AUGMENTED REALITY IN MOBILE DEVICES

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ABSTRACT

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Recent advancement in smartphone technology has fueled the popularity of Augmented Reality in mobile devices. This paper presents an introduction to mobile Augmented Reality. We focus on the key technology required to develop a mobile Augmented Reality application. Discussing the existing problems and a generic framework required for its development. Finally, we provide an overview of the future scope and applications for Augmented Reality in mobile devices.

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1. INTRODUCTION

Augmented Reality (AR): Augmented Reality is a technology that composites virtual objects into the real world. It has gained popularity because of its wide application uses in various fields such as gaming, entertainment, advertising and promotion and medical [1].

Mobile Augmented Reality (MAR): It is a new technology based on Augmented Reality and can be used on mobile devices such as smartphones, iPad, iPod, gaming console and military Head-Up Display (HUD). It extends and enhances the user experience of the mobile device [2].

Figure 1: Mobile application display AR Source: [1]

Applications in Augmented Reality: There are vast applications in Augmented Reality in various fields like navigation, sightseeing, military, medical, maintenance and repair, gaming, advertising and promotion and entertainment [1].

- Navigation: Many applications are using enhanced GPS and Augmented Reality to navigate from point A to point B. Through the phone camera, users see the selected route over the live view [1].
- Sightseeing: There are a number of applications in sightseeing and tourism industry which use Augmented Reality. For example, an application which augments a live view of displays in a museum with facts and figures. Another interactive kiosk which allows guests in the museum to interact with the 3D display. A tourist can walk through a historic site with a smartphone equipped with a camera and an AR application. The AR application uses image recognition and GPS to present facts about the historic site as an overlay on their live screen. It looks up data from an online database, in addition to historical information, the application looks back in history and present how the location looked 10, 50 or 100 years ago [1].
- Military: The military uses a Heads-Up Display (HUD) which has an Augmented Reality application embedded into it. For example, a fighter pilots display will show details such as the plane's altitude, airspeed, the horizon line and other critical data. This way the pilot doesn't have to look down at the aircraft's instrumentation to get the required data [1].

Ground troops use the Augmented Reality display to display critical data such as enemy location. Many simulation applications exist for military training purpose.

- Medical: Medical students use an Augmented Reality application to practice surgery. Visual aid AR can be provided to patients while explaining complex medical condition. Augmented reality can give surgeons improved sensory perception during an operation, thereby reducing the risk.
- Maintenance and Repair: A mechanic repairing an engine can see superimposed imagery and information about the engine by wearing an Augmented Reality headset. The AR headset can display important steps for the repair procedure along with displaying the tools and the exact motion the mechanic needs to perform. Training expenses can be reduced by using simulations to train technicians [1].
- Gaming: Gaming in Augmented Reality is an upcoming market with people investing a lot of money in this area. Few of the popular mobile AR games are Zombie shootAR, the zombies are superimposed on your mobile phone. The players can shoot the zombies using their mobile phones. Pokémon go is another popular Augmented Reality game [1].
- Advertising and Promotion: Details about a popular place near you can be Augmented on your mobile device, thereby promoting their brand. Coupons, 3D animations and offers can also be Augmented for advertising.

- Entertainment: Many Augmented Reality applications are developed for an entertainment purpose. For example, Lego's Augmented Reality application allows you to interact with 3D Lego products.

Concerns in Augmented Reality applications: Social acceptance is one of the concerns of AR. Getting people to use AR is challenging, as people are concerned about their privacy. Users private data can be easily accessed and hackers can get to know the location of the user [4].

The display screen is too small for the user to interact which might hinder the user experience of the user [4].

External devices might have to be worn to have an Augmented reality effect. For example, a headset might have to be worn which might spoil the users fashion style [4].

Scope of Paper: The remainder of the paper is organized as follows: Chapter 2 consists of problems existing in mobile Augmented Reality. In Chapter 3 we discuss the generic framework of Mobile Augmented Reality. Chapter 4 we describe the key technology. Chapter 5 we describe the existing Augmented Reality Software Frameworks. Finally, Chapter 6 concludes the paper.

2. PROBLEMS AND CURRENT ISSUES EXISTING IN MOBILE AUGMENTED REALITY

There are quite a few challenges in the implementation of Augmented Reality despite the advances in research and development area. The challenges are due to problems related to context-awareness, usability, navigation, visualization and interaction design [3].

Navigation and Tracking: AR system utilize GPS for outdoor navigation because of its accuracy and high availability. But in urban environments the GPS reception and accuracy can deteriorate, where the GPS signal can be reflected and shadowed by the surrounding buildings. Magnetometers available in mobile devices can be used for the purpose of navigation and tracking, however, they can be affected by the local magnetic fields [3].

AR indoor navigation systems cannot use the GPS solution, as the GPS signal are unavailable or too weak indoors. High Sensitivity GPS (HSGPS) or Ultra-Wide Band(UWB) location sensors can be used to detect indoor navigation, but currently no sensor technology is capable of providing precise navigation tracking indoor [3].

Content Management: Many AR applications are limited in the way new content is be added to them. Programming skills are required for linking data sources to an existing system. Regular users should be able to add their own content with minimal technical effort [3].

Usability: A user's position and orientation is very important for an Augmented Reality application to behave as expected. Based on the location of the user, the digital

3D object is rendered into the real world. GPS sensors on smartphones have an accuracy of only 20 meters and the magnetometer compass orientation is only about 20 degrees. This will affect while calculating the field of view for the application, which will lead to digital objects and the real world not aligning with each other [3].

Although existing smartphones have high resolution camera they provide a limited field of view. Consequently, only a small portion of the user's mobile field of view can be augmented. Identifying the Point of Interest to view the Augmented reality objects is a challenge the user must face. The user might have to rotate around while holding the device to locate the Point of Interest [3].

Visualization: The small display, brightness, resolution, contrast and field of view post as a challenge in Augmented Reality applications. The entire Augmented Reality application might not fit in the small display. The correct handling of the device is important for a realistic view if the virtual object is to rendered into the real world [4].

Interaction Design: The user interface and interaction of the user with an Augmented Reality application is still a problem, due to the small display of the mobile device. There are many challenges in achieving interaction of the user with the digital object [4].

Hardware problems: The hardware used should light weight and small so that it is easily portable. The problem with having a small device is its computational power. The battery life will be low and camera quality might not be good in most devices to display the augmented reality objects [4].

Environmental issues: The environment needs to be set up with markings to identify the locations for an AR application [4].

3. MOBILE AUGMENTED REALITY FRAMEWORK

Based on the type of application you are developing you can have a different kind of frameworks. In this chapter we discuss a generic mobile Augmented Reality framework needed to develop an Augmented Reality application.

A generic Mobile Augmented Reality(MAR) Framework will have the following features [5].

MAR Observer: The MAR Observer identifies which Augmented Reality application requires data files, and downloads the relevant data file from the MAR server. It's very important to obtain the target image or text which has to be Augmented in the application. After the MAR overserve obtains the relative data files, it will use them to get the AR effect at the right position when the user hovers the display over Point of Interest [5].

MAR Server: The core framework is the MAR Server. It is a web server which runs Internet Information Services (IIS) and includes FTP service. The server consists of the following data files, image recognition files (.Dat and .Xml files), configuration XML files which are produced by the application customizer and Resource files which is used for rendering the AR effect. Additionally, MAR Server serves as a bridge between the MAR customizer and MAR observer [5].

MAR application customizer: it is a tool kit for developing an image based Augmented Reality applications. It defines the interactions between the user and target image which is processed by a website called "Vuforia", which results in the generation of an XML configuration file. With the help of Vuforia, the MAR application customizer defines hot points to link the region of interest on the image and its relative resource. Hot point on the image is the place where the Virtual object will be Augmented over the real world. The generated configuration file is uploaded into the MAR server which will be interpreted by the MAR observer [5].

The architecture diagram of a Generic MAR framework is as shown below.

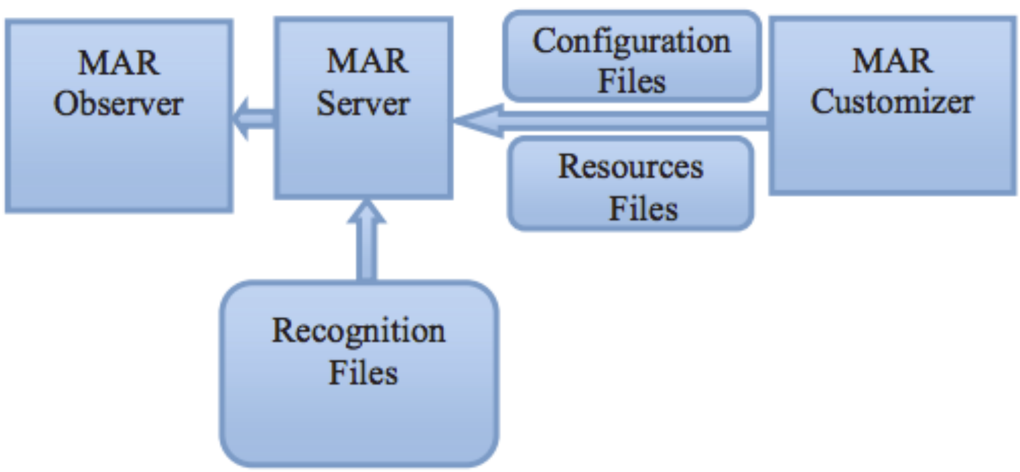

Figure 2: Generic MAR framework source: [5]

4. KEY TECHNOLOGY

In this chapter we discuss the key technology required for developing an Augmented Reality application. The main technologies are Tracking and Registration technology, object detection and recognition, calibration, model rendering and display interaction technology.

Tracking and Registration Technology: Tracking and registration is the most challenging technology as it requires precise and accurate orientation tracking to align the virtual objects into the physical world. In an ideal scenario the tracking and registration technology should return the accurate camera position so that the rendered virtual objects can be placed in the correct position. When the camera position and orientation changes, the virtual object also should get superimposed on the changed position to make it perceive like it's a real scene [2].

There are two steps involved in the Tracking and Registration technology.

- Registration process: the virtual object should completely align itself to the correct position in the real world to achieve correct superposition.
- Tracking process: When the observer position changes, the correct position between the virtual object and the real scene has to be reconstructed [2].

There are three types of tracking and registration methods

- Hardware-based tracking and registration method: This method mainly involves calculating the orientation and the spatial position of the object, based on the sensor data and signal sources acquired [2].

- Vision-based tracking and registration method: The data generated in the tracking phase, compares with stored data. Then it calculates the current orientation and position. It is fast simpler and has greater scalability [2].
- Hybrid tracking and registration method: It is the most promising method to deal with the indoor and outdoor environment difficulties [2]. It is expensive and difficult to transplant [2].

The comparison of the three kinds of tracking and registration methods along with Its advantage and disadvantages is as shown in the below table.

Table 1: Comparison of the three tracking and registration methods source: [2]

Tracking and Registration Method	Advantages	Disadvantage
Hardware-based tracking and registration method	short system delay	expensive; difficult to install; poor scalability
Vision-based tracking and registration method	great scalability; high accuracy	high algorithm complexity; long system delays; low robustness
Hybrid tracking and registration method	high accuracy	expensive; difficult to install and transplant

Object Detection and Recognition Technology: The main purpose of an Object detection and recognition technology is to discover the scene and find the target. It is divided into two parts. The first part is to emphasize on enhanced supplementary information to get a better perspective on the detection and classification. For example, in an Augmented Reality application after detecting the face, gender, name and age is displayed. The second part is image matching, the image features and corresponding information are stored in the database on the MAR server. In an Augmented Reality system, the camera of the mobile device is used to capture the current image scene. Recognition technology is used to process the image, matches with respect to feature value. Finally displays the corresponding image in the camera field of view [2].

Calibration: Calibration technology utilizes the pixels of the image by the camera and restores the objects in real space. It is responsible for detecting the position and orientation and reporting the result data to the system. The calibration measured values are: the scope of vision, camera parameters, sensor offset, deformation and object localization [2].

Model rendering: The Model rendering technique is a process which utilizes 3D data to generate 2D images. The resulting image is usually stored in a frame buffer. OpenGL ES rendering technology is used in mobile devices to achieve rendering in Augmented Reality applications. It is a 2D/3D lightweight graphics library, specially designed for embedded and mobile devices [2].

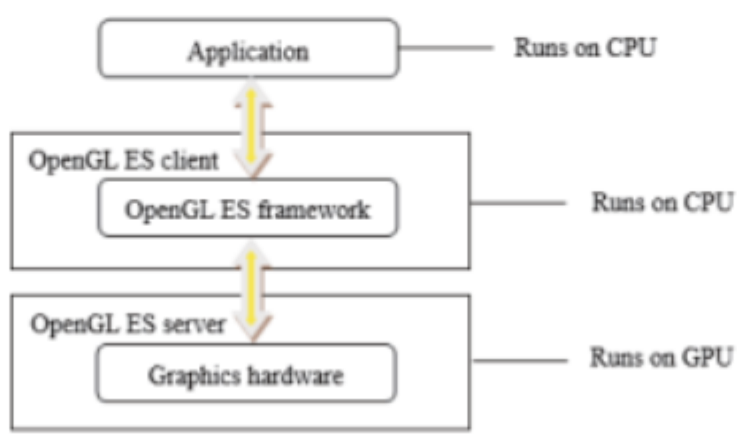

Figure 3. OpenGL ES rendering process source: [2]

Display interaction technology: This technology deals with how to display and interact with mobile AR effortlessly and efficiently on the mobile device. To achieve efficient user interface and interaction with MAR is still a challenge. The mobile devices have a small display screen, no mouse, no keyboard and poor data computing power. Interaction is just reduced to touch and swipe gestures [2].

5. SOFTWARE FRAMEWROKS

To build a MAR application from scratch is complicated and time-consuming. There are many existing software frameworks which can be used by developers to focus on developing their high-level applications rather than worrying about the low-level implementations. In this section of the paper we discuss the different existing frameworks available and compare them in a tabular form [6].

Studierstube ES: It is one of the most successful MAR application framework developed by the Institute of computer graphics. It was rewritten from scratch to leverage new graphics API's and provide better rendering capability. The system uses Open-Tracker, a network module middleware and high-level description language. Studierstube ES is currently available for Android and Windows phones [6].

Wikitude: It is a location based Augmented Reality SDK (Software Development Kit). Which provides augmentation on mobile phones, tablets and smart glasses. When the user points their mobile phone's devices to a specific geo- site, Wikitude overlays image and text information over the current view [6].

Nexus: It is a software framework developed by the University of Stuttgart to support location-aware mobile applications. It supports both distributed and local data management to provide uniform access to virtual and real objects. Nexus proves to be more stable and portable than other platforms [6].

UMAR: It is a conceptual software framework which is based on client –server architecture. Most of the processing in UMAR happens on the client side to reduce over – dependence on network infrastructure and data traffic. It imports ARToolkit, the camera calibration module for visual tracking and accuracy. It is only available on Symbian platforms and does not support collaborative MAR applications [6].

Tinmith-evo5: It is an object-oriented software framework developed by the Wearable Computer Lab, University of South Australia. The data flow has sensor data as its input and display device as its output. The objects have a certain amount of memory allocated at the object repository to support persistent storage, distributed and runtime configuration. The Render system is based on OpenGL and supports hardware acceleration [6].

DWARF: It is a reconfigurable distributed software framework, designed to manage the sequence of task flow operations. Several MAR applications including Pathfinder, SHEEP and FIXIT have been developed using the DWARF software [6].

KHARMA: It is an open architecture software developed by the GVU, Georgia Institute of technology. It is based on KML (Keyhole Markup Language), which is a type of XML notation for expressing geographic annotation and visualization. It consists of three major components, channel server, tracking server and infrastructure server. KHARMA is suitable for geospatial MAR applications [6].

ALVAR: It is a client-server based software platform. Developed by VTT technical Research Center, Finland. In ALVAR, the rendering of virtual contents and calculations are outsourced to server to leverage its powerful rendering and computing capabilities. Images are sent from the server to the client side to render onto the real world. It supports both a marker and markerless tracking. ALVAR was used to develop several MAR applications in plant life management, retail and maintenance fields [6].

CloudRidAR: It is a cloud-based architecture software platform. CloudRidAR provides a local rendering engine, for rendering AR content in cases of low requirements. The user's interaction is recorded on the local device and uploaded to the cloud [6].

ARTiFICe: It is a software platform used to develop distributed and collaborative MAR applications. It allows multiple user collaboration, for example, multiple users can focus on the same physical area or the same AR content is rendered on different physical scenarios. ARTiFICe is implemented in several desktop and mobile platforms [6].

Open source frameworks: There are several other open source frameworks available from developer communities. Few are listed below [6].

- AndAR – It is a framework to enable Augmented Reality on Android platforms [6].
- DroidAR – It is a framework which supports both marker-based and location-based applications [6].
- GRATF- It is a framework which provides recognition, localization and pose an estimation of optical glyphs in video files and images [6].

Table 2: Comparison of different software frameworks source: [6]

Software	Programming Language	Rendering Language	Auxiliary Tools	Tracking & Positioning	Device Support
Studierstube ES	C++	OpenGL/ES	Authoring tools (APRIL)	ARToolkitPlus [162]	Windows phone / Android
Wikitude	HTML & Javascript	Unity 3D	Cross-platform deployment		Windows phone / Android / iOS
Nexus	unknown	unknown	AR language (AWML)	external sensor system	Portable computers / handheld devices
UMAR	Web scripts	OpenGL ES[a]	no	ARToolkit [154]	Symbian mobile devices
Tinmith-evo5	C++	OpenGL	no	OpenTracker [150]	Portable computer
DWARF	C++ / Java	VRML/ OpenGL	Profiling/ debugging tools	self-contained	Portable computers / PDA
KHARMA	KML& Web scripts	OpenGL ES	Authoring tools (KML)	GeoSpots [161]	handheld devices
ALVAR	C++	third-party graphical libs	camera calibration, basic filters	ARToolkit [154]	Portable computers / handheld devices
CloudRidAR	C++	third-party graphical libs	no	OpenCV	Android
ARTiFICe	C# & C++	Unity 3D	multiuser support	Kinect	Android & iOS
AndAR	Java	OpenGL	no	ARToolkit [154]	Android
DroidAR	Java	OpenGL	no	self-contained	Android
GRATF	C♯	Direct3D	Prototyping /debugging tools	glyph recognition [163]	unknown

6. CONCLUSION

This paper gives a brief introduction about Mobile Augmented Reality. It defines what Mobile Augmented Reality [MAR] is and what are its challenges and concerns. It describes the generic framework required to develop an Augmented Reality application. We also discuss the existing Mobile Augmented Reality application available in different fields such as gaming, medical, military and advertisement and promotions. We have enlisted the different available Augmented Reality software platforms.

Cloud computing will play an important role in the future development of Augmented Reality applications. It will become a new trend and become a key role in developing MAR applications, since the cloud will undertake the heavy computational task, thereby saving energy and extending the battery life of the mobile device [6]. Cloud services can operate as caches, decreasing the computational cost for both cloud services as well MAR applications. Mobile cloud computing seems as a promising new technology for promoting the development of MAR applications [6].

There seems to be a lot of future scope for Mobile Augmented Reality applications provided we eliminate all concerns and challenges. Privacy is one of the major concern for Augmented Reality. For example, pointing your phone to someone’s face which automatically pulls up their Facebook page could make some people weary [1]. Even the user’s data such as the location of the user and personal information about the user present on the mobile device can be compromised while using an AR application. We hope more research on the topic will lead to the development of amazing Augmented Reality application without compromising user’s privacy and comfort [2].

7. REFERENCES

1. Tim Pedure. (2017). Applications of Augmented Reality[Online].
Availabe: https://www.lifewire.com/applications-of-augmented-reality-2495561

2. Junwei Yu, Lu Fang and Chuanzheng Lu. (2016). Key technology and application research on mobile augmented reality[Online].
Available: http://ieeexplore.ieee.org.libaccess.sjlibrary.org/document/7883129/

3. Stan Kurkovsky, Ranjana Koshy, Vivian Novak, Peter Szul. (2012). Current Issues in Handheld Augmented Reality[online].
Available:http://ieeexplore.ieee.org.libaccess.sjlibrary.org/stamp/stamp.jsp?arnumber=6285844

4. Zunaira Ilyas Bhutta, Syedda Umm-e-Hani, Iqra Tariq. (2015). The next problems to solve in augmented reality[Online].
Available:http://ieeexplore.ieee.org.libaccess.sjlibrary.org/stamp/stamp.jsp?arnumber=7469490

5.Qingfeng Zhang1 , Weilong Chu1 , Changhong Ji2 , Chengyuan Ke3 , Yamei Li1. (2015). An implementation of generic augmented reality in mobile devices[Online].
Available: http://ieeexplore.ieee.org.libaccess.sjlibrary.org/document/7065112/

6. Dimitris Chatzopoulos,Carlos Bermejo,Zhanpeng Huang,Pan Hui.(26 April 2017). Mobile Augmented Reality Survey: Fom Where We Are to Where We Go [Online].
Availale: http://ieeexplore.ieee.org/document/7912316/