Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Emerging Frontiers and Challenges in Augmented Reality Applications

Jitendra Kumar [1],Anshul Kumar[2], Dr. Manoj Kumar Singh[3]
IIMT College of Management
Greater Noida,U.P.India

Abstract:- A developing field of interactive design is augmented reality, in which displays of real-world scenes are seamlessly combined with virtual content. The enormous potential of augmented reality has started to be explored with the rise of personal mobile devices that can create engaging environments. This paper examines the state-of-the-art in augmented reality and technology at the moment. It explains the current problems that arise when developing augmented reality and emerging challenges applications taking into account the ergonomic and technological constraints of mobile devices and describes work done in various application domains. Future directions are introduced, along with areas that need more study.

Keywords: Augmented Reality, Virtual Environments, Mobile Technology

1-Introduction

A collection of technologies that enable the real-time blending of computer-generated content with live video display are collectively referred to as augmented reality (AR). In addition to interacting with a virtual world, AR also has some interdependence with the real world thanks to techniques developed in VR. Hugues11 makes the point that "augmenting" reality is pointless in and of itself. However, once we return to the human being and his perspective of the world, this phrase makes sense. Although reality cannot be made more real, perceptions of it can. Even though we define augmented reality as a "increased perception of reality," we will still use the term. Augmented reality, where virtual content is seamlessly integrated with representations of real scenes, is a growing area of interactive design. With the advent of personal mobile devices that can create interesting augmented reality environments, people have started exploring the great potential of AR. This article provides an overview of the current state of the art in augmented reality. It discusses the work done in various application domains and discusses the exciting issues that arise when creating augmented reality applications given the ergonomic and technical limitations of mobile devices. Future directions and areas for further research are presented and discussed. The remainder of the essay is structured as follows: Section 2 introduces the technologies that make augmented reality possible, explains the differences between augmented reality (AR) and virtual reality (VR), and focuses on the role that mobile technology plays in augmented reality. In Section 3, the applications of AR are categorized into 12 different groups, including well-known industries like the medical, military, manufacturing, entertainment, visualization, and robotics. It also discusses novel fieldslike civil engineering, geospatial, navigation, and path planning, as well as education, marketing, and geospatial. In Section 4, we list and discuss the typical technological obstacles and constraints related to both technological and human factors. Finally, Section 5 concludes with a number of potential directions for future AR research.

2. Augmented Reality

2.1. Definition

Computer science interface research is where the development of augmented reality began. Many of the fundamental ideas behind augmented reality have at least been referenced in science fiction and films going back to The Terminator (1984) and Robocop. (1987). A constant stream of annotations and graphical overlays are added to the cyborg characters' views of the real world by their vision systems in these movies. The term "augmented reality" was first coined by Boeing researcher Tom Caudill in 1990 when asked. improve the expensive letters and marking devices used supervise workers on the factory site . He suggested replacing the large sheets of plywood containing wire instructions designed for each level with a head-mounted device that displayed the machine's special schematics. using high-tech glasses and projecting them onto multi-purpose reusable whiteboardsThe use of Head-Mounted Displays (HMDs) is a requirement for most definitions of augmented reality (AR). However, to avoid restricting AR to particular technologies, we suggest defining AR as systems with the following features: combines the real and virtual, is real-time interactive, and is registered in three dimensions. This definition aims to preserve the fundamental elements of augmented reality while allowing other technologies, such as mobile technology. Interactive 2-D virtual overlays can be placed over live video, but they cannot be combined in 3-D with the real world. However, this definition does permit mobile devices, see-through HMDs, monocular systems, and monitor-based interfaces**.**

2.2. Components of Augmented Reality

According to Augmented reality Bimber and Raskar,Systems are built around three main building blocks: tracking and recording, display technology and real-time imaging. First, augmented reality is a technology that should be interactive in real time and recorded in three dimensions. To achieve a believable composite image, accurate tracking and recording is importantbecause whenthe goal is to get a believable, realistic image for the user the camera should be connected to the virtual camera so that that the perspectives of both environments are compatible . Because the computer-generated object should appear to be fixed, the system must constantly determine the user's position within the environment of the virtual object when the user is moving. One can distinguish between outside in and inside out tracking. if such a type of comprehensive tracking with a global coordinate system is necessary. The first refers to systems that use environmental sensors to track emitters on moving objects, such as triangulating a mobile device's position between phone masts or using sensors based on the Global Positioning System (GPS) to track where a mobile device is situated. Thesecond type uses internal sensors attached to moving objects; camera for vision-based tracking, a digital compass that lets you track which direction your phone is facing accelerometer to monitor acceleration. But these systems both have their drawbacks, as GPS, for example, is not as accurate inside buildings as outdoor and vision-based tracking. mostly depends on lighting conditions and visibility . Real-time rendering and display technology are also seen by Bimber and Rasker as future challenges and fundamental building blocks. The first is related to physical constraints that are related to optical (such as a narrow field of view), technical (such as resolution), and human factors (such as size and weight). The second, real-time rendering, relates to the capability of augmented reality devices to quickly and realistically overlay a layer of graphic elements on top of the actual environment. According to Bimber and Raskar, the integration of computer-generated objects should be done so that the user cannot tell the difference between real and virtual objects.

2.3. Augmented Reality and Virtual Reality

Popular people usually use the term virtual reality a way to present imaginary worlds that only exist in computers and our minds. However, let's define in more detail deadline in fact, virtual is defined as being inside nature or effect but not fact. As opposed to something that is merely apparent, reality is something that constitutes a real or actual thing. It is something that exists independently of the concepts that gave rise to it. Fortunately, a more recent definition of virtual reality by states that it is an artificial environment that is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions influence the environment's events to some extent. A computer-generated environment that can be interacted with as though it were real is what further defines as a virtual reality. A good virtual reality system allows users to physically walk around **and touch objects these objects are like real. Ivan** Sutherland, creator one of the world's first virtual reality systems was reported by “The final show would of course be a room where the computer can verify the presence of the substance. A chair displayed in such a room would be good enough to sit on. Handcuffs displayed in such a room would be restrictive and a bullet displayed in such a room would be fatal" sutherland68

Image Data:-

- Reality100% real
- Argument reality 75% real 25% virtual
- Virtual reality 100% virtual

2.4. Mobile augmented reality

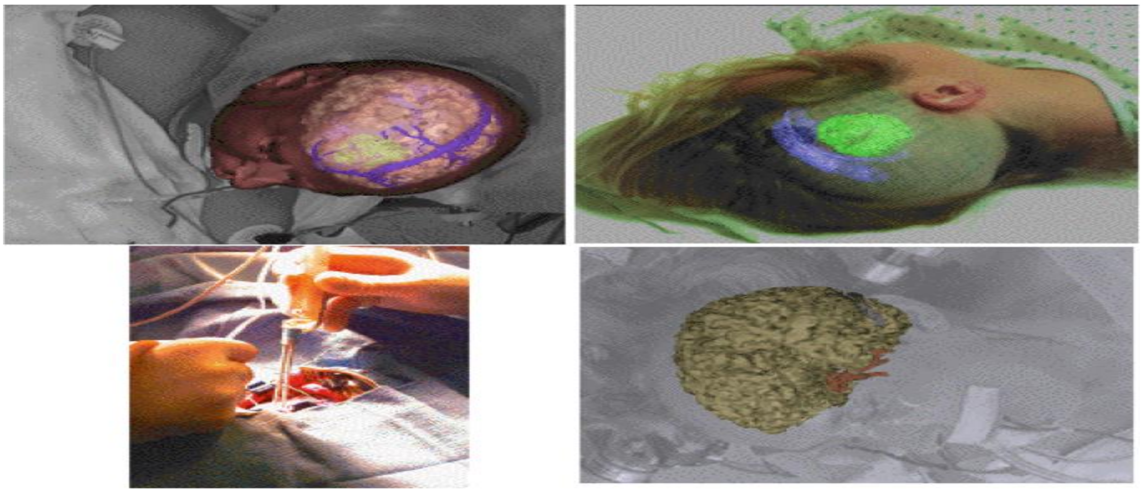
Material presented on the computer is directly integrated the real world surrounding a free-roaming person who can interact with it to display relevant information, send and resolve questions, and collaborate with other people. World comes the user interface . That's why mobile AR is trustedPrinciples of AR in truly mobile environments;maybe not in the carefully ventilated environment of research laboratoriesand special workrooms. Quite a few techniques must be combined to make this possible: global tracking technologies, wireless communications, location-based computing (LBC) and services (LBS) and portable information technology. Material presented on the computer is directly integrated the real world surrounding a free-roaming person who can interact with it to display relevant information, send and resolve questions, and collaborate with other people. World comes the user interface . That's why mobile AR is trusted Principles of AR in truly mobile environments; maybe not in the carefully ventilated environment of research laboratories and special workrooms. Quite a few techniques must be combined to make this possible: global tracking technologies, wireless communications, location-based computing (LBC) and services (LBS) and portable information technology.

3. Applications of AR

Augmented reality enhances user perception and interaction with the real world. Virtual objects display information that users cannot directly see for themselves feelings. Information conveyed by virtual objects can help with this Users perform real tasks. AR is a concrete example -What Fred Brooks called Intelligence Amplification (IA):Use computers as tools to facilitate human work Run At least 12 different classes of AR application areas have been discovered as of the time this study was written. These classes cover well-known industries like the medical, manufacturing, military, entertainment, visualization, and robotics. They also cover brand-new and original fields including marketing, tourism, urban planning, GIS, navigation, and path planning. Each field's most recent research projects are described in the following subsections. Although they don't completely cover all of the application domains for AR technology, these do cover the ones that have already been investigated.

3.1. Medical Field

Medical augmented reality is his main motivationthe need to visualize medical data and the patients it contains same physical space. This requires real time on the fly Visualization of co-registered heterogeneous data, and it is probably the target of many medical augmented reality solutions proposed in the literature.



Proposing a tracking type head-mounted display as a novel

Ultrasound imaging is a further use for augmented reality in the medical field. The ultrasound technician can examine a volumetric generated image of the fetus superimposed on the pregnant woman's abdomen using an optical see-through display. As the user advances, the image is accurately rendered and appears to be inside the abdomen. sielhorst2008. A brain-computer interface (BCI) device and a gaze tracker are utilized to enable the user to manipulate the AR visualization in Blum et al.'s description of the first steps towards a Superman-like X-ray vision. More recently, Wen et al. Propose a cooperative surgical system supported by an augmented reality-based surgical field and led by hand gestures. The authors develop a natural AR steering method with system assistance.

3.2. Military Organizations

Use AR to show real battlefield scenes,We augment it with annotation information . Some HMDs Researched and manufactured by Lite eye for military use use. Uses a hybrid optical-inertial tracker.A miniature MEMS (micro-electro-mechanical system) sensor was developed to track the helmet inside thecockpit.

In Explain how AR technology is being used for military planning training in the city. Display using AR technology Animated terrain for military intervention planning was developed by Arcane. A Helicopter Night Vision System was developed by the Canadian Aerospace Research Institute (NRC-IAR) using AR to extend the operational range of rotorcraft and improve pilots' ability to maneuver in poor visibility conditions. .Developed as display that can be paired with an HMDMilitary Portable Information Systems. Training may provide further military users-only advantages. Like in the Battlefield Augmented Re (BARS) by Julie et al. , which simulates real-time enemy action and large-scale battle scenarios. The BARS system additionally offer stools for creating the environment with new 3D data those subsequent system users see.

3.3. Manufacturing Fields

Research on AR manufacturing applicationsA strongly growing field [?]. The challenge in manufacturing is to design and implement integrated AR manufacturing systems that lead to improved manufacturing processes and product and process development.

Shorter lead times, lower costs, and better quality.The ultimate goal is to create a system as good as this The real world, if not better and more efficient A person's view of their environment and comprehension of the activities involved in product assembly can both be improved with AR. Graphical assembly instructions and animation sequences for common tasks can be pre-coded using an AR method during the design stage. (b). When necessary, these sequences can be virtually superimposed on the actual goods at the assembly lines and supplied upon request. The animations and instructions are conditional and can be automatically changed to reflect the real circumstances at the manufacturing lines.

Periodically updated information from the manufacturers can be used to update these instructions and animation sequences. By using this strategy, assembly operators won't need as much training or to process as much information. By cutting down on product assembly time, it can shorten the lead time for products.

3.4. Visualization

AR is a practical visualization method for superimposing computer pictures on the physical world. Numerous applications for AR can mix visualization techniques. a focus on vision In , an AR system was introduced for interaction with visualization.In order to serve specific applications like city, landscape, and architectural visualization, a device called Gyroscope was created. In an approach to AR visualization for laparoscopic surgery By superimposing virtual objects or information onto actual objects or settings, AR also makes it possible to visualize invisible concepts or events. By utilizing virtual things like molecules, vectors, and symbols, AR systems could assist students in visualizing abstract scientific concepts or unobservable phenomena, such as airflow or magnetic fields. Students could choose chemical components, combine them into 3D molecular models, and rotate the models, for instance, using Augmented Chemistry. Children were given a pop-up book experience to see the book's information by Clark et al.'s proposed augmented paper-based coloring book with 3D material. These enhanced real items produce fresh visualizations that could improve comprehension of ethereal and unseen ideas or events.


3.5. Entertainment and Games

In the entertainment sector, augmented reality has been used to create games as well as to make significant game elements more visible in live sports broadcasts. When a large audience is involved, AR may also help advertisers by displaying virtual adverts and product placements. Sports venues including football grounds, racetracks, and swimming pools are well-known and simple to construct, making it simple to add video through monitored camera feeds. One example is the Fox-**Tax system,** which is used to highlight a hard-to-see hockey puck's location as it moves quickly over the ice. AR is also used to annotate racing automobiles, snooker ball trajectories, life swimmer performances, etc. . Due to situations that are predictable (uniformed players on a green, white and brown field),


3.6. Robotics

AR is a great platform for collaborating with robots . Image guided surgery and medical robotics were covered in . Based on AR, predictive displays for telerobotics have been developed. Research on remote robot manipulation via AR can be found in . Robots can communicate information to humans using the AR approach to provide complex information. For the development and testing of robots, the AR approach was presented in writers outline how to perform head surgery using a surgical robot system and AR method. Visualizing robot input, output, and status information was suggested using an AR technique. It was explained in how to teleoperate robotic systems using AR tools. In a method for employing AR to enhance robotic operator performance was devised.

3.7. Education

Educational researchers are increasingly acknowledging the new opportunities that augmented reality (AR) offers for teaching and learning. The coexistence of virtual objects and real environments enables learners to visualize intricate spatial relationships and abstract ideas, to encounter phenomena that are not possible in the real world, to interact with two and three dimensional synthetic objects in mixed reality, and to develop critical habits that cannot be developed and put into practice in other technologically enhanced learning environments. Due to these educational advantages, augmented reality (AR) will be one of the most important developing technologies in education during the next five years.

3.8. Marketing

The automotive sector pioneered the use of augmented reality in advertising. Some businesses produced unique flyers that webcams could recognize automatically, displaying a three-dimensional model of the advertised car on the screen. Then, this strategy spread to a variety of business segments, including footwear and furniture as well as video games and motion pictures. The commonplace QR-code is a relativelystraightforward illustration of this augmented reality: it is a black-and-white image that, when decoded by a computer or mobile device, transforms into more complicated information. Trying on shoes virtually is an illustration of more complicated augmented reality. The user dons a specific pair of socks, and then goes in front of a camera to see an image of him wearing the socks of his choice.

3.9. Navigation and Path Planning

It has been practiced for some time to navigate in prepared surroundings. RekimotointroducedNaviCam, a camera for interior use that added footage from a handheld camera while monitoring a user's position using fiducially markers. Applications and restrictions of augmented reality (AR) for wearable computers are discussed by Sterner et al. Including issues with finger tracking and facial recognition. Navigation paradigms for (outdoor) people and cars that overlay routes, highway exits, follow-me cars, risks, fuel prices, etc. are discussed by Narzt et al. . They created prototypes of video see-through PDAs and mobile phones with the intention of using them as heads-up displays in automobile windscreens. The effectiveness of using AR alerts to draw a car driver's attention to danger is examined by Tonnis et al.. Kim et al. explain

3.10. Tourism

Visitors to cultural heritage locations can get archaeological knowledge through the ARCHEOGUIDE, a project AR based on cultural heritage on-site guide, according to the description. To improve cultural tourism experiences on mobile devices, especially historical tourism, an interactive visualization system based on AR technologies was developed in. For a tourist guide based on AR technology, the Augmented City design with information sharing and filtering was suggested in .

Using multimedia sketching, the creation of AR interfaces for guided tours (visiting culturally significant locations) was explored in. Based on AR technologies and mobile devices, a platform for tourist guides was made available in . In, augmented reality (AR) technologies were employed to improve visitors' knowledge exploration experiences, exhibitions, mobile multimedia museum guides, and museum watching.

3.11. Geospatial

Two interfaces based AR were used to describe hardware and software for collaborative spatial data representation and manipulation. AR can be used to arrange military training exercises in urban environments. Based on AR technology, addressed how to depict biological barriers and illustrate where they are in the terrain. The use of AR to represent GIS-model-based landscape changes in an immersive environment was suggested as a method for accurate landscape visualization. In order to provide improved location-based services for urban navigation and way finding, AR interface paradigms were addressed in. In, a tangible augmented street map (TASM)-based AR was created. For the purpose of creating and presenting geographical information, one system-based MAR approach was created in.

3.12. Urban Planning and Civil Engineering

AR is a method for supporting decisions in interior and architectural design. In a method for building distributed AR-based collaborative design applications was introduced. The AR technique was created to investigate the connections between the structural systems and the perceived architectural environment.It was created with the intention of utilizing AR systems to enhance procedures for the building, inspection, and maintenance of architectural structures in image. The use of AR to visualize architectural ideas in an outside setting is one method in for an architectural application in facility management and maintenance, a prototype system has been created. Urban planning using calibration-free AR based affine representation was described in example. It was inquired about using a tactile interface and an augmented reality tabletop that uses projection.

4. Challenges And Issues

Despite the increased interest in AR and the enormous body of advances and research, some obstacles and issue still exist and need to be addressed. In this part, we categories the constraints that define the state-of-the-art of augmented reality based on technology, societal acceptability, and usability. Considerable gains made in each of the topics described in this report. However, there are still limits with the technology that has to be overcome. The amount of information in reality that an AR system must handle is enormous. As a result, the gear should be easy to transport, lightweight, and quick enough to display graphics. Another restriction on the uses of AR is the battery life that these sophisticated AR gadgets require. The use of AR tracking

5. Conclusion And Future Trends

It is hypothesized that future study could go in a number of different areas. There must be a large number of HMDs designed expressly with AR in mind. The usage of HMDs and other wearable devices, such as data suits and data gloves, is restricted. All wearable equipment's need be designed to be lighter, smaller and easier to work with the user. Researchers working on AR systems must also take into account other difficulties like response time lags and hardware or software malfunctions. Registration mistake is oneof AR systems' drawbacks. Various tracking techniques are examined, and potentialtracking research avenues are outlined that allow scientists to take full advantage of AR and VR.

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 Sa and E. Churchill, “Mobile augmented reality: explor- ´ ing 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
[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. Applied Computational Science ISBN: 978-960-474-368-1 211
[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 InternationalSymposium 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," {CIRP} 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. Citeseer, 2004, pp. 520–525. [35] W. Qi, "A vision-based augmented reality system for visualization

interaction," in Information Visualisation, 2005. Proceedings.Ninth International Conference on. IEEE, 2005, pp. 404–409.

[36] V. P. Claus Brenner, J. Haunert, and N. Ripperda, "The geoscope-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.

[39] M. Fjeld and B. M. Voegtli, "Augmented chemistry: An interactive educational workbench," in Mixed and Augmented Reality, 2002. ISMAR 2002.Proceedings.International Symposium on. IEEE, 2002, pp. 259–321.

[40] A. Clark and A. Dunser, "An interactive augmented reality coloring book," in 3D User Interfaces (3DUI), 2012 IEEE Symposium on. IEEE, 2012, pp. 7–10.

[41] R. Cavallaro, "The foxtrax hockey puck tracking system," IEEE Computer Graphics and Applications, vol. 17, no. 2, pp. 6–12, 1997.

[42] R. Azuma, I. Neely, H., M. Daily, and J. Leonard, "Performance analysis of an outdoor augmented reality tracking system that relies upon a few mobile beacons," in Mixed and Augmented Reality, 2006.ISMAR 2006. IEEE/ACM International Symposium on, 2006, pp. 101–104.

[43] R. Cavallaro, M. Hybinette, M. White, and T. Balch, "Augmenting live broadcast sports with 3d tracking information," IEEE MultiMedia, pp. 38–47, 2011.

[44] S. A. Green, M. Billinghurst, X. Chen, and G. Chase, "Humanrobot collaboration: A literature review and augmented reality approach in design," 2008.

[45] N. Suzuki, A. Hattori, and M. Hashizume, "Benefits of augmented reality function for laparoscopic and endoscopic surgical robot systems," navigation, vol. 1, p. 6, 2008. Applied Computational Science ISBN: 978-960-474-368-1 212

[46] W. S. Kim, "Virtual reality calibration and preview/predictive displays for telerobotics," 1995. [47] S. Tachi, "Experimental study on remote manipulation using virtual reality," in Proceedings of the Eighth international symposium on measurement and control in robotics, Czech Technical University in Prague, Czech Republic, June 8-12 1998, pp. 29–34.

[48] M. Daily, Y. Cho, K. Martin, and D. Payton, "World embedded interfaces for human-robot interaction," in System Sciences, 2003. Proceedings of the 36th Annual Hawaii International Conference on.IEEE, 2003, pp. 6–pp.

[49] M. Stilman, P. Michel, J. Chestnutt, K. Nishiwaki, S. Kagami, and J. Kuffner, "Augmented reality for robot development and experimentation," Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, Tech. Rep. CMU-RI-TR-05-55, 2005.

[50] H. Worn, M. Aschke, and L. Kahrs, "New augmented real- ¨ ity and robotic based methods for head-surgery," The International Journal of Medical Robotics and Computer Assisted

1.