Improving Situational Awareness in Military Operations using Augmented Reality

Alejandro Mitaritonna [1]

[1] Instituto de Investigaciones Científicas y Técnicas para la Defensa (CITEDEF)

San Juan Bautista de La Salle 4397 (B1603ALO) Villa Martelli, Buenos Aires, Argentina

amitaritonna@citedef.gob.ar

María José Abásolo [2,3]

[2] Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CICPBA)

[3] Instituto de Investigación en Informática LIDI (III-LIDI)
Facultad de Informática – Universidad Nacional de La Plata (UNLP)

Calle 50 y 120 (1900) La Plata, Buenos Aires, Argentina

mjabasolo@lidi.info.unlp.edu.ar

ABSTRACT

During military operations, the battlefields become fractured zones where the level of confusion, noise and ambiguity impact on achieving tactical objectives. Situational Awareness (SA) becomes a challenge because the unstable perception of the situation leads to a degraded understanding that disables the soldier in projecting the proper results. To meet this challenge various military projects have focused their efforts on designing integrated digital system to support decision-making for military personnel in unknown environments. This paper presents the state of art of military systems using Augmented Reality (AR) in the battlefield.

Keywords

Augmented Reality, Situational Awareness, Devices Mobile, Context Awareness, Network-Centric Warfare.

1. INTRODUCTION

According to [Bry09a] the fratricide remains a very real threat in the current battlefields. To address this, the military have put much effort in the development of combat identification technologies to improve the ability of soldiers to accurately identify the enemy.

[Saa10a] argue that future military operations will be based on tools of Command, Control, Communications, Computers, Information and Intelligence for optimal performance in their assigned tasks in versatile and hostile environments.

Situational Awareness (SA) is a mental representation and understanding of objects, events, interactions, environmental conditions and any other factors in a specific situation that may affect the development of human tasks. Many military operations take place in unknown environments. The SA solutions allow soldiers to make effective use of diverse information in a context of battle being one of the major goals the reduction of cognitive load in times of stress. New technologies offer innovative methods of getting contextual information and then this information is visually represented in a natural and non-invasive way without affecting the cognitive process of the soldier. This is the case of Augmented Reality (AR).

AR, defined by [Azu97a] refers to interactive applications in which 3-D virtual objects (3-D objects, sounds, text, etc) are integrated into the real environment in real time and according to the position of the user. There are several projects that incorporate the use of AR in military applications, since its use could produce dramatic improvements in the soldier performance and provide a great advantage in combat.

The rest of the article is organized as follows: section 2 introduces definitions such as Situational Awareness, Context Aware, Augmented Cognition, Augmented Reality and Network-Centric Warfare. Section 3 presents the requirements of an AR software framework for a military application. Section 4 presents a review of various military projects using AR to improve the SA on the battlefield. Finally, Section 5 presents the conclusions and future work.

2. DEFINITIONS

Situational awareness

[Bro12a] defines SA as the perception, understanding and anticipation of the elements within an operational environment required to act effectively within that environment.

[Tre11a] mentions that SA is a prerequisite to timely and accurate decision-making in the fast and highly stressful context of infantry operational environments. The introduction of electronic support technologies onto the battlefield is expected to improve SA by providing the right information, at the right time and in the right format.

[End88a] and [End95a] mention that SA is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.

Figure 1 depicts the SA model in the dynamic decision making. Endsley mentions that the formal definition of SA is categorized into three hierarchical phases: perception of elements in current situation; Comprehension of current situation; and Projection of future status. The relationships between these phases and task/system and individual factors.

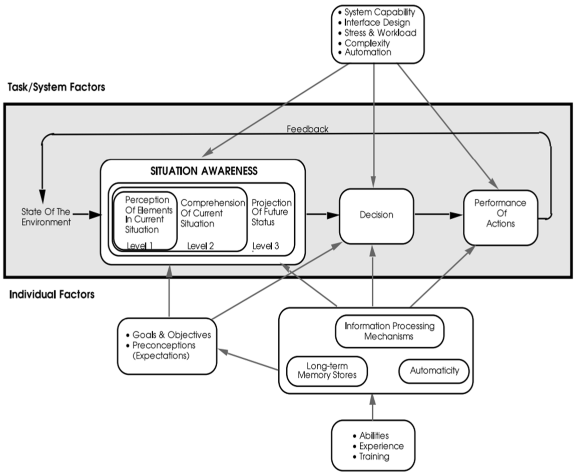


Figure 1 – Endsley's model of situation awareness (Endsley, 1995)

[End03a] determine that one of the most important factors which underlies in the development of a suitable SA is the presence of mental models and prototypical situations schemes. It provides a fundamental mental construction that leads the way to allocate attention and to highlight the critical issues.

Context aware

The formal definition of Context Aware most widely accepted is provided by [Dey00a]: "*Context is any information that can be used to characterize the situation of an entity. An entity can be a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*".

According to [Dey99a] the context may be considered as a set of information including user activity, location, personal preferences and current status. The mobility creates situations in the user context. The context is dynamic and keeps on changing. The context is best defined as states or environmental settings, such as location, orientation, time, nearby objects or people, ambient light level, noise and temperature.

According to [Sch94a] the access to the context increases the wealth of man-machine communication and the effectiveness of the elaboration of the task.

[Hul97a] define Context Aware as computer systems capable of sensing, interpreting and responding, according to the environment in which the user is located.

Augmented cognition

To develop an information display system the information needs must be examined and also the best way to present that information in order to make the system robust, usable and effective must be determined. The information processing capabilities of humans have quickly become a limiting factor in human-computer interaction. This problem has motivated the development of a new scientific discipline called Augmented Cognition (AC) [Kob06a]. The specific concerns of AC are the design of methods to detect and mitigate the limitations of human processing of information and the design of solutions to improve the exchange and use of information on man-machine systems.

Augmented reality

According to [Hic03a], AR provides the user with superimposed information that can be seen in the real world, that is, it complements the real world with virtual information. AR improves the perception of the natural world by adding information to the senses such as visual, sound, smell or tactile sensations. AR refers to the mix of the signals from the tridimensional real environment on the user perception. Particularly it denotes the fusion of virtual 3-D images on the users' natural vision of the world around them, using glasses or HMD (head-mounted display). Through the ability to present superimposed information integrated in the user environment, AR has the potential to provide significant benefits in many application areas. Many of these benefits arise from the fact that the virtual signals shown through AR system may go beyond what is physically visible.

Network-centric warfare

According to [Dod05a] network-centric warfare is a military doctrine that aims to turn an informational advantage in a competitive advantage through a strong network of forces, geographically dispersed, but well-connected and informed.

[Mof02a] describe that it is moving towards an organizational structure of network-centric warfare which is flat, fast and it is based on information, in contrast to the hierarchical structure of slow movement, based on the model of command and control. In the Network-Centric Warfare, computers integrate information acquired from multiple sources creating an image that provides critical and relevant information to all levels of command and control including the soldier. The networks are formed by nodes with the information transmitted through command positions, vehicles and the soldiers' wearable computer.

3. REQUIREMENTS OF AUGMENTED REALITY MILITARY PROJECTS

In this section is detailed the minimum requirements to have in consideration when we are thinking about augmented reality software in the military area. Therefore, the section is organized as follows: the Information Model explains the information transformation process. Information filtering and representation explains the importance of filtering and the representation of information acquired from the context of the environment. Operational capabilities describe a set of specific needs of military infantry in order to improve the SA of soldiers in the battlefield.

Information Model

In the present study, the term Information Model (IM) is used to describe the information transformation process that starts when the information is acquired from the context and that ends when the information is visually displayed (Fig. 2). The IM describes how the information passes through different stages focused on Acquiring, Sending, Processing and Representing the information obtained from the environment context. In the Acquiring stage the information is obtained from the environment context mainly through sensors geographically dispersed. In the Sending stage the acquired information in the previous stage is sent through communication devices. In the Processing stage the received information is computed. The information is treated through processing techniques such as detection, extraction, classification, recognition, identification, etc. Representing is the last stage of the IM where the information that was processed in the previous step is represented. In this stage AR techniques could be used to enrich the user's perception of the real world.

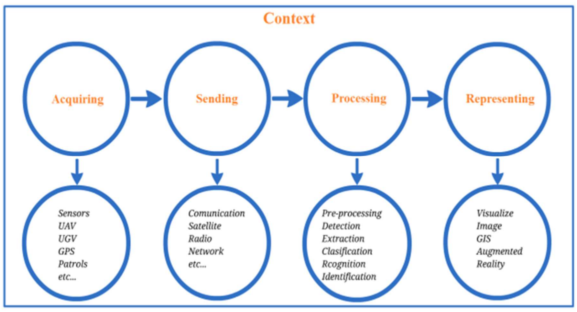


Figure 2 – IM stages. The information transformation process

Information filtering and representation

[Jul00a] have presented the idea of using a real-world context as a search cue in information retrieval and implemented a system which filters information based on physical location, for selecting what is displayed to the user by means of AR. The main purpose of information filtering is to prioritize and reduce the amount of information presented in order to show only what is relevant to the user.

[Ses00a] mention that because of the soldier's mobility through the environment, the context can change dramatically depending on their position. The amount of information that can be displayed to a user in a virtual world can be overwhelming. To fix this problem, the system must sort and prioritize the information so that it should show the features that are relevant to the soldier, such as threats.

[Liv02a] use an information filter to add objects to, or remove objects from, the user's display. They use a spatial filter to show only those objects that lie in a certain one around the user. This zone can be visualized as a cylinder whose main axis is parallel to the user's up vector, where objects that fall within the cylinder's walls are shown, and the user can vary the inner and outer diameters of the cylinder walls.

[Kei13a] propose a method for contextual information filtering based on the user’s movement and location in order to enable the intuitive usage of an ”internet of things” via AR without information overload. They are employing concepts of camera- and motion-based interaction techniques and use the metaphors of ”investigation” and ”exploration” to control the way augmented and visually superimposed elements are presented.

Operational capabilities

We have analyzed a set of specific needs of military infantry in order to improve the SA of soldiers on the battlefield by obtaining information from the context of the environment and then to represent it visually by using the AR in order to help the soldier to make decisions under stress. The following operational capabilities are based on an understanding of the current state of digital technology in warfare, the changing nature of combat, the changing role of the soldier and the growing importance of SA.

Operational Capabilities:

- Interactions with gesture and voice recognition for data collection
- Multiple tracking (GPS, sensors, vision, etc.)
- Detection and recognition of 3-D objects
- Face recognition

 ISBN 978-80-86943-67-1

- Identification of allies and enemies
- Information filter system
- Implementation and integration of the prototype on mobile devices

Potential features:

- Stand-alone (just a few dependence on external network access)
- Omnidirectional (communication among members of the patrol and command and control center)
- Light-weight (gesture & voice recognition) and Low-power devices
- Security (data & communication channel encryption)
- Open source (Framework & OS)
- Mobile (Smartphone, tablets and goggles -see-through display-)

4. REVIEW OF MILITARY PROJECTS

In this section is presented a review of various military projects using small wearable computers and AR systems in order to improve the SA on the battlefield.

Background

[Zie02a] mention that in 1989, the U.S. Army used a small wearable computer to help soldiers on the battlefield tasks.

James Schoening, a research analyst working at the CECOM (Communications Electronics Command) of U.S. Army, is who started to use wearable computers. Working with Matt Zieniewicz, Schoening transformed his idea into system architecture with specific technologies, such as wireless data transmission, image capture and integrated Global Positioning System (GPS). In 1990, Schoening and Zieniewicz associated with John Flatt, Sal Barone and Almon Gillette to demonstrate the Soldier's Computer System. Later, based on the Soldier's Computer project it gave rise to project SIPE (Soldier Integrated Protective Ensemble). It was in the SIPE Project, directed by Carol Fitzgerald, that the U.S. Army treated the components of the combat devices as an integrated system for the first time.

Eyekon

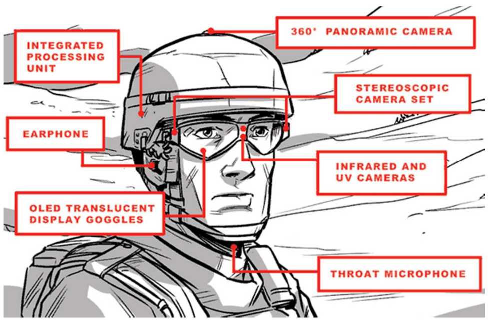
[Hic03a] define the Eyekon project as a support system for decision-making based on intelligent agents installed on a wearable computer carried by the soldiers. The dismounted soldier visualizes the target information and other information on his weapon. The aim of the project is to develop the smart icons and notations that are superimposed on the video of soldier's weapon. The basic functions are on a wearable computer connected via a secure wireless network to a local and remote database. The system incorporates sensors that provide real-time information (e.g. inertial sensor, GPS, IR, etc.). Eyekon is an intelligent agent-based decision support system hosted on a wearable computer with an available database. This system updates via radio links and on the weapon display, the information is superimposed using AR techniques.

BARS

The Naval Research Laboratory (NRL) developed a prototype augmented reality system known as BARS (Battlefield Augmented Reality System) [Liv02a]. BARS focused on developing a digital system to help address the increasing emphasis on Military Operations in Urban Terrain (MOUT). The BARS user interface includes a sophisticated but disjoint set of functions that assist the warfighter in understanding the surrounding environment, including information filter to annotate the most important or nearby objects, a set of representations of occluded objects, etc. BARS tracked the position and orientation of the user's head and superimposed graphics and annotations that aligned with real objects in the user's field of view. Multiple units shared a common database, where individuals could choose to join a given channel to access its graphic data.

iARM

Tanagram Partners was awarded a contract from the Defense Advanced Research Projects Agency (DARPA) to develop the Intelligent Augmented Reality Model project (iARM) [Juh10a]. The objective of iARM is to develop an integrated digital system that could significantly improve decision making of military personnel in complex contested environments via an integrated operating system, a data services model, and a digitally enhanced head-mounted display. The aim is that all these components work together in a seamless fashion which allows soldiers to perceive, comprehend and what is most important, project the best course of action for increased performance to achieve tactical objectives. iARM project covers many of the attributes of artificial intelligence. In Figure 3 is depicted the conceptual design of the HMD and the soldier's vision through glasses



 ISBN 978-80-86943-67-1

Figure 3 – Conceptual design of iARM (Tanagram Partners. Final Project Report, 2010)

ULTRA-Vis

In [Ult08a] is detailed the Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) project, supported by the Defense Advanced Research Projects Agency (DARPA), has developed an AR prototype system for soldiers on the battlefield. The ULTRA-Vis system overlays full-color graphical iconography onto the local scene observed by the soldier. To enable this capability, the program developed and integrated a light-weight, low-power holographic see-through display with a vision-enabled position and orientation tracking system. Using the ULTRA-Vis system, a soldier can visualize the location of other forces, vehicles, hazards and aircraft in the local environment even when they are not visible to the soldier. The prototype will be equipped for the gesture recognition using a glove. The system allows superimposed symbols in the 3-D battlefield, to locate enemy targets and locate the allied forces. ULTRA-Vis provides to squads a clear tactical advantage enabling collaboration among members of the squadron. ULTRA-Vis enables high SA and the ability to make decisions while on the move in the field of operations. In addition, the system can be used to communicate to the soldier a variety of tactically significant information including imagery, navigation routes and alerts. In Figure 4 is depicted the conceptual design of ULTRA-Vis.

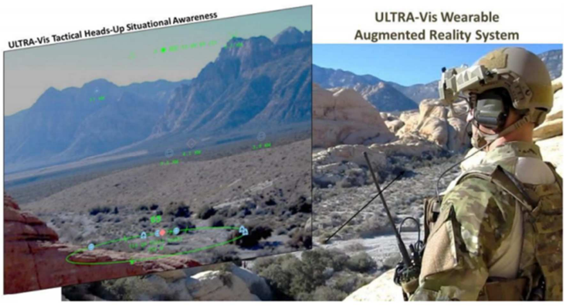


Figure 4 –ULTRA-Vis Prototype System (DARPA, 2013)

5. CONCLUSION AND FUTURE WORK

This article has described how to improve the Situational Awareness by using Augmented Reality as an advanced technique of information representation in a military context. For a right understanding was defined the meaning of terms such as Situational Awareness, Context Awareness, Augmented Reality, Augmented Cognition and Network Centric Warfare. The Information Model represents how the information goes through different stages from the information acquisition from the context of the environment to the information representation by using AR techniques. The importance of filtering information is enhanced because it dictates what kind of information should be displayed to the soldier and when. The article provided the historical review of military digital systems using AR to improve SA.

6. REFERENCES

[Azu97a] Azuma R. A survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, vol. 6, no. 4, pp. 355-385, 1997

[Bro12a] Brown, David Wm. A Survey of Mobile Augmented Reality Technologies for Combat Identification Applications.MSc thesis.Athabasca University, 2012

[Bry09a] Bryant, D.; Smith, D. Comparison of Identify-Friend-Foe and Blue-Force Tracking Decision Support for Combat Identification. DRDC: Toronto, Rep. 2009

[Dod05a] Department of Defense of USA –DoD-. The Implementation of Network-Centric Warfare. Washington, D.C.. p. 7, 2005

[Dey99a] Dey, Anind K.; Abowd, Gregory D.; Brown, Peter J.; Davies, Nigel; Smith, Mark; Steggles, Pete. Towards a Better Understanding of Context and Context-

Awareness. Proceedings of the 1st international symposium on Handheld and Ubiquitous Computing.Pages 304-307, 1999

[Dey00a] Dey, A.; Abowd G. D. Towards a better understanding of context and context-awareness. En: CHIA'00 workshop on Context-Awareness, 2000

[End88a] Endsley, M. R. Design and evaluation for situation awareness enhancement. In Proceeding of the Human Factors Society 32nd Annual Meeting (pp. 97-101). Santa Mónica, CA: Human Factors Society, 1988

[End95a] Endsley, M. R. A taxonomy of situation awareness errors. In R. Fuller, N. Johnston & N. McDonald (Eds.), Human Factors in Aviation Operations (pp. 287-292). Aldershot, England; Averbury Aviation, Ashgate Publishing Ltd., 1995

[End03a] Endsley, M. R.; Bolstad, Cheryl A.; Jones, Debra G.; Riley, Jennifer M. Situation Awareness Oriented Design: From User's Cognitive Requirements to Creating Effective Supporting Technologies. Human Factors and Ergonomics 47th Annual Meeting, Denver, Colorado, EEUU., 2003

[Hic03a] Hicks, Jeffrey; Flanagan, Richard; Dr. Petrov, Plamen; Dr. Stoyen, Alexander. Eyekon: Distributed Augmented Reality for Soldier Teams. © Copyright 21st Century Systems, Inc., 2003

[Hol01a] Holmquist, J.; Barnett, J. Digitally Enhanced Situation Awareness: An Aid to Military Decision-Making. Proceedings of the Human Factors and Ergonomics Society Annual Meeting , vol. 45 no. 4 542-546, 2001

[Hul97a] Hull, R.; Neaves, P.; Bedford-Roberts, J. Towards situated computing. En: 1st International Symposium on Wearable Computers, pp. 146–15, 1997

[Jul00a] Julier, S.; Lanzagorta, M.; Baillot, Y.; Rosenblum, L.; Feiner, S.; Hollerer, T.; Sestito S. Information filtering for mobile augmented reality. In: Augmented Reality. (ISAR 2000).Proceedings.IEEE and ACM International Symposium, 2000

[Juh10a] Juhnke, Joseph; Kallish, Adam; Delaney, Dan; Dziedzic, Kim; Chou, Rudy; Chapel, Tim. Tanagram Partners.Final Project Report.Aiding Complex Decision Making through Augmented Reality: iARM, an Intelligent Augmented Reality Model, 2010

[Kei13a] Keil Jens, Zoellner Michael, EngelkeTimo, WientapperFolker, Schmitt Michael. Controlling and Filtering Information Density with Spatial Interaction Techniques via Handheld Augmented Reality.Virtual Augmented and Mixed Reality.Designing and Developing Augmented and Virtual EnvironmentsLecture Notes in Computer Science Volume 8021, 2013, pp 49-57, 2013

[Kob06a] Kobus, D. A.; Brown C. M. DARPA Improving Warfighter Information Intake Under Stress—Augmented Cognition. Pacific Science & Engineering Group, Inc. SSC San Diego, 2006

[Liv02a] Livingston, Mark A.; Rosenblum, Lawrence J.; Julier, Simon J.; Brown, Dennis; Baillot, Yohan; Swan II, J. Edward; Gabbard, Joseph L.; Hix, Deborah. An Augmented Reality System for Military Operations in Urban Terrain. Proceedings of Interservice / Industry Training, Simulation & Education Conference (I/ITSEC), December 2 -5, Orlando, Florida, page 89 (abstract only), 2002

[Mof02a] Moffat, J.; Atkinson, S. R. Libro: The Agile Organization: From Informal Networks to Complex Effects & Agility, 2002

[Moo10a] Moon, Yong-Woon; Jung, Hae-Sun; Jeong, Chang-Sung. Context-awareness in Battlefield using Ubiquitous Computing. Network Centric Warfare. 2010 10th IEEE International Conference on Computer and Information Technology, 2010

[Saa10a] Saarelainen, Tapio; Jormakka, Jorma. C4I2-Tools for the Future Battlefield Warriors.IEEE - Fifth International Conference on Digital Telecommunications, 2010

[Ses00a] Sestito, Sabrina; Julier, Simon, Lanzagorta, Marco; Rosenblum, Larry. Intelligent Filtering for Augmented Reality. In: Proceedings of SimTecT 2000, Sydney, Australia, 2000

[Sch94a] Schilit, B.; Adams, N.; Want R. Context-aware computing applications. En: 1st International Workshop on Mobile Computing Systems and Applications, pp. 85-90, 1994

[Tre11a] Tremblay, Sébastien; Jeauniaux, Patrick; Romano, Paul; Lowe, Jacques; Grenier, Richard. A Multi-Perspective Approach to the Evaluation of a Portable Situation Awareness Support System in a Simulater Infantry Operation.IEEE - International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA), Miami Beach, FL., 2011

[Ult08a] ULTRA-Vis. BAA 08-36. Broad Agency Announcement for Information Processing Techniques Office and Defense Advanced Research Projects Agency, 2008

[Zie02a] Zieniewicz, Matthew J.; Johnson, Douglas C.; Wong, Douglas C.; Flatt, John D. The Evolution of Army Wearable Computers. PERVASIVE Computing, 2002