Current State of Mobile supported Augmented Reality Research

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Fig. 1: Virtual cat placed in real environment via AR app

ABSTRACT

Over the last few years **Augmented Reality** has gained unprecedented popularity in both academia and industry. Mostly because of **Mobile Augmented Reality** applications, facilitated by massive improvements in smartphone hardware. A rigid, external, physical device such as- head mount or wearable is no longer needed for an immersive AR experience. Smartphones with multi-core processors, long battery life, powerful camera and IMU sensors; are more than capable for providing AR extensive apps to users. The AR domain is now endless. Gaming in real-life environment, visual & interactive educational materials, photo filters/effects in social media apps, remote manufacturing, remote workspace collaborations, navigation guide are just a few to mention. In this study we will present an overview of the current state of MAR by analyzing some of its application mechanisms, existing popular applications and development tools- Google ARCore, Apple ARKit and Facebook Spark AR Studio that simplify the creation of MAR applications.

1. Introduction

Augmented Reality (AR) is the modification of real-life environment around us by influencing visual, audio and other sensory stimuli. When such augmentation is made possible by handheld devices such as-smartphones, it is called Mobile Augmented Reality (MAR). The popularity of Pokémon GO, with almost 1 billion downloads till March 2019 [1], is truly a testament to the impact MAR apps can have. However, MAR is not confined to gaming only. Easy to use development tools like Google ARCore, Apple ARKit, Facebook Spark AR Studio have

propelled the application domain of MAR. Global mobile augmented reality app users is estimated to reach 2.4 billion by 2023 **[2]**. However, augmented reality apps face very real challenges. The price of full-fledged AR features supported devices are slightly on the higher range, approximately 200 USD and above. Such financial barriers make it tough to intercept the customer base of developing countries like Bangladesh. Nevertheless, the number of AR supported devices are growing day by day and with the advent of 5G, offloading hardware intensive tasks to remote servers is also becoming a viable option. But then again in developing countries there are many isolated areas where even 3G hasn't reached. Software upgrades seem to be the only sustainable option to make up for such hardware and network speed requirement of MAR.

2. Literature Review

To analyze the current state of mobile supported AR research, the literature taken into account focus on three aspects- typical implementation mechanisms, development tools and popular applications of MAR. In **[3]** before discussing the possibilities of Web AR, the authors presented the steps of typical AR application and its implementation mechanisms- sensor based, vision based and hybrid tracking. The paper also goes on explaining the computational, storage and networking complexity of each mechanism. In **[4]** a AR enhanced heart monitoring app is designed. The app lets users monitor their heart rate as well as share the monitored data history with doctors as well. **[5]** is a remote maintenance platform using off the

shelf MAR technology as a feature of "Industry 4.0". The app acts as a bridge between expert technicians and local unskilled operators to find errors in faulty factory equipments. **[6]** and **[7]** are studies of acceptance level of AR based application among users. In **[6]** an experiment is performed among two groups of university students in promoting anti-litter activities- one group through AR app and the other with non-AR app. Similarly, in **[7]** the effect of AR and non-AR guided video editing course is observed among two groups of college going students, and shows that AR supported increases student engagement in learning. Finally, the paper will review the popular AR development tools- Google ARCore **[8]**, Apple ARKit **[9]** and Facebook Spark AR Studio **[10].**

3. Current State

3.1 MAR application design principals

As discussed in **[3]** the fundamental principal of MAR is to perceive the user's ambient environment using sensor readings to bring in virtual reality as an enhancement and allow the user to seamlessly interact with it. The typical workflow of an AR application is shown in Fig. 2. The camera, IMU and GPS sensors continuously collect user ambient information. User interactions are also tracked via these sensors. Finally, they are rendered altogether to provide a seamless integration of virtual contents into real space to provide an immersive AR experience.
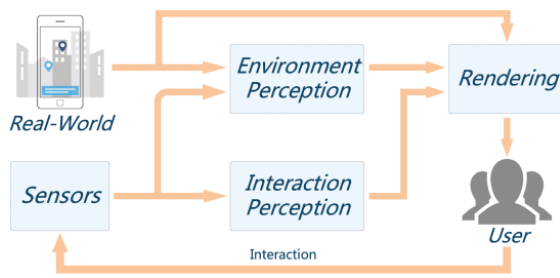
Fig. 2: Typical AR process [3].

The paper [3] goes on to divide the implementation mechanisms of AR applications in terms of three aspects- sensor based, vision based and hybrid tracking. The sensor based mechanism puts less strain on computation as it utilizes sensors single or multiple embedded in the phone like- accelerometer, gyroscope, GPS etc. The vision based mechanism focuses more on camera captured data, and requires high computing capability for extensive image processing. Both the methods have their shortcomings- sensor based approach cannot provide completely blended virtual content into the real environment whereas visual based mechanism requires heavy computation and/or high speed network. The hybrid implementation mechanism, a combination of both, overcome the disadvantages of previous individual methods. The computational, storage and networking complexity of the three mechanism are shown in Fig. 3.
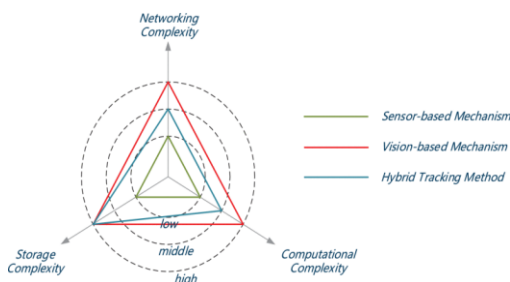

Fig.3: Complexities of

AR implementation mechanisms [3].

3.2 MAR in Healthcare: Heart Diagnoses System

In [4] a mobile application is built to monitor heart beats and generate an online graph. The author presents an argument that for heart diagnoses visualization of heart rhythms is more important for doctors than to listen to them with a stethoscope. The application is paired with a sensitive microphone which listens to heart beats. Any unusual data reported to the user, the doctor is also able to view the data from the app by scanning QR code shared from patient's end.
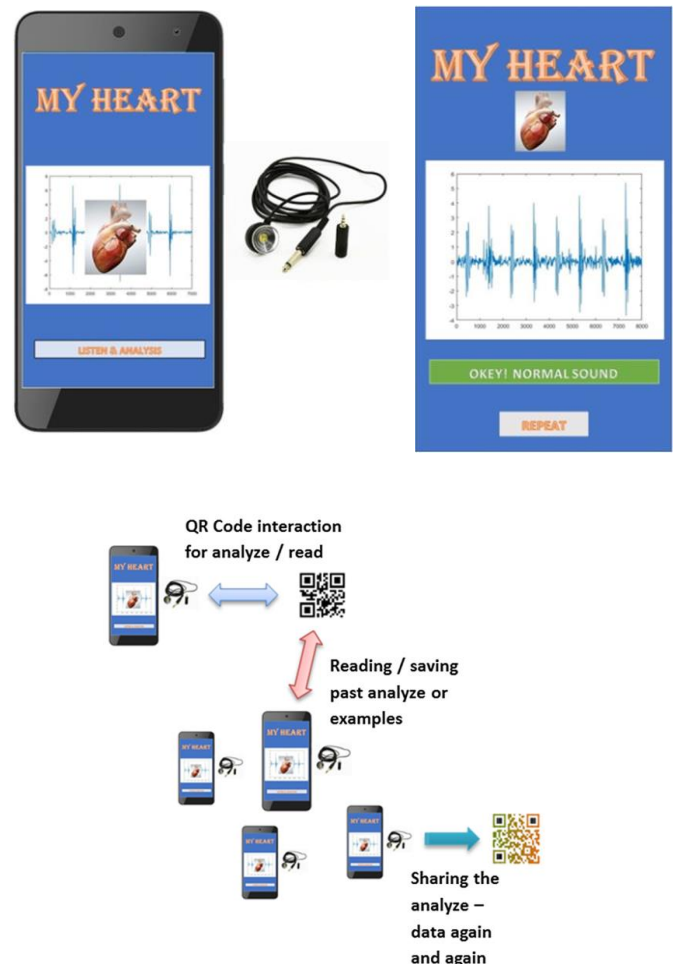

Fig. 4: MY HEART- AR based heart diagnose system [4].

3.3 MAR in remote maintenance- Industry 4.0

Remote capability of augmented reality can play a vital role in ushering Industry 4.0, especially in maintenance of complex factory equipment. In **[5]** a remote maintenance system has been proposed using off the shelf mobile phone AR technology. The system is a collaboration platform between skilled and unskilled maintenance workers. Unskilled workers can take pictures that act as markers and share with the skilled ones, who in turns can sketch symbols and/or add texts to help the unskilled worker. The interaction can also take place with live streaming audio and video, however network unavailability inside factories make the stream ineffective. The usage of symbols makes the communication process universal, language independent.
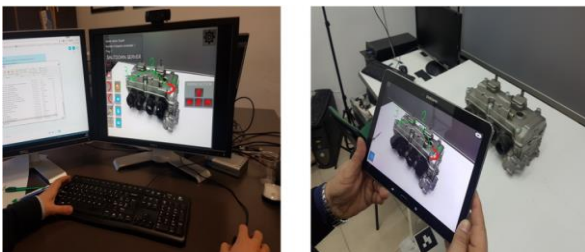

Fig. 5: Example usage of the application. On the left side the maintenance expert, on the right side the local operator **[5]**.

3.4 MAR for Environmental Awareness: Anti-littering

In **[6]** an acceptance study was performed of an MAR app built to raise anti-littering awareness. The experiment was performed among three groups of university students- (i) with a standard mobile app without any AR features, (ii) app with marker-based AR features, (iii) app with marker-based AR & AR-Game features. Markers were placed at various locations in the campus that showed anti-litter materials to users with the AR feature apps. The study found that the second app yielded the most perceived value among users, even the necessity of downloading the non-AR app rather than by scanning QR code acted as a big barrier for users.
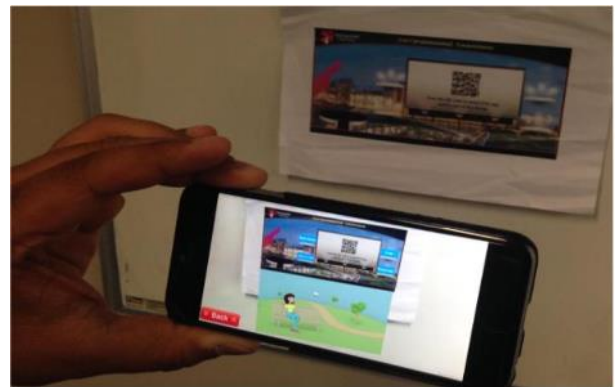

Fig. 6: AR Anti-littering app Interface **[6]**.

3.5 AR App in Education: Video Editing Course

In **[7]** a study was performed among two group of college going students on the use of AR-app and Online-app for a video editing course. The first week of the experiment students were taught in traditional way through in class demonstration by the instructor. On week 2, a group of student were given AR-app to aid the study material and the other group were provided with pre-recorded videos viewable over the internet. At the end of the experiment it was found that assignment submission rate and overall productivity of both group of students rose in week 2. Interestingly, there were significant difference in the two groups in one criteria. The group with AR-app were more engaging and cooperative among themselves, whereas the online-app group kept to themselves while watching the online videos. In week 3

both the aiding apps were removed, this resulted in significant drop in assignment submission among the previously online-app provided group but the submission rate of the AR-app group remained steady.

3.6 Google ARCore

Google's ARCore **[8]** is a platform for augmented reality based mobile app development. The API supports a large number of popular devices out in the market including both Android and iOS. It is an easy to use tool that lets developers enrich their apps with augmentation. The fundamental concepts of the ARCore are,

Motion Tracking, allows phones to track its position relative to the surrounding environment. Internally the API uses a process called simultaneous localization and mapping (SLAM) to achieve this. It identifies distinct points through the camera, called feature points and combines it with inertial sensor readings to detect the device's location changes. All the internal complex mechanisms allow developers to position virtual contents in the real environment seamlessly.

Environmental Understanding, ARCore builds its understanding of the surrounding environment by detecting feature points-distinct features and planes- horizontal or, vertical. The boundaries of detected planes are made available to API, which lets you place virtual objects exactly where you want. Although the API does have a drawback in detecting flat surfaces without texture such as- white walls.

Light Estimation, detection of light allows to bring more realism to the virtual objects. Objects can react differently based on different light levels and also apply color correction to blend in with the lighting.

Depth API, ARCore's latest addition to the toolset. Depth understanding lets you create depth maps with data about distances between virtual content and actual objects. As a result, virtual objects don't collide with real object and appear in front of or behind of real objects. The API is only available to supported devices with RGB camera.
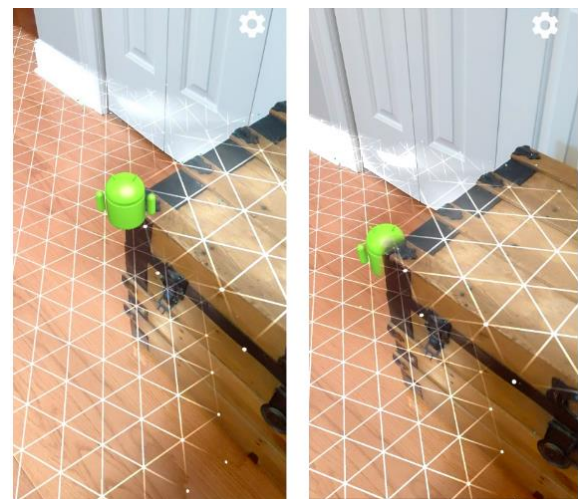

Fig.7: ARCore **Depth API** feature.

3.7 Apple ARKit

Apple ARKit **[9]** is an augmented reality platform for apps in iPhones and iPads. Some core features of the development tool are,

Depth API, lets developers use per-pixel depth information to position virtual objects synced with the surroundings. The feature uses LiDAR Scanner available in iPhone 12 Pro, iPhone 12 Pro Max and iPad Pro.

Location Anchors, location anchors are placed at specific latitude, longitude and

altitude coordinates in the map. The locations can be any specific place such as- famous landmarks, restaurants, shopping malls etc.

Expanded Face Tracking, front cameras of devices with the A12 bionic chips support face tracking feature. Up to three faces can be detected using the TrueDepth camera, useful for apps like- Snapchat.

3.8 Facebook Spark AR Studio

Facebook's Spark AR Studio **[10]** is a full-fledged AR effects editing software available in Windows and macOS. There are over 400,000 active creators using the platform. The software can be used with or without coding. The created effects are specific to Facebook and Instagram. AR effects can be created based on people effects- face detection, body gestures; world effects- external objects, places.

4. ROADBLOCKS

Mobile AR applications have brought the like of AR technology in the palm of thousands of users worldwide. The continuous growth of smartphone computing capability, sensor precision, long battery life and high quality camera have opened infinite domains for MAR. Although a large number of handheld Android and iOS devices support most of the AR features, the price range of these devices are a bit on the higher range. Especially in a developing country like Bangladesh technology that requires smartphones costing above 250 USD is doubtful to cause mention-worthy influence among the mass.

User acceptance and understanding of AR technology can act as a barrier as well. Vast amount of features provided by MAR tools makes it easy for developers to over-complicate apps and hinder user experience. Proper UI/UX standards need to be followed by developers like- ARCore's design guidelines. Complex computational overhead and/or offloading heavy tasks to cloud can potentially cause unexpected delays. Inadequate screen size can also affect user experience in case of interactive AR applications. It is up to the developers to keep these things in mind while creating MAR apps.

Finally, the AR technology itself is very crowd pleasing, popularity of the game Pokémon GO is a testament to this statement. Downloaded almost a billion times the app has created mixed reactions among people. Players were so invested in the game, the reported incidents varied from people bumping into walls to breaking into restricted personal property **[11]**. Just like with the emergence of any other technology, policies need to be formed by authorities regarding MAR as well. In **[12]** it is argued that permission-less policy making should be practiced by governments as to not hinder the development of AR technology.

5. Conclusion

Augmented reality is among the most influential technologies of the next generation, especially AR-based mobile apps. The domain for AR app development is unbounded. Smartphones with powerful hardware, off the shelf sensors, availability of easy to use AR development tools have all played a big role in giving the tech center

stage by fitting into the palm of users. Research works are being continuously conducted in this field. Industry adoption of AR services are growing day by day as well. However, the roadblocks MAR faces are undeniable. Price constraint seems to be the predominant one among them. Taking into account all its potential as well as the shortcoming the future of AR tech will be very interesting to observe.

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