Understanding of AR Technologies

S M Nazmuz Sakib [1]

[1]Faculty of Medicine

October 30, 2023

Abstract

A lot of progress has been made in the field of augmented reality tracking over the last few years. Several dependable tracking systems that provide real-time tracking in an indoor setting have been developed. As previously stated in this survey report, there are still some challenges with AR tracking, such as occlusion, varying lighting environments, variable backdrop contrast, and varying color intensities. The development of algorithms that use marker-based tracking to enable robust and accurate tracking in a variety of illumination, contrast, and lighting conditions will be a future focus.

Posted on 22 Apr 2020 — CC-BY 4.0 — https://doi.org/10.36227/techrxiv.19614549.v1 — e-Prints posted on TechRxiv are preliminary reports that are not peer reviewed. They should not b...

Understanding of AR Technologies

[1]S M Nazmuz Sakib (Orchid- https://orcid.org/0000-0001-9310-3014) (sakibpedia@gmail.com)

[1] Graduate of BSc in Business Studies
School of Business And Trade
Pilatusstrasse 6003, 6003 Luzern,
Switzerland

[1] Student of LLB(Hon's)
Faculty of Law
Dhaka International University
House # 4, Road # 1, Block - F, Dhaka 1213

[1] Student of BSc in Civil Engineering
Faculty of Science and Engineering
Sonargaon University
147/I, Green Road, Panthapath, Dhaka

[1] Student of BSc in Physiotherapy
Faculty of Medicine
University of Dhaka
Nilkhet Rd, Dhaka 1000

1 

[1]Author Biography

S M Nazmuz Sakib is an eLearning expert and done more than 500 MOOCs or Massive Open Online Courses and experienced as an instructor in sites like Udemy. He has completed his BSc in Business Studies from School of Business And Trade, Switzerland with CGPA 4 in the scale of 4 and 97.06% grade marks on an average. He is also a certified Google IT Support Professional, Google Data Analytics Professional and IBM Customer Engagement Specialist Professional.

Abstract

A lot of progress has been made in the field of augmented reality tracking over the last few years. Several dependable tracking systems that provide real-time tracking in an indoor setting have been developed. As previously stated in this survey report, there are still some challenges with AR tracking, such as occlusion, varying lighting environments, variable backdrop contrast, and varying color intensities. The development of algorithms that use marker-based tracking to enable robust and accurate tracking in a variety of illumination, contrast, and lighting conditions will be a future focus.

Keywords: AR, Augmented reality, AR Technology, Technology, AR tracking.

Introduction:

The overlay of computer visuals over the real world is known as augmented reality (AR) [1]. It's a collection of technologies aimed at bringing the digital and physical worlds together [2]. AR is a new situation in which the actual world is supplemented by software content linked to specific places/activities

[3]. AR is a form of virtual reality and virtual reality describes a condition in which the user is entirely immersed in a computer-generated world. The user is unable to perceive the real world when engaged in the setting. AR, on the other hand, allows users to even see the actual environment with software items projected on it [4]. It refers to a set of techniques that allow for the real-time blending of software content and lives stream presentation. The origins of AR applications can be traced back to computer science interaction research [5].

Critical review the understanding of the AR technologies and emerging trends

Definitions of Augmented Reality:

AR has been described in a variety of ways by researchers in computer science and instructional technology. They used two techniques to define "augmented reality": a *general approach* and a *narrow one*. AR refers to, improving natural input to the user with synthetic cues in a general context. The narrower approach, on the other hand, stresses the technological side of AR, defining it as a type of VR technology in which the participant's face display is translucent, allowing a direct vision of the world [6]. AR is described as a system that combines real and virtual worlds, allows for real-time interaction, and accurately registers virtual and real things in three axes [7, 8].

According to some researchers and experts, the term AR really shouldn't be defined narrowly. This phrase can be used to describe any system that enables real and virtual data in a useful way. They define AR as a situation in which a real-world context is constantly layered with cohesive position or context-sensitive virtual data. In this case, AR could offer users a technology-mediated interactive experience in which the real and virtual worlds are mixed, and users' contact and participation are enhanced [8-11]

For academics and artists, a general definition of AR would be much more fruitful because it implies that AR may be generated and deployed using a variety of technologies, including desktops and laptops, portable devices, helmet monitors, etc. That is, the concept of augmented reality is not tied to any specific technology and can now be examined in a broader context. AR takes advantage of the actual world's advantages by delivering additional and relevant information that enhances learners' perceptions of reality. Although AR is founded on and accompanied by technology, it must be conceptualized in a way that goes well beyond that [8, 12].

AR Components:

Augmented reality systems are built upon on three major buildings blocks:

- Tracking and Registration.
- Display Technology.
- Real time Rendering.

First and foremost, augmented reality is a technology that should be interactive in real time and three-dimensionally registered. Correct tracking and registration are critical when attempting to create a credible augmented picture. It's because, in order to convey a convincing picture to the viewer, the actual camera must be transferred to the virtual one in such a manner that the viewpoints of both surroundings are the same [5, 13]. So because digitally created objects should seem to be stable, the system must constantly determine the user position inside the surroundings around the virtual object, particularly for a mobile user [13]. If entire monitoring with a global coordinate system is necessary, outside in and inside out monitoring can be distinguished [14]. The first relates to systems in which sensors are put in the environment to track transmitters on mobile objects, such as employing GPS-based sensors to track where a smartphone is located or equivocating a portable device's location across phone towers.

Intrinsic detectors fixed to portable items are used in the second type; a camera for sight tracking, a computerized compass to monitor which way the smartphone is facing, and an accelerometer to monitor acceleration. However, both technologies have drawbacks: GPS, for example, may not be as reliable within buildings as it is outdoors, and sight tracking is highly dependent on illumination and visibility [15]. Both real-time rendering and display technology are seen as fundamental building blocks and problems in the future by researchers. The first is due to physical and technological limits, as well as human factors. The second, real-time rendering, refers to the ability of augmented reality devices to quickly and realistically layer graphical components on top of the real world. The ultimate goal would be to merge digitally generated objects to the point where the user can't tell the difference between real and virtual [5, 13].

Taxonomies of AR:

AR, as a circumstance, denotes a variety of virtual reality that serves as a supplement rather than a substitute for reality [7, 16]. Previous research has proposed numerous taxonomies of AR to define the extent to which reality is replaced or augmented. The authors created a Reality–Virtuality continuum, which ranges from a wholly real to a completely virtual environment. Mixed reality can be characterized as a situation in which actual and virtual world elements are presented together inside this continuity. Furthermore, there are two key concepts in mixed reality: augmented reality and augmented virtuality (AV). AR, they claim, is a mix of the real and the virtual, with more real than virtual information, whereas AV refers to bringing elements of reality to a virtual environment, with more virtual data. In AR, for example, virtual things might be added to a real-world environment, and in AV, a real-world object might be displayed into a virtual world. It's possible that the difference between them comes down to whether reality or virtuality is being improved [6, 17].

Although advocates push for an immersive learning environment in which virtual and real items mix in a seamless manner, the differences between AV and AR must be noted. As a result, augmented reality (AR) can be considered mixed reality, as it may contain more actual than virtual elements and information. They also used a spectrum to underline the importance of the augmentation provided in AR when addressing the issue of differentiation between AV and AR [9]. The weight is determined by how much virtual information is offered to users. A situation in which consumers use a great deal of data and physical items from the actual world while having limited access to virtual information is referred to as lightly augmented reality. A substantially augmented reality, on the other hand, has often accessible virtual information. This spectrum shows that technology might play a role in augmented reality. Most immersive technology, such as head-mounted displays, are applied in a significantly enhanced reality. Users in weakly augmented reality interact primarily with tangible materials and objects, manipulating and accessing virtual information only on rare occasions. They also developed a three-dimensional framework consisting of "immersion" (from reality to virtual), "ubiquity" (stationary to ubiquitous), and "multiplicity" to emphasize the qualities of AR (single user to potentially everyone).

The reality-virtuality continuum is represented by the "immersion" dimension. The "ubiquity" dimension deals with how and where the system may be utilized, whereas the "multiplicity" dimension deals with the number of concurrent users. As a result, AR may be found at the middle of each dimension. This framework also includes instructions for designing an AR system that may be built using a variety of technologies [6, 12].

Emerging Trends of AR Technologies:

In AR research, technology plays a critical role. The term "technology" has been used to define AR in certain prior research. Klopfer and Sheldon, characterized AR as a "technology" that combines real and virtual world experiences. AR is viewed as a type of virtual reality with a face display in an above-constrained manner [6]. This concept represents the early stages of AR technology when virtual information was generally superimposed on the actual environment via face gear. With the rapid advancement of technology, the AR idea might be expanded even further, as additional hardware &

software modules become available for creating augmented reality. For example, advances in portable computing bring up new possibilities for augmented reality, resulting in a subset of AR known as mobile-AR [14, 18, 19]. Handheld gadgets' mobility would enhance the realism of an educational environment and boost learners' connections with one another [20]. Furthermore, mobile devices enable widespread AR systems [12]. Rather than employing face displays, ubiquitous AR systems use location-registered technologies to run on mobile PCs (e.g., Global Positioning System [GPS]). With an emphasis on real-world surroundings, pervasive or mobile-AR systems are less intrusive. A mixture of blended realities and remote labs is yet another use of AR [21]. Learners could operate and engage with both real and virtual equipment by superimposing virtual features on distant devices. Computer simulations, remote laboratories, physical models, and three-dimensional or virtual items are all possible with various AR technologies together [8, 11, 12].

So, how might augmented reality be employed in the classroom? First, augmented reality technologies enable pupils to learn in realistic discovery in the actual world, with virtual things like as texts, videos, and images serving as supplemental materials for pupils to perform explorations of their surroundings in the actual world [22]. Among the most typical applications of AR is to add a layer of location-based information to existing places [23]. Furthermore, augmented reality technology may be used to combine genuine world and digital learning materials. As Klopfer and Squire shown, augmented reality allows students to explore scientific events that are impossible to replicate in the actual Universe, like some chemical reactions [8, 10]. Numerous AR systems were established by Liu et al. for this aim; students were able to examine the simulated solar system here on a classroom table or visualize the photosynthesis process through AR investigations [8, 17]. Furthermore, according to Kerawalla et al., AR devices have the power to engage students in handling virtual objects from a range of viewpoints [24]. A three-dimensional structural analysis system (Construct3D) was created by Kaufmann, Steinbugl, Dunser, and Gluck with the purpose of aiding mathematical and geometrical instruction. Construct3D, as an augmented reality system, not only offered pupils a real-world context in which to cooperate, but also presented virtual 3D objects for them to control, gauge, and modify in order to comprehend spatial connections [8, 25].

Despite the fact that AR technologies use high-end equipment and advanced tools, as Bronack claimed, educational academics are not interested in these technologies [26]. What's more essential is how technology aids and facilitates effective learning. Students, researchers, and architects would be more fruitful if they thought about AR as a philosophy rather than a specific sort of technology. As a result, in the following part, we'll go through the characteristics and benefits of augmented reality for academic reasons [8].

Critical review on Impact of Augmented Reality on Potential Application Areas:

There are many potential application areas where augmented reality has a great impact but some of the main potential application areas are given below;

- Medical
- Military
- Manufacturing
- Visualization
- Entertainment and Games
- Robotics
- Education
- Marketing
- Navigation and Path Planning
- Tourism
- Geospatial
- Urban Planning and Civil Engineering

Medical:

Sutherland proposed a monitored face projection as a unique human-computer interaction for viewpoint-dependent virtual scene rendering in 1968 [27]. Roberts et al. created the first medical augmented reality system barely two decades later [28]. Ultrasound imaging is another use for augmented reality in the healthcare profession [29]. Furthermore, Blum et al. present the initial steps toward a Superhero X-ray vision, in which the user controls the AR visualization via a brain-computer interface (BCI) device and a gaze-tracker [30]. Wen et al. have recently proposed a collaborative surgical system that is led by hand movements and assisted by an augmented reality surgical field [31].

Military:

AR may be used to display a real-life combat scenario and add annotations to it [32]. For pilot helmet tracking, a combined optical and inertial tracker with small MEMS (micro-electro-mechanical systems) sensors was created [33]. The chopper night camera module was created by the

National Research Council of Canada's Centre for Aerospace Research (NRC-IAR) utilizing AR to broaden the functional envelope of rotorcraft and improve operators' ability to navigate in low-light settings [34]. HMD is a device that may be used in conjunction with a transportable data system in the army [35].

Manufacturing:

AR may improve a person's perspective of the environment around them as well as their knowledge of the product assembly activities that need to be completed. Using an AR method, graphical process documentation and animation sequences for common tasks may be pre-coded during the designing phase [36].

Visualization:

The use of augmented reality (AR) to overlay computer visuals over the actual environment is a helpful visualization tool. AR may use a variety of visualization methods to apply to a variety of applications [37]. Geo Scope is a gadget that was created to enable various applications in the field of city, landscape, and architectural visualization [38]. By superimposing virtual items or information onto actual things or settings, AR also allows for the representation of previously unseen concepts or occurrences [39]. By employing virtual objects such as molecules, vectors, and symbols, AR systems might assist learners in comprehending abstract science ideas or non - observable processes such as airflow or magnetic fields [40]. Clark et al. suggested an augmented paper-based coloring book with 3D content that gave kids a pop-up book experience to visualize the information of the book [41].

Entertainment and Games:

In the entertainment business, augmented reality has been used to develop the game as well as to boost the visibility of key game elements in live sports coverage. AR can also let companies offer virtual adverts and product placements in these scenarios where a wide audience is reached. Pools, football fields, racing tracks, and other sporting venues are well-known and simple to set up, making video see-through augmentation with monitored camera feeds simply [42].

Robotics:

AR is a great way for humans and robots to work together. Robots can use the Augmented Reality (AR) method to communicate complicated information to humans [43].

Education:

Pupils can visualize complex geometric distribution and hypothetical situations, experience occurrences that aren't realistically possible, connect with two and three-dimensional artificial items in mixed reality, and develop important practices that can't be developed and enacted in other technology-enhanced learning environments thanks to the togetherness of virtual elements and global approach [44, 45].

Navigation and Path Planning:

Kim et al. show how GIS data for AR navigation may be used to turn a 2D traveler guide service into a 3D experience. When compared to ordinary displays, the usage of augmented displays results in a considerable reduction in navigation mistakes and difficulties linked to split attention [46, 47].

Tourism:

The ARCHEOGUIDE, a project AR-based cultural heritage on-site guide, was presented as a way for people to learn about archaeology while visiting cultural heritage sites. To improve cultural tourism experiences, especially historical tourism, on mobile devices, an interactive visualization system based on AR technologies was developed. A tourist guide based on AR technology was presented with one design, Augmented City, which included information exchange and filtering [48, 49].

<u>One Application Area In-Depth:</u>

Augmented Reality in Surgery:

Neurosurgery:

Since its start, no field has been more engaged than neurosurgery in the application of computer-assisted surgery. Neurosurgeons are always attempting to re-sect the least amount of tumor-containing brain tissue feasible. While there are technologies for imaging and showing the brain's 3D structure, the surgeon must match what he or she views on the 3D projection to the patient's real anatomy. Understanding the concepts of registration, stereotactic surgery, and stereoscopic surgery provided insight into how to navigate a brain tumor. The challenge was first solved by using a stereotactic frame for the patient's skull and imaging the skull and frame as a unit. Automatic registration approaches for frameless stereo-taxy, image-guided operation, and AR were developed in response to the need for a more dependable frame that was both safe for the surgeon and agreeable for the patient [50].

A navigation system overlaid a 3Dimage of the histological section of the brain over the real area of operations in the AR environment. For the exploring surgeon, this generates a 3D anatomic atlas–like interactive environment [51]. As a result, surgical navigation is critical for reducing surgical intervention in a limited operating field. The surgical anatomy is more fixed in space than the vital cavity, which gives the neurosurgeon an advantage in registration. Interactive photo neurosurgery is the name given to these emerging technologies for surgical navigation and image analysis. This system is made up of five main components: an image and physical space registration technique, an interactive localization gadget, a pc with the necessary software interface and video display system, real-time feedback integration, and robotics. Concerns about the use of AR are comparable to those raised in other surgical fields. During surgery, tissue movement due to cerebrospinal fluid leaking, gravity, and tumor removal can all impact registration [51].

General Surgery:

A variety of advances have been taken toward the creation of an AR system that works in tandem with the computer-assisted operation, particularly in the field of liver surgery. Through the precise translation of anatomical knowledge into topologic and geometric restrictions, Soler et al released the first completely automated 3D reconstruction liver model. Based on the Coined characterization of the 8 subsegments of the liver and delineation of the hepatic and portal veins in VR, such a method allows the operator to automatically create an anatomical division of the liver [52]. The creation of tele immersive cooperation in virtual pelvic floor and virtual abdomen were other milestones toward visualizing complicated anatomy [53]. Although these simulations have not been employed in the operating theatre, it is believed that they will help to disseminate surgical knowledge more widely. Another significant development was the use of frameless stereotactic liver surgery in the removal of tumors [54].

An interactive image-guided surgical system for liver surgery was tested for precise tool tracking in the same way that it was tested for neurosurgery. Accuracy ranged from 1.4 to 2.1 mm in both human and porcine data. In laparoscopy, total liver motion during breathing was 10.8±2.5 mm, whereas insufflation caused 2.5±1.4 mm of motion.

AR visualization has been demonstrated to be helpful in phantom and clinical data in the field of breast cancer. The surgeon could see the exact 3D position of the tumor as though it were visible through the breast skin using this unique technology, which allowed superimposition of 3D tumor models onto live video pictures of the breast. Surgical AR, according to Sato et al, allowed the surgeon to target surgical resection in a more objective and precise manner, reducing the chance of relapse and optimizing breast conservation. In surgical oncology, further study is needed to determine AR's reliability and validity [55].

Orthopedic Surgery:

Many research systems are being employed to tackle orthopedic difficulties, despite the fact that AR applications in musculoskeletal surgery are not yet clinically ready. Implant orientation in complete knee and hip replacement is one of these applications, where an AR system may be utilized to advise the appropriate positioning of implant components based on preoperative designs [56].

The mathematical examination of stress distribution and soft-tissue tension during motion is known as limb kinematics. Total knee restoration and high tibial better functioning might be changed and adapted to the particular patient in an AR environment, thanks to the viewing of the vector shape [57].

A recent experimental and hold instrument, the mechatronic arthroscope, highlights the use of AR in knee surgery. This technology enables the surgeon to apply force without causing injury, to travel the knee joint during the planning stage, and to intervene during the AR phase by digitally merging preoperative and intraoperative pictures [58]. Accurate intramedullary rod implantation, correct bone manipulation, tumor removal, and cartilage resurfacing are all variations within the same subject.

Cardiovascular:

AR may now be employed in thoracic surgery thanks to minimally invasive surgery in the chest through a thoracoscope. It remains to be seen if a thoracoscopic approach to diagnosis or therapy might eventually replace more traditional methods. According to Colt, though, the training skills will soon be expanded by the addition of virtual reality simulators. The effect of laparoscopic surgery on general surgical practice led to the development of thoracoscopy. Pleural fluid overload, lung cancer, mediastinal tumors, and vasospastic illness can all be diagnosed and treated with thoracoscopic sympathectomies, empyema, and closure of the patent ductus arteriosus through this window into the pleural and pericardial cavities [59].

The use of thoracoscopic access with a remotely operated robot handled by the surgeon's hands in cardiac surgery promises a unique way of optical coronary artery bypass grafting. The surgeon may perform delicate prehensile functions with the help of the robot's tools. The surgeon can utilize his or her eyes to follow both the robot hands and the anatomy for coronary anastomoses using a television-video screen. Surgical technique utilizing this method has been described as hard for the surgical team. There is currently no literature on real-time AR. This technology, on the other hand, promises to contribute to fewer hospital days, a faster return to regular activities, less discomfort, and improved cosmesis [60].

Mitral valve repair and aortic valve replacement can now be done entirely endoscopically. More research is needed to find techniques to make the anastomosis go more smoothly, eliminate mistakes, and superimpose anatomic pictures on genuine anatomic landmarks. To determine the effectiveness and therapeutic utility of these approaches, multicenter research will be required. Currently, the risk of graft occlusion following minimally invasive direct coronary artery bypass is somewhat greater than that following conventional revascularization [61]. Real-time imaging and automation will be at the forefront of improving the quality of coronary anastomosis in off-pump coronary artery bypass grafting. To provide a still image of a beating heart, visual synchronization and motion correction will be needed [62].

Critical discussion on the open Challenges on the Road to Large-Scale Deployment of AR:

Challenges in Augmented Reality:

Although a lot of progress has been achieved in the field of augmented reality, there are still a few obstacles to overcome or enhance. These difficulties can be classified as follows:

- Performance Challenges
- Alignment Challenges
- Interaction Challenges
- Mobility/ Portability Challenges
- Visualization Challenge.

Performance challenges:

Real-time computing, reacting, and developing with the changing real-world situation are all performance problems. The performance of augmented reality apps can be slowed by real-time computing. The performance of mobile AR is a big concern [63]. Visual recognition is computationally costly even for simple markers[64]. To obtain an acceptable memory footprint, the 3D models for a mobile AR solution should be simple [65].

Alignment challenges:

The term "alignment" refers to the appropriate arrangement of a virtual entity in relation to real-world objects. Erroneous alignment can result in issues such as incorrect information presentation in the real world. In medical applications, the misalignment is more severe. Registration issues, which are the most basic difficulty in AR, are among the alignment obstacles [7]. The appropriate alignment of virtual items to real-world objects is known as registration [7, 66]. Another key challenge with outdoor AR is tracking [67]. Because even a minor tracking mistake can generate an obvious mismatch between virtual and actual objects, an accurate tracking system is necessary for AR systems[68]. The calibration of an augmented reality system is also necessary [69].

Interaction challenges:

The engagement of users with virtual and actual items at the same time is referred to as an interaction problem. Interaction employs a variety of interfaces to interact with virtual objects, including auditory, haptic, physical, gaze, and text-based interfaces. Interaction with virtual objects may lead to a variety of issues, such as when a virtual line appears solely to television viewers during a football or cricket match. Ulhaas and Schmalstieg developed a finger tracker that uses a customized glove with retro-reflective markings. User Interfaces and Interaction Techniques are still issues that need to be addressed [70].

Mobility challenges:

The mobility of augmented reality systems is one of these problems. It should be tiny and light so that it may be taken with you wherever you go. Outside of a controlled setting, the ideal augmented reality technology will be portable. Schmalstieg et al. created a wearable device that can carry a large amount of heavy equipment for an extended period of time. [71].

Visualization challenges:

Display difficulties (HMD or monitor), contrast, resolution, brightness, and field of vision are all visual obstacles. The virtual object and the real-world item must both be illuminated in the same way. Another difficulty with visibility is occlusion, which is a mechanism that decides which sections of a surface or its pieces are not visible from a certain vantage point. Correct management of occlusion between virtual objects and real-world items in the scene is critical for a realistic perspective. Lepetit and Berger demonstrated a semi-automated occlusion solution for AR systems. [72].

Apart from these challenges, the issues of privacy, social and ethnical acceptance are also worth considering when thinking about the growth of augmented reality in different applications.

Issues in Augmented Reality Tracking:

Despite the advancements achieved in the field of augmented reality tracking, there are still certain challenges to be addressed. These concerns will be highlighted in this section.

There is currently no one tracking approach that gives the optimal option for monitoring orientation and posture in an unprepared outside environment. Tracking is the most difficult aspect of constructing an augmented reality system in an unprepared outdoor world. Tracking is an important study field in augmented reality, and there is now a lot of research being done in this area. The issue is with the modelling of complicated 3D geographic models, as well as the arrangement of storage and querying of such data in spatial databases, which must change quickly to keep up with changing real-world situations. Similarly, abrupt movements frequently result in tracking failures, which are time-consuming to recover from and result in a temporary loss of real-time monitoring capabilities.

Optical, magnetic, inertial, acoustic, or ultrasonic sensors are utilized in sensor-based tracking. Optical tracking sensors are susceptible to optical noise and occlusion, as well as being computationally expensive and time-consuming. When monitoring numerous comparable items in a scene, optical tracking becomes tough. The presence of electrical gadgets near magnetic sensors causes them to malfunction. Magnetic tracking sensors are likewise susceptible to electromagnetic noise and suffer from jitter. Their accuracy declines as their distance from the source rises. Because sound travels slowly, the acoustic system's update rate is modest. The speed of sound in air might fluctuate owing to changes in temperature or humidity in the surroundings, reducing the tracking system's performance. Small friction between the axis of the wheel and the bearing might cause a difficulty in an inertial tracking system. Tracking becomes more complicated and expensive with hybrid systems.

In a prepared indoor setting, marker-based tracking can be employed. Marker-based tracking cannot be employed in large-scale outdoor contexts due of its restricted range. Model-based tracking expands the range of tracking by leveraging natural traits, however these approaches are insecure and expensive to implement. For building models of complicated environments, model-based tracking necessitates a lot of processing. Hybrid tracking is reliable and precise, but it is expensive and has computational challenges.

The key problem in the augmented reality system is to provide rapid and accurate tracking in the settings and changes in the environment with least effort and expenditures. In augmented reality applications, tracking is a problem in huge facilities that meet industrial objectives.

Augmented reality security and privacy issues

AR concerns

One of the most feared consequences of augmented reality is the loss of privacy. Because AR technology can observe what a user is doing, the user's privacy is jeopardized. AR captures a lot of data on who the user is and what they're doing - far more than social media networks or other types of technology, for example. This presents a number of issues and questions:

- If hackers obtain access to a device, there is a significant risk of losing personal information.
- What do AR businesses do with the data they collect from consumers, and how do they keep it safe?
- Is augmented reality data stored locally on the device or in the cloud by businesses?
- Is the data encrypted before it is delivered to the cloud?
- Is this information shared with other parties by AR companies? If so, how do they put it to use?

Unreliable content:

The augmentation process is aided by AR browsers, but content is developed and distributed by third-party companies and applications. Because AR is such a new sector, and authorized material production and transmission technologies are still emerging, this poses the topic of unreliability. Hackers with advanced skills might replace a user's AR with one of their own, deceiving others or offering false information.
Even if the source is legitimate, several cyber dangers might make the material untrustworthy. Spoofing, sniffing, and data manipulation are examples [73].

Social engineering:

Because of the possibility for material to be unreliable, augmented reality systems can be a useful tool for fooling consumers as part of social engineering assaults. Hackers might, for example, influence users' perceptions of reality by using phony signs or displays to persuade them to take actions that benefit the hackers [73].

Malware:

Hackers can use advertising to inject harmful material into AR applications. Unsuspecting users may click on advertising that direct them to hostage websites or malware-infected AR servers with shaky images, putting AR security at risk [73].

Stealing network credentials:

Criminals may be able to steal network credentials from Android-based wearable gadgets. Hacking might be a cyber concern for merchants who utilize augmented reality and virtual reality shopping apps. Many clients' card information and mobile payment options are already stored in their user accounts. Because mobile payment is such a flawless process, hackers may be able to acquire access to them and deplete accounts invisibly [73].

Denial of service:

Denial of service is another possible AR security threat. Users who rely on AR for work, for example, can find themselves cut off from the information stream they're getting. This would be especially troubling for professionals who rely on technology to do jobs in dangerous settings, when a lack of knowledge might have significant implications. A surgeon losing access to important real-time information on their AR glasses, or a driver losing sight of the road because their AR windshield transforms into a dark screen, are two examples [73].

Man-in-the-middle-attacks:

Attackers on the network can listen in on conversations between the AR client and the AR supplier, as well as AR channel owners and third-party servers. Man-in-the-middle attacks may result as a result of this [73].

Ransomware:

Hackers might acquire access to a user's augmented reality device and record their movements and exchanges in the AR world. They may later threaten to publicize the recordings unless the user makes the payment. Individuals who do not want their gaming and other AR activities made public may find this unpleasant or disturbing [73].

Physical damage:

Physical damage is one of the most serious AR security issues for wearing AR systems. Although some wearables are more durable than others, they always have physical flaws. It is critical to keep them functioning and secure — for example, by not allowing someone to walk away with a headset that may be easily lost or stolen [73].

Conclusion:

Over the previous few years, a lot of progress has been achieved in the field of augmented reality tracking. Several reliable tracking systems have been created that provide real-time tracking in an indoor setting. As previously noted in this survey report, there are still certain challenges with AR tracking, such as some occlusion, varied lighting environments, variable backdrop contrast, and different color intensities. Future work will include the development of algorithms that use marker-based tracking to enable robust and accurate tracking in a variety of illumination, contrast, and lighting conditions.

References:

1. *<RelatorioTecnicoLNCC-2503.pdf>*.

2. Berryman, D.R., *Augmented reality: a review.* Med Ref Serv Q, 2012. **31**(2): p. 212-8.
3. *<986.pdf>*.
4. *<1743384.1743462.pdf>*.
5. *<ACACOS-29.pdf>*.
6. Milgram, P., et al. *Augmented reality: A class of displays on the reality-virtuality continuum*. in *Telemanipulator and telepresence technologies*. 1995. International Society for Optics and Photonics.
7. Azuma, R.T.J.P.t. and v. environments, *A survey of augmented reality.* 1997. **6**(4): p. 355-385.
8. Wu, H.-K., et al., *Current status, opportunities and challenges of augmented reality in education.* Computers & Education, 2013. **62**: p. 41-49.
9. Klopfer, E., *Augmented learning: Research and design of mobile educational games*. 2008: MIT press.
10. Klopfer, E., K.J.E.t.r. Squire, and development, *Environmental Detectives—the development of an augmented reality platform for environmental simulations.* 2008. **56**(2): p. 203-228.
11. Babai, R., A.J.J.o.S.E. Amsterdamer, and Technology, *The persistence of solid and liquid naive conceptions: A reaction time study.* 2008. **17**(6): p. 553-559.
12. Broll, W., et al., *Toward next-gen mobile AR games.* 2008. **28**(4): p. 40-48.
13. Bimber, O.J.C.P., *Spatial Augmented Reality. USA: AK Peters.* 2005. **392**: p. 132.
14. Zhou, F., H.B.-L. Duh, and M. Billinghurst. *Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR*. in *2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality*. 2008. IEEE.
15. Shatte, A., J. Holdsworth, and I.J.E.s.w.a. Lee, *Mobile augmented reality based context-aware library management system.* 2014. **41**(5): p. 2174-2185.
16. Martín-Gutiérrez, J., et al., *Design and validation of an augmented book for spatial abilities development in engineering students.* 2010. **34**(1): p. 77-91.
17. Liu, W., et al. *Mixed reality classroom: learning from entertainment*. in *Proceedings of the 2nd international conference on Digital interactive media in entertainment and arts*. 2007.
18. Squire, K.J.A.r.s.o.h.c.I.o.L.S., *8: Klopfer, E.(2007).* **16**(3): p. 371-413.
19. Martin, F., J.J.C. Ertzberger, and Education, *Here and now mobile learning: An experimental study on the use of mobile technology.* 2013. **68**: p. 76-85.
20. Klopfer, E. and J.J.N.d.f.y.d. Sheldon, *Augmenting your own reality: Student authoring of science-based augmented reality games.* 2010. **2010**(128): p. 85-94.
21. Andujar, J.M., A. Mejías, and M.A.J.I.t.o.e. Márquez, *Augmented reality for the improvement of remote laboratories: an augmented remote laboratory.* 2010. **54**(3): p. 492-500.

22. Dede, C.J.s., *Immersive interfaces for engagement and learning.* 2009. **323**(5910): p. 66-69.
23. Johnson, L.F., et al., *Key emerging technologies for elementary and secondary education.* 2010. **76**(1): p. 36.
24. Kerawalla, L., et al., *"Making it real": exploring the potential of augmented reality for teaching primary school science.* 2006. **10**(3): p. 163-174.
25. Kaufmann, H., et al., *General training of spatial abilities by geometry education in augmented reality.* 2005. **3**: p. 65-76.
26. Bronack, S.C.J.T.J.o.C.H.E., *The role of immersive media in online education.* 2011. **59**(2): p. 113-117.
27. Sutherland, I.E. *A head-mounted three dimensional display*. in *Proceedings of the December 9-11, 1968, fall joint computer conference, part I*. 1968.
28. Roberts, D.W., et al., *A frameless stereotaxic integration of computerized tomographic imaging and the operating microscope.* 1986. **65**(4): p. 545-549.
29. Bajura, M., H. Fuchs, and R.J.A.S.C.G. Ohbuchi, *Merging virtual objects with the real world: Seeing ultrasound imagery within the patient.* 1992. **26**(2): p. 203-210.
30. Blum, T., et al. *Superman-like X-ray vision: Towards brain-computer interfaces for medical augmented reality*. in *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. 2012. IEEE.
31. Wen, R., et al., *Hand gesture guided robot-assisted surgery based on a direct augmented reality interface.* 2014. **116**(2): p. 68-80.
32. Mekni, M. and A.J.A.C.S. Lemieux, *Augmented reality: Applications, challenges and future trends.* 2014. **20**: p. 205-214.
33. Foxlin, E., et al. *Flighttracker: A novel optical/inertial tracker for cockpit enhanced vision*. in *Third IEEE and ACM International Symposium on Mixed and Augmented Reality*. 2004. IEEE.
34. Yu, D., et al., *A useful visualization technique: a literature review for augmented reality and its application, limitation & future direction.* 2009: p. 311-337.
35. Sanders, B., et al., *Defense advanced research projects agency–Smart materials and structures demonstration program overview.* 2004. **15**(4): p. 227-233.
36. Reinhart, G. and C.J.C.A. Patron, *Integrating augmented reality in the assembly domain-fundamentals, benefits and applications.* 2003. **52**(1): p. 5-8.
37. Silva, R.L., et al., *Augmented reality for scientific visualization: Bringing datasets inside the real world.* 2004.

38. CLAUS BRENNER, V.P. and N. Ripperda. *THE GEOSCOPE–A MIXED-REALITY SYSTEM FOR PLANNING AND PUBLIC PARTICIPATION*. in *25th Urban data management symposium*. 2006.
39. Arvanitis, T.N., et al., *Human factors and qualitative pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities.* 2009. **13**(3): p. 243-250.
40. Fjeld, M. and B.M. Voegtli. *Augmented chemistry: An interactive educational workbench*. in *Proceedings. International Symposium on Mixed and Augmented Reality*. 2002. IEEE.
41. Clark, A. and A. Dünser. *An interactive augmented reality coloring book*. in *2012 IEEE symposium on 3D user interfaces (3DUI)*. 2012. IEEE.
42. Van Krevelen, D. and R.J.I.j.o.v.r. Poelman, *A survey of augmented reality technologies, applications and limitations.* 2010. **9**(2): p. 1-20.
43. Daily, M., et al. *World embedded interfaces for human-robot interaction*. in *36th Annual Hawaii International Conference on System Sciences, 2003. Proceedings of the*. 2003. IEEE.
44. Billinghurst, M. and A.J.C. Duenser, *Augmented reality in the classroom.* 2012. **45**(7): p. 56-63.
45. Yuen, S.C.-Y., et al., *Augmented reality: An overview and five directions for AR in education.* 2011. **4**(1): p. 11.
46. Kiyokawa, K., et al. *An occlusion capable optical see-through head mount display for supporting co-located collaboration*. in *The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings.* 2003. IEEE.
47. Kim, S., et al., *A reliable new 2-stage distributed interactive TGS system based on GIS database and augmented reality.* 2006. **89**(1): p. 98-105.
48. Fritz, F., A. Susperregui, and M.T. Linaza. *Enhancing cultural tourism experiences with augmented reality technologies*. 2005. 6th International Symposium on Virtual Reality, Archaeology and Cultural ….
49. Ingram, D. *Trust-based filtering for augmented reality*. in *International Conference on Trust Management*. 2003. Springer.
50. Grimson, W.E.L., et al., *An automatic registration method for frameless stereotaxy, image guided surgery, and enhanced reality visualization.* 1996. **15**(2): p. 129-140.
51. Masutani, Y., et al., *Augmented reality visualization system for intravascular neurosurgery.* 1998. **3**(5): p. 239-247.
52. Soler, L., et al., *An automatic virtual patient reconstruction from CT-scans for hepatic surgical planning.* 2000. **70**: p. 316-22.

53. Satava, R.M. *Accelerating Technology Transfer: New Relationships for Academia, Industry and Government*. in *Medicine Meets Virtual Reality*. 1998. IOS Press.
54. Herline, A.J., et al., *Image-guided surgery: preliminary feasibility studies of frameless stereotactic liver surgery.* 1999. **134**(6): p. 644-650.
55. Sato, Y., et al., *Image guidance of breast cancer surgery using 3-D ultrasound images and augmented reality visualization.* 1998. **17**(5): p. 681-693.
56. DiGioia, A.M., et al., *Image guided navigation system to measure intraoperatively acetabular implant alignment.* 1998. **355**: p. 8-22.
57. Blackwell, M., et al., *Augmented reality and its future in orthopaedics.* 1998. **354**: p. 111-122.
58. Dario, P., et al., *A novel mechatronic tool for computer-assisted arthroscopy.* 2000. **4**(1): p. 15-29.
59. Colt, H.G.J.C.i.c.m., *Therapeutic thoracoscopy.* 1998. **19**(2): p. 383-394.
60. Tang, L.W., et al., *Robotically assisted video-enhanced-endoscopic coronary artery bypass graft surgery.* 2001. **52**(2): p. 99-102.
61. Moussa, I., et al., *Frequency of early occlusion and stenosis in bypass grafts after minimally invasive direct coronary arterial bypass surgery.* 2001. **88**(3): p. 311-313.
62. Nakamura, Y. and K. Kishi, *Robotic stabilization that assists cardiac surgery on beating hearts*, in *Medicine Meets Virtual Reality 2001*. 2001, IOS Press. p. 355-361.
63. Yang, J. and F. Maurer, *Literature survey on combining digital tables and augmented reality for interacting with a model of the human body.* 2010.
64. Wagner, D., D.J.I.C.G. Schmalstieg, and Applications, *Making augmented reality practical on mobile phones, part 1.* 2009. **29**(3): p. 12-15.
65. Wagner, D., D.J.I.c.G. Schmalstieg, and Applications, *Making augmented reality practical on mobile phones, part 2.* 2009. **29**(4): p. 6-9.
66. Hoff, W.A., K. Nguyen, and T. Lyon. *Computer-vision-based registration techniques for augmented reality*. in *Intelligent Robots and Computer Vision XV: Algorithms, Techniques, Active Vision, and Materials Handling*. 1996. International Society for Optics and Photonics.
67. Azuma, R.T.J.M.r.M.r. and v. worlds, *The challenge of making augmented reality work outdoors.* 1999. **1**: p. 379-390.
68. Wang, X. and P.S.J.J.o.i.t.i.c. Dunston, *Design, strategies, and issues towards an augmented reality-based construction training platform.* 2007. **12**(25): p. 363-380.
69. Rabbi, I. and S.J.A.g.z.č.z.t.i.g.k. Ullah, *A survey on augmented reality challenges and tracking.* 2013. **24**(1-2): p. 29-46.

70. zhou, f., duh, h. b.-l. & billinghurst, m. (2008) Trends in Augmented Reality Tracking, Interaction and Display: A Review of Ten Years of ISMAR. IEEE International Symposium on Mixed and Augmented Reality 2008, 193-202

71. schmalstieg, d., fuhrmann, a. & hesina, g. (2000) Bridging Multiple User Interface Dimensions with Augmented Reality. In International Symposium of Augmented Reality 2000 (ISAR ‘00).

72. lepetit, v. & berger, m.-o. (2000) Handling Occlusion in Augmented Reality Systems: A Semi-Automatic Method. of the IEEE and ACM International Symposium on Augmented Reality [ISAR 2000].

73. https://usa.kaspersky.com/resource-center/threats/security-and-privacy-risks-of-ar-and-vr.