The Role of Augmented Reality within Ambient Intelligence

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ABSTRACT

An Augmented Reality (AR) is a technology which provides the user with a real time 3D enhanced perception of a physical environment with addition virtual elements—either virtual scenery, information regarding surroundings, other contextual information—and is also capable of hiding or replacing real structures. With Augmented Reality applications becoming more advanced, the ways the technology can be viably used is increasing. Augmented Reality has been used for gaming several times with varying results. AR systems are seen by some as an important part of the ambient intelligence landscape. Therefore, the authors present several types of augmentation applications of AR in the domestic, industrial, scientific, medicinal, and military sectors which may benefit future ambient intelligent systems.

Keywords: Ambient Intelligence Landscape, Ambient Intelligence Systems, Augmented Reality, Intelligent Interfaces, Virtual Elements

1. INTRODUCTION

Ambient intelligence is a human interface metaphor referring to the environment of computing which is aware and responsive to the presence of human interaction. The aim is to place great emphasis on the aspect of being user friendly and efficient and provide support for human interaction. We are still striving for a future world where we will be surrounded by intelligent interfaces that are to be placed in everyday objects. These objects will then be able to recognise but also respond invisibly to the presence of people. The interaction between the technology and the users should be natural (Aarts & Marzano, 2003; Curran, 2009). It also aims to create a system that will be able to recognise all the different scents that are in the environment.

In fact, one can argue that the holy grail of the mobile Augmented Reality (AR) industry is to find a method of delivering the right information to a user before the user needs it, and without the user having to search for it (ReadWriteWeb, 2009). The Ambient Intelligence concept builds upon ubiquitous computing and user-centric design and this paper seeks to provide a snapshot of aspects of modern Augmented Reality systems which may play important roles in the ambient computing landscapes of tomorrow.

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Augmented Reality systems provide contextual information to the user such as the head mounted display within a modern cockpit, by allowing the pilot firstly to see reality through the glass window then overlaying information regarding plane speed, plane trajectory and any relevant information about the current target or objectives. This process of overlaying virtual information on top of reality is the essence of AR and as technology progresses so too will the quality and functionality of these devices. It has been used more recently in the creation of car maintenance visual guides. By overlaying a virtual component and demonstrating to the user how to manipulate the counterpart physical component. The implementation of such AR applications would drastically reduce the level of knowledge required to deal with complex tasks from engineering to surgery (Zhou et al., 2008; Holden, 2011).

Augmented Reality, as a label, is credited to Tom Caudell, who coined the term when he was working at Boeing in 1992 (King, 2009). Caudell was involved in the development of one of the first AR systems; whereby users would be able to follow the installation of complex wiring looms in Boeing aircraft using a head worn device that would allow the engineers to see wiring diagrams ‘projected’ onto their field of vision as they worked. This significantly increased productivity and accuracy as the installations progressed without the need for engineers to constantly move back and forth between the wiring diagrams and the work location. It is thought that the first Augmented Reality (AR) system used simple wire-frame graphics, and a cumbersome head mounted display (HMD) and was first demonstrated in 1968. The HMD was so heavy that had to be suspended from the ceiling. The system was designed by Ivan Sutherland in Harvard University (Cawood & Fiala, 1998). Augmented reality describes the way in which someone’s perception of the real world, and the extraction of information from that perception by their senses, can be augmented to provide more information than can be garnered by those senses alone. All sensory input of the ‘real-world’ can be augmented in one way or another:

- **Sight** - Something as simple as the added graphics on a sports broadcast showing on-screen banners with scores and statistics to more sophisticated displays used in commercial and military aircraft.
- **Haptic** – games controllers that ‘rumble’ when certain game-play actions take place. Mobile phones that vibrate to let you know they are ringing.
- **Hearing** – the beeping noise that is heard in an automobile when reversing, to warn the driver that they are approaching an object behind.
- **Smell** – an example being the ‘Digilog’ Book whose development is currently under way at Culture Technology Institute at GIST (Singer, 2010) in which the user smells scents based on the storyline.
- **Taste** - A Meta Cookie (Wilkins, 2010), has been created by researchers at the University of Tokyo, where an otherwise tasteless cookie is given ‘virtual’ flavour.

The possibility of group contribution areas where groups of users can interact in a shared Mixed Reality space could lead to future workspace being more useable as working environments even with participants been located remotely. When dealing with AR systems the technical requirements will be determined by the end functionality required, but most AR applications will require the tracking of real time locations and objects, 6 degrees of freedom allowing the user to move freely along 3 axis, good quality virtual elements well aligned within reality and a reliable refresh rate.

It is straightforward to define a generic Mixed Reality (MR) environment as one in which real world and virtual world objects are presented together within a single display, that is, anywhere between the extrema of the RV continuum (Milgram & Kishino, 1994). The continuum demonstrates that there are separate Real and Virtual Environments on either ends.
and as they blend together become a Mixed Reality (Figure 1). Augmented Reality and Augmented Virtuality are the Mixed Realities, AR primarily consists of a view of reality enhanced with virtual elements whereas AV is comprised largely of virtual elements with some features used from reality.

In this paper, we discuss the technologies used for AR, such as methods and approaches to tagging the environment. We also look at the use of the ‘Magic Mirror’ method of AR display, as opposed to the Magic Lens approach and advances in technology that will, for instance, mean an increased use of heads-up type displays (HUD). We discuss advances made in hardware relating to the processing power and capacity of devices used to enable AR as well as advances in sensory apparatus used to gather the additional information that is presented to the end user of any such system. We keep in mind that many of the applications highlighted here could be ported to the ambient intelligence field with relative ease.

2. AUGMENTED REALITY TECHNOLOGY

The technological demands for AR are much higher than for virtual environments or VR, which is why the field of AR took longer to mature than that of VR (Van Krevelen & Poelman, 2010). The technical functions needed to provide a suitable platform for AR systems are based around a few principle capabilities. They must have the ability to read in environmental data via camera or other input while tracking the location of the user updating the virtual elements according alteration in view angle or direction. They need to provide the user with a view of the physical reality using Optical See-through, Video See-through or Projection based technology. GPS and accelerometers can be utilised in the determination of the user’s location in context of the real and virtual elements around them as an aid to calculating the alignment of virtual objects to real world space. Depending on the required utility of an AR application, a specific set of different technologies will prove more compatible than others.

Figure 2 shows the release of AR applications by time and brand and measuring the search requests received for Augmented Reality through monitoring Google Trends. It shows that from before December 08 only two companies had an AR campaign, each of which only had a search volume index of 1. From December 08 there is a rise interest in Augmented Realities peaking in August as 4 new AR applications are released as part of marketing campaigns to further brand awareness. This rise in availability of AR applications was facilitated in part by these companies and their use of the technology in innovative media campaigns but also due to improved computing power, the increased availability of fast wireless internet connections, the growth of social networking websites and growth in people on the web either via mobile devices or computers. AR systems can be split into two main groups depending on the type of visualisation employed for viewing reality either optical or video see-through. Optical see-through allows the user to perceive the physical world directly whereas video see-through blocks out the user’s physical view of reality but then streams a video feed from a camera input to the visual output device or head mounted display.
Video See-through are the cheapest and easiest to implement. Since reality is digitised, it is easier to mediate or remove objects from reality. Also, brightness and contrast of virtual objects are matched quite easily with the real environment (Van Krevelen & Poelman, 2010). When turned off, Video See-through will not allow the user to perceive anything at all through the system or device. In contrast, Optical See-through uses optical combiners, such as mirror beam-splitters, to layer the computer generated image on top of the user’s view of the environment (Höllerer & Feiner, 2004). Optical see-through is more difficult to implement as it requires the overlaying of virtual components over the users existing vision of the environment. If the system is turned off, the user will still be able to see through the device to perceive reality. Optical See-through is expected to become more viable as the technology develops. Currently, the majority of AR systems are implemented using a Video See-through display for simplistic culling and location tracking.

### 2.1. Magic Mirror and Magic Lens

Two common paradigms for methods to display Augmented Reality elements are known as the ‘Magic Mirror’ and the ‘Magic Lens’. The magic mirror is a real-time display where the augmented scene being captured by a video camera is displayed, with an augmentation overlay shown on it as shown in Figure 1. As can be seen from the Figure 1, the magic mirror is only suitable for static installations where the user and AR system are in a fixed location. The system above appears unwieldy when compared to modern designs of this type of system even when compared to games consoles such as the Wii and PlayStation. The cards attached to the accessories worn by the user are called the fiducial marker system, fiducial meaning trusted. These tags are used in the real-world part of the system to provide the virtual representation with the ability to render the necessary elements in three dimensions.

Systems, such as the Wii, with its sensor and controller provide the same sort of functionality using two infrared beams in the sensor to calculate orientation of the controller and inexpensive accelerometers, developed for NASA and the military to calculate the direction and speed of the motion of the user. This new technology is removing the need for the cumbersome marker technology shown in the picture although it is still in use for some applications. One of the newest applications for the Magic Mirror is being used in retail as a mirror! This mirror allows the user to virtually try on clothes or test make-up without actually having to change their clothes or apply and remove make-up time after time (Hickey, 2010).

Augmented Realty using the Magic Lens method is a completely different approach to accessing AR. As opposed to ‘looking at’ AR enhanced scenes, the magic lens method allows
the user to look through an interposed medium, to a real-world image. AR elements displayed on this medium then appear to exist in the real-world image. The actual mechanism can involve a headset with the processing and computing power local to the headset and perhaps even in a mobile configuration, or sitting in front of a transparent screen positioned between user and real-world onto which the AR elements are projected in some form to overlay them onto the real-time image visible through the screen.

The HMD shown in Figure 4 can be used to provide AR elements projected into the environment such as that shown in the example in Figure 3. This example depicts the marker system where the 3D elements of the AR system are positioned using 2D ‘fiducial’ markers (Figure 5) in the real world. The magic lens is about to take a giant leap forward as the prominent method of access, where the general population is concerned, with the advent of technologies like Organic Light-Emitting Diode displays (OLED), that can be manufactured in thicknesses that produce a transparent and flexible display.

When these OLEDs are integrated with photodiodes on a CMOS substrate, then the possibility of producing glasses that can combine the display and camera functionality used by AR systems becomes a reality. Using glasses such as these to view the world means AR elements and information can be shown seamlessly to the wearer based on the real-world image captured and processed in real time (Herold et al., 2008). With the addition of eye tracking technology then the display/camera becomes an interactive way to view content, or access more information through AR simply by the act of the wearer moving their eyes.
2.2. Marker versus Marker-less AR

Simultaneous Localisation and Mapping or SLAM, algorithms are at the cutting edge of development for mapping AR virtualisations onto the real-world. This approach is sounding the death knell for the fiduciary marking approach to the positioning of AR elements onto a view. SLAM, as a technology from the world of robotics, will provide a means of autonomously mapping an unknown environment or location (Bailey and Durrant-Whyte, 2006). SLAM algorithms will be used particularly in the area of mobile AR applications, where SLAM can, in conjunction with GPS and other sensory input, provide a method of discerning the location of the user in any three dimensional space and then provide AR information relevant to this space.

SLAM algorithms for AR applications have been modified as PTAM (parallel tracking and mapping) algorithms and demonstrated in prototypes on mobile handsets such as the iPhone. The phone camera uses the SLAM techniques to ‘map’ an area, building up an image that can be used in real-time to provide AR functionality (Klien & Murray, 2009). Steps in the PTAM process can be seen in Figure 6 where (a) a map is constructed on a book, (b) map is expanded to encompass 200 points and (c) AR elements are inserted into the scene. Figure 7 shows a purely SLAM application.

3. AUGMENTED REALITY APPLICATIONS

Because the very nature of Augmented Realities is the overlaying of additional virtual elements or information the possible uses for the technology are far reaching. There is no specific one...
area which can boast the most useful application of Augmented Reality since each time it is applied to a new task it will have a different mixture of benefits for the users. Augmented Realities are an ideal method for providing a large quantity of contextual information. Based on this principle the full scale to which AR will become engrained into modern society is hard to gauge, although if advances continue at the current pace AR will be used much more frequently within the next few years. Already there is a diverse selection of corporate marketing campaigns, research studies and applications out there with many more in the design stage all continuing the development and refinement of AR technology and how it is perceived by the public and private sector.

3.1. Augmented Reality in Education

The possibilities of Augmented Reality technology applications for educational purposes range from simple visualisation based learning for younger students to large complex virtual laboratories where real world hardware interacts with the virtual to recreate lab conditions. It could for instance allow the replication of experiments and reactions like that in chemistry but with no element of danger to the user. For further realism the actual simulation could be carried out in a second safe location and the results read back into the AR simulation to validate the computations. By removing the danger of associated with such tasks like operator error or mechanical error it allows a user to become familiar with the 3D visualisation of the activity without any pressure, ensuring when in the real situation they are adequately prepared. Networked laboratory hardware equipment is linkable to virtual learning environments by means of special bidirectional sensor-actuator coupling interfaces. At the moment this seems to be a quite visionary approach. Future laboratories will benefit from further developments in computer simulation technology, mobile computing and sensor/actuator devices enabling connections to be made between real-life phenomena and their virtual representation or continuation (Muller et al., 2007).

3.2. Augmented Reality for Contextual Information and Guidance

Contextual Information is extremely useful to users and as the number of AR applications rise, the industry will learn what AR is most viable for and which standards should be implemented regarding inputs, tracking and visualisation. Currently existing applications on Smartphones allow the user to view tagged locations and information about them. Some are designed to provide the user with recommendations on specific shops, hotels or commercial premises and others can show the activity of nearby social networking users. Combining things such as location, the presence of other people and

Figure 7. Pure SLAM generated visualisation for AR
objects, the actions presently occurring, the user’s goals and other situational components, the system discerns the user’s “context” and determines how best the subject can maximize efficiency in the performance of particular tasks; in effect, the CM allows a single individual to successfully accomplish the functions of three or more individuals (Cowper & Buerger, 2003).

Existing commercial uses of AR applications are mostly centred on the navigation of complex urban environments and rating local restaurants and businesses for others to view. As AR becomes more functional and viable there will be many other contextual displays such as local advertisements and environmental notifications. Through constant internet access and a wide range of virtual information, the user could be informed of changing weather conditions in the vicinity according to local forecasts.

Smartphones allow the user to interact with the Augmented Reality by either the touch screen, physically moving from one location to another can be tracked by GPS, accelerometers, a solid state compass or any additional sensors which could be attached or detached. Next generation games console manufacturers are releasing new input devices which will be AR capable. Another emerging area in AR is Haptic AR, where the user can touch a real object, a virtual object, or a real object augmented with virtual touch. AR with both sensory modalities, i.e., visuo-haptic AR, can create simulations of great realism and immersion, e.g., palpating a virtual tumour inside a real mannequin for medical training, which is not possible in a pure real or virtual environment. Haptic interfaces will allow the user to physically interact with the virtual objects within an AR environment. This combination of several technological modules as they are developed will continue to improve the usability and functionality of current AR systems. 3D Surround Sound Effects will improve the quality of information available to the user as well as providing a choice to how each user would prefer information either visually or aurally. As experience develops within the computing industry on dealing with Augmented Reality, the first fully AR desktop will allow users to control every process of the computer through gestures and touch. With even more advanced input equipment it may be possible to use overlay virtual keyboards on flat surfaces and track the keys pressed to convert them to digital information.

### 3.3. Augmented Reality in Medicine

AR is beginning to be used in Medicine as a training aid for medical staff to allow them to improve their skills. In German speaking countries it was found that there was a trend away from natural delivery to caesarean sections. Even with new techniques and medicines the perinatal mortality rate had not improved since 1980. This trend, when coupled with the increased risk to the patients inherent in a caesarean delivery, led to the introduction of an AR system to facilitate the training of medical professionals in the techniques involved (Sielhorst et al., 2004). The goal of the AR system was to reduce the mortality rate by providing training for new doctors, while allowing experienced doctors to refresh their skills and knowledge.

The AR simulator provides multimodal AR visualisation. Using audio, Haptic, and visual elements the proposed system consists of a body ‘phantom’ with a Haptic device representing the infant and software to simulate physiological and biomechanical functions. The system used a stereoscopic headset, and interaction with the phantom is facilitated by the head movements of the user. The student does not have to learn to navigate through the use of a mouse or menu, but can focus attention or bring areas of interest into the field of vision by simple movement of her/his head and looking in the direction of interest. Due to the fact that the scene is modelled internally and externally then the user can see where their instruments are inside the ‘phantom’ while the skin still in place. This allows them to ‘view’ the movements and position of the instruments without removing the skin which provides a Haptic element to the AR session.

The Haptic feedback is further enhanced by a force/torque sensor in the head of the baby which allows for interaction with the user and...
forceps. Software calculations based on the output of these sensors are used to simulate the level of distress and physiological responses of the patients. The software will also provide audio and visual feedback in the form of simulated instrumentation monitoring vital signs and showing various feedback with regard to foetal heart rate, blood pressure and oxygen levels. The tracking of the interaction of the user, the forceps, and the phantom and child, is facilitated by two separate systems as seen in Figure 8. External tracking is accomplished by a use of a stereo camera infra red system. Tracking of the instruments and their effects is carried out by a combination of the torque/force sensors and a called real-time augmentation in medical procedures or (RAMP), which uses retro-reflective markers and an infra-red flash and camera.

Another application for AR in the field of medicine is its use in the treatments of psychological problems such as phobias. The AR system produces an experience that gives the patient a feeling of presence. This reality judgement on the part of the patient allows their phobia to be presented to them in a manner that they perceive as real, while allowing them the tools to overcome the phobia with clinical assistance (Carmen et al., 2005). The system consists of the HMD shown in Figure 9. When worn by the patient, the image captured by a simple fire-wire or USB camera is augmented by the use of a fiducial marker based system whereby three dimensional representations of various insects are overlaid onto their field of view. The images vary between dead cockroaches, through to static live or moving versions. The patients are then encouraged to either spray, swat, or actually pick up the markers and therefore the representations of the insects. This aversion therapy assists the psychologists in negating or reducing the phobic reaction to the object of the patients fear.

3.4. Augmented Reality and the Military

Augmented Reality for the battlefield soldier is a delicate balance of providing enough relevant information to the individual soldier without causing informational overload whereby the soldier is swamped with information to such a degree that he/she is rendered ineffective (Hicks et al., 2009). As part of the US Military’s twenty-first Century Land Warrior program - a system called Eyekon attempts to strike this balance by minimising the amount of hardware worn and superfluous information provided. Networked communications provide strategic information that can be displayed using the eyepiece of the soldiers existing weapon in conjunction with a wearable computing system. The provision of a threat level can be represented using icons displayed in perspective, more prominent - more
Figure 9. HMD used in Phobia research

Figure 10. Command and control supply strategic information

Figure 11. On site spotter ‘paints’ a dangerous location using the AR interface
dangerous. The viewfinder of the weapon will, using the software developed for the system, prioritise targets, and guide the soldier between current and next best prospective target using arrows in the sight display, as well as icons and colours that will represent threat levels. The weapons sight is removable and the helmet eyepiece can be used in conjunction with this sight to ‘look round corners’ thus providing the same AR view to the eyepiece while using the sight as the camera element of the system.

The Eyekon AEDGE system uses three levels of human agents, these agents inputs are combined, or fused into a decision making model which provides the soldier with the best possible information as to the situation they are facing. Figure 10 and Figure 11 show this process as envisioned by a company called Tanagram Partners (Cameron, 2010), funded by the American Defence Advanced Research Projects Agency (DARPA). Outlandish as this scenario may seem, the company involved intends to have a prototype running on an iPhone by the first quarter of next year.

Drones are the future of aerial warfare and AR based control systems are the future of drone operation (Payatagool, 2008). Existing technology used to operate drones is limited and extremely difficult to learn to use, resulting in loss of life and equipment. The defence contractor Raytheon decided to employ games developers to redesign the controls and a wrap-around display of widescreen monitors to provide the operator with a 120 degree field of vision. The real-time video feed from the drone is integrated with a digital overlay of buildings and terrain in the area in which the drone is operating. This interactive digital overlay is then combined with information provided about the surroundings, the drone status, and operating environment in a state of the art AR application.

American helicopter pilots are currently in trials of systems to assist them to safely maneuver their helicopters in poor visibility or bad weather. The Tactile Situation Awareness System (TSAS) uses vibrating pads integrated into flight garments to augment the information available to pilots particularly during hover operations. In conditions of poor visibility during hover the pilot can sometimes become disorientated due to the lack of visual cues from the surroundings, especially the attitude, height and relative position of the aircraft. At these times of high stress, the pilot can suffer from ‘task saturation’ where they simply have too much information to make best use of it all. The TSAS system allows the pilot to know where they are and how the aircraft is operating without having to access this information visually through their instrumentation. This allows them to concentrate more on the task of flying and less on processing flight data. The harness allows the pilot to process flight data on an almost subliminal level using the sense of touch which is normally used only in a minimal way during flight. Tests of this system have shown that in particularly difficult flight conditions, TSAS can reduce the likelihood of loss of aircraft or personnel due to pilot error.

3.5. Augmented Reality and the Automobile Industry

The automobile industry intends to use AR applications to display information in the driver’s line-of-sight. Normally the driver would be required to look away from the road to the dashboard instrumentation to see the speed, engine temperature. Manufacturers have begun the process that will eventually lead to the inclusion of AR instrumentation and systems being included in cars that will use software, sensors and display technology that will allow this to take place (Humphries, 2010). The AR application of this information at the present time relies on cameras, various sensors and the car windscreen. General Motors are currently working on applications of this type; a prototype of the ‘Enhanced Vision System’ is shown in Figure 12.

Sensors include infrared, visual, potentially radar and night vision all look forward and this sensor data is then processed by the system and used to display information as AR elements on the windscreen display. Figure 12
shows a road-sign being highlighted by the system to draw the attention of the driver to perhaps the current speed limit. In-car cameras monitor the driver to see where their attention is focused, and what they are doing so that information can be targeted to the area of the view that is being looked at by the driver (Figure 13). This is also used in order that the relative position of the driver is known by the system. This better enables it to overlay the information on the real-world image in perfect registration with relation to the position of the driver. The sensor data is also used to provide road-edge projection in situations such as fog, or heavy rain, where the edge of the road is overlaid onto the windscreen providing the driver with an indication of the position of the car on the road in difficult driving conditions shown in Figure 14.

Another area that GM and other manufacturers are targeting is ‘Enhanced Driver Experience’. Imagine not only a windscreen that provides you satellite navigation but that actually highlights the building that you are navigating towards as shown in Figure 15. This application of AR when combined with an OLED display sandwiched between the laminated windscreen can also be used, with appropriate sensors, to show pedestrians, animals and obstructions to the driver during bad driving conditions improving road safety for both the car driver and those around them.

The design process to manufacture a new car involves the use of prototypes so that designers and engineers can visualise how the new designs look and work together. The prototyping of these components can take from two to several weeks to produce. The costs
involved in this process can be prohibitive. AR is being used to remove the need for the initial prototype being produced by the designers (Frund et al., 2004). The design process of most modern cars begins with a common base or chassis and standard components that are common to many manufacturers’ models. This common base is placed in the AR arena, and both the arena and base are marked using the fiduciary marking system. The AR elements are created through a 3D visualisation system that `takes original 3D-CAD drawings and projects them in the AR stage to scale and in correct registration. Designers and engineers can then ‘see’ the parts that have been so represented, through HMD sets that allow them to walk-round the AR vehicle. This facilitates a much more detailed control of the design. Errors and conflicts between parts can lead to instant modifications without resulting in the alteration to real-world prototypes, but by changes to the CAD drawings then being transferred to the AR element.

Only when the team is satisfied with the completed part or component does the process of building the prototype begin. The time and cost savings to the company are significant. AR is also used in the ergonomic analysis and simulation of the interior and exterior of the vehicle. The accessibility and positioning of pedals, switches and dashboard items can all be simulated. The empty space where the dashboard will be represented via AR is marked and camera systems monitor the head position or pose of the users head so that all the AR elements are produced correctly. The AR elements

Figure 14. Road edge enhancing in bad weather

Figure 15. Satellite navigation showing destination
are again composed from 3D CAD drawings and data. Collaborative design prototypes have also been created for use primarily in the automobile industry. These systems involve multiple users using the system in an interactive way to facilitate the design process and communication between engineers and designers.

One prototype system that has moved on to real-world use involves the use of a desktop turntable that has AR markers placed on its surface. Multiple users can access the system. Local and remote users can, using HMD and networked computers with identical physical layouts on each site, view prototype components displayed in relation to the head position and orientation of individual users. His prototype is constructed from both 2D and 3D CAD drawings processed by the system to provide an AR element updated in real-time as the users change their orientation in respect to the object, and the orientation of the object in relation to the users through use of the turntable.

Users can interact with this AR rendering of the three dimensional automobile component using specially designed ‘markers’ to highlight areas of the model for discussion or modification (Regebrecht et al., 2006). Figure 16 shows a user point of view of the collaborative design AR system in use. The coloured markers in front of the users can be used to ‘mark’ the 3D AR representation of the automobile component to highlight areas of interest or debate. The AR system again provides a quicker, more economical and flexible method of prototyping components in a manner that is more integrated with the design process, feeding back directly to the CAD and engineering process. This allows for production of a physical prototype when all concerned; designers and engineers are satisfied that the component is ready.

3.6. Augmented Reality in Everyday Life

SixthSense is a wearable gestural interface that augments the physical world around us with digital information and lets us use natural hand gestures to interact with that information (Mistry & Maes, 2009). Consisting of ‘off-the-shelf’ components; a camera, pocket projector, mirror and mobile computing device, it is fashioned as a necklace that hangs round the users neck and connects to the computing device in the users pocket. The user can interface with the system using hand gestures that are tracked by the camera using coloured thimble-like covers for finger ends. The display for the system can be any flat surface that is available to the user and can even be used to project AR elements onto the user him/her-self. Figure 17 shows the system being used to dial the users mobile phone using a keypad projected onto their hand. Figure 18 shows the system projected a virtual wristwatch.

The AR wristwatch can be created and destroyed by simple hand-gestures of the system wearer. An example of this system worn in a head-mounted configuration is shown in Figure 17.
The user is viewing and interacting with the images projected onto a suitable surface.

The system processes the video data in real time and tracks the finger-end markers or visual tracking fiducials. Several applications have been designed to show the versatility of the prototype, including book reviews being projected onto the cover of a book held by the user while browsing in a book-shop, and information relating to the ecological impact of products being projected onto the packaging of the product based on image recognition. (Mistry & Maes, 2009).

Mobile technology advances, including those demonstrated in the ‘Sixth-Sense’ prototypes shown in Figures 19 and 20; can be harnessed to the task of mobile gaming. Global positioning, SLAM, powerful computing, miniturised high resolution cameras, and light OLED HMDs, constitute the beginnings of the next-generation in computer gaming. The current headset and backpack wearable computer used to produce a proof-of-concept system ‘AR Quake’, are shown in Figure 20. AR Quake is based on the popular game by Id Software (Piekarska, 2006). The concept design used a surveying grade GPS-like system that could track user position to 50cm accuracy with 10 updates per second. Combined with magnetic and gyroscopic sensors to track head position and orientation the system provides registration information in order that the overlaid AR elements perform as expected. Monsters and game elements appear super-imposed on the real world through the HMD and can be interacted with as in the standard version of the game; the difference being that the game arena is the real-world.

Figure 17. Mobile phone using projected keyboard

Figure 18. AR Wristwatch projected onto user
4. CONCLUSION

Domestic applications of AR in the Sports TV, gaming console, and mobile applications aside, the fact that AR is used widely in industry, medicine, and in the military means that advances in these fields will affect everyone individually and society as a whole. Computing power and display technology have advanced to the point where we are now in the position that AR is ready to take the next step from research, small scale implementations, and high-end military applications to the mainstream. As the concept of Augmented Realities continues to rise in popularity along with the trends of internet use and multimedia entertainment, then in the future AR may be widespread and used for learning in a group and alone and perhaps for sharing collaborative workspaces.

The state of the art within the area of Augmented Realities is progressing swiftly with new creative and useful applications being developed constantly. While trends promising an increase in portable platforms which are AR enabled there are still a range of issues to deal with some of which will become apparent as the depths of AR are explored thoroughly over the coming years. New hardware technologies such as the iPhone, and Android platforms, with their powerful processors, connectivity, and access to positioning systems, when coupled with software technologies such as SLAM and...
its variants, means that we are on the cusp of a revolution in how we interact with the world and each other.

The impact of Augmented Reality systems within the ambient intelligence field are not yet wholly visible however some aspects are such as the impact that Cloud Computing will have on the technology. Cloud computing will allow the excessive and complex computations required by an AR device to be wirelessly transmitted to a centralised machine dedicated to the task. By alleviating the majority of the computing from the user’s device the necessary size will be reduced significantly. This approach could improve upon the Head Mounted Displays reducing the necessary parts to the inputs and outputs, with the calculations being done elsewhere. There are numerous ambient intelligent systems currently implemented which could benefit from such a technology.

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