|| Volume 2 ||Issue 9 || April 2017||ISSN (Online) 2456-0774

INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH
AND ENGINEERING TRENDS

Augmented Reality

Ms. Shraddha C. Chauhan[1], Mr. Santosh Londhe[2]

P.G. Student, Computer Science & Engineering, Everest Educational Society's Group of Institutions, Aurangabad, MH,India[12].

Abstract— **Augmented reality, in which virtual content is seamlessly integrated with displays of real-world scenes, is a growing area of interactive design. With the rise of personal mobile devices capable of producing interesting augmented reality environments, the vast potential of AR has begun to be explored. This paper surveys the current state-of-the-art in augmented reality. It describes work performed in different application domains and explains the exiting issues encountered when building augmented reality applications considering the ergonomic and technical limitations of mobile devices. Future directions and areas requiring further research are introduced and discussed.**

I INTRODUCTION

The term Augmented Reality (AR) is used to describe a combination of technologies that enable real-time mixing of computer-generated content with live video display. AR is based on techniques developed in VR [1] and interacts not only with a virtual world but has a degree of interdependence with the real world.

Augmented Reality (AR) is an area of research that aims to enhance the real world by overlaying computer-generated data on top of it. Azuma identifies three key characteristics of AR systems:

(1) Mixing virtual images with the real world,
(2) Three-dimensional registration of digital data and
(3) Interactivity in real time.

The first AR experience with these characteristics was developed over 40 years ago, but mainstream adoption has been limited by the available technologies.

Early Augmented Reality applications ran on stationary desktop computers and required the user to wear bulky head mounted displays (HMDs). Despite the ergonomic shortcomings with this configuration, there have been successful applications developed in certain domain areas, such as industrial assembly, surgical training or gaming. Recently, AR experiences have begun to be delivered on mobile phones. Researchers such as M¨ohring [Mh04] and Wagner [Wag08b] have shown how phones can be used for computer vision based AR tracking, while companies such as Layer are deploying compass and GPS based mobile outdoor AR experiences. However, widespread use of AR-based mobile technology that allows "Anywhere Augmentation" away from the desktop has not yet been realized. In this paper, we describe how recent developments in mobile and web technologies allow Augmented Reality applications to be deployed on a global scale and used by hundreds of thousands of people at the same time.

II AUGMENTED REALITY

A .Definition

Augmented reality technology has its roots in the field of computer science interface research [3]. Many of the basic concepts of AR have been used in movies and science fiction at least as far back as movies like the terminator (1984) and RoboCop (1987). These movies feature cyborg characters whose views of the physical world are augmented by a steady stream of annotation and graphical overlays in their vision systems.

The term "augmented reality" was first coined by researcher Tom Caudell, at Boeing in 1990, who was asked to improve the expensive diagrams and marking devices used to guide workers on the factory floor[4]. He proposed replacing the large plywood boards, which contained individually designed wiring instructions for each plane, with a head mounted apparatus that displays a plane's specific schematics through high-tech eye ware and project them onto multipurpose, reusable boards. Many authors agree to define AR in a way that requires the use of Head-Mounted Displays (HMDs) [5]. This definition aims to allow other technologies, such as mobile technology, besides HMDs while preserving the essential components of AR [6]. 2-D virtual overlays on top of live video can be done at interactive rates, but the overlays are not combined with the real world in 3-D [7]. However, this definition does allow monitor based interfaces, monocular systems, see-through HMDs or mobile devices.

B. Components

According to Bimber and Raskar [8], augmented reality systems are built upon on three major buildings blocks: tracking and registration, display technology and real time rendering. First, augmented reality is a technology that should be interactive in real time and registered in three dimensions. When trying to achieve a plausible augmented image, accurate tracking and registration is important, this because when aiming to get a believable image across to the user, the real camera should be mapped to the virtual one in such a way that that the perspectives of both environments precisely match. Especially for a moving user, the system needs to constantly determine the position within the environment of the user surrounding the virtual object, this because the computer generated object should appear to be fixed [8]. If such a form of complete tracking with a global coordinate system is required, one can distinguish between outside in and inside out tracking [9]. The first refers to systems where sensors are placed in the environment that track emitters on mobile objects: for example using sensors based on Global Positioning System (GPS) to track where a mobile device is situated, or triangulating the position of a mobile device between phone masts. The second type makes use of internal sensors fixed to mobile objects; a camera for vision based tracking, digital compass to track which way the phone is facing, an accelerometer to track.

C. Augmented Reality and Virtual Reality

The term virtual reality is commonly used by the popular media to describe imaginary worlds that only exist in computers and our minds. However, let us more precisely define the term. According to [11], virtual is defined to be being in essence or effect but not in fact. Reality is defined to be something that constitutes a real or actual thing as distinguished from something that is merely apparent; something that exists independently of ideas conceiving it. Fortunately [12] has more recently defined the full term virtual reality to be an artificial environment which is experienced through sensory stimuli (as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment. [13] further defines a virtual reality to be a computer-generated environment that can be interacted with as if that environment was real. A good virtual reality system will allow users to physically walk around objects and touch those objects as if they were real. Ivan Sutherland, the creator of one of the world's first virtual reality systems stated "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal" sutherland68.

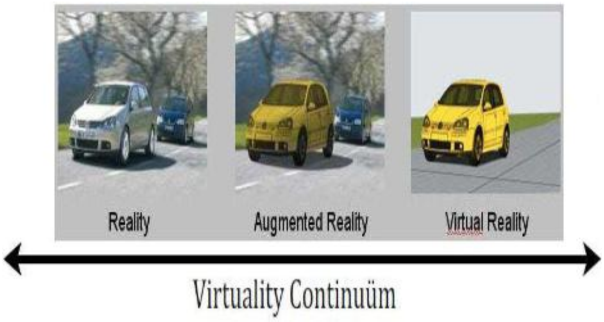

Figure 1: Adapted schema of a virtuality continuum.

D. Mobile augmented reality

As computers increase in power and decrease in size, new mobile, wearable, and pervasive computing applications are rapidly becoming feasible, providing people access to online resources always and everywhere [10]. This new flexibility makes possible new class of applications that exploit the person's surrounding context [15]. Augmented reality already presents a particularly powerful user interface (UI) to context aware computing environments. AR systems integrate virtual information into a person's physical environment so that he or she will perceive that information as existing in their surroundings [16]. Mobile augmented reality systems provide this service without constraining the individual's whereabouts to a specially equipped area [17]. Ideally, they work virtually anywhere, adding a palpable layer of information to any environment whenever desired. By doing so, they hold the potential to revolutionize the way in which information is presented to people [7].

Computer-presented material is directly integrated with the real world surrounding the freely roaming person, who can interact with it to display related information, to pose and resolve queries, and to collaborate with other people. The world becomes the user interface [10]. Hence, mobile AR relies on AR principles in truly mobile settings; that is, away from the carefully conditioned environments of research laboratories and special-purpose work areas. Quite a few technologies must be combined to make this possible: global tracking technologies, wireless communication, location-based computing (LBC) and services (LBS), and wearable computing.

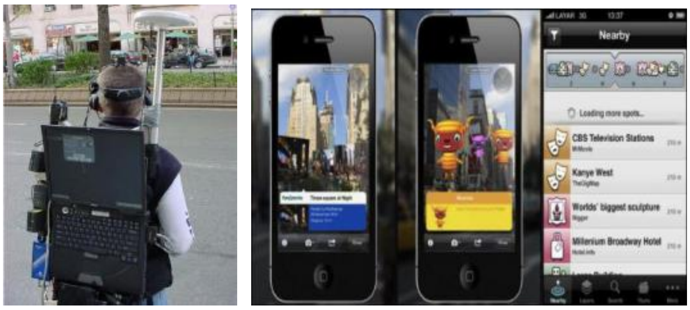

Figure 2: Mobile AR: (a) user with Mobile AR system backpack; (b) example of AR application that uses mobile devices.

III APPLICATIONS OF AR

Augmented Reality enhances a user's perception of and interaction with the real world. The virtual objects display information that the user cannot directly detect with his own senses. The information conveyed by the virtual objects helps a user perform real-world tasks. AR is a specific example of what Fred Brooks called Intelligence Amplification (IA): using the computer as a tool to make a task easier for a human to perform [18]. At the time of writing this paper, at least 12 distinct classes of AR application domains have been identified. These classes include well-established domains like medical, military, manufacturing, entertainment, visualization, and robotics. They also include original and new domains such as education, marketing, geospatial, navigation and path planning, tourism, urban planning and civil engineering. The following sub-sections describe recent research project that have been done in each field. While these do not exhaustively cover every application domain of AR technology, they do cover the areas explored so far.

A. Medical

Medical augmented reality takes its main motivation from the need of visualizing medical data and the patient within the same physical space. This would require real-time in-situ visualization of co-registered heterogeneous data, and was probably the goal of many medical augmented reality solutions proposed in literature Figure 3(a). In 1968, Sutherland [19] suggested a tracked head-mounted display as a novel human-computer interface enabling viewpoint-dependent visualization of virtual objects. It was only two decades later when Roberts et al. implemented the first medical augmented reality system [20].

Figure 3(a): Guided Surgery

B. Military

AR can be used to display the real battlefield scene and augment it with annotation information [25]. Some HMD’s were researched and built by company Liteye for military usage. In [26] hybrid optical and inertial tracker that used miniature MEMS (micro electro-mechanical systems) sensors was developed for cockpit helmet tracking. In [27] it was described how to use AR technique for planning of military training in urban terrain. Using AR technique to display an animated terrain, which could be used for military intervention planning, was developed by company Arcane. The helicopter night vision system was developed by Canada’s Institute for Aerospace Research (NRC-IAR) using AR to expand the operational envelope of rotor craft and enhance pilots’ ability to navigate in degraded visual conditions [28]. HMD was developed to display that can be coupled with a portable information system in military [29].

C. Manufacturing

Research on the manufacturing applications of AR is strong and growing area. The challenge in the manufacturing field is to design and implement integrated AR manufacturing systems that could enhance manufacturing processes, as well as product and process development, leading to shorter lead-time, reduced cost and improved quality [4]. The ultimate goal is to create a system that is as good as the real world, if not better and more efficient.

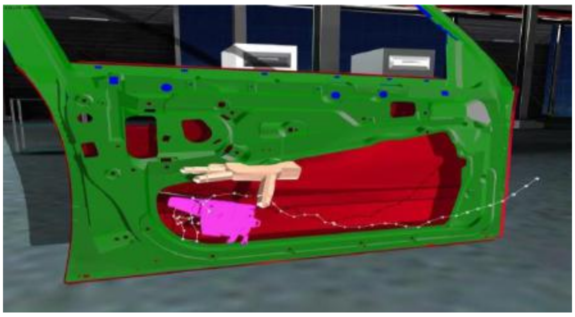

Figure 3(b): Product Assembly

D. Visualization

AR is a useful visualization technique to overlay computer graphics on the real world. AR can combine visualization method to apply to many applications [34]. A vision-based AR system was presented for visualization interaction in [35]. A device, Geo Scope, was developed to support some applications such as city, landscape and architectural visualization in [36]. AR visualization for laparoscopic surgery was approached in [37]. AR also enables visualization of invisible concepts or events by superimposing virtual objects or information onto physical objects or environments [38].

E. Entertainment and Games

Augmented reality has been applied in the entertainment industry to create games, but also to increase visibility of important game aspects in life sports broadcasting. In these cases where a large public is reached, AR can also serve advertisers to show virtual ads and product placements. Swimming pools, football fields, race tracks and other sports environments are well-known and easily prepared, which video see-through augmentation through tracked camera feeds easy [13]. One example is the Fox-Trax system, used to highlight the location of a hard-to-see hockey puck as it moves rapidly across the ice, but AR is also applied to annotate racing cars, snooker ball trajectories, life swimmer performances, etc. Thanks to predictable environments (uniformed players on a green, white, and brown field) and Chroma-keying techniques, the annotations are shown on the field and not on the players.

F. Robotics

AR is an ideal platform for human-robot collaboration. Medical robotics and image guided surgery based AR was discussed in. Predictive displays for tele robotics were designed based on AR. Remote manipulation of using AR for robot was researched in. Robots can present complex information by using AR technique for communicating information to humans. AR technique was described for robot development and experimentation in. In, authors describe the way to combine AR technique with surgical robot system for head-surgery. An AR approach was proposed to visualizing robot input, output and state information. Using AR tools for the tele operation of robotic systems was described. It was developed how to improve robotic operator performance using AR. It was explored for AR technique to improve immersive robot programming in unknown environments. 3D AR display during robot assisted Laparoscopic Partial Nephrectomy (LPN).

G. Navigation and Path Planning

Navigation in prepared environments has been tried and tested for some time. Rekimoto presented NaviCam for indoor use that augmented a video stream from a hand held camera using fiducially markers for position tracking. Starner. Consider applications and limitations of AR for wearable computers, including problems of finger tracking and facial recognition. Narzt discuss navigation paradigms for (outdoor) pedestrians and cars that overlay routes, highway exits, follow-me cars, dangers, fuel prices. They prototyped video see-through PDAs and mobile phones and envision eventual use in car windshield heads-up displays. Tonnis investigate the success of using AR warnings to direct a car driver’s attention towards danger Kim describe how a 2D traveller guidance service can be made 3D using GIS data for AR navigation.

Results clearly show that the use of augmented displays result in a significant decrease in navigation errors and issues related to divided attention when compared to using regular displays. Nokias MARA project31 researches deployment of AR on current mobile phone technology.

Figure 3(c): Navigation in urban environments.

IV COMPARIOSION AGAINST VIRTUAL ENVIRONMENT

The overall requirements of AR can be summarized by comparing them against the requirements for Virtual Environments, for the three basic subsystems that they require.

1) Scene generator: Rendering is not currently one of the major problems in AR. VE systems have much higher requirements for realistic images because they completely replace the real world with the virtual environment. In AR, the virtual images only supplement the real world. Therefore, fewer virtual objects need to be drawn, and they do not necessarily have to be realistically rendered in order to serve the purposes of the application. For example, in the annotation applications, text and 3-D wireframe drawings might suffice. Ideally, photorealistic graphic objects would be seamlessly merged with the real environment (see Section 7), but more basic problems have to be solved first.

2) Display device: The display devices used in AR may have less stringent requirements than VE systems demand, again because AR does not replace the real world. For example, monochrome displays may be adequate for some AR applications, while virtually all VE systems today use full color. Optical see-through HMDs with a small field-of-view may be satisfactory because the user can still see the real world with his peripheral vision; the see-through HMD does not shut off the user's normal field-of-view. Furthermore, the resolution of the monitor in an optical see-through HMD might be lower than what a user would tolerate in a VE application, since the optical see-through HMD does not reduce the resolution of the real environment.

3) Tracking and sensing: While in the previous two cases AR had lower requirements than VE that is not the case for tracking and sensing. In this area, the requirements for AR are much stricter than those for VE systems. A major reason for this is the registration problem, which is described in the next section. The other factors that make the tracking and sensing requirements higher.

V CHALLENGES AND ISSUES

Despite the growing interest in AR and the large body of advances and research, several challenges and issue still exist and need to be addressed. In this section, we classify the limits that characterize the current state of the art of AR based on the following aspects: technology, social acceptance, usability. Considerable advances made in each of the areas described in this paper. However, there are still limitations with the technology that needs to be overcome. AR system has to deal with vast amount of information in reality. Therefore the hardware used should be small, light, and easily portable and fast enough to display graphics.

Also the battery life used by these complicated AR devices is another limitation for AR’s uses. Also, AR tracking needs some system hardware such as GPS to provide accurate marker, ask them to be both accurate and reliable enough. These hardware obstacles need to be resolved for practical AR use. AR systems usually obtain a lot of information, and need software to filter the information, retain useful information, discard useless data and display it in a convenient way.

VI CONCLUSION AND FUTURE TRENDS

Several possible future directions are speculated for further research. Many HMDs created specifically with AR in mind need to be developed. HMDs are still too clumsy and have limited field of vision, contrast and resolution. HMDs and other wearable equipment's, such as data-gloves and data suits, is a limitation for the user. All wearable equipment's need be developed to be lighter, smaller and easier to work with the user. Also the AR system researchers need consider other challenges such as response time delays, hardware or software failures from AR systems. One limitation of AR systems is registration error. Occlusion detection is an active area of study of AR systems. Analyzing various tracking methods, possible tracking research directions are identified that allow researchers to effectively capitalize on knowledge in video frames, or integrate vision-based methods with other sensors in a novel way. It is important to incorporate a recognition system to acquire a reference representation of the real world. Further research on this direction could provide promising results, but it is mostly a top-down process and hard to deal with objects dynamics, and evaluation of different hypotheses. The challenge is to construct a pervasive middleware to support the AR system.

This section identifies areas and approaches that require further research to produce improved AR systems.

Hybrid approaches: Future tracking systems may be hybrids, because combining approaches can cover weaknesses. The same may be true for other problems in AR. For example, current registration strategies generally focus on a single strategy. Future systems may be more robust if several techniques are combined. An example is combining vision-based techniques with prediction. If the fiducially are not available, the system switches to open-loop prediction to reduce the registration errors, rather than breaking down completely. The predicted viewpoints in turn produce a more accurate initial location estimate for the vision-based techniques.

Real-time systems and time-critical computing: Many VE systems are not truly run in real time. Instead, it is common to build the system, often on UNIX, and then see how fast it runs. This may be sufficient for some VE applications. Since everything is virtual, all the objects are automatically synchronized with each other. AR is a different story. Now the virtual and real must be synchronized, and the real world "runs" in real time. Therefore, effective AR systems must be built with real time performance in mind. Accurate timestamps must be available. Operating systems must not arbitrarily swap out the AR software process at any time, for arbitrary durations. Systems must be built to guarantee completion within specified time budgets, rather than just "running as quickly as possible." These are characteristics of flight simulators and a few VE systems. Constructing and debugging real-time systems is often painful and difficult, but the requirements for AR demand real-time performance.

Perceptual and psychophysical studies: Augmented Reality is an area ripe for psychophysical studies. How much lag can a user detect? How much registration error is detectable when the head is moving? Besides questions on perception, psychological experiments that explore *performance* issues are also needed. How much does head-motion prediction improve user performance on a specific task? How much registration error is tolerable for a specific application before performance on that task degrades substantially? Is the allowable error larger while the user moves her head versus when she stands still? Furthermore, not much is known about potential optical illusions caused by errors or conflicts in the simultaneous display of real and virtual objects. Few experiments in this area have been performed. Jannick Rolland, Frank Biocca and their students conducted a study of the effect caused by eye displacements in video see-through HMDs. They found that users partially adapted to the eye displacement, but they also had negative after-effects after removing the HMD. Steve Ellis' group at NASA Ames has conducted work on perceived depth in a see through HMD. ATR has also conducted a study.

Portability: Some potential AR applications require giving the user the ability to walk around large environments, even outdoors. This requires making the equipment self-contained and portable. Existing tracking technology is not capable of tracking a user outdoors at the required accuracy.

Multimodal displays: Almost all work in AR has focused on the visual sense: virtual graphic objects and overlays. Augmentation might apply to all other senses as well. In particular, adding and removing 3-D sound is a capability that could be useful in some AR applications.

Social and political issues: Technological issues are not the only ones that need to be considered when building a real application. There are also social and political dimensions when getting new technologies into the hands of real users. Sometimes, perception is what counts, even if the technological reality is different. For example, if workers perceive lasers to be a health risk, they may refuse to use a system with lasers in the display or in the trackers, even if those lasers are eye safe. Ergonomics and ease of use are paramount considerations. Whether AR is truly a cost-effective solution in its proposed applications has yet to be determined. Another important factor is whether or not the technology is perceived as a threat to jobs, as a replacement for workers, especially with many corporations undergoing recent layoffs. AR may do well in this regard, because it is intended as a tool to make the user's job easier, rather than something that completely replaces the human worker. Although technology transfer is not normally a subject of academic papers, it is a real problem. Social and political concerns should not be ignored during attempts to move AR out of the research lab and into the hands of real users.

REFERENCES

[1] R. T. Azuma et al., "A survey of augmented reality," Presence, vol. 6, no. 4, pp. 355–385, 1997.

[2] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, "Recent advances in augmented reality," Computer Graphics and Applications, IEEE, vol. 21, no. 6, pp. 34– 47, 2001.

[3] I. E. Sutherland and C. A. Mead, "Microelectronics and computer science," Scientific American, vol. 237, pp. 210–228, 1977.

[4] T. P. Caudell and D. W. Mizell, "Augmented reality: An application of heads-up display technology to manual manufacturing processes," in System Sciences, 1992. Proceedings of the Twenty-Fifth Hawaii International Conference on, vol. 2. IEEE, 1992, pp. 659–669.

[5] A. L. Janin, D. W. Mizell, and T. P. Caudell, "Calibration of head-mounted displays for augmented reality applications," in Virtual Reality Annual International Symposium, 1993., 1993 IEEE. IEEE, 1993, pp. 246–255.

[6] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, "Recent advances in augmented reality," Computer Graphics and Applications, IEEE, vol. 21, no. 6, pp. 34–
47, 2001.

[7] M. de S´a and E. Churchill, "Mobile augmented reality: exploring design and prototyping techniques," in Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services. ACM, 2012, pp. 221–230.

[8] O. Bimber, R. Raskar, and M. Inami, Spatial augmented reality. AK Peters Wellesley, 2005.

[9] F. Zhou, H. B.-L. Duh, and M. Billinghurst, "Trends in augmented reality tracking, interaction and display: A review of ten years of ismar," in Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality. IEEE Computer Society, 2008, pp. 193–202.

[10] A. Shatte, J. Holdsworth, and I. Lee, "Mobile augmented reality based context-aware library management system," Expert Systems with Applications, vol. 41, no. 5, pp. 2174–2185, 2014.

[11] W. Piekarski, B. Gunther, and B. Thomas, "Integrating virtual and augmented realities in an outdoor application," in Augmented Reality, 1999.(IWAR'99) Proceedings. 2nd IEEE and ACM International Workshop on. IEEE, 1999, pp. 45–54.

[12] S. K. Ong, A. Y. Nee, and S. K. Ong, Virtual Reality and Augmented Reality Applications in Manufacturing. SpringerVerlag, 2004.

[13] D. Van Krevelen and R. Poelman, "A survey of augmented reality technologies, applications and limitations," International Journal of Virtual Reality, vol. 9, no. 2, p. 1, 2010.

[14] P. Milgram and F. Kishino, "A taxonomy of mixed reality visual displays," IEICE TRANSACTIONS on Information and Systems, vol. 77, no. 12, pp. 1321–1329, 1994.

[15] S. M. Land and H. T. Zimmerman, "Synthesizing perspectives on augmented reality and mobile learning," TechTrends, vol. 58, no. 1, p. 3, 2014.

[16] H.-Y. Chang, H.-K. Wu, and Y.-S. Hsu,
"Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue," British Journal of Educational Technology, vol. 44, no. 3, pp. E95–E99, 2013.

[17] L. Alem and W. T. Huang, Recent trends of mobile collaborative augmented reality systems. Springer, 2011.

[18] F. P. Brooks Jr, "The computer scientist as toolsmith ii," Communications of the ACM, vol. 39, no. 3, pp. 61–68, 1996.

[19] I. E. Sutherland, "A head-mounted three dimensional display," in Proceedings of the December 9-11, 1968, fall joint computer conference, part I. ACM, 1968, pp. 757–764.

[20] D. W. Roberts, J. W. Strohbehn, J. F. Hatch, W. Murray, and H. Kettenberger, "A frameless stereotaxic integration of computerized tomographic imaging and the operating microscope," Journal of neurosurgery, vol. 65, no. 4, pp. 545–549, 1986.

[21] M. Bajura, H. Fuchs, and R. Ohbuchi, "Merging virtual objects with the real world: Seeing ultrasound imagery within the patient," in ACM SIGGRAPH Computer Graphics, vol. 26, no. 2. ACM, 1992, pp. 203–210.

[22] T. Blum, R. Stauder, E. Euler, and N. Navab, "Superman-like x-ray vision: Towards brain-computer interfaces for medical augmented reality," in Mixed and Augmented Reality (ISMAR), 2012 IEEE International Symposium on. IEEE, 2012, pp. 271–272.

[23] R.Wen,W.-L. Tay, B. P. Nguyen, C.-B. Chng, and C.-K. Chui, "Hand gesture guided robot-assisted surgery based on a direct augmented reality interface,"
Computer Methods and Programs in Biomedicine, 2014.

[24] T. Sielhorst, M. Feuerstein, and N. Navab, "Advanced medical displays: A literature review of augmented reality," Display Technology, Journal of, vol. 4, no. 4, pp. 451–467, 2008.

[25] E. C. Urban, "The information warrior," in Technology and society. Prentice-Hall, Inc., 1999, pp. 493–501.

[26] E. Foxlin, Y. Altshuler, L. Naimark, and M. Harrington, "Flighttracker: a novel optical/inertial tracker for cockpit enhanced vision," in Proceedings of the 3rd IEEE/ACM

International Symposium on Mixed and Augmented Reality. IEEE Computer Society, 2004, pp. 212–221.

[27] M. A. Livingston, L. J. Rosenblum, S. J. Julier, D. Brown, Y. Baillot, J. E. S. II, J. L. Gabbard, and D. Hix, “An augmented reality system for military operations in urban terrain,” in The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC), vol. 2002, no. 1. NTSA, 2002.

[28] D. Yu, J. S. Jin, S. Luo, W. Lai, and Q. Huang, “A useful visualization technique: A literature review for augmented reality and its application, limitation & future direction,” in Visual Information Communication. Springer, 2010, pp. 311–337.

[29] B. Sanders, R. Crowe, and E. Garcia, “Defense advanced research projects agency–smart materials and structures demonstration program overview,” Journal of Intelligent Material Systems and Structures, vol. 15, no. 4, pp. 227–233, 2004.

[30] S. Julier, M. Lanzagorta, Y. Baillot, L. Rosenblum, S. Feiner, T. Hollerer, and S. Sestito, “Information filtering for mobile augmented reality,” in Augmented Reality, 2000.(ISAR 2000). Proceedings. IEEE and ACM International Symposium on. IEEE, 2000, pp. 3–11.

[31] Y. Baillot, D. Brown, and S. Julier, “Authoring of physical models using mobile computers,” in Wearable Computers, 2001. Proceedings. Fifth International Symposium on. IEEE, 2001, pp. 39–46.

[32] G. Reinhart and C. Patron, “Integrating augmented reality in the assembly domain - fundamentals, benefits and applications,” fCIRPg Annals - Manufacturing Technology, vol. 52, no. 1, pp. 5 – 8, 2003.

[33] A. Tang, C. Owen, F. Biocca, and W. Mou, “Comparative effectiveness of augmented reality in object assembly,” in Proceedings of the SIGCHI conference on Human factors in computing systems. ACM, 2003, pp. 73–80.

[34] R. L. Silva, P. S. Rodrigues, J. C. Oliveira, and G. Giraldi, “Augmented reality for scientific visualization: Bringing data sets inside the real world,” in Proc. of the 2004 Summer Computer Simulation Conference. Cite seer, 2004, pp. 520–525.

[35] W. Qi, “A vision-based augmented reality system for visualization interaction,” in Information Visualization, 2005. Proceedings. Ninth International Conference on. IEEE, 2005, pp. 404–409.

[36] V. P. Claus Brenner, J. Haunert, and N. Ripperda, “The geo scope-a mixed-reality system for planning and public participation,” in 25th Urban data management symposium, 2006.

[37] O. Hugues, P. Fuchs, and O. Nannipieri, “New augmented reality taxonomy: Technologies and features of augmented environment,” in Handbook of Augmented Reality. Springer, 2011, pp. 47–63.

[38] T. N. Arvanitis, A. Petrou, J. F. Knight, S. Savas, S. Sotiriou, M. Gargalakos, and E. Gialouri, “Human factors and qualitative pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities,” Personal and ubiquitous computing, vol. 13, no. 3, pp. 243–250, 2009.