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Augmented Reality for Smarter Bangladesh

Muhtasim Riffat, Abrar Yasir, Intisar Tahmid Naheen, Shuva Paul and Md Tanvir Ahad

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Muhtasim Riffat[1], Abrar Yasir[2], Intisar Tahmid Naheen[3], Shuva Paul[4], Md Tanvir Ahad[5]
[1,2,3]Dept. of Electrical & Electronic Engineering, North South University, Dhaka, Bangladesh
[4]School of Electrical & Computer Engineering, Washington State University, Washington, USA
[5]School of Electrical & Computer Engineering, University of Oklahoma, Oklahoma, USA
Corresponding Author: [1]muhtasim.riffat@northsouth.edu

***Abstract*—Augmented Reality (AR) is an emerging form of experience where the real world is enhanced by computer-generated content. It is often considered as a type of futuristic technology, but a part of it has been reality for years. It is a step between reality and virtual reality. Over the past several years AR technology has become more accessible and is starting to branch out into many different fields. AR can already be found in news, entertainment, sports, e-commerce, scientific research, education, marketing, and travel etc. But in Bangladesh there are virtually no applications of AR. In order to find out the potential of AR technology in Bangladesh this paper gives an overview of the technology, examines recent development of the technology abroad, and explores its sustainability and implications in Bangladesh from the education, medical and traffic management perspectives.**

***Index Terms*—Augmented Reality, AR, Technologies, Education, Medical, Traffic, Safety, Information, Projection, Superimposition**

I. Introduction

Augmented Reality is an experience where the real world is enhanced by computer-generated content that can be tied to a specific activity or situation and/or location. Simply put, AR allows content that is digital to be overlaid and mixed with our perception of reality which we can see in the real world. From objects that can be shown in 2D and 3D, different types of information, audio and video, and tactile or olfactory information can be incorporated into the users' view of the real world. This lets users perceive the real world with augmented and/or added information as one seamless environment. These augmentations serve as a way of enhancing the individuals' understanding and knowledge of everything that is around them.

AR can be a significant part of future industrial control systems (ICS) like smart grids or cyber-physical power systems in different areas of application including power grid security, reliability, resilience, etc. [1], [2]. AR might have been seen as a future technology that was only largely shown to be works of science fiction but in recent years with the wave of technological advancement AR has come a long way and has been slowly incorporated into many aspects. In some cases it is on the verge of becoming a part and parcel of our everyday life. The technology for AR has been present for some time now but the main roadblock for it was making it consumer friendly. AR was being used for applications that did not concern the everyday consumer but now the acceleration in technological advancement has enabled it to become accessible to everyone. The growing popularity of mobile platforms running Android and iOS has opened the door to allow AR to be accessible to everyone. Flash based AR detection algorithms have allowed the technology to be accessible to the masses in conjugation with mobile platforms. AR can be seen being used in news presentation, sports coverage, entertainment aspects, marketing campaigns, travelling, and in e-commerce. AR has potentials to be included in critical infrastructure security and many machine learning applications. More exciting ideas are already in development which will have AR technology in almost all aspects where any form of digital technology is present.

AR has many interesting and useful applications that are already in use or in development. But in Bangladesh these are almost non-existent. In its preliminary stages AR can be tested for many different practices in our countries context. The most promising of these are in the education, medical and traffic management sectors. Since AR has shown the potential it has in improving many aspects of everyday situations by making the completion of tasks much more efficient and easy, from the context of Bangladesh it can have immense growth in these sectors if they can be implemented properly. For Bangladesh the focus needs to be on seeking to identify emerging technology and understanding the impact it can have on various sectors, and see the potential change it can provide to help accelerate the technological progress. Augmented Reality can help to achieve these goals with its introduction and proper incorporation in Bangladesh.

II. Background

A. Augmented Reality

The technology known as Augmented Reality (AR) refers to the digital technologies that augment or change a users' perception by bringing in or projecting materials that are computer generated into the real world. This definition was too simplistic and with the evolution of AR technology it was defined by three characteristics by RT Azuma [3], H Kaufmann [4], and F Zhou, HBL Duh and M Billinghurst [5]. These were: (a) combining elements of the virtual and real-world, (b) real-time interaction, and (c) 3D registered. F Zhou, HBL Duh and M Billinghurst [5] on the other hand defined AR to be anything "which allows computer generated virtual imagery to exactly overlay physical objects in real time" [6]. AR has been pursued due to (a) enabling the enhancement to an users' interaction and perception of real world objects [7] and (b) potential for improvement to productivity of tasks. The present implementations of AR is the result of four decades of development

and research on the technology [8]. At the beginning of the 90's the number of research and developments towards this technology increased dramatically. Google, Layar, ARTool-kit, metaoi, Inglobe Technologies, Webtitude, and ARQuake are some of the companies that have made significant progress with this technology in recent years [9]. AR research pursues (i) technology and equipment development to input, display, and track virtual and real world data, (ii) utilization of present technologies to increase development of augmented reality applications [8]. Five areas of focus for current augmented reality research are - tracking, registration and calibration, interaction, display, and application [5]. Future directions for augmented reality include - multi-modal AR, authoring, visualization, rendering, mobile and/or wearable applications, and testing and evaluation [5]. 4 types of environments were defined [10] - real world environment, virtual environment, the augmented environment where computer generated objects and real world objects are merged, and mixed reality environment where the computer generated objects have data provided from real world. Figure 1 illustrates this mixed environment.

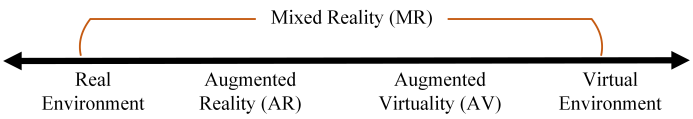

Figure 1: Mixed Reality Spectrum [6]

B. Augmented reality for Education

Augmented reality provides real world or virtual world information in real time to the user in their real world perception. The first idea of AR was given back in the 1960's. When the purpose is of education and training for people, many different methods can be used to provide them with specific skills and information. Different electronic appliances, computers, standard textbooks and handheld devices are used to provide lectures in classrooms. The education platform can use the wide array of applications that augmented reality technology now provides from virtual and real world interaction to transitions between virtuality and reality for lessons which gives this technology really high value for the education sector and the educational experience. Smart phones, tablets and other small devices offer a great deal with the feature of AR in the field of education and training. Topics like physics, mathematics, astronomy, biology and chemistry have seen applications of augmented reality based learning in classrooms by teachers and researchers. In some schools in Norway, tablets are available in the classrooms. The kids are allowed to see the things (Apple, Ball) through that tablet. And the app or device makes a 3D structure of an object and gives the proper description. The potential of augmented reality to replace the old educational devices such as textbooks, models and manuals is really high in the near future. Almost 70% of teenagers use smartphones, and augmented reality technology is easily accessible to the target audience at its majority. Students have shown better learning outcomes when they have game-like augmented reality learning tools. Augmented reality can offer more opportunities for diversified learning to reduce the boredom of students in classes. This generation is known as generation Alpha. This generation has started their knowledge acquiring process through screens by touching, doing things, and experiencing through digital means. Benefits of AR in education include increased understanding of educational content, retention of memory for longer terms, and collaboration improvement. Co spaces edu and Merge cube are some of the tools that teachers can use for their classrooms. Co spaces edu, a tool for designing 3D virtual worlds allow students that have experience in coding to create their own work.

C. Augmented Reality for Medical

The medical sector has grown at a fast pace alongside with the growth of technology. Learning in the medical sector is different from others as here learning in the workplace which involves clerkship at undergraduate level to residency training in postgraduate. At present European countries are making the most use of augmented reality for medical purposes. They are employing different techniques of AR, one that visualizes the human anatomical structure. Human anatomy is essential for almost every practice in the medical sector and understanding it gives us the formulation for diagnostics of medical conditions. In the past the method of anatomical education was done through the dissection of cadavers. The dissection used to be done by dividing the different layers of tissue and removing the structures from the interior of the human body. The aim was to achieve visual and tactile experience through the systematic exploration of the human body which provides the learners with a three dimensional view of the human anatomy. This type of learning enables the learners to be able to connect the knowledge they acquired through studying lectures and books. But, this type of learning is often time consuming, expensive and subject to availability of required components. Augmented reality technology provides the learners a new method to learn about anatomy. One of the main advantages that this technology brings is the inclusion of the three dimensional rendering of the anatomy which increases the visualization capabilities. Tactile feedback is also used to increase sensory experiences. Augmented reality enables the manipulation of the visualizations and these systems can also provide direct feedback to the students which increase their learning experiences. For anatomical education, several augmented reality systems have already been developed. Blum et al. describes ('Miracle') which utilizes augmented reality to educate in education of anatomy for undergraduates. At present the most common augmented reality technology being used in medical purposes is laparoscopy. Laparoscopy is the result of new surgical approaches that were introduced through the emergence of minimalistic invasive surgery (MIS). Since Laparoscopic procedures are highly intensive in terms of being able to handle the person-specific requirements that come with every different patient while also having the pressure of not making mistakes which can give rise to complications. These skills can be trained through augmented reality systems which

will help improve the individual accuracies which in turn will make the participants more efficient and effective.

D. Augmented Reality for Automobiles, Pedestrians and Traffic

Humans have relied on automobiles as the primary mode of transportation from the onset of mass automobile production. Driving is now ubiquitous and it is something that almost every human being will take part in within their lifetime. Even though driving might feel like second nature to many people it is a complex task that requires them to process large amounts of information ranging from roadway information to environmental information while also being under constant pressure and tight time restrictions. Drivers are the main part of the whole transportation system and they are prone to making mistakes because of the inherent human physical, perceptual, and cognitive limitations. It has been identified that driver error is the main reason in 75 percent to 90 percent of roadway accidents [11]. The major driving errors are categorized into failure of recognition, failure in decision, and failure to perform required actions. Recognition can be categorized into driver interpretation and their perception. Decision can be identified as planning and intention. Action executions are identified as performance. In-vehicle technologies have grown in the past few years by a significant margin. Manufacturers and industry researchers have tried and tested several in-vehicle display systems for both commercial applications and research. The common type of in-vehicle displays that are presently available are head-down displays (HDD), HUD, and AR displays. Although the HDD and HUD are basically a variation of AR displays. Head-up display or HUD project the required information directly onto the driver's line of sight i.e. on the windshield. This helps the driver receive the necessary information without them having to take their eyes of the road while driving. Augmented reality display is the most advanced technology that is currently available on the market and most mainstream manufacturers are testing these in their prototype vehicle and some are making it into mainstream production vehicles albeit only on the high end luxury models for the time being. Pedestrians are the most vulnerable users who are part of the transportation system. They are at the most risk when they are crossing a road. Study of the behavior of pedestrians and their interactions with vehicles has concluded that children are alone the highest risk of pedestrian-vehicle accidents [12]. Advanced driver-assistance systems (ADAS) have been developed to enhance driving safety and driving experience.

III. Augmented Reality in Bangladesh

A. Augmented Reality for Education in Bangladesh

In Bangladesh, Augmented reality has not developed that much. In the sector of education there is little use of AR, but nothing out of the ordinary. In a school in Dhaka they used an AR app to teach the kids basic lessons.In Bangladesh, the cost of education is increasing, but the use of newer and better technology in education is very limited. In most areas the system that education is provided with is old school. Implementing AR education systems can help to give them a better experience in learning whilst making it easier. AR based apps will be able to show the pictures in 3D, and the children will be able to perceive the pictures as real world pictures, and it will be easier for them to learn about something. For undergraduate and graduate geography students in public universities, an app can be helpful for learning about Earth-Sun relation and other topics. This app can be developed using AI and machine learning. Apart from books, a 3D structure and real world image will be more helpful for their understanding.

B. Augmented Reality for Medical in Bangladesh

Though the use of AR is growing rapidly, in our country there is almost no usage of it in the sector of medical science. In Square Hospitals (Panthapath) around two years back they used an AR based instrument in surgery, but after that there is no use at all. It has huge potential to help improve the experiences of both doctors and patients. We can discuss about some ideas of AR that can be used in Bangladesh in the medical sector. As mentioned above, we know that the technology is growing rapidly, so there should be proper use of AR in medical science. In the case of Augmented Reality, visualization tools are effective for medical training and prognosis. A deformation method can be implemented as a pre-computational approach in showing a 3D lung model [13]. The next thing we can talk about is making a birth simulator based on Augmented Reality. The baby delivery process is not proper in all hospitals, comparatively expensive hospitals provide proper treatment. To get a good delivery these expensive hospitals can also take the help of AR. AI based IT firms can make a simulator which will be able to add on the user interface on a AR delivery simulator system. This simulator will be able to give haptic and auditory feedback, including various physical data, blood pressure, heart rates etc. The major thing about this simulator will be the indirect viewing of both the virtual models and the final delivery process. This will make the delivery process for the doctors much easier.

C. Augmented Reality for Automobiles, Pedestrians and Traffic in Bangladesh

The roads of any country are one of the most important infrastructures that they have and Bangladesh is no different. But sadly the whole transportation system as a whole in Bangladesh is really outdated and lags behind those of other countries in many ways. The traffic situation is one of the worst in the world here in Bangladesh. Most of the issues that plague the transportation system here is due to outdated laws, old technology, poor implementation of rules, negligence on part of the authorities and ignorance of the general public as a whole. Many of the issues of our transportation system are easily fixable if we follow and adopt the systems already in use abroad. But instead of just adopting proven systems from other countries we should also look to use innovation and new technology to alleviate the problems that plague our transport system. Augmented reality can provide many solutions to the

common problems that are in our transport system along with other solutions. The main focus of augmented reality for our transport system in Bangladesh can be categorized into 4 sections:

1) Provide Information to Drivers: Drivers are the main integral part of any transport system. In Bangladesh they are also one of the main reasons that accidents occur. Driver error is the main contributor for 90% of road accidents in our country. The preliminary estimation revealed that the annual cost of road traffic accidents and injuries in Bangladesh to be between $\$9.5$ billion to $\$11.5$ billion of economic loss [14]. Most drivers on the road do not even pay attention to the environment around them and they just drive as they wish on the road. This is partly due to the poor quality of teaching that drivers receive before they get their driving licenses. As studies from abroad show that augmented reality can help in reducing the driver distractions while simultaneously increasing their situational awareness. In order to make AR technology available to the masses in Bangladesh we don't necessarily have to do much of innovation as opposed to in other sectors. Most of the AR technology that can help drivers when they are on the road are already available or will soon become available for everyone. The issue with Bangladesh is our outdated policy. Since most of the safety features are available on newer vehicles and augmented reality technology is also coming into new vehicles in the last few years we need to update our policy on the vehicles we use on the road and change our tax structure so that it's easier to import newer vehicles. This will increase the safety of drivers and other road users as the new safety features can help decrease the number of road accidents drastically since newer vehicles are clever enough to almost drive themselves and they are very unlikely to cause accidents. The AR technology in newer vehicles shows drivers almost all the information required to make driving safe on the road. The pre-collision avoidance systems, pedestrian detection systems, blind spot monitoring and augmented reality navigation can enable drivers to be safer themselves while also making the roads safer to other users as well. These systems are so advanced that even if a driver is incapable of driving safely on the road they can prevent many types of accidents.

2) Provide Information to Pedestrians: Pedestrians are the most vulnerable road users in any country and in Bangladesh that is also the case. In the big cities pedestrians comprise about 75% of all fatalities. Pedestrians here do not even wait for the traffic at a signal to come to a standstill before getting on the road to cross it. Many people take huge risks while crossing the road in the highways with speeding vehicles coming from all directions. At the very first we need to counsel the pedestrians and teach them the proper etiquette for road usage and have to introduce some sort of punishment if they break the rules. Since one of the main reasons for pedestrian accidents is that they are not attentive enough and that they assume that it is safe to get on the road without proper evaluation, augmented reality can provide the necessary information to these pedestrians so that they can make proper informed decisions while they are on the road. Some of the advanced systems can even determine pedestrian trajectory based on preconceived information and by anticipating pedestrian movement patterns. When a pedestrian is about to cross a road the system can show a visual warning accompanied by an auditory warning to warn the pedestrian if it's safe to cross the road or not.

3) Control Traffic: Traffic and traffic management as a whole are one of the main issues that plague our country. Human factor is one of the main concerns here as traffic is controlled by the traffic police. It is not possible for any human being to make the correct decision based upon so many different factors and the mass of information that the traffic police needs to consider while they are doing their job. If the traffic system is fully automated then it also lowers the need for traffic officers on the road which also saves the government a hefty amount from the budget. The AR systems can be placed on the same place as the other equipment required for the automated traffic system. Our government is already bringing in some of the automated traffic management systems for use in Dhaka city. The AR systems will work together with the automated traffic systems to gather data and make necessary decisions to maintain the correct flow of traffic and manage congestion. These systems will read the traffic flow from different locations where they will be set up and all the data will go to the central control from where traffic will be managed. They can detect the different flows of traffic and make decisions on whether they need to provide more green light time on traffic signals or if the flow is in the proper region. The system can also use projection methods to highlight which lanes and roads are to be taken by which traffic participants. Some of the augmented reality applications that are being tested for traffic management on the roads of countries abroad are ARTEMIS in Japan and a system by FLIR Technologies in Germany. FLIR Technologies used their system to make traffic flow smoother and make traffic management more intelligent. This was deployed in over 200 locations in the German city of Darmstadt. They have reported a 35% reduction in congestion in parts of the city where this system has been deployed. In Mumbai, India they have deployed a variation of the ARTEMIS system in the testing phase and they have also reported a reduction in congestion by 50% in the time they had this on trial in selected areas of Mumbai. They read the flow of traffic and make necessary adjustments on the whole network to stop congestion from manifesting.

Since Dhaka city has similar traffic congestion to Mumbai we can expect to see at least 30% reduction in congestion. But further evaluation and testing of this system is needed to get the actual results. In India traffic congestion costs the government nearly $\$200$ million every year where drivers spend an average of 32 hours yearly stuck in traffic, according to BBN Times [15]. In Dhaka city alone most regular commuters spend an average of 1 hour everyday stuck in traffic congestion which adds up to about 5.2 million wasted work hours. We can estimate that a 30% reduction in congestion in Dhaka can

add up to $50 million in savings for the economy [16].

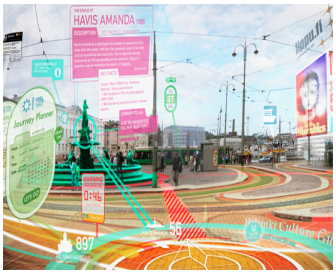

Figure 2: Display of a sample AR road from Hyper-Reality [17].

4) Assist Authorities: Authorities have the possibility to use augmented reality to make the whole system more efficient. Many drivers break traffic rules in Dhaka even when there are traffic police present but they do not have the means to catch the culprits due to limitations of equipment. many drivers are still not being held accountable for their wrong doings on the road because they cannot be identified fast enough. In China, the police are taking the help from augmented reality technology to apprehend law breakers. A Beijing-based augmented reality startup company Xloong, have created smart glasses that they are providing to the Chinese authorities to tackle law breakers. Their system works on facial recognition to identify people who have broken a law and updates that information to the augmented reality system that the police are using. The Chinese authorities have reported positive results from this system since they started using it in 2017. In Bangladesh we already have an online database of registered vehicles and their owners in Bangladesh Road Transport Authority (BRTA) servers. With augmented reality technology we can incorporate the central database with the system to help in "marking" vehicles that have committed an offense. Introducing this system also enable a lower number of traffic officers on the road which in turn will save our government around $1.2 billion [18].

IV. Implementation Estimation

Road traffic accidents cost Bangladesh around 2% of its annual GDP [19]. Augmented Reality provides the potential to reduce economic loss. Driver error costs our government around $9.5 billion to $11.5 billion yearly in loss to the economy [14]. Statistics from countries around the world point to the fact that proper implementation and regulation of traffic rules can reduce traffic accidents by 50%. Augmented reality can have a key part in helping drivers to follow the traffic rules properly and reduce the amount of economic loss. A 50% decrease in accidents can lower the yearly economic loss due to traffic accidents to $5 billion to $7 billion. The estimated cost to implement the augmented reality technology for vehicles should range from $45 million to $65 million. Already different companies have invested around $20 million in Bangladesh's automotive industry to introduce new technology and vehicles and it is slated to reach around $1 billion in 5 years [20]. An Augmented Reality traffic system would benefit pedestrians while also being able to control traffic. It is estimated that accidents involving pedestrians cost the national economy around $644 million [21]. Most of these accidents happen during the night time with pedestrians. With the introduction of new augmented reality technology for vehicles and for traffic management it would lower the number of accidents involving pedestrians to around half. This would save our economy around $320 million every year.

Table I: Yearly estimated economical loss and estimated budget with probable economical savings (USD)

Section	Estimated Loss	Estimated Budget	Estimated Savings
Drivers	9.5 - 11.5 billion	45 - 65 million	5 - 7 billion
Pedestrians	644 million	1.1 billion	320 million
Traffic	12.5 billion	1.1 billion	3.8 billion
Authority	1.2 billion	23 million	1 billion

The present situation of traffic congestion in Bangladesh costs our economy around $12.561 billion [22]. An advanced traffic management system with AR enabled can be estimated to reduce this congestion to at least 30% and that would amount to a savings of $3.76 billion annually. The cost of implementing such a system is estimated to be around $1.1 billion [23]. An AR based traffic system would also decrease the number of traffic officers needed to maintain and control the traffic system. The excess number of traffic officers cost our economy around $1.2 billion every year [18] and this amount can be saved by implementing an AR based traffic system. Reduction in the number of traffic officers will also mean the remaining officers need to be equipped with better technology to be efficient in their job. The AR smart glasses that are being used in China can be brought and implemented to maintain road safety. The estimated cost of that would be around $23 million for around $10,000$ units according to the cost of individual units at this time. This would mean close to $1 billion in savings for the economy if the number of traffic officers are drastically decreased and the remaining equipped with the new technology.

V. Conclusion And Future Works

Augmented reality as a concept is still in its infancy when it comes to actual practical applications. More testing and trial is needed in order to make augmented reality a robust technology that can be implemented in every sector imaginable. With new technology also comes new security risks. Augmented reality, like any other digital system will have security issues and these have to be evaluated so we can come up with better security solutions for this technology. Since any digital system can be access illegally, augmented reality is no different in that sense and with all the information that will be channeled through this system there will be many loop holes where a vulnerability can be exploited. If there is any major flaw in the AR systems for transportation then that can have serious consequences for all the users of the roads, vehicles and pedestrians. Consideration needs to be given to privacy challenges and new security issues that might arise from the implementations of these new systems and we have to explore every opportunity to introduce better security and privacy solutions and applications. If these initial problems are dealt with then augmented reality can

help improve the vision and perception of those people who unfortunately have difficulty with their vision and perception of the world. The mixed reality world is claimed to be worth $\$25$ billion and growing by the year 2025 [24]. The industry is predicted to have a growth of 65% from $2017-2024$ [25]. For Bangladesh, first we have to educate the general population on augmented reality technology before introducing them to everyone. Augmented Reality has already been tested in the school setting in Bangladesh and the results from that indicate at least 30% learning improvement. Improved planning and road construction analysis will be required to facilitate the introduction of augmented reality for our roads. Another factor that needs to be researched is the consumers readiness and willingness to adopt to the new technology and ways that can be accelerated. Concern also needs to be given to the law, societal, and ethical condition of the country where augmented reality is to be introduced and Bangladesh is no exception. Augmented reality has shown its positive qualities in helping improve many different sectors such as education, commerce, economy, marketing, travel, medical, transportation, design and many more. In the future we will keep on finding more applications for augmented reality that will benefit us for the better and reduce our problems that plague us in the present. The reason for taking up augmented reality is for the purpose of our need for progress, innovation, and betterment. Augmented reality was a part of science fiction many years back and now we are slowly immersing our world with a once "out of reach" technology. In future augmented reality in together with Artificial intelligence can be used in smart grid security For Bangladesh [26]–[29]. Augmented reality has started its journey already and what we need to do is make it more accessible to the general population so they can get the benefits of a technology that will make our lives easier and more efficient. From what we learned about augmented reality we can use our knowledge to make this technology even better and come up with more ways to incorporate it so that it can satisfy our requirements for innovation, progress, and prosperity.

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