Augmented Reality and Application Areas

Yusuf UZUN
Necmettin Erbakan University

M. Hanefi CALP
Karadeniz Technical University

Resul BUTUNER
Beypazari Fatih Vocational and Technical Anatolia

Augmented Reality

Augmented Reality (AR) technology dates back to the 1960s, but its adoption has been limited to existing technologies. The idea of how to represent two-dimensional objects in three dimensions in the real world has been tested on a limited number of computers (Sutherland et al., 1968).

AR technologies draw attention in the field of rapidly developing information technologies. In recent years, AR; It has made a name for itself in fields such as education, medicine, digital advertising, technical service, robotic technologies, entertainment and navigation. AR is a technology in which simultaneous interaction between real and virtual objects was provided by placing computer-generated models and data on the real world (Azuma, 1997). Azuma identifies three basic components of AR systems.

These are respectively;

1. merging virtual images with real world
2. three-dimensional recording of digital data
3. is the interaction in real time.

Azuma also states that AR is an advanced derivative of Virtual Reality (VR). VR applications have similar basic components to AR. These key components are virtual objects, real-time response, and visual equipment, respectively. In addition, there are some differences from each other. While VR technologies offer the user a virtual environment completely independent of the real world, AR technologies allow the user to see virtual objects in the real world. The most important factor that distinguishes AR from VR is to provide interaction between the real world and the virtual world by allowing 3D images produced on computers to be displayed on a real world environment (Sin et al., 2010). The virtual, augmented and hybrid reality process was shown in Figure 1.

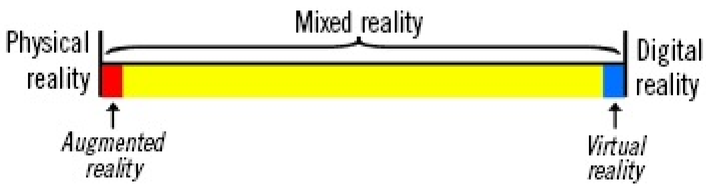

Figure 1. Virtual, Augmented and Mixed Reality Process

Many of the basic concepts of AR have been used in the movie industry. It has been used extensively, especially in science fiction movies such as Terminator and RoboCop. These movies feature cyborg characters rendered on the real world with 3D graphical overlays.

The term AR was coined by Tom Caudell in 1990 for the development of directional diagrams and marking plates used on the ground for guidance purposes at the Boeing aircraft factory (Caudel et al., 1992). Many researchers talk about the use of head-mounted displays (HDM) for AR technology (Janin et al., 1993). While this statement provides the accepted basic components for AR, it also aims to enable some advanced technologies such as mobile technology (Azuma et al., 2001). 2D images can be rendered in interactive proportions on top of a live image from the camera, but 3D images cannot be combined in the real world.

Today, the rapid spread of mobile devices and wireless network technologies brings with it a number of opportunities for the use of technologies such as AR and VR. These innovative technologies, which have been developed, bring two-dimensional or three-dimensional content produced on computers to the realms of reality, sensory immersion and interaction. Thanks to the unique interaction features of AR and VR technologies, a number of special skills and applications that cannot be realized with traditional methods can be developed.

Technologies for AR

AR systems basically contain three elements. These are respectively; monitoring and recording, imaging technology and real-time processing. AR is a real-time interactive three-dimensional recording technology. Virtual data (audio dec video, 3D animation, images, etc.) is added to this information by collecting real-world information experienced in AR technologies and using it as a tool.b.) occurs when it is integrated (Butuner & Toraman,2018)

Correct viewing and recording is essential to obtaining a quality enhanced image. While presenting a realistic image to the user, the camera must be mapped to real-world space and virtual data, taking into account perspectives. Especially for a camera system in motion, the user's position in the real environment where the virtual object is located must be determined continuously. The aim here is to display the object created on the computer in a real environment (Bimber et al., 2005). In the future, both imaging technology and real-time imaging seem to be the fundamental building block and challenge for AR. The first of these are limitations such as the optical system of limited value (ie field of view), technical capability (resolution etc.) and user factor (eg human height and weight). The other, real-time image processing, depends on the AR devices' ability to quickly, reliably and realistically position a virtual object layer on top of the real-world environment. The aim here is to integrate the virtual object created on the computer in a way that users cannot distinguish between the real environment and the virtual object.

Hardware Technologies

We can list the hardware components that are frequently used for AR as processor, screen, sensors and input devices. Mobile devices such as smartphones and tablets can run AR applications due to the MEMS sensors they have such as camera, GPS, accelerometer and solid state compass.

Display devices

A number of technological devices such as monitors, optical projection systems, manually controllable devices and body-worn imaging systems were used to develop AR applications (Pair et al., 2002).

- Head-Mounted: A head-mounted display (HMD) is an AR display device paired with a headset. HMDs transfer images of both the real world and virtual objects into the user's field of view. The most popular HMDs today use six degrees of freedom sensors that allow virtual objects to be positioned in accordance with the real world and adjusted by taking into account the user's head movements.

- Glasses: AR applications can also be shown in glasses-like devices. AR glasses contain technology that uses cameras in which the AR image was projected from the surfaces of the lens parts of the glasses to display the virtual object image over the real world image.

- HUD (Head-Up Display): These AR devices can be defined as portable head-up displays that enable users to see data, information and a number of virtual images while watching real-world images. As an example, we can give the HoloLens manufactured by Microsoft.

- Contact Lenses: Bionic contact lenses under development are an embedded imaging system consisting of LEDs, electronic integrated circuit and a Wi-Fi antenna to provide wireless communication.

- Virtual Retina Display: Developed at the University of Washington's Human Interface Technology Laboratory. In this technology, the image was transferred directly to the retina of the eye of the user.

- EyeTap: Also known as 2nd generation glasses, it captures rays passing through the center point of the wearer's eyepiece and replaces computer-controlled light for each beam.

- Portable Displays: Handheld AR displays used MEMS sensors such as GPS, digital compass and six degrees of freedom accelerometer-gyroscope.

- Spatial Augmented Reality: This technology uses digital projectors to display graphical information over the real world. The difference of this device from others is that the screen is separate from the user.

Some of the headsets produced for virtual, augmented and hybrid reality were shown in Figure 2.

Figure 2. Headsets for Virtual, Augmented and Hybrid Reality.

Tracing

Modern mobile AR systems consist of digital cameras, accelerometers, GPS, optical sensors, solid-state compasses, gyroscopes, RFID and wireless sensors. These mobile AR technologies offer varying levels of accuracy and precision. The most important of these is the location and direction information of the user's head.

Input Devices

There are also wearable AR technologies, which include voice recognition systems that convert the user's voice into computer instructions, systems that can detect body movements or interpret from sensors placed on devices such as pointers, stylus, and gloves. Two types of AR platforms, beacon-based and unsigned, were used for input devices to detect AR applications. Example applications of marker-based and markerless

AR were shown in Figure 3.

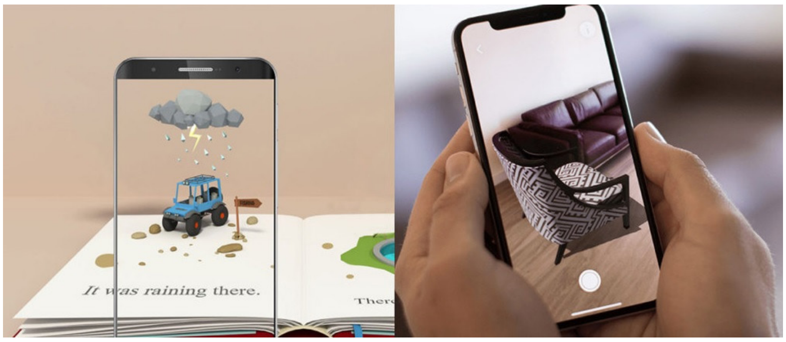

Figure 3. Marker-Mased and Markerless AR.

Computer

The computer analyzes the perceived visual and other data to synthesize and position virtual objects.

Software Technologies

In AR systems, the software should be capable of deriving real world coordinates from camera images using computer vision methods and recording the image. Many computer vision methods used in AR were derived from visual odometry. These methods consist of two stages. First, reference marks or optical flow are detected from the camera images. In the first step, some feature detection methods such as edge detection, blob detection, corner detection, or thresholding and other image processing methods can be used. The second stage restores the real world coordinate system from the data obtained as a result of the first stage (Segura et al., 2005).

Some methods used in AR accept objects with known reference pointers in the scene. Here, the 3D structure of the scene must be calculated prior to processing. If there are unknown parts of the scene, the simultaneous localization and mapping (SLAM) method can map on relative positions. If no information about the geometry of the scene is available, the structure can be determined from motion algorithms such as beam tuning. The mathematical methods used at this stage include geometric algebra, exponential map and rotation representation, projective (epipolar) geometry, nonlinear optimization, robust statistics, Kalman and particle filters.

A number of software development kits (SDKs) have been produced in order to enable easy and fast development of AR applications. Vuforia, CloudRidAR, Catchoom CraftAR ARToolKit, AR, Layar, Blippar, Wikitude, and Mobinett offer some of the AR SDKs available in the market.

Application Areas of AR

AR has many applications such as education, military, arts, industrial, medical, commercial and entertainment.

Archaeology

AR was used to assist research in the archaeological field by incorporating a number of archaeological features into modern landscape techniques. It is especially useful for archaeologists to draw some conclusions about the layout and configuration of research areas. Another important benefit is that it helps archaeologists to rebuild ruins, historical buildings and historical sites in accordance with the original. An example of the use of AR in archeology was shown in Figure 4.

Figure 4. AR in Archeology (AR in archeology, 2021).

Architectural

With the AR method, 3D images of a building can be placed on the physical real area where the building will be built. With AR, an architect's 2D drawings can be transferred to an animated 3D visual view. Users can virtually see the exterior and interior of a building, as well as make virtual object layouts. An example of using AR in architectural projects was shown in Figure 5.

Figure 5. AR in Archeology (AR in architecture, 2021).

Build

Today, with AR construction applications, underground construction components such as sewage and water and electrical wiring installations on a construction site can be easily visualized with the help of GPS technology. As an example of such applications, we can give the AR supported Daqri Smart Helmet helmet such as visual instructions, warnings and 3D mapping for employees. Especially in disasters such as earthquakes, these applications provide great benefits. An example of AR application in the construction industry was shown in Figure 6.

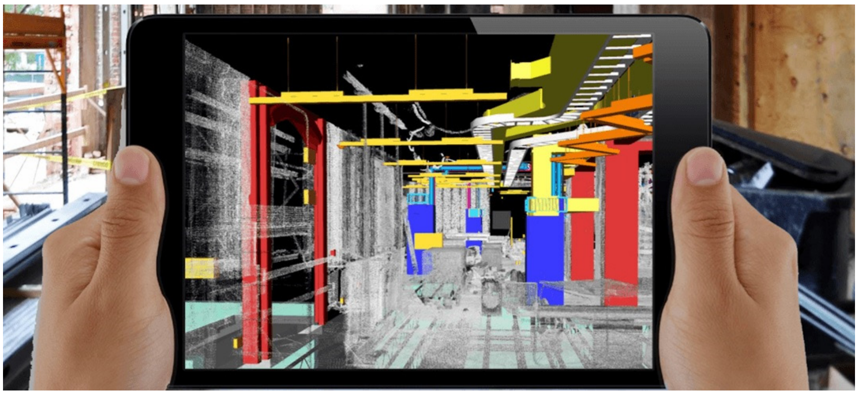

Figure 6. AR in Construction (AR in construction, 2021)

Industrial Design

AR offers industrial designers the opportunity to virtually experience the design and manufacture of any product in the real world, before realizing it. Volkswagen, one of the leading companies in the automotive industry, uses AR technology to compare theoretically calculated values with actual crash test data. With AR applications, experimental calculations can be made by visualizing the structure of a car body, engine system and other materials before production. An example of pre-production use of AR technologies in industrial design applications was shown in Figure 7.

Figure 7. AR in Industrial Design (AR in industry, 2021)

Education

A real-time training application can be developed by using materials such as text, graphics, video and audio in AR applications. Using the AR mobile device, interaction can be made through markers placed on textbooks, flashcards and other materials. With the AR applications developed, students provide an interactive participation in the lessons by discovering and learning. Construct3D application, a Studierstube system used in higher education, enables students to actively learn the basic concepts of mechanical engineering, mathematics or geometry with virtual experiments and applications. AR applications can also help students understand the course topics in courses that require laboratory studies such as chemistry, physics and biology.

It can also enable medical education to visualize the anatomical structure of the human body in 3D. Especially in surgical applications, cadaveric problems are experienced. AR human models were used instead of cadavers. AR technology gives students the opportunity to experience an educational experience without being in a certain physical space. Considering that distance education was used extensively, especially during the pandemic process, we cannot ignore the positive contributions of AR systems to education. An example of the use of AR application in the education sector was shown in Figure 8.

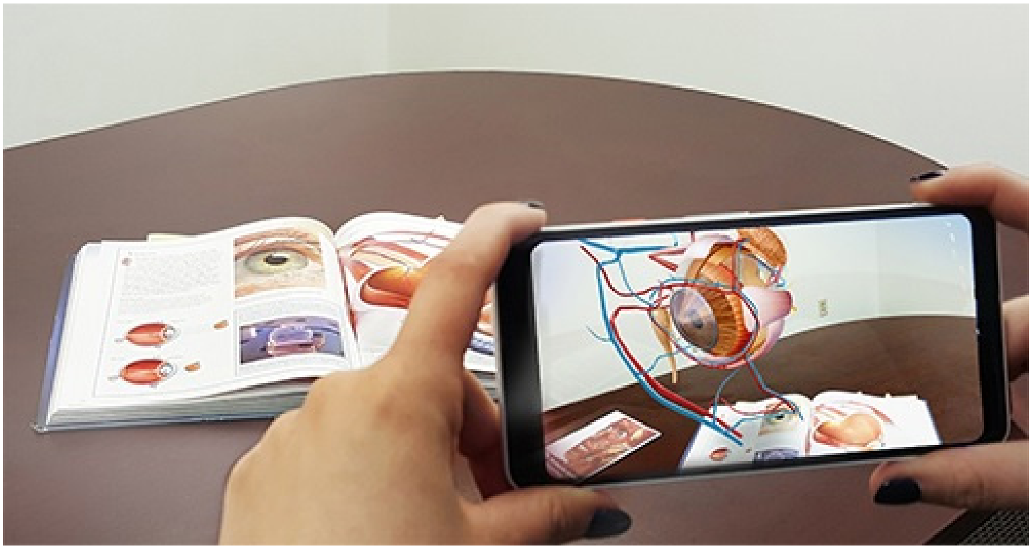

Figure 8. AR in education applications (AR in education, 2021)

Art

AR technology has also started to make a name for itself in the field of art. Many applications have been developed in order to increase the interest of the disadvantaged groups in art. By adapting eye tracking systems to physically disabled people, the experience of drawing pictures was provided. An example of the use of AR application in the field of art was shown in Figure 9.

Figure 9. AR in Art Practices (AR in art, 2021)

Card Apps

One of the interesting and innovative application areas of AR technology is the development of interactive applications such as digital content, 3D animation, video and sound on cards such as business cards, greetings, weddings and invitations. An example of the use of the commercial card AR application was shown in Figure 10.

Figure 10. AR in Commercial Card Applications (AR in cards, 2021)

Tourism and Travel

AR applications try to engage customers by providing real-time informative data and images about the location and features of the venue on a tourism and travel website. It allows users to experience historical events, places and objects in 3D simulations of the real world by using AR applications about places in sightseeing trips. An example of the use of AR application in the tourism and travel sector was shown in Figure 11.

Figure 11. AR in Tourism and Travel Applications (AR in tourism, 2021)

Translation

AR systems can translate foreign language texts on signboards and menus into the user's language and display the text again in an augmented view. A foreign person's spoken language can be translated and displayed with subtitles on the user's AR display device. AR translation applications provide great convenience, especially in travels to different countries. An example of using the translation application in AR was shown in Figure 12.

Figure 12. AR translation application (AR in translation, 2021)

Business

Today, AR also makes a name for itself in the field of trade. Mobile AR applications, which enable customers to get detailed information about the contents of product packages on the shelves in shopping malls, make the daily lives of the visually impaired significantly easier. In the e-commerce sector, customers were provided with the opportunity to try products interactively. Especially jewelry and watch companies offer such opportunities to their customers. The customers were provided with the opportunity to experience AR with a mobile camera through the sign-based cardboard watches and jewelry apparatuses they send. The AR clock application developed by Tissot was shown in Figure 13.

Figure 13. LV clock application of Tissot (Tissot, 2021)

Military

By using AR glasses, AR applications in which war scenarios are processed on the real world environment can be developed to enable soldiers to experience how they can act in the face of potential dangers interactively. Rockwell International has developed an AR application for video map layers of satellite and orbital debris traces to aid in space observations of an Air Force Maui Optical System. This application allowed telescope users to identify satellites in outer space, as well as identify and catalog threatening space debris. AR applications have been developed to increase the flight skills of pilots in aircraft simulations in the aviation system. An example of the use of AR application in the military field was shown in Figure 14.

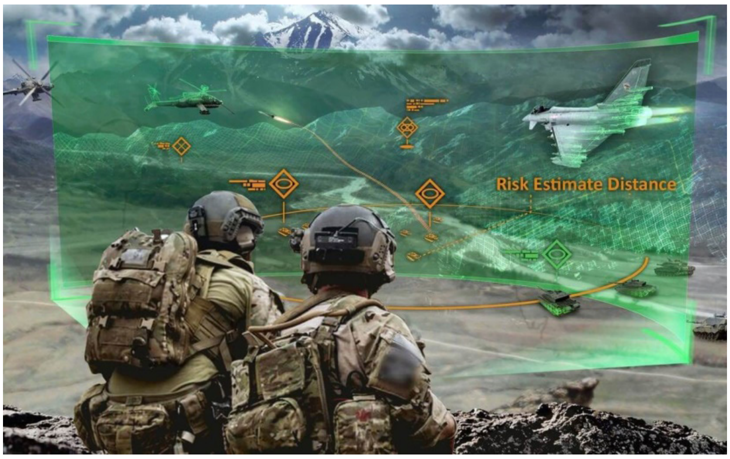

Figure 14. AR Application in the Military Field (AR in the military, 2021)

Medical

In medicine, a vein imaging device is used that films the subcutaneous veins, processes the image of the veins and reflects them on the skin to detect the location of the veins in the human body. AR applications can provide the surgeon with some useful information such as the patient's heart rate, blood pressure, and the instantaneous state of the organ in surgical procedures.

Examples of AR applications include an AR system in which real data was virtualized on real-time images taken from tomography or ultrasound devices. AR systems have been used extensively in many disciplines such as anatomy, neurosurgery, general surgery and biochemistry in the medical field. An example of the use of AR application in medicine was shown in Figure 15.

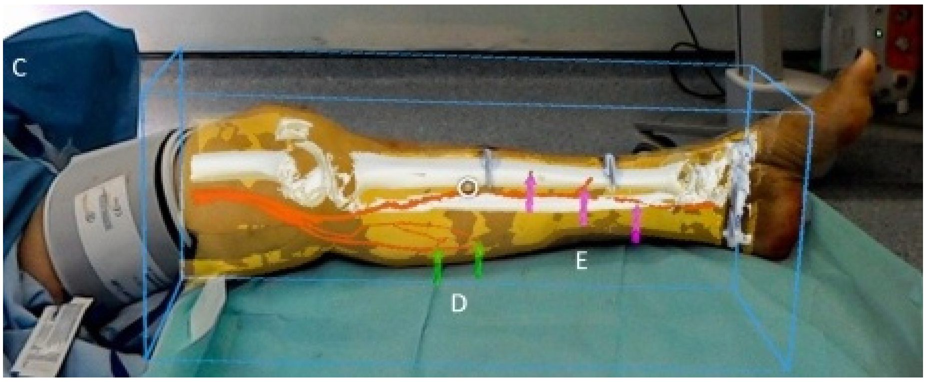

Figure 15. AR Medicine Application (AR in medicine, 2021)

Technical Maintenance and Support

It is a great advantage for technical personnel to display AR images of assembly and operating instructions on the parts of a system using pointer labels or unmarked methods during the repair, maintenance and repair processes. In addition to Boeing, many automotive industries such as BMW and Volkswagen have incorporated AR technology into their assembly lines to improve the production and assembly processes in factories. With the use of AR, employees can immediately intervene in problems and problems on the machines. An example of AR use in technical maintenance services was shown in Figure 16.

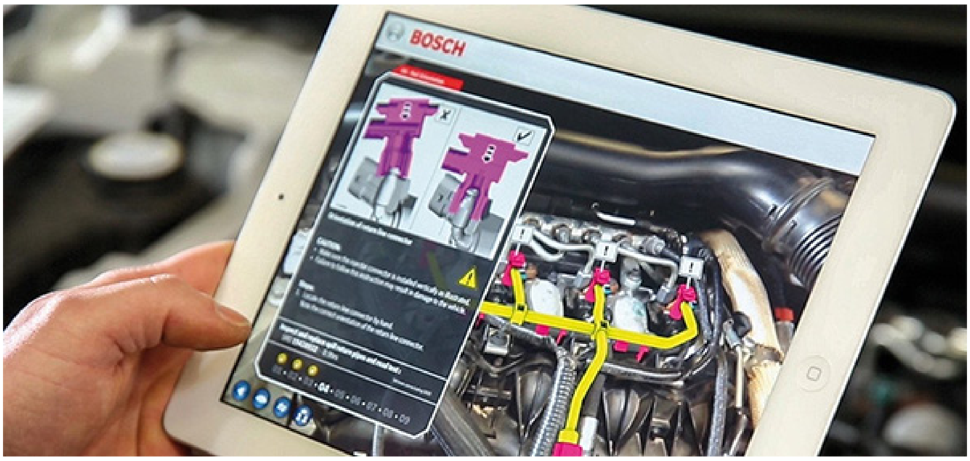

Figure 16. AR Application in Technical Maintenance Services (AR in technical, 2021)

Television

Almost many television channels have started to use AR applications in their programs such as weather, news programs and sports events. AR is also used in football and other sports competitions to display a number of sports details such as commercial advertisements placed on the view of the sports field, information about the team, technical information about the game. AR technology allows TV viewers to interact visually with the programs they watch, such as TV series, movies and documentaries. Day by day, we started to see AR applications more frequently in TV programs. One of them was shown in Figure 17.

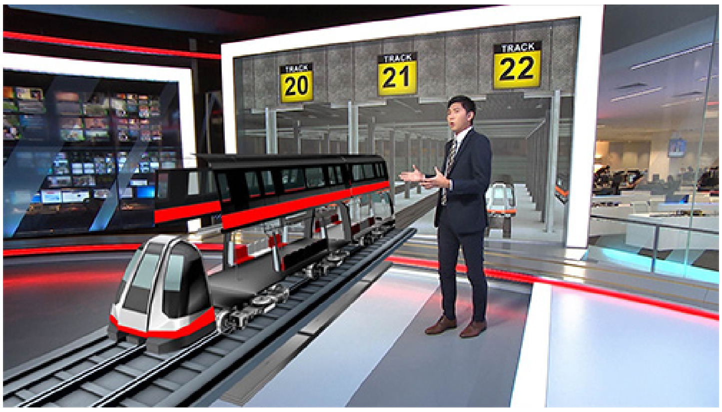

Figure 17. AR Application in Television Programs (TV AR, 2021)

Navigation Systems

AR applications help increase the efficiency and effectiveness of navigation devices used in automobiles. Target direction and distance, terrain and road conditions, weather and traffic flow information projected on the windshield of the cars provide drivers with a safer and more comfortable travel opportunity. It also contains some useful information that warns drivers of potential hazards on their roads. AR navigation systems were used in the maritime and aviation industries as well as in the automotive industry. An example of AR application used in automotive navigation was shown in Figure 18.

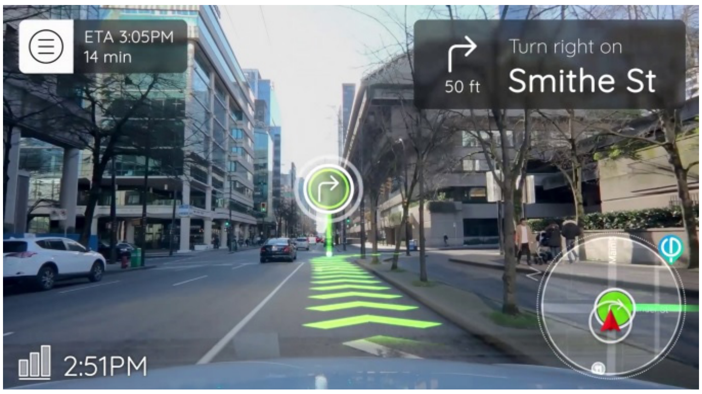

Figure 18. AR Application in Navigations (Nav AR, 2021)

Game

AR-based computer and mobile games developed today allow players to experience playing games using digital objects in the real world. At the same time, the comfort of playing an interactive game by perceiving the movements of the player was provided. In this regard, many game developers have started to adapt new technologies to their games. An AR game application developed on the real world was shown in Figure 19.

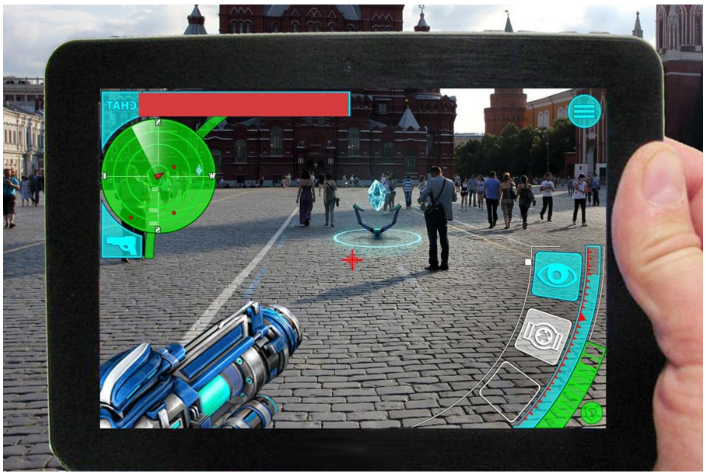

Figure 19. AR Game Application (Game AR, 2021)

References

Azuma, R.T. (1997). A survey of augmented reality. Presence, 6(4), 355-385

Butuner, R., & Toraman, L. (2018). The Use of Augmented Reality (Aurasma) in Education and the Application of a Course Business Card. 2. International Symposium on Social Sciences and Educational Research(s. 68). Konya: Palet.

Sutherland, I. (1968). A head-mounted three-dimensional display. Proceedings of Fall Joint Computer Conference, 757-764.

Sin, A.K. & Zaman, H.B. (2010). Live Solar System (LSS): Evaluation of an Augmented Reality book-based educational tool. In Information Technology (ITSim), IEEE International Symposium,1, 1-6.

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

Janin, A.L., Mizell, D.W. & Caudell, T.P. (1993). Calibration of head-mounted displays for augmented reality applications, Virtual Reality Annual International Symposium, IEEE, pp. 246-255.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. & MacIntyre, B. (2001). Recent advances in augmented reality, Computer Graphics and Applications, IEEE, 21(6), 34-47.

Bimber, O., Raskar,R. & Inami, M. (2005). Spatial augmented reality. AK Peters Wellesley.

Pair, J., Wilson, J., Chastine, J. & Gandy, M. (2002). The Duran Duran Project: The Augmented Reality Toolkit in Live Performance. The First IEEE International Augmented Reality Toolkit Workshop.

Segura, C., George, E., Doherty, F., Lindley , J.H. & Evans, M.W. (2005). SmartCam3D Provides New Levels of Situation Awareness, CrossTalk: The Journal of Defense Software Engineering. 18(9), 10-11.

AR in archeology, https://www.arkeolojikhaber.com/haber-turizmde-vr-cagi-arkeoloji-vr-ile-sunuluyor-6947/. Accessed Date: 19.07.2021.

AR in architecture, https://tr.pinterest.com/pin/529524868681198831/. Accessed Date: 19.07.2021.

AR in construction, https://www.avatardigital.co.uk/how-ar-can-benefit-construction/. Accessed Date: 19.07.2021.

AR in industry, https://www.digitalengineering247.com/article/can-ar-enhance-design/simulate. Accessed Date: 19.07.2021.

AR in education, https://rubygarage.org/blog/augmented-reality-in-education-and-training. Accessed Date: 19.07.2021.

AR in art, https://www.unitear.com/blog/augmented-reality-for-art. Accessed Date: 19.07.2021.

AR in cards, https://www.intermedasia.com/projects/prominate-magic-card-160-with-augmented-reality/. Accessed Date: 19.07.2021.

AR in tourism, https://jasoren.com/augmented-reality-in-travel/. Accessed Date: 19.07.2021.

AR in translation, https://www.meetcortex.com/blog/6-reasons-we-should-be-talking-about-ar. Accessed Date: 19.07.2021.

Tissot, https://www.geeky-gadgets.com/tissot-lets-you-try-their-watches-using-augmented-reality-18-05-2010/. Accessed Date: 19.07.2021.

AR in the military, https://medium.com/@info_35021/augmented-reality-in-military-ar-can-enhance-warfare-and-training-408d719c2baa. Accessed Date: 19.07.2021.

AR in medicine, https://techradar.softwareag.com/technology/augmented-reality-ar/. Accessed Date: 19.07.2021.

AR in technical, https://augmented.reality.news/news/bosch-wants-speed-up-ar-adoption-auto-industry-0176485/. Accessed Date: 19.07.2021.

TV AR, https://www.vizrt.com/broadcasting/virtual-set-and-ar. Accessed Date: 19.07.2021.

Nav AR, https://tr.pinterest.com/pin/265923552983802178/. Accessed Date: 19.07.2021.

Game AR, https://app.emaze.com/@AOLLLOIZW#1. Accessed Date: 19.07.2021.

About the Authors

Yusuf UZUN, PhD, is an Assistant Professor of Computer Engineering at Necmettin Erbakan University in Konya, Turkey. He holds a PhD in Mechanical Engineering from Necmettin Erbakan University. His main areas of interest are artificial intelligence, autonomous systems and augmented reality applications. He also works as the Rector's Advisor at Selcuk University.

E-mail: yuzun@erbakan.edu.tr, ORCID: 0000-0002-7061-8784.

M. Hanefi CALP received Ph.D. degree in 2018 from the department of Management Information Systems at Gazi University, one of the most prestigious universities in Turkey. He works as Associate Professor in the department of Management Information Systems of the Faculty of Economics & Administrative Sciences of the Karadeniz Technical University. His research interest includes Management Information Systems, Artifical Neural Networks, Expert Systems, Fuzzy Logic, Risk Management, Risk Analysis, Human-Computer Interaction, Technology Management and Project Management.

E-mail: mhcalp@ktu.edu.tr, ORCID: 0000-0001-7991-438X.

Resul BUTUNER is a Computer Teacher at Beypazari Fatih Vocational and Technical Anatolian High School in Konya, Turkey. He has a master's degree in Computer Engineering from Necmettin Erbakan University. His main areas of interest are artificial intelligence, robotic coding, data mining and augmented reality applications. He is an instructor in the field of Robotic coding within TUBITAK. He continues to write a book in the field of robotic coding at the Ministry of National Education. He worked as a coordinator in budgeted projects related to student education.

E-mail: rbutuner@gmail.com, ORCID: 0000-0002-9778-2349.

To Cite This Chapter

Uzun, Y., Calp, M. H., & Butuner, R. (2021). Augmented reality and application areas. In M. Ozaslan & Y. Junejo (Eds.), *Current Studies in Basic Sciences, Engineering and Technology 2021*(pp. 2–18). ISRES Publishing