they can be used to support both training and decision-making.

The study of Human-Computer Interaction is an ever-expanding field of research that requires an appreciation of the psychological issues related to human perception and cognition. It recognises that the proper design and evaluation of user interfaces is a critical step in providing efficient and effective task-level support for applications such as training and decision-making. However, often trade-offs need to occur in the interface development process and so when evaluating the final interface it may be critical to consider one or more core usability criteria such as the utility, efficiency, memorability, learnability or safety of the system. Considerations such as fun, or engagement, are also gaining importance in interface design. This is driven, in part, by the widespread use of computer games for entertainment.

In the past there has been some reliance on the 'art' of developing good interfaces. However, in the future, better 'science' will be required, especially in the design of critical systems. This will involve the development of more empirical and objective approaches to validating interface reliability. This report discusses issues of validation and raises other research questions that need to be addressed to advance the design of systems that support better decision-making and better training for decision-makers.

The report has been divided into four main sections, each introducing a particular aspect of advanced interface technology, namely, Simulation and Modelling (section 2), Virtual Reality (section 3), Serious Games (section 3), and Augmented Reality (section 4). While these technologies can be considered separately they have much in common and together their key elements are promising to reinvent the way humans interface with computers for virtual training and immersive, evidence-based decision-making.

2 Simulation and Modelling

Two terms that are often discussed in relation to training and decision-making are *Simulation* and *Modelling*. **Simulations** simply provide a representation of something in the real world. Simulations typically represent systems that change state, either continuously over time or more discretely in response to events. Often simulations are made up of familiar objects that are found in the real world. However, more abstract entities such as processes or events can also be represented in a simulation. **Models** are specific representations of these objects or processes. These models may be mathematical, logical or physical in nature (see figure 1). These models may even provide representations of human thought processes such as perception and cognition. Often these models are used to predict or anticipate the future state of the system. Where the parameters of a simulation can be manipulated in real-time, these systems might be described as interactive simulations. While the initial development of these simulations can be expensive, they benefit from reuse.

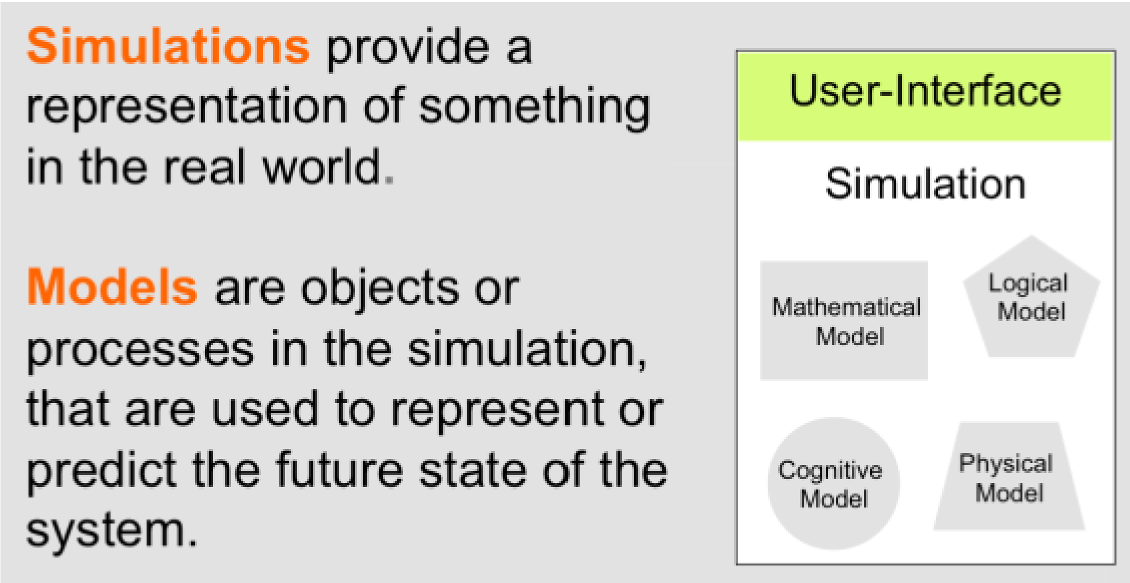


Figure 1: Simulation and Modelling

Interactive simulations are frequently used in training systems as they allow real-world scenarios to be presented, and also to respond 'naturally', as the trainee, makes decisions. The term, **live simulation** is used to describe training situations where real people role-play scenarios in the real world. This approach has been frequently used in the medical and health sciences as well as the Defence industry. Live simulation allows for natural interaction with real people, although this training is dependent on suitably trained actors or subject matter experts who must be involved in each training session. This can make these simulations expensive to run, difficult to organize and lead to variable quality. Furthermore, a training session is not easily repeated. In the future it is likely the cost and lack of flexibility and reuse of such live simulations will see their use decline.

An alternative approach, called **virtual simulation** has the trainee operating in a synthetic computer generated world, where various scenarios can be developed for training. Although it can be expensive to develop these applications, they are reusable and can often be adjusted to provide a wide range of training experiences. It is also typically possible to record trainee performance for play back and review after training in virtual simulations.

If training is too dangerous or prohibitively expensive to take place in the real world, then a virtual simulation may well be the only viable alternative. For example, pilots have used some form of simulation training since World War I. In 1913, a mock up wooden simulator was used to train rookie pilots and it noticeably improved survival rates for pilots on first time missions (Rheingold, 1991). Over time the sophistication of flying simulators has developed until now most pilots train on complex rigs that use moving platforms to simulate the motion of the aircraft. The trainee pilot also experiences immersive, realistic visual and auditory displays of the changing world while responding in real-time to simulated dynamics as they operate carefully replicated cockpit controls.

Although live simulation and virtual simulation can be useful adjuncts to training, more traditional forms of training, such as classroom activities, project-based assignments, lectures and general bookwork, will remain an important part of training for some time. Even though systems that support virtual training are becoming cheaper, more flexible and easier to develop, there are still considerable costs associated with developing content and maintaining systems. Indeed for many organisations that use virtual training, the business case for each training application, needs to be carefully considered. This requires further research into objective measures of training effects but also better characterisation of the precise goals of each virtual training scenario.

Regardless, the potential application for virtual simulations is diverse (see Figure 2). Important applications of the technology include Education and Training, Immersive Analytics (finding patterns in large datasets) and Computer Games. Potentially, anything that you can do in the real world can be simulated in a virtual world. Once a simulation is developed then the simulation can then also be used in training.

Education and Training	Immersive Analytics
Urban Planning	Theme Parks
Engineering	Concerts
Architectural Design	Tourism
Remote Collaboration	**Computer Games**
Psychological Therapy	Film
Exercise and Fitness	Media
Retail	Fine Arts
Archaeology	Marketing

Figure 2: Application Areas for Virtual Simulation

3 Virtual Reality

Virtual Reality is a key technology that can be used to implement both training and decision-making interfaces. **Virtual Reality** is intended to provide an immersive, interactive computer simulation of a three-dimensional environment, where the user experiences either a realistic or abstract model of the world and is able to interact with it in a natural way. In virtual reality the intention is to put the user inside the computer-generated world, and allow them to accomplish tasks in the virtual world as they would in the real one (see Figure 3). This contrasts with a more traditional user interface where the interface creates a clear boundary between the user and the computer. The user enters commands in the interface that cross this boundary to control the computer. The computer responds to these commands, and then uses the interface to provide feedback to the user about the changed state of the computer. In Virtual Reality, the idea of an *interface*, becomes seamless, and the notion of a boundary between human and computer should disappear altogether. Unfortunately, as of 2016, this ultimate vision for Virtual Reality is still a way from being realised.

Some other key concepts related to Virtual Reality are Immersion, Presence, Natural Interaction, Stereographic display, and Multisensory (visual, auditory, haptic) interfaces. ***Immersion*** refers to the strong engagement of the user in the virtual world and it often requires a suspension of disbelief that the virtual world is not real. Technologies that block out the real world and most faithfully reproduce real world sensory effects support this effect. So technologies that provide a wide field of view and high spatial and temporal fidelity are often used to enhance this effect. Immersion also requires a seamless, non-distracting and natural level of interaction and can be difficult to achieve as the equipment itself may fight against the users suspension of disbelief. Immersion is closely related to the idea of ***Presence***, which is a person's subjective sensation of feeling present in the virtual world.

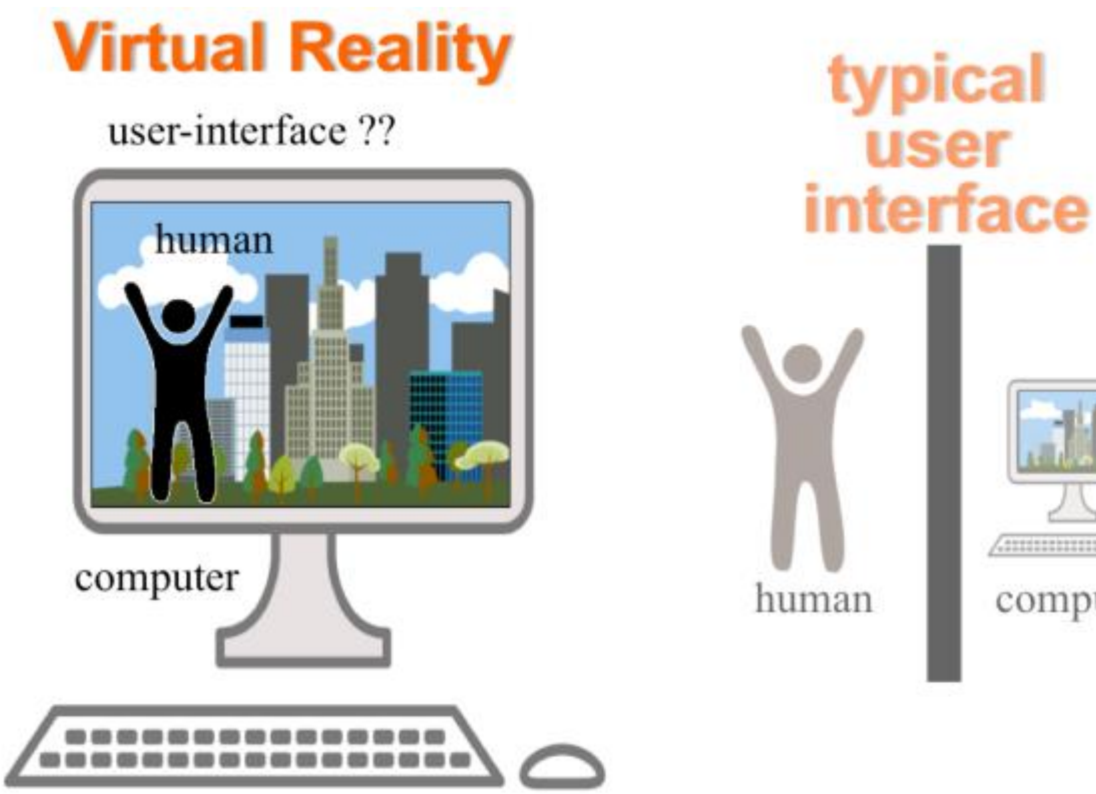


Figure 3: Contrasting Virtual Reality interfaces with traditional user interfaces.

Natural interaction implies that people should interact in the virtual world with virtual objects just as they interact with objects in the world. As part of this desire for 'natural interaction', a common feature of Virtual Reality is the use of stereographic displays and multi-sensory input and output. ***Stereographic displays*** provide alternative views of the virtual scene to each eye. These left and right eye scenes are created by rendering the virtual world from two cameras positioned about one eye distance apart. The view is usually dependent on the user's current head position. Thus, as the user looks about, the scene changes for each eye. Stereographic displays provide an extra depth cue for objects in the 1-3 metre range. Although it is only one of many depth cues, it can help provide immersion and might be important for helping disambiguate complex 3D structure. The sense of immersion can also result from using a wide field of view that engages the peripheral visual field.

Multi-sensory input and output can take many forms (see Figure 4). There is a current move towards using gesture and voice commands in these interfaces, although many interfaces incorporate traditional pointing devices or real world props to support interaction. Visual feedback remains the primary focus, but 3D sound is also used frequently. Moving motion platforms are used with larger simulators for professional vehicle simulators, but also for theme park rides. Other forms of haptic (touch) feedback, such as force feedback displays, are still rudimentary as they provide only limited capabilities and require significant programming effort. In effect, human 'touch' involves the integration of multiple different sensory receptors reacting to different types of stimuli. The ability to simulate this full range of sensory inputs in the computer interface is likely many years away.

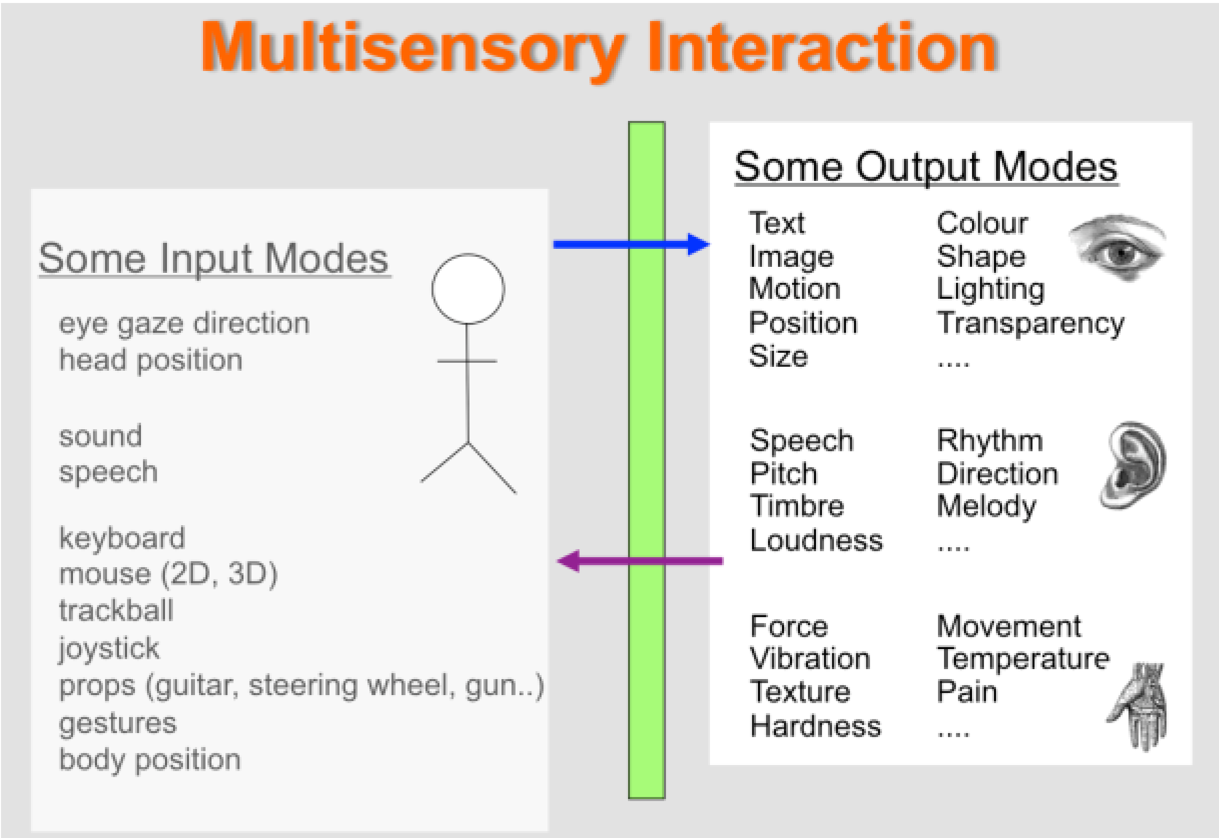


Figure 4: Possible types of Multi-sensory interactions that can be used in Virtual Reality

One common misconception surrounding Virtual Reality is that it provides only a single type of interaction. In effect there are many different forms of Virtual Reality, and each is suited to different types of applications as they vary in underlying technology, cost, interaction style, levels of immersion, and even the number of people that can share the experience. Some of the more common configurations are shown in Table 2.

In terms of the general use of Virtual Reality, and more specifically when using the technology for training, a number of open research questions remain (see Table 1). Virtual Reality as a natural way of interfacing with computers, along with the various applications suggested for the technology are not new. Virtual Reality has been advancing steadily since the concept of computer-generated, virtual worlds were described by Ivan Sutherland in the 1960's (Sutherland, 1965). Sutherland went on to demonstrate the first immersive visualisation by creating his prototype head-mounted display in 1968. Sutherland's work in scene generation eventually led to the development of 3D display hardware and the field of computer graphics emerged.

While the early science of Virtual Reality was led by Ivan Sutherland, the entertainment industry also recognised the potential of this new concept. In 1960, the concept of a multi-sensory experience was marketed by Morton Heilig. By 1962, this led to the development of a patented virtual reality arcade ride called the Sensorama Simulator. This arcade ride allowed users to ride a motorbike through New York and experience a 3D view with sound, wind, vibration, and even aroma (Hamit 1993).

Table 1: Research Questions related to Virtual Reality, Multi-sensory Display and Training

General
How do we increase performance of the various technologies? For example, how to make them faster, cheaper, and with higher fidelity?
Given the broad range of possible Virtual Environments, what is the best way to interact in these different interfaces?
How best to integrate multisensory displays into these interfaces? For example better haptics, and context-dependent, 3D spatialised sound.
How to design to avoid the unpleasant side effects of nausea, tiredness, headaches and other symptoms associated with cybersickness and simulator sickness? (Davis et al, 2014; Davis et al, 2015; Nalivaiko et al 2015)

Multisensory Display
What information do we map to each sense? For example, How can established theory from psychological studies in perception and cognition be integrated into the design of visual, auditory and haptic displays? (Chang and Nesbitt 2005, McAdam and Nesbitt 2011, McAdam and Nesbitt 2012, Nesbitt and Barass 2004, Nesbitt 2006)
When using Virtual Reality for immersive analytics, how to best map specific data attributes to different sensory stimuli? (The notion is to increase human-computer bandwidth using multisensory displays).

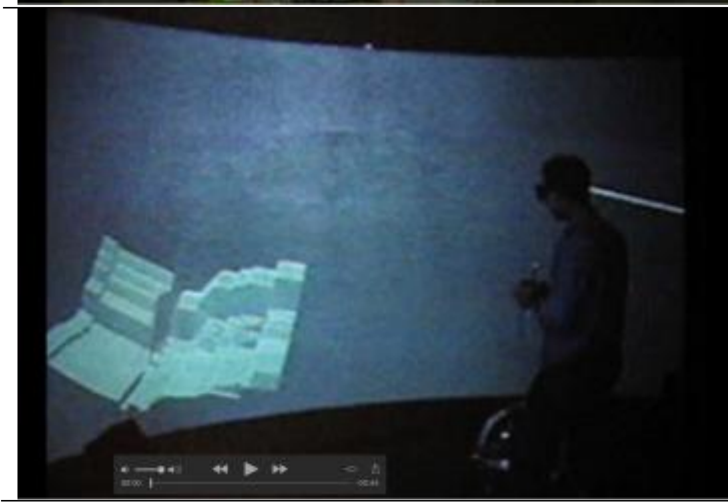
Training
What level of fidelity (realism) is required for training?
What design/interface factors impact on Immersion/Presence/Training?
What is the business value of the various training applications?
How to best build and integrate sound and haptics for training?

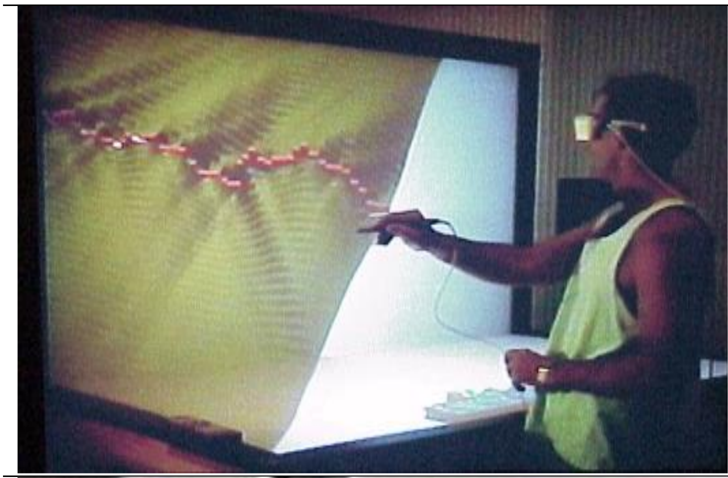
The potential of Virtual Reality for building aircraft flight simulators drove much of the early work in this field. It cost millions of dollars to build simulator hardware for a single aircraft configuration, and the promise of producing the same system in software was enticing. The software could simply be upgraded with the aircraft. This led to a substantial investment by the military in this technology for training. NASA also became interested in simulation for astronaut training and in 1981 they developed their own Virtual Visual Environment Display (Burdea and Coiffet, 1994).

The initial focus of the technology was on trying to replicate reality. Being able to mimic the real world was useful for providing experiences, prototyping designs, or for training. In terms of immersive human-centred exploration of data, the concept of a more abstract data world, called *Cyberspace,* was popularised by the science fiction author William Gibson in the 1984 novel, Neuromancer.

> "*A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding.*" (Gibson 1984).

Table 2: Historical images illustrating the diverse styles of interaction used with Virtual Reality.

	CAVE – Argonne National Labs, 1994. (Cruz-Neira, et al. 1993). Application: Immersive Fluid Dynamics Small room-sized environment suitable for small groups (3-5 people). Stereographic images are projected onto 3 walls and the floor of the environment.
	iCone – Fraunhofer, 2000. (Simon et al 2004, Nesbitt and Barass 2004) Application: Stock Market Analysis Large curved screen with projected stereographic display. Suitable for medium sized groups (3-10 people). The wide horizontal field of view creates an immersive display space.

	Responsive Workbench – Fraunhofer, 2003. (Hanrahan, and Fröhlich1997, Nesbitt 2001) Application: Stock Market Analysis Double screen, table or bench top display with projected stereographic display. Suitable for small sized groups (2-3 people). The interaction is akin to manipulating a model on a table-top.
	Head-mounted Displays – University of Seattle, 1998. Application: Architectural Walkthrough Head-mounted displays (HMD) provide highly immersive displays for a single person, although more that one person can be present in the same virtual world.
	Haptic Workbench – CSIRO, 2002. (Nesbitt, et al. 1997). Application: Data Analytics Single person workstation incorporating a 3D stereographic display with a force-feedback device (Phantom) and auditory display to provide a multi-sensory environment for exploring a 3D cube of data.

Despite this early visionary work, it has taken quite a while since the 1960s to develop the computer power, in terms of hardware and software, to generate realistic interactions in virtual worlds. For example, the field of computer graphics had its genesis in Virtual Reality and now underpins much of the technology used for visual display. Over time, the main trend has been to increase fidelity (realism) with more powerful graphics processing and higher resolution displays. This is illustrated through the development of Head-

Mounted Displays (see Table 3, Figure 5), where costs have steadily decreased while graphical performance has improved significantly. Other improvements such as position tracking, wireless connectivity, and the reduced weight of these devices, have all served to enhance the usability and affordability of this technology. Further dramatic improvements are likely to occur in the future.

It is important to recognise that many advances in the technologies that make up Virtual Reality have been, and continue to be, driven by the computer gaming industry. Indeed many styles of Virtual Reality interaction, affordable hardware, and even development processes such as Agile methodology, have been rapidly advanced by the large consumer demand for computer games. In the next section we will also discuss the use of Serious Games for training.

Table 3: Cost and Performance Trends in early commercial Head-Mounted Displays (Burdea and Coiffet 1994; Holloway and Lastra 1993) compared with the Oculus Rift (Antonov, Mitchell, Reisee, Cooper, LaValle and Katsev 2013; Oculus Rift 2014)

Head-Mounted Display	Resolution per eye	Horizontal Field of View	Weight (kg)	Cost (US$)	Year
VPL Eyephone 2	360 x 240	90	2.4	9,150	1989
LEEP Systems Cyberface II	479 x 234	140	1	8,100	1992
Virtual Research Flight Helmet	360 x 240	100	2	6,000	1993
Oculus Rift DK1	640 x 800	110	0.22	500	2014
Oculus Rift DK2	960 x 1080	100	0.32	600	2016

Figure 5. Recent (2015-2016) commercial varieties of Head-Mounted Displays. Note the Hololens has a see-through display for Augmented Reality.

4 Serious Games

Many of the technologies associated with Virtual Reality have been applied in the domain of computer games. Indeed the high demand and broad market for computer games has helped drive developments in affordable and novel interface technologies. This includes fundamental hardware such as Graphical Processing Units, novel interactive devices such as the Wii and Microsoft Kinect as well as Head-Mounted Displays such as Oculus Rift, HTC Vive and Playstation VR for the PS4 console. Popular game engines, such as Unity (Unity, 2017) and Unreal Engine (UnrealEngine, 2017) have also supported more rapid prototyping and development of applications in both games and Virtual Reality. Furthermore, player-centric and Agile development processes that have become fundamental in games development also support better development processes for Virtual Reality applications. All these advances will support more user-friendly experiences being developed for Virtual Reality into the future.

While computer games are developed primarily for entertainment, the term "Serious Games" has been applied to applications of games that have a serious intention. ***Serious Games*** share the design goal of traditional games in trying to engage, motivate and entertain players (Abt, 1970), but a further goal of a serious game is to achieve a specific psychological, educational, training or business objective.

In terms of training, an interesting question is how to dynamically adjust the current difficulty level of a game task. The motivation for the designer is to balance game difficulty with player ability in such a way that the game is sufficiently challenging that it maintains interest and entertains across the broadest possible range of player abilities. One approach is to continuously measure player performance during the game and adjust the difficulty based on how well the player is performing. This approach has been utilised in a number of commercial games. Some good examples are the third-person shooter, Max Payne (Remedy Entertainment, 2001), Far Cry (Crytek, 2005), Left 4 Dead (Valve Corporation, 2008) and the Mario Kart (Nintendo, 1992) series of games. Indeed, the technique was commonly used in racing games and became known as 'rubber-banding', as the mechanics of the game were adjusted to ensure the player was always held close to other cars, as if all the racers were held together by rubber bands (Missura & Gartner, 2009). A key feature of good dynamic balancing is that it remains invisible to the player (Hawkins et al 2012). For training, this may well provide an optimal strategy for maintaining the user's engagement in the learning task.

More general questions remain about how to design for best engagement and how to objectively measure engagement? Engagement itself is a complex construct, and can sometimes be used to indicate behavioural engagement, affective engagement (Nesbitt et al, 2015) or indeed cognitive engagement (Hookham 2015; Hookham 2016). The same questions around designing for engagement can be extended from games research to the development of training experiences in Virtual Reality.

Finally, it is possible to consider using commercial off-the-shelf games to support skill training in general areas of cognitive performance such as such as decision-making, communication or pattern recognition. Although, questions related to how well learning from general gameplay transfers to more specific skills, still require further investigation and validation.

5 Augmented Reality

Augmented Reality adds, or overlays, computer-based information to objects or locations in the real world. In Virtual Reality the user is immersed in a completely simulated computer world. Comparatively, in Augmented Reality the user remains in the real world but their experience is modified by digital sound or images intended to enhance or "augment" their real-world experience. This additional information that the user observes and interacts with can be dependent on where the user is, what they are looking at, and also what they are doing.

The hardware used to implement an augmented experience can be as simple as a mobile phone, where GPS coordinates and the phone camera can be used to provide an enhanced view of the world on the mobile phone screen. In this example, the user points their phone at something and sees or hears additional information displayed. In 2016, the Pokemon Go application for mobile devices has been widely used for entertainment. A similar, educational application might provide historical information overlaid at specific real-world locations. Even everyday shopping might well be enhanced in this way. For example, by allowing the user to point their phone at an item on the supermarket shelf and then see additional product information such as price, country of origin, health ratings, and recipes that use the product.

More complex 3D versions of Augmented Reality make use of similar hardware as that used in Virtual Reality. For example, more complex interactive 3D models might also be displayed over the real world. This requires see-through head-mounted displays that detect locations and objects in the real world, and then project these 3D models onto the see-through lens of the head-mounted display. The release of the developer version of the Microsoft Hololens in 2016 has seen a renewed interest in this more complex form of interfacing (see Figure 5). While the technology is impressive, it should be remembered that it is the application and the underlying simulation and modelling that are critical to creating useful experiences.

Like Virtual Reality, there is an almost unlimited number of potential applications for Augmented Reality for training and guiding decisions. To illustrate, one of the early applications for Augmented Reality was to assist in training technical staff in the complex task of laying out wires into preconfigured looms for use in large commercial aircraft. The user would look through a head-mounted display at the wiring loom and would see the location for placing each wire overlaid on this loom (Rheingold, 1991).

The aircraft industry also uses augmented reality incorporated into the helmets of modern fighter jet pilots. Critical information is projected on to their see-through helmet visors to assist with navigation, control, threat detection, and deployment of offensive assets. In our own research work, we have been exploring the use of augmented reality to assist decision making for helicopter pilots. This is particularly relevant in visually degraded environments, such as dust, dark, or poor weather. Modern flight systems can integrate stored terrain data, fused sensor information, conformal 2-D and 3-D symbology, and landing guidance, with Lidar and Infrared imagery (see Figure 6).

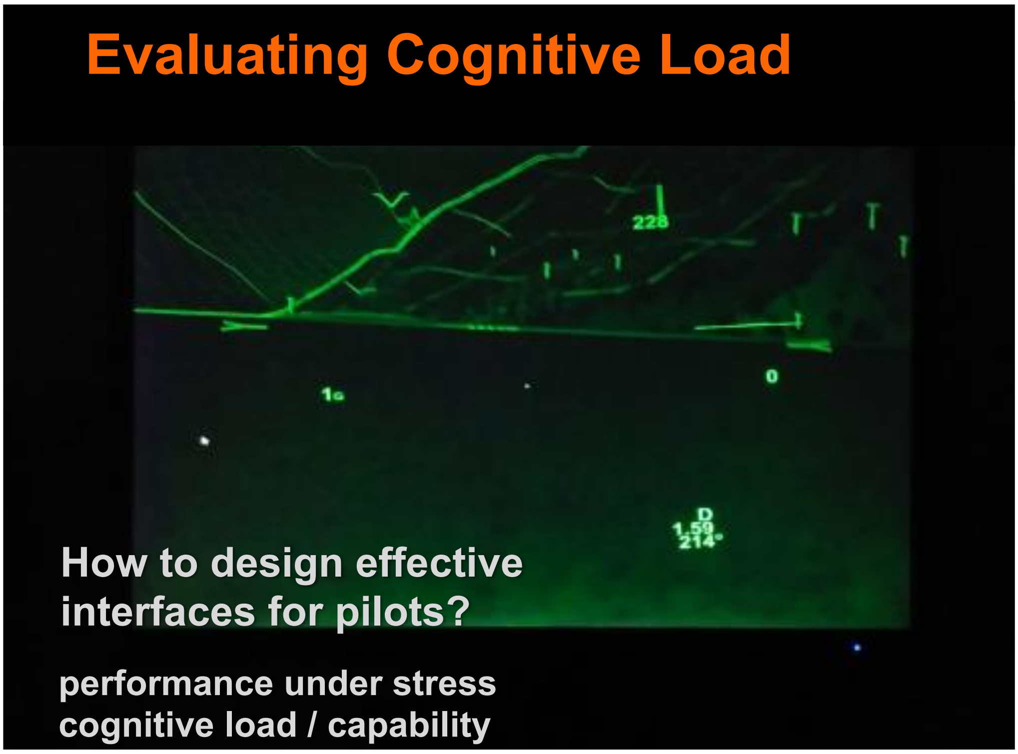


Figure 6. Example of possible symbology for pilot Head-Mounted Displays.

Such visually enhanced flight systems provide a complex, integration challenge with different sensors having different resolutions, different latencies, different processing techniques, and different processing capabilities in different weather. Integrated hardware is one challenge, however, an optimized pilot-vehicle interface, using augmented reality displays, is also critical for meeting the expectations of regulated enhanced flight vision systems. Hardware aside, a general question is how we design better interfaces and then test them to regulation standards? Perhaps more importantly there is a need to train pilots for rapid, perhaps unexpected decision making under stress. As with existing pilot control systems, the training and evaluation of new pilot interfaces can take place in simulators. This raises further research questions, such as: how to design effective simulation-based training? Finally, as with most training applications it is important to find reliable research methods to objectively measure flying performance and the cognitive load experienced by pilots.

6 Conclusion

As computer technologies continue to evolve so do the ways we interface with them. This brief report has discussed some of the emerging interface technologies such as simulation and modelling, virtual reality, computer games, and augmented reality. Into the future, these maturing technologies promise to deliver a broad range of new interface styles that support training and a range of decision-making tasks.

This report has highlighted a number of important research questions related to the design of future human-computer interfaces. In terms of decision-making under stress, training, and the general design of interfaces we expect this future research to deliver more objective measures of constructs such as task performance (Smith et al 2015), physical demand, training effects, user behavioural profiles, user affective responses (Nesbitt et al, 2015), and cognitive load.

7 References

Abt, C. C. Serious games. New York: The Viking Press, 1970.

Antonov, M., Mitchell, N., Reisse, A., Cooper, L., LaValle, S., & Katsev, M. (2013). Oculus VR SDK Overview: SDK Version 0.2. 5

Burdea, G. and P. Coiffet (1994). *Virtual Reality Technology*. New York, John Wiley & Sons.

Chang, D. and Nesbitt, K. (2006). Identifying Commonly-Used Gestalt Principles as a Design Framework for Multi-Sensory Displays, IEEE International Conference on Systems, Man, and Cybernetics, pp 2452- 2457, Taipei, Taiwan, 8 - 11 October 2006.

Cruz-Neira, C., D. J. Sandin, et al. (1993). "Surround screen projection-based virtual reality: The design and implementation of the CAVE". *SIGGRAPH*, 1993.

Crytek. (2005). Far Cry. [Windows], France: Ubisoft.

Davis, S., Nesbitt, K., & Nalivaiko, E. (2014). "A Systematic Review of Cybersickness". In K. Blackmore, K. Nesbitt, & S. P. Smith (Eds.), IE2014 Proceedings of the 2014 Conference on Interactive Entertainment (pp. 8:1-8:9). New York: ACM.

Davis, S., Nesbitt, K. and Nalivaiko, E. (2015). "Comparing the onset of cybersickness using the Oculus Rift and two virtual roller coasters". In Proc. 11th Australasian Conference on Interactive Entertainment (IE 2015) Sydney, Australia. CRPIT, 167. Pisan, Y., Nesbitt, K. and Blackmore, K. Eds., ACS. 3-14.

Durlach, N. I. and A. S. Mavor, Eds. (1995). *Virtual Reality: Scientific and Technological Challenges*. Washington, D.C., National Academy Press.

Gibson, W. (1984). *Neuromancer*. New York, Berkley Publications Group.

Hamit, F. (1993). *Virtual Reality and the Exploration of Cyberspace*. Carmel, Indiana, Sams Publishing.

Hanrahan, P. and B. Fröhlich (1997). "The Two-User Responsive Workbench: Support for Collaboration Through Individual Views of a Shared Space." *Computer Graphics Proceedings*, Annual Conference Series, 1997.

Hawkins, G., Nesbitt, K. and Brown, S. (2012) *Dynamic Difficulty Balancing for Cautious Players and Risk Takers*. International Journal of Computer Games Technology, vol. 2012, Article ID 625476, 10 pages, 2012. doi 10.1155/2012/625476.

Holloway, R. and Lastra, A. *Virtual environments: A survey of the technology*, (1993).

Hookham, G., Mark Deady, M., Kay-Lambkin F. and Nesbitt K. (2013) "Training for Life: Designing a Game to Engage Younger People in a Psychological Counselling Program". Australian Journal of Intelligent Information Processing Systems. Vol 13 No 3, Special Issue on Edutainment 2013, ISSN:1321-2133.

Hookham G, Nesbitt K, Kay-Lambkin, F. (2016) "Comparing Usability and Engagement between a Serious Game and a Traditional Online Program", In Proc. of the Australasian Computer Science Week Multiconference, AUIC 2016.

McAdam R., Nesbitt K.V., (2011). "Movement-based interfaces for problem solving in dynamics", Proceedings of the Australiasian Conference on Information Systems ACIS 2011 - "Identifying the Information Systems Discipline", Sydney, NSW (2011).

McAdam, R; Nesbitt, K. Leveraging Human Movement in the Ultimate Display. In Proceedings of the 13th Australasian User Interface Conference (AUIC 2012), Melbourne, Australia, January, 2012.

Missura, O., & Gartner, T. (2009). Player Modeling for Intelligent Difficulty Adjustment. Lecture Notes in Computer Science, 5808, 197-211.

Nalivaiko E., Davis S.L., Blackmore K.L., Vakulin A., Nesbitt K.V., "Cybersickness provoked by head-mounted display affects cutaneous vascular tone, heart rate and reaction time.", Physiol Behav, 151 583-590 (2015).

Nintendo. (1992). Mario Kart. [Super Nintendo], Japan: Nintendo.

Nesbitt, K. V., Orenstein, B. J., Gallimore R. (1997). "The Haptic Workbench applied to Petroleum 3D Seismic Interpretation". *The Second PHANToM User's Group Workshop*, Cambridge, Massachusett, USA, MIT.

Nesbitt, K. (2001). "Interacting with Stock Market Data in a Virtual Environment". Joint Eurographics IEEE TCVG Symposium on Visualization, Ascona, Switzerland, SpringerWein New York. 273-282.

Nesbitt, K. and Barrass, S. (2004). *Finding Trading Patterns in Stock Market Data,* IEEE Computer Graphics and Applications, September-October 2004, pp45-55.

Nesbitt, K. (2006). "Modelling Human Perception and the Multi-sensory Design Space", Australian Computer Science Communications, Volume 28, Number 6. pp.65-64. Proceedings of the Third Asia-Pacific Conference on Conceptual Modelling (APCCM2006), Hobart, Tasmania, Australia, 16-19 January, 2006.

Nesbitt K, Blackmore K, Hookham G. Kay-Lambkin F, Walla, P. (2015) "Using the Startle Eye-Blink to Measure Affect in Players", Serious Games Analytics: Methodologies for Performance Measurement, Assessment, and Improvement, Springer, New York 401-434 (2015)

Oculus Rift. (2014). Announcing the Oculus Rift Development Kit 2 (DK2) [Web log post]. Retrieved from https://www.oculus.com/blog/announcing-the-oculus-rift-development-kit-2-dk2/

Remedy Entertainment. (2001). Max Payne. [Windows], USA: Gathering Of Developers.

Rheingold, H. (1991). Virtual Reality. Great Britain, Mandarin.

Simon, A., Smith, R. C., Pawliki, R.R. "OmniStereo for Panoramic Virtual Environment Display Systems", Proceedings of the 2004 Virtual Reality (VR'04), 2004 March 27-31, Chicago, IL USA.

Smith S.P., Blackmore K, Nesbitt K, 'A Meta-analysis of Data Collection in Serious Games Research', Serious Games Analytics: Methodologies for Performance Measurement, Assessment, and Improvement, Springer, New York 31-55 (2015)

Southgate, E., Smith, S. P., Cheers, H. (2016). Immersed in the future: A roadmap of existing and emerging technology for career exploration. *DICE Report Series*, Number 3. Newcastle: DICE Research.

Sutherland, I. E. (1965). "The Ultimate Display". *IFIP'65 International Federation for Information Processing*.

Sutherland, I. E. (1968). "A head-mounted three-dimensional display". AFIPS.

Unity. (2017). Unity Game-Engine. https://unity3d.com/, Retrieved March 9, 2017.

UnrealEngine. (2017). Unreal Engine, https://www.unrealengine.com/, Retrieved March 9, 2017.

Valve Corporation. (2008). Left 4 Dead. [Windows], USA: Valve Corporation.