Augmented Reality as an Emerging Military Training Technology

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ABSTRACT

Theoretically, Warfighters can already acquire access to the information they need in the battlefield through traditional training materials, technical manuals, Interactive Electronic Technical Manuals (IETMs) and Computer-Based Training (CBT) modules. However, most of these methods require Warfighters to cease operations and focus on informational analysis instead of survival tactics, leaving them critically vulnerable to enemy attacks.

While mLearning solutions for mobile communications devices and training surrogates have quelled some of the demand for instantaneous information in the battlefield, these methods are generally not yet efficient enough to deliver real-time geo-targeted updates. This paper discusses the progress that augmented reality has made in eliminating such informational gaps and how it will continue to streamline the military's training exercises and informational materials without sacrificing operational security.

First, the technical aspects of augmented reality as applied to military training exercises will be outlined. The technologies needed to create augmented reality markers, overlays, readers and viewers will be discussed in detail, laying the foundation for an analysis of the technology's applications. Since different types of augmented reality exist—including marker-based, spatial and headset augmented reality—each type will be examined for production, implementation and end-user constraints across a broad spectrum of training programs.

Finally, the paper will describe several particular applications of augmented reality that have assisted in military training exercises, operations and logistics and technical documentation and how they can be implemented for use with other services and allied partners. Each of these applications will be thoroughly analyzed and explained to highlight the best elements that can be extracted for use in forthcoming projects.

All of these augmented reality applications serve to convey training information without distracting users, boosting both efficiency and security in the battlefield when it is most important.

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INTRODUCTION

Throughout history, militaries around the world have relied on new and emerging technologies to accomplish a number of goals ranging from recruiting and training to operational and tactical milestones. Despite its long history, military technology remains true to its top priority: providing troops with the expertise needed to survive the trials and tribulations of the battlefield.

Modern military technologies are focused on maximizing Warfighters' abilities to access and absorb timely, relevant information. The addition of interactive technologies to training has a profound positive effect on learning; one study measured learning gains of 56% over traditional teaching methods and 25-50% higher content retention rates when interactive media elements were introduced (Adams, 1995).

Each technology used in military exercises serves to modernize the activity while making it more familiar to younger new recruits. According to the US General Accounting Office, approximately half of American recruits were between the ages of 25 and 41 (Brown, 2003). This fairly young age range is beneficial to the introduction of new training technologies. A study by Morris and Venkatesh showed that the ability to adopt new technologies is directly related to the age of those using the newer technique. Researchers discovered that younger users were more likely to successfully adopt and use new technologies to the fullest extent than their aged peers with similar backgrounds (Morris, 2000).

The military has already started relying on this correlation to integrate new technologies and methodologies. For instance, video games with handheld controllers and m-learning modules on smartphones are commonplace on military bases for use in training. The young recruits who handle such technologies have grown up with video games and cell phones, and they are quite familiar with the medium.

In this paper, an emerging technology—augmented reality—will be examined for possible applications within the military. Augmented reality has the potential to revolutionize the way Warfighters learn to maximize their strengths, prepare for combat and operate in the field, saving lives and achieving greater degrees of mission performance. Thanks to its versatility and reliance on existing technology platforms, augmented reality in the military is logistically sound and theoretically viable.

The RDECOM-STTC-RFI: Augmented Reality Systems Technology Roadmap Survey

On March 12, 2010, the Army RDECOM at Aberdeen released a request for information (RFI) to industry, academia and other government agencies seeking details and data for use in constructing, "a comprehensive technology roadmap for the development of augmented reality capabilities for dismounted soldier applications," (RDECOM-STTC-RFI, 2010).

The RFI covers multiple applications of augmented reality in the military, including training and operational uses. The research is currently seeking applications that can be developed at a low cost while remaining portable in the field and around the base.

The timeline for the research has both short-term and long-term goals. Within 1-2 years, a man-wearable system with an augmented reality environment (including any bulky technologies needed for display or interactive purposes) is expected for use in training individual tasks. The 3-5 year milestone expands on the augmented reality functionalities, permitting both individual and squadron tasks, while simultaneously reducing the size and intrusion of the required technologies. Beyond this point, the goals transition to include higher levels of augmented reality team collaboration and a minimal to nonexistent technology presence requirement.

AUGMENTED REALITY

Augmented reality has been in development in research labs for at least the past 30 years. The terminology dates back to the 1990s when scientists at Boeing developed a solution that assisted workers in the construction of wire harnesses for aircraft. While many companies and corporations have invested resources into augmented reality solutions, the majority of funding for augmented reality research has come from the US Military (Kaplan, 2005).

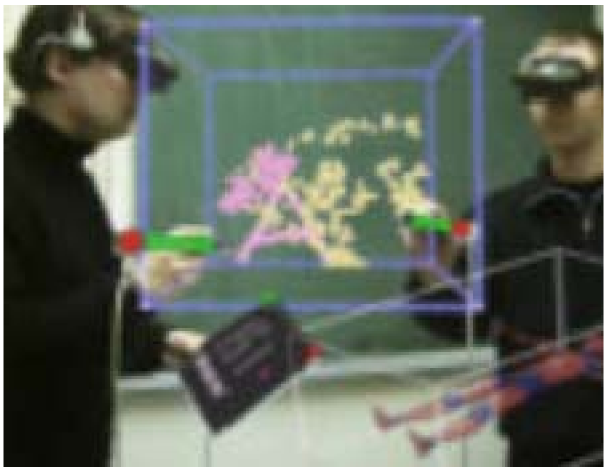

Figure 1. A collaborative augmented reality environment (Silva, 2003)

In recent years, augmented reality has become increasingly popular in the consumer market. Even as technology components have decreased in price, capabilities have continued to strengthen. Cell phones have evolved into smartphones capable of capturing and processing video feeds, and laptop computers now ship with multiple megapixel webcams built in. Small netbooks offer the processing power of laptops built just two or three years ago in a third of the size, and tablet computers are as thin as standard magazines.

An important idea to keep in mind is that augmented reality merely provides an interactive outlet for accessing existing training content. Quiñones argues that without fundamentally sound training content, every delivery platform will be subject to reduced performance and lackluster results (Quiñones, 1997). Thus, every augmented reality system is only as effective as the sum of its parts, including the content it conveys.

Components of Augmented Reality Technologies

Every augmented reality system is composed of several key components. The first component is the scene generator, which is responsible for rendering a live video scene with augmented elements. This is generally a computer with a relatively fast video processor, and it is generally dedicated entirely to this task.
Augmented reality technologies also include tracking systems. These align the real time video feed and virtual elements properly to avoid distortions. Registration can be bolstered with better processors and geo targeting capabilities.

The third and final component of all augmented reality systems is the display. This is the area where augmented elements are visible superimposed over live video feeds. Optical and video technologies can be used for varying purposes with different strengths. At present, this is considered to be one of the most limiting factors of augmented reality since headset displays are rarely bright enough to convey information and video displays distract users from their tasks (Silva, 2003).

Types of Augmented Reality

At present, there are currently three main variations of augmented reality: handheld, head-mounted and spatial augmented reality.

Handheld augmented reality systems use a device with a built-in processor and camera coupled with augmented reality software to convey augmented reality in any situation. Modern smartphones have shown great promise as handheld augmented reality devices, and it is likely that these devices will be forerunners in military augmented reality thanks to their relatively low cost, flexible software offerings and ability to provide a full portable system available to Warfighters at any time and place. By using wireless capabilities and remote server processing power, this type of augmented reality will be able to accommodate increases in performance required by future implementations (Wagner, 2003).

Head-mounted or headset augmented reality systems are a hands-free application of the technology that uses information processed in a carried computer to convey real-time augmented elements superimposed over a live video stream. Headsets can either display information on a piece of glass or plastic or they can project images directly into the eye. While such systems are useful for Warfighters who cannot be distracted from the task at hand, they do require bulky equipment that must be carried at all times.

The final type of augmented reality is spatial augmented reality. In this case, augmented reality is displayed onto a tabletop or video screen as if to show

3D models moving in real-time. Complex visual displays situated at multiple angles allow models to seemingly move through space, almost as though holographic (though unlike holograms, the image is not actually displayed in mid-air; its presentation is merely a matter of perspective). While potentially useful for tactical operations, this type of augmented reality will follow handheld and headset technologies due to its complexity.

Existing Commercial Applications

Historically, the military is cautious to adopt new technologies until they are thoroughly analyzed and reviewed. Augmented reality, which has been available to consumers for the past several years, is no exception.

One of the earliest and most widespread uses of augmented reality has been in sporting events. Markings can be displayed on television sets without actually appearing on the field, allowing viewers to better understand the happenings of the game. Advertisements have also been added to stadium walls and turf using augmented reality visible only to viewers at home.

Mobile smartphone apps have also made gains in the field of augmented reality in 2009. Apps such as Junaio allow users to view real time information about the shops, restaurants and landmarks around them by holding their phone's camera in the air and viewing available information. Another app, Layar, is an augmented reality browser that uses superimposed information and links culled from the real world location of the phone and the on-screen imagery to create a rich browsing experience. According to a study by Juniper Research, augmented reality took flight in 2009 on mobile devices because they finally contained all five elements needed for a successful portable system: camera, GPS, broadband connectivity, tilt sensors and digital compass functionalities (Juniper Research, 2009).

Video games are also beginning to incorporate augmented reality. One example is Sony's EyePet, in which a virtual animal is shown in a live video feed within the player's environment. The animal reacts to the player's motions and can even construct toys that look like drawings made on paper by the user.

There are numerous other augmented reality applications available to consumers, and these examples serve to demonstrate the current state of consumer augmented reality. With the appropriate research, military augmented reality can become equally advanced.

Augmented Reality and the Military

While augmented reality is relatively new to the military, simulations and virtual reality are tools first dating back to nearly 90 years ago. The first simulators were flight trainers built by the Link Company in the late 1920s, and they consisted of sawed off coffin-like wooden barrels mounted on pedestals. These early simulators were used to teach instrument flying at night and were pivotal in the training of pilots for World War II (Baumann, 2007). Technology has progressed since then, and military applications have followed almost every major technological advancement. Augmented reality is a perfect example of this progression; in 1997, Azuma theorized a concept in which military pilots would be able to access flight information from instruments directly on the plane's cockpit or through a headset, essentially bringing the Link Company's original simulators into the next century (Azuma, 1997).

Figure 2. Land Warrior Gear (including Augmented Reality Elements) for Warfighters of the Future (Skillings, 2007)

Augmented reality is at a tipping point for its adoption by the US Military. Personnel from across the US Armed Forces are beginning to view the technology as a potential source of better, faster information delivery with adoption and development strategies just over the horizon. Whether or not augmented reality will transform military information delivery will remain unseen until it is placed in the hands of deployed Warfighters. However, like the first wooden flight simulators in the 1920s, this emerging technology certainly has the potential to revolutionize the military and the way its personnel perform many day-to-day operations.

In 2000, the Naval Research Laboratory proposed a concept for a Battlefield Augmented Reality System (BARS). The system would allow Warfighters to wear a bulky system and see selected few pieces of information about their surroundings, including building names and other basic details. The prototype, though rudimentary, marked one of the first major breakthroughs in connecting augmented reality to the military (Julier, 2000).

A slightly more efficient prototype of an augmented reality concept appeared in 2005 to help the United States Marine Corps fight wartime fires. Using a head-mounted display, Marines can train in a real range using virtual targets, greatly reducing the danger levels of fire exercises. The software is based on the BARS platform. Preliminary tests were received positively by Marines and their commanders (Brown, 2005).

Researchers at NASA proposed an augmented reality situational awareness application in 2007. Designed for use in commercial airline cockpits, the system is aimed at increasing efficiency and enhancing situation awareness when planes are performing taxi operations on the ground. The system displays relevant information from several critical instruments and maps on a dashboard located in the pilot's field of vision, allowing him to properly taxi without diverting attention from the runway (Foyle, 2005).

The military is also interested in using augmented reality for maintenance tasks. A concept that uses augmented reality for task localization in armored personnel carrier turrets was reviewed by Columbia University, and the researchers found that the prototype augmented reality application proved extremely effective at reducing repair time and Warfighter movement during the maintenance tasks on this particular vehicle (Henderson, 2009).

CONCEPTS

As an emerging technology, augmented reality remains abstract to many within the military. The following concepts demonstrate methods in which augmented reality can be used to bolster three of the largest functional areas of the military: training, operation and logistics and technical documentation. While these examples offer specific, high level insight into potential applications, there are thousands of additional uses that have not yet been theorized or explored in any level of detail.

Training

Augmented reality naturally lends itself to military training by virtue of its inherent ability to inform. Like 3D modeling and simulations, augmented reality conveys information in a unique visual representation. Training information benefits from augmented reality's 3D nature as well as its extreme interactivity. Warfighters can initiate themselves to the equipment and technologies they will use in the battlefield using virtual representations of the exact technologies they will encounter during deployment. Augmented reality also works extremely well with its target audience within the military, which are typically young men from the ages of 18-30 years of age who are engaged and intrigued about the latest technologies.

Ghadirian performed research into augmented reality's benefits as a visualization system for training purposes. His findings, coupled with previous research into the subject, showed that immersive technologies like augmented reality made conditions more similar to reality than other visualization platforms, increasing the system's performance and effectiveness. The system's interactive and realism were also correlated to its usefulness (Ghadirian, 2002).

The first training technology that will be examined is the augmented Interactive Electronic Technical Manual (A-IETM). IETMs have long been used in the Department of Defense as a way to present detailed instructions, diagnostic repair sequences and other information previously contained in technical manuals. Never before has this technology been combined with augmented reality. However, the resulting combination enhances the manual exponentially while proving to be one of the easiest and least expensive augmented reality solutions to implement.

Figure 3. Concept of the A-IETM

Augmented reality is well-suited to Class 2 and above IETMs that can be incorporated with multimedia. Class 2 IETMs support electronic scrolling within a text- and graphics-capable window. Supported data formats include ASCII text, HTML, XML, SGML and bitmap graphics, and hotspots allow information to be browsed by users. That being the case, A-IETMs are ideal for New Equipment Training (NET), Advanced Individual Training (AIT) and Sustainment Training. In an A-IETM, markers are embedded directly into the training text and can either be printed out and viewed with a webcam or accessed with a mobile phone camera. When viewed on either the mobile device screen or webcam, the marker would trigger a 3D model of the training element at hand.

There are several benefits to using augmented reality instead of traditional multimedia resources. First, augmented reality visualizations are more detailed than 2D drawings and illustrations. This is evidenced by a study conducted by Schwald and de Laval in which the overlays and other unique elements of an augmented reality training system are found to yield superior learning results than other media (Schwald, 2003). Second, they offer immense interactivity not seen in traditional IETMs. Tiernan emphasizes this in his abstract for a paper about an augmented reality maintenance system, and the result of using the technology is an automated system that users can intuitively navigate to a better degree than traditional methods would have allowed (Tiernan, 2003). Users can scale models on-screen and rotate them as if interacting with a physical piece of equipment. If a maintenance procedure is being trained, the learner can attempt the procedure on the augmented model using his actual hands. If he fails, the model is simply reset and his errors are replayed for added instructional value. Another application for A-IETMs would be for Equipment Maintainers or Field-Service Representatives who are tasked with operating on and inside electronic machinery. Often times machinery is limited in theater and a 3D representation of a given system would be a direct benefit to our troops. Previously, such interactions and training exercises were only available using costly equipment and in-person instruction.

Development for the A-IETM includes the creation of augmented reality markers, the design of detailed 3D models and the creation of simple mechanical animations. Additionally, these elements must be seamlessly integrated with the existing IETM content.

The second training concept is integrated within the Combat Lifesaver Course (0825CC). This medical training allows users to view and examine realistic wartime wounds including shrapnel injuries, IED burns and lacerations. Such training is in compliance with the United States Special Operations Command's top priority of reducing loss of life in the battlefield; it strictly follows the regulations set forth in the Tactical Combat Casualty Care (TCCC) guidelines. Combat Lifesavers work in tandem with Soldier Medics when casualties are encountered in the battlefield and their missions are not put at risk by treating the injured. Augmented reality elements can easily be embedded within this existing 40 hour course of didactic and practical training.

Figure 4. Concept of the Augmented Reality Combat Lifesaver Course

In a training environment, two Warfighters would role play to diagnose various wounds the Combat Lifesaver might encounter in theater. The Warfighter playing the role of the injured soldier would wear an augmented reality marker in the wounded area. The second

Warfighter uses a mobile device camera or webcam to view the marker, which effectively superimposes a realistic wound on the live video feed of the soldier.

When viewed on-screen, 3D models and animations would show how the wounds occurred, immediate first aid and treatment protocols. This supports both collective and individual training, and it offers realistic collaborative practice and learning in any situation.

The required elements for this training technology include the wearable markers, detailed anatomic wound models and complex medical animations. Additionally, the marker capture software must be integrated with the Combat Lifesaver Course to convey the appropriate wound identification and treatment information.

Logistics and Technical Documentation

The military relies on logistics and technical documentation to power its vast deployment operations around the world. Augmented reality is a powerful tool that streamlines both areas.

The logistics concept brings a greater degree of organization to theater, particularly within storerooms. New items that are shipped to bases are marked with barcodes or MIL STRIP labels that can double as augmented reality markers. A marker reader would be contained within a smartphone app and would be linked to information about each piece of equipment.

As new items arrive in theater, they can be sorted into the correct holding places using the augmented reality app. Each item will be scanned and its correct placement shown on-screen in the real-time video feed. Since this would be directly integrated into the organization’s lifecycle logistics support cycle, the stocking process would be seamless from ordering through sorting new shipments.

Additionally, the marker serves to educate Warfighters about how to use the equipment stored in each box. When viewed on-screen, usage instructions, quantities remaining and other pertinent information would be displayed for reference. An added benefit for logisticians is the ability to view package parameters including weight, dimensions and shape, allowing maximum storage capacities to be reached. Links to technical manuals can also be included to educate users on detailed, difficult equipment.

The logistics augmented reality app can support several CASCOM tasks, including Logistics Functional Training, Logistics Collective Training and Logistics Experimentation. It can easily be retrofitted into existing training, such as the Army Quartermaster School and Logistics Modernization Program.

Due to the immense quantity of materials available in storerooms, this app would require the creation of thousands of individual markers, models, animations and a database of information filled with details about individual pieces of equipment. However, since any image can be a marker, existing barcodes and MIL STRIP labels can serve the purpose and do not need to be revised, reducing deployment costs and efforts. The system can also be integrated with existing logistical databases to further reduce development costs.

The Technical Manual Instant Lookup concept would assist with maintenance, one of the 11 CSS functions that support soldiers and their systems in the battlefield. The application aids in sustaining equipment in a serviceable condition as well as upgrading equipment in need of updates.

Like the previously discussed technologies, the Technical Manual Instant Lookup concept can be retrofitted into existing training to assist with preventative maintenance checks and services as well as complex depot operations. It would place augmented reality markers on system components and, when viewed on-screen, would link to the associated technical manuals instantly. Such a technology is invaluable for use in adjustments and alignments, calibrations, removals and installations, tests and inspections.

Using this augmented reality application, maintenance personnel could practice sophisticated procedures without damaging expensive equipment. It is applicable to all stages and level of war, from strategic CONUS-based depot maintenance to tactical repairs and replacements.

The Technical Manual Instant Lookup system requires small printed markers for each system component as well as a database of linked technical manuals. The system has the ability to rely on either augmented reality headsets or portable mobile devices.

Operations

The most sophisticated augmented reality military applications apply to operations. These systems must be able to withstand the rigors of combat zones while remaining portable enough for use by individual

Warfighters. The concepts outlined here rely on mobile devices equipped with cameras, which many Warfighters already have access to in the field.

The first operational concept is the IED Threat Locator. This mobile app counters the biggest threat facing modern Warfighters in Afghanistan: the IED. These devices have caused the majority of injuries and deaths in the Global War on Terror, and measures aimed at reducing their threat greatly improve mission performance.

Figure 5. Concept of the IED Threat Locator

The IED Threat Locator relies on a database of information about previous IED attacks, including locations, dates, times, triggers used, types of IEDs, types of explosive, amounts of explosive and the suspected affiliation. This would be viewed in a user-friendly manner when Warfighters hold up their mobile devices and look at their surroundings on-screen. Areas where attacks previously occurred would be marked with a pin point that could be selected for more information. The pin points could be sorted by location, date and triggers used to best fit the Warfighter's current situation and to help him avoid a similar attack.

For larger territories, GPS terrain maps can also be used. This is helpful when vehicles are being driven in order to avoid attacks over the course of a long journey. The same information is relayed to both outputs, providing a cohesive overview of nearby attacks. Both solutions fit Baumann's requirement that Warfighters be supplied with as much necessary information as possible without distracting from the mission (Baumann, 2007).

The app would provide a complete solution at a moderate cost for deployed military personnel. A database of IED attacks with specific information must be kept up to date, and the app must be able to access GPS services in order to show the best information possible. Minimal modeling and simulation is required for the IED Threat Locator, though a user-friendly interface that does not require intricate controls is a necessity as Warfighters must be able to access and use the application in the field with ease.

A second operational concept relies on a similar interface but uses a robust real-time approach to information collection. The Augmented Reality Drone Relay would use an unmanned drone to locate enemy forces in the field and relay their positions back to a central computer. The computer could then deliver real time updates about enemy locations to Warfighters in the field, allowing them to avoid ambushes and sniper attacks.

The concept uses a camera-equipped drone with GPS functionalities to locate and place insurgent locations on the maps. These coordinates would be collected by a central computer and fed to the Warfighters based on their locations. Headsets or mobile devices are suitable for delivering the content to the troops, though headsets are preferred for ease of use and lack of intrusion. Once a threat is neutralized, the drone recognizes the decreased danger and updates its report.
This concept requires significant investment and development. First, unmanned drones with the proper capture equipment are required, and such drones need to be easily replaceable if disabled by enemy fire. Solid encryption services are also required to protect soldiers during the battle. The app needs a continuously updated database with geo-targeting capabilities to provide timely updates to specific soldiers as well as on-screen models of enemies. The viewing devices must also be provided to the Warfighters.

Issues and Solutions

The majority of these concepts rely on mobile devices to function properly. If not already provided with ruggedized camera-equipped devices, a large investment must be made. Fortunately, following the initial implementation, maintenance costs should be significantly less than the initial investment.

Another major issue facing augmented reality applications within the military is compatibility with legacy systems. Older webcams may not be equipped to handle rigorous frame rates and resolutions, and newer webcams may pick up too sharp of an image to register a marker. The same compatibility issues apply to other systems that use augmented reality, and each individual system must be evaluated prior to use. Mitigation can be achieved through careful analysis of the legacy systems prior to development of the technology.

For certain applications, such as the Logistical Augmented Reality concept, development requires inputting tremendous amounts of information and deploying an immense network of markers across the organization. Such a major transition could be possible by integrating the technology slowly using a multi-stage roadmap. In terms of cost effectiveness, a 1982 study by Orlansky proved that new computer-based military technologies and equipment generally were cost effective in the long run because they freed up actual equipment for missions and prevented equipment damage and loss (Orlansky, 1982). The same factors would apply to augmented reality with space and other logistical considerations at a premium and this application reducing spatial and resource waste significantly.

Since most of these applications require Warfighters to capture markers themselves, the equipment must be carefully calibrated to avoid misalignment on-screen. Proper training and systematic update courses would be required. Azuma highlights this problem, noting that superior tracking equipment and registration software are needed for all augmented reality solutions being used outdoors (Azuma, 1999). One such piece of software that uses high-fidelity edge tracking was developed at Cambridge University in 2006; the system is quite robust and even allows for breaks in imagery caused by vehicles and moving persons thanks to a heavily programmed recovery mechanism (Reitmayr, 2006).

Performance issues are a major problem for current computer systems. Successful augmented reality involves processing, responding to and evolving with the world around the capture device. System delays compromise the system's utility. Fortunately, most modern processors are able to handle augmented reality. However, legacy systems will need to be evaluated and potentially replaced at a considerable cost.

In the Middle East, there are social implications to using handheld augmented reality apps that resemble a camera. Local customs shun photography, and the illusion of a Warfighter using the smartphone to take a photograph can set off alarms. The public must be made aware of the systems in their native language, and Warfighters must be trained on cultural sensitivity and dealing with potential conflicts.

There are a handful of other possible issues surrounding the implementation of such systems. However, for every problem that may be encountered, there are several positive benefits to using augmented reality. Each issue must be analyzed and mitigated on a case-by-case basis, and findings should be communicated across the industry to avoid repetition of errors in forthcoming developments.

CONCLUSION

In light of the preceding six examples and the previously provided augmented reality overview, several conclusions can be drawn, predictions made and milestones listed. These final comments outline a roadmap for developing the previously discussed technologies and moving forward to additional innovations in the field of augmented reality.

Milestones

While the milestones for augmented reality are not entirely tangible at such an early stage of the technology's development, the general provisions and concepts covered for each major stage are outlined within this section.

The first milestone for the development of such augmented reality applications is an understanding of the military's interest in the technology. This has been met through the BAA from Aberdeen soliciting a roadmap for augmented reality development.

Next, the appropriate equipment must be developed and a fulfillment and deployment schedule must be designed. For training, such equipment includes camera-equipped laptops or other computer systems that have the processing power to integrate virtual elements into a live video stream. Operational and logistical uses require portable systems such as smartphones that meet the minimum technical requirements for capturing, rendering and displaying augmented reality streams.

Finally, the military must design an implementation plan with a heavy focus on logistics and deployment strategies. The plan must take into account learning curves and technology hurdles, and it should span the course of several years. Encryption and operational security must also be developed to fit the deployed augmented reality technologies.

Future Developments

As noted in the RFI from Aberdeen, augmented reality systems will likely expand in their capabilities while decreasing in size and system complexity. The result: more augmented reality solutions will be portable for use across organizations.

As many of these concepts demonstrate, augmented reality has a clear connection to the smartphone and other camera-equipped mobile devices. Smartphone processors are becoming faster and more similar to laptop computers with each new generation, and it is quite likely that augmented reality will find a semi-permanent home on small, handheld devices that offer the ability to carry entirely portable augmented reality systems.

While the Warfighters of today will begin to see augmented reality training and operational technologies in the coming years, the Warfighters of tomorrow will likely notice a trend toward mixed reality technologies. Mixed reality environments include both augmented reality, augmented virtuality and virtual reality. The continuum pictured below shows the scale along which reality gradually transforms into total virtuality (Zlatanova, 2002).

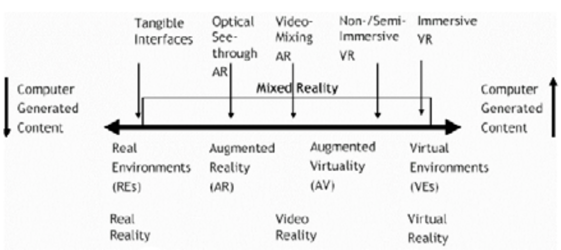

Figure 6. Reality-Virtuality Continuum (Zlatanova, 2002)

While augmented reality involves superimposing virtual objects on a real time video feed of a physical environment, augmented virtuality involves superimposing video feeds of real elements into a virtual background. The two technologies meet at an indistinct point on the continuum where 50% of an environment is virtual and 50% is a live video feed. As the ability to enhance virtual elements progresses and the number of such elements appearing in scenarios increases, augmented reality begins to approach this point. As expanded virtuality is a current goal of augmented reality projects, this will inevitably become a physical characteristic of augmented reality applications at some point in the future.

Recommendations

Researchers should continue along the current course of augmented reality development to learn the technology's strengths and weaknesses. Only by testing extensively can a working model that fits the military's needs be developed.

In order to make augmented reality as effective as possible, the military needs to select projects that will best fit their immediate needs. This will streamline the funding and development cycles and ensure that the project is as useful as possible.

The military must adopt and implement new technologies cautiously. The best adoption method is one that slowly integrates and introduces the technology to Warfighters without overwhelming them. A perfect example of this method is seen in the A-IETM concept. By setting augmented reality elements into a familiar platform, Warfighters learn how to use the new technology while surrounded by familiar modules and content. This eases the transition period and makes it easier for Warfighters to use this new technology to its fullest extent.

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