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Rise of Augmented Reality: Applications, challenges, and future trends

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ABSTRACT

Augmented reality is an interactive experience of today's world environment where the object that resides in the real world is augmented by the computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, soma to-sensory and olfactory. As personal mobile devices are growing which are capable of augmented reality environments, the majority of the potential of AR has come into existence and expands accordingly. Today, the industry of different kinds which are disseminated all over the world are using augmented reality applications. In future, AR will change the perception of people viewing the world and its objects. The AR is currently in beginning phase of research and development at different universities and institutes. Since last years, the apps supporting AR is spreading and are available on various devices. Also, AR has been occupying its place in the audio-visual media and is used in numerous diverse fields of our life in tangible and exciting ways like e-commerce, promotion, design, business, news etc. Other than these features, AR is also used to facilitate learning where it allows students to access specific-location information. This growth and diverse spreading of AR into numerous application pushes organizations to challenge one another and each one of them endeavours their best to gain the support of the customers. This paper provides a detailed study of augmented reality including its past history, architecture, current and future challenges and future trends.

Keywords— *Augmented Reality, Virtual reality, Mobile technology, Image processing, AR based navigation system*

1. INTRODUCTION

Combination of technologies that enable real-time to a mix of computer-generated content with live video is described by the term augmented reality (AR). AR is related to VR techniques where it interacts with the virtual world and has a degree of interconnection with the real world. It is best explained by Hugues11 stating that "augmenting reality is meaningless in itself". However, on refocusing on the humans and their perceptions of the world, the term AR makes sense. Digital content gets effortlessly superimposed and intermixes into our sights and formation of the real world with the help of AR. We cannot increase the reality but we can expand our perception. The different type of human-computer communication accepted with the emergence and diffusion of smartphones and AR browsers. Although AR has acquired enormous research interest and awareness recently, several meanings are attached to the term AR by researchers.

Besides, development is being done by using and involving original technologies (mobile phones, advances computers and emerging technologies). During the last years, the applications of AR are becoming transportable and broadly accessible on mobile phones. In fact, AR has now become audio-visual media like means of entertainment, sports, news etc. In addition, it is becoming a booming technology in the field of e-commerce, tourism and promotions. Thus, it has now turned out be-be a significant part of virtual reality domain. One of the advantages of AR is having better sense and inter-mingles of reality whereas it lays its impact on the organic interaction of the real world and the virtual environment. Augmented reality can be exhibited on a wide variety of displays, from monitors and screens to handheld and worn devices or glasses. Glasses and other HUD i.e. head-up-displays put the augmented reality directly on our face.

Therefore, in this article, we present a brief survey of the state of art in the AR.

Augmented reality is an interactive and innovative experience of a real-world environment where the objects that reside in the real world are augmented by computer-created perceptual information. Such information is generated on basis of multiple sensory modalities, such as visual, auditory, haptic, somato-sensory and olfactor. The overlaid sensory information can be a constructive (i.e. additive to the natural domain) or destructive (i.e. hiding the natural environment) and is combined with physical world such that it is recognized as an immersive aspect of the real environment, whereas virtual reality (VR) completely replace the user's real world with a simulated environment. Augmented reality is associated with two synonymous terms: mixed and computer-mediated reality. In 1997, Azuma defined augmented reality. He recognized that the augmented reality is not only associated with technical hardware components only whereas it brings real and virtual

contents together in a real environment. Many of the basic concepts of AR has been used recently in movies and some of the science fiction movies such as Avatar, Iron Man, Robocop and many more presented and utilized the augmented reality. These movie feature cyborg character whose views of the physical world are augmented by a steady stream of annotation and graphical overlays in their vision systems. The main aim of AR is to make user's life easier by providing the virtual information to his adjacent environment as well as to any indirect view of the real world environment like live video streaming. Another goal of AR is to develop the user's insight into communication with the real world and provide better perception towards the real environment. As named by Milgram virtual reality or virtual environment engages users into a completely artificial world without seeing the real world. Whereas augmented reality boosts the sense of reality by laying virtual items over the real world in the real time frame. Augmented Reality not only attaches items in the real world but also provides digital information about it in the real world.

2. AUGMENTED REALITY AND VIRTUAL REALITY

Augmented Reality is used for the addition of digital elements to a live view often by use of smartphone camera. Snap chat lenses or games like Pokémon Go include augmented reality experiences.

Virtual Reality indirect an overall immersion experience that often shuts out the physical world. VR devices like HTC Vive, Oculus Rift or Google cardboard are often used by users who can be transported into numerous real world and imaginary environments like the middle of the of a squawking penguin colony or the back of a dragon.

Mixed Reality combines elements of both AR and VR, where the real world and digital object interact. Microsoft Holo Lens is one of the most notable early mixed reality apparatus which proves to be the best example of mixed reality.

Fig. 1: Example of AR versus VR

2.1 The architecture of the AR System

The four main tasks carried out by augmented reality are scene capture and scene identification for selecting the accurate information for boosting it. Along with scene processing and visualization of the augmented scene, these tasks are briefly described in details as follows:

2.2 Scene Capture

Generally, the devices which are utilized in scene capture are physical components which recognize the reality which needs to be boosted. There are two types of scene capture devices:

2.3 Video-through devices

Such devices capture the reality in a unique way apart from other devices used for visualizing purpose of augmented reality. (for instance, video camera and smartphones).

2.4 Scene Identification Techniques

Scene identification classifies the scenarios. It is considered as the main actions taken in reality augmentation. There are two basic types of scene identification technique which are discussed as follows:

2.4.1 Marker-based: The marker-based approach uses the markers. Markers are in the form of visual tags contained within the real scene which is perceived by the AR System.

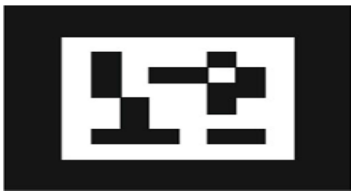

Fig. 2: Example of marker

2.4.2 Non-marker-based: Such AR systems which do not uses markers make use of devices for scene identification such as AR Browser. AR browser uses tags in order to help users forecast and surf digital data in the real-world environment. For instance, we may go around in the city and searching for a highly rated and better restaurant. By using video feature in AR browser we can easily find appropriate restaurant instead of having a look on the map. In addition, as long as we move around, the browser provides information concerning our place, e.g. a particular location we are interested in the clinic, shopping mall.

Fig. 3: Example of Non-marker

2.5 Mobile augmented reality

As nowadays computers are decreases in size and increases in computation power, new mobile, wearable devices and pervasive computing application are rapidly becoming feasible by providing people access to online resources everywhere and anytime. This revolution makes possible a new class of application that exploit the person's surrounding context. Augmented reality already presents a powerful user interface (UI) to the context-aware computing environment. Augmented reality system integrates virtual information into a person's physical so that he or she perceives the information as per existing in their surroundings. Mobile augmented reality system provides this service without constraining the individual without a specially equipped area. Ideally, they work virtually anywhere, adding a palpable layer of information to any environment where ever desired. Augmented reality application holds the potential to revolutionize the way in which information is presented to people.

The Computer presented material gets directly integrated with the real world's freely roaming person, who can interact with it to display related information, to pose and resolve queries and to collaborate with other people. The world simply becomes User Interface (UI). Hence mobile AR relies on AR principles in truly mobile settings i.e. away from the carefully conditioned

environment of research laboratories and special purpose work areas. Quite a few technologies must be combined to make it possible such as computing (LBC), services (LBS) and wearable computing.

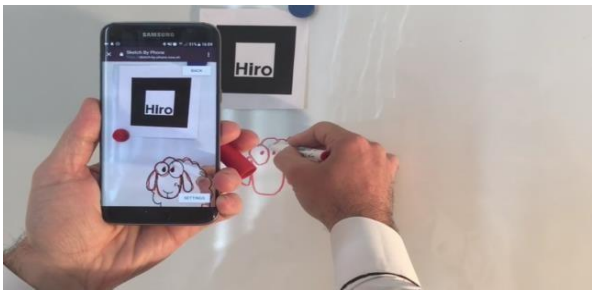

Fig. 4. Example of Mobile AR

2.6 Applications of Augmented Reality

There is a wide number of applications which is utilizing augmented reality whose outcomes are clear in numerous domains like healthcare, education, business and amusement. The next section basically describes the prior researches which exploit the augmented reality applications.

2.6.1 Medical: Augmented reality allows surgeons to monitor patient's data in the style of fighter pilot head up display and provide imaging records of the patients which include functional videos to be accessed and overlaid. Virtual X-Ray view based on prior tomography or on the real-time images from ultrasound and co-focal microscopy probes are the best example which allows visualizing the position of a tumour in the video of an endoscope or radiation exposure risks from X-Ray imaging devices.

Enhancement of viewing a fetus inside a mother's womb can be done using AR. A system for laparoscopic liver surgery has been developed by Siemens, Karl Storz and IRCAD, this system uses AR to view subsurface tumours and vessels. Nowadays, AR is growing its scope for cockroach phobia treatment. The patients who wear AR glasses can be reminded of taking treatment and medication. Thus, virtual reality is seen promising in the field of medical science since the '90s.

AR can also be used to provid4e crucial information to a doctor or surgeons with having them take their eyes off the patient. In 2015, Microsoft announced Microsoft Holo Lens as their first shot at AR. The technology using Holo Lens has advanced through the years and is used to project holograms for near-infrared fluorescence-based image guiding system. The advances in AR are growing its impact in the field of medicine. AR and other computer-based utility is being used today to provide training to medical professionals and students. The creation of Google Glass and Microsoft holo-lens has pushed AR into the field of medical education.

2.6.2 Education: In the field of education, AR has been used to supplement a standard curriculum. Student's real-time environment is superimposed with audio, video, text and graphics. Embedded markers or triggers are now the part of textbooks, flashcards and other educational reading materials. These materials are scanned by AR device and it produces supplementary information to the student rendering in multimedia format. These features make AR a good alternative methodology for presenting information and it leads to multimedia learning technology application.

With the evolution of AR, interactive participation of students arises with more authentic knowledge. Historic events are explained by computer-generated simulations which allow the students to learn and explore the details of each and every significant area of the event site.

A studiers-tube system and Construct3D allows higher education of students with ease by explaining mechanical engineering concepts, math or geometry. Chemistry can be visualized by students with the help of AR which allow students to interact with the spatial structure of a molecule using a marker object held in the hand. Also, the use of HP reveal, a free app to create AR note card to study organic chemistry mechanism is also used to demonstrate the use of laboratory instrumentation. Students of anatomy can get great help by AR which allows them to visualize different systems of the human body in 3D.

Fig. 5. Example of augmented reality training

2.6.3 Marketing: An automotive industry first used augmented reality for advertising. Special flyers were printed by some companies that were automatically recognized by webcams which causes the 3D model of the car being advertised and showed on the screen. This methodology was then spread to numerous markets i.e. from movies and computer games to furniture and shoes. The pervasive QR code is an example of such AR where black and white explanation turns into complex information on analyzing mobile phones or computers. The most complex augmented reality example is virtually trying on shoes. In this case, the customer wears a special pair of socks and sees his/her own image in front of the camera, the screen shows him desired pair of shoes. The colour, model and accessory of the shoe can be changed by him in an instant which allows him to select the shoes with ease.

On a wide and large scale the AR techniques for deforming surfaces like shirts, cups and environment present direct marketing agencies by providing many opportunities by offering coupons to pedestrians, showing virtual prototypes, placing virtual billboards etc. Thus, with all these beneficial uses, AR becomes most preferable to offer a filter to manage the content of the display.

Fig. 6: Marketing AR based application.

2.6.4 Military: The most curious early application of AR occurred by Rockwell International when they created video map overlaying satellite and orbital debris to aid in space observations at Air Force Maui Optical System. In a newspaper of 1993, the author described the use of map overlaying applied to video from space surveillance telescope. The map indicated the trajectories of several objects in geographical coordinates. The telescope operators identify satellites by using it and catalogue any potentially dangerous space debris.

In 2010, Researchers of Korea looked to implement mine-detecting robots into the military. The proposed design for such a robot included a mobile platform which is like a track which was able to cover uneven distances including stairs. The combination of metal detectors and ground penetration radars is included in the robot's mine detection to locate mines or IEDs. This is the eccentric design which is immeasurably helpful in saving the lives of Korean soldiers.

AR can also serve as a network communication system in combat that render useful battlefield data onto soldier's goggles in real time. Soldier's viewpoint for people and various objects can be marked with special indicators to warn of potential dangers. Soldier navigation and battlefield is aided by virtual maps and 360-degree view camera which is transmitted to military leaders at a remote command centre.

2.6.5 Entertainment: Games in the entertainment industry are created using augmented reality which also increases the visibility of important games aspects in life sports broadcasting. AR can also serve as advertisers to show virtual ads and product placement where the large public is reached.

Using AR, Sports environments like swimming pools, football fields, race tracks etc. are well known and easily prepared. This augmentation video is tracked camera feeds easily. Fox Trax system is one of the examples, which is used to highlight the location of a hard-to-see hockey puck as it moves rapidly across the ice.

AR is also applied to annotate racing cars, life swimmer performances, snooker ball trajectories, etc. This is possible using uniformed players on the field and chroma keying techniques, the annotations are shown on the field and not on the players.

Fig. 7: Video Games using AR

2.6.7 Manufacturing: AR is having strong and growing applications in the field of manufacturing. The design and implementation of integrated AR manufacturing systems is a challenge in this field that could enhance the manufacturing process, as well as product and process development, leading to short lead time and reducing cost by improving quality.

The ultimate goal of researchers is to create a system that is equal to the real world and much more producing better and efficient quality. A person's perception of the surrounding world and understanding of the product assembly tasks can be enhanced by using AR. Graphical assembly instructions and animation sequences can be pre-coded at the design stage for typical procedures by using an AR approach. These various sequences are transmitted on request and virtually over-laid on the real products at assembly lines whenever they are needed. These instructions and animations are conditional and can be automatically adjusted to actual information conditions at the assembly lines. There is a phenomenon of periodic updating and recasting of these instructions and animated sequences with updated knowledge from the manufacturers. Thus, the information overloading can be reduced by using such an approach and training required for assembly operators. It leads to a reduction of the product assembly line by reducing product lead time.

The three instructional media in an assembly system are a printed manual, computer-assisted instruction (CAI) using monitor based display and CAI using a head mounted display. These three instructional media are compared by the authors and they found that use of overlaying instructions on actual components reduces the error rate for an assembly task by 82%.AR benefits are explored by many manufacturers in an industrial environment. As a relatively new technology, we have begun to start the surface of what augmented reality can do for manufacturing.

2.6.8 Robotics: Augmented Reality is a significant platform for human-machine collaboration. Tele Robotics were designed on the basis of AR which gave roots to medical robotics and image-guided surgery. AR technique serves as an intermediary for robots which can communicate any complex information to the humans. AR technique is combined with a surgical robot system for head surgery. The author proposed and described the AR approach to visualize robot input, output and state information.

Researchers of "University of Berkley" developed a platform that trains the artificial intelligence behind the physical robot, like a robot arm. Their training works include exposing up to a thousand objects to AI in a virtual world so that it understands everything about them and how to operate them.

In 2016, a demo was presented by an engineering team of Silicon Valley showing a robot arm controlled through virtual reality. The team allowed a person with a VR headset to hold a virtual handle in the virtual world which would then control the real world robot arm.

Fig. 8. Robotics using AR

2.6.9 Tourism: AR has its vat application in the field of tourism allowing travellers to access real-time information which includes location, its features and comments or content which is provided by previous visitors. It also includes advance AR such that simulation of historical events, places, and objects rendered into the landscape. Geographical locations are also linked to AR which provides location information by audio and announcing features of interest at a particular site visible to the user.

AR grows its application areas for companies that use AR to attract tourists to particular areas that may not be familiar with its name. These sites can be experienced by tourists like beautiful landscapes with the use of AR devices. Some companies like Phocuswright use such technology to expose the lesser known areas of the planet and thus increase tourism.

Other companies like Matoke tours use the application of AR which allows people to view 360 degrees from different locations in Uganda. Thus, these companies have the skills and ability to show their apps on virtual reality headset like oculus rift or Samsung VR.

2.6.10 Navigation and Path Planning: The navigation system was enhanced when NASA X-38 was flown using a Hybrid Synthetic System that overlaid map data on video to provide navigation for the spacecraft during the test of flights from 1998 to 2002. They used the Land-Form software which was useful for limited visibility, including an instance when video camera window frosted over leaving astronauts to rely on maps. At Army Yuma proving ground in 1999, this software was tested. It uses the map markers which indicated runways, air traffic control tower, taxiways and hangars overlaid on the video.

The effectiveness of the navigation devices is augmented by the use of AR. An automobile windshield is used to display information which indicates directions to the destination, meter, terrain, weather, traffic information, road conditions and potential hazards in their paths. Way- Ray, Swiss-based Company is developing a holographic AR navigation system since 2012 that use holographic optical elements for projecting all route-related information like directions, important notifications and point of interest of driver line of sight of the vehicle. AR can allow a bridge between watch and standers in abroad maritime vessels to monitor important information continuously like speed while moving or ship's heading, performance etc.

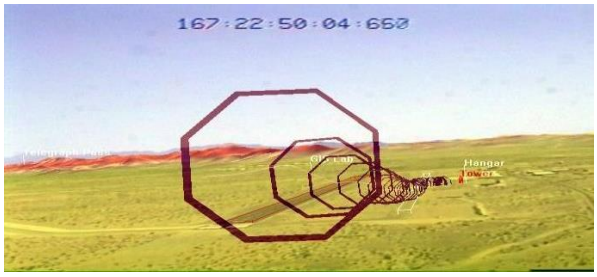

Fig. 9: AR for navigation

2.6.11 Urban Planning and Civil Engineering

AR has grown its area for decision support in architecture and interior design. It was developed to explore the relationships between perceived architectural space and structural system. AR system improved the methods for construction, renovation and inspection of architectural structures. This approach uses AR to visualize the designs in an outdoor environment. The blueprint system was developed to use AR for architectural application in providing the facility of management and maintenance. The urban planning was described by calibration-free AR based affine. AR was used for tangible interface and projection-based AR tabletop interface in research of urban simulation and planning table. This was a system based on AR with luminous and tangible interface demonstrated for city planning.

Fig. 10: AR for Urban Planning

To capture and create 3D geometry of large outdoor construction, AR user interaction was developed. Architecture, Building performance visualization, retrieving information of building equipment and construction managing started using AR tool. One such system based AR was designed to support planning decisions and design for an architect. These can be used basically for urban design.

2.6.12 Image Recognition Using AR: Image recognition is used to identify objects, places, people, writing and action in images by using the appropriate software. The modern computer uses machine vision technologies along with a camera and artificial intelligence software to achieve image recognition. Deep machine learning, Image recognition algorithm is required for image recognition software. Currently, image recognition is used in the wide area of applications like smart photo libraries, better advertising, interactive media, and accessibility for visually impaired and enhanced research capabilities. Image recognition. Image recognition algorithms work by using 3D models, an appearance from different angles like edge detection or by component.

Today well-known brands like Apple, Microsoft, Facebook, and Twitter are investing significant resources and research into image recognition and related application. Image processing works on the concept of image processing which covers factors like environment understanding and light estimation. AR uses the camera for image processing which provides average intensity and colour correction.

Fig. 11: Image Recognition Using AR

3. CHALLENGES AND SOLUTIONS OF AR

In this section, we described challenges and hurdles in augmented reality. They are classified as follows:

3.1 Limited hardware capabilities

Electric Interference mostly occurred in urban areas which causes visual sensor accelerometer failure which ultimately causes hurdle in perfecting the visual. 3 D images are difficult to be rendered by cell phone camera as they are made for 2D capture. For AR markers, we need more accuracy as currently, GPS is able to read up to 6 meters only.

We can improve accelerometer reading by using exponential smoothing techniques. We can also improve camera performance by using 2D, QR and barcode markers and use big landmarks(like building Eiffel tower) to overcome GPS issues till better solutions come out.

Hardware optimization is always a big problem for us. It is not convenient for wearing a heavy wearable device on the head all the time. As time passes developers are trying to decrease the size of devices to fit everything in the size of normal spectacles. As far as concerned there are still many limitations which are yet to overcome. Currently, Microsoft compact AR prototype seems to address all these concern in near future.

3.2 Software issues

Software interoperability has a lot of issues which needs to be addressed in the coming future.AR browser connectivity with social media is still not supported as current application architecture is unable to provide the required support. There are many privacy issues which are being addressed by augmented reality vendors. The application needs to overcome such issues.

Currently, the development of scalable application has emerged as the augmented reality technology is infancy. Apple created ARK Toolkit and Google's AR core seems to be a game changer for current development and seems promising for future expansion of augmented reality. Developers are facing challenges in adapting above toolkits launched on devices recently. New devices are coming every day along with their personalized toolkit. Many developers are confused as development platforms are changing rapidly with a new launch of toolkits along with devices.

We have not created a functional multiuser experience in the single user interface as provided by current AR development tools.

This is the biggest limitation for development and we are failing to run AR on off the shelf devices which are bigger than mobile and tablets. Recently developed Invisible Train game (initiated by Graz University of technology) is worth mentioning in this case. Thought developers faced certain issues they were able to create an attractive game for 4 players.

3.3 Unsatisfying experience

The Augmented reality is very broader and its demand in future is extreme that we end up expecting too much. As user expectation for visuals and graphics for AR games is always high and it makes us feel not good enough although AR gaming evolved a lot problem for the developer. AR keeps users constantly in touch with real-world objects. Hence it fails to bring immersive experience. AR always keeps the users in engaged. A groundbreaking product like Microsoft Holo-lens has the potential to augment the real world and cut off any disturbing visual that impact user experience.

3.4 Uncomfortable architecture

The Idea behind mixing virtual and real world seems kind of messy. There is a possibility of a virtual mess as glasses control our everyday surrounding and it causes inconvenient.

As a lot of cars and other instruments causes health issue and environment degradation similarly it would cause a similar effect if used on large scale. With augmented reality, we would be able to address our everyday work but along with we need to face its ill effects. It will cause digital fatigue. Thus a lot of use of augmented reality causes problems and affect our environment.

3.5 Public acceptance

Like any other emerging technology augmented reality is bound to take time to be widely accepted by the people. This company needs to invest today for the evolution of AR in future. There is a lot of limitation associated with AR development and developers. One of them is awareness a lot of people are still not aware of the AR technology and it causes low people interest towards AR development. Many still consider Failure of Google glasses is the ultimate failure of AR technology, but it is a small setback which Google itself recovered. In the coming future, we will see a wider adaption of technology and you should definitely invest today if you want to make it a larger and growing technology in future. A user needs to have Google glasses, Microsoft Hololens which may not be liked by many people in terms of looks and inconvenient to carry. As AR is now in growing phase a lot of people may not adopt it but future makes it most awarded technology.AR have few privacy issues as its integration with social media would impact and discloses a person's personal details without his permission.

4. CONCLUSION AND FUTURE PROPENSITY OF AUGMENTED REALITY

Augmented Reality in its initial phase is consequently growing its areas and applications. The research in the field of AR suggests an era where there is direct interaction between individual and information is accessed without the need of any halfway devices utilization.

AR has a vast future and apart of having lots of challenges the technology is still growing and is used in a wide range of areas like military, education, healthcare etc. Recently image recognition with AR is a new future trend. Augmented reality application area increased with the support of modern operating systems like IOS and Android. AR is now able to solve day to day problem. It can be used for data visualization as well which make it an important asset for a company. AR-based application development is growing like never before. AR is used for sentiment analysis as well. It changes our perception of looking at objects which we come across day to day life.

Detection of occlusion is an active area of study of the AR system. The analysis of various tracking system and research direction are done using study of AR. Due to this study, the researchers capitalize effectively on the knowledge in various fields like video frames or integrate vision-based methods with any sensor.

A recognition system is incorporated to acquire a representation of the real world. There are many people with disability of hearing; these people can be guided by providing visual signals which help them to catch the missed aural signals. The people with disability of vision can be given aural signals to guide them to visual events. In addition, AR applications can also be used in social challenges like privacy concerns, ethical concerns or acceptance issues arising.

Fig. 12: Worldwide growth of AR

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