Preserving Cultural Heritage with Mobile Augmented Reality – A survey

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ABSTRACT

A worldwide trend is the inclusion of multimedia in cultural heritage(CH) for preservation. This will increase the user perception as well. So the Mobile Augmented reality(MAR) technology is very much used in this respect. This paper survey the state-of-art of application of MAR in CH(MARCH). Besides, a comparative analysis of the different frameworks is done. Finally, this survey gives future research direction in this field.

Keywords: Mobile augmented reality, Cultural Heritage, Registration, Tracking, Interaction, AR application, AR display

1 Introduction

Presently in the modern technology era, the term Augmented reality, Cultural Heritage [51] and Smartphone (mobile device) are highly connected in the field of Cultural Heritage for preservation, education [57], and entertainment. Augmented reality is the superimposition of perfectly aligned computer-generated virtual content in a real scene in real-time to enhance the perception of the user. In 1997 [3] Azuma defines Augmented reality and in 2001 [4] they redefine it with the following properties a) combines real and virtual objects in a real environment, b) runs interactively, and in real-time, and c) registers (aligns) real and virtual objects with each other.

One of the modern research topics is Augmented reality due to its applicability. It gains huge popularity due to enormous applications in almost all the modern fields like tourism [18] [60], medical, defence, and many more [3]. one of the major fields where AR has a huge application is in Cultural Heritage.

The research started in Augmented reality from the date back to 1960[1]. After the survey done by Azuma in this field in 1997 and discuss the future scope of application of AR in a different field. And then there is much development are made in this field still date. Currently, there are many mobile apps as well as web-based AR applications in the field of cultural heritage. It starts with a backpack computer as a processing unit, a low-speed network, and a 3D graphics card.

Cultural Heritage is an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions, and values. It gives people a connection to certain social values, beliefs, religions, and customs. It allows them to identify with others of similar mindsets and backgrounds. Cultural heritage can provide an automatic sense of unity and belong within a group. It allows us to better understand previous generations and the history of where we come from. According to UNESCO, the Cultural heritage is divided as shown in figure 1.

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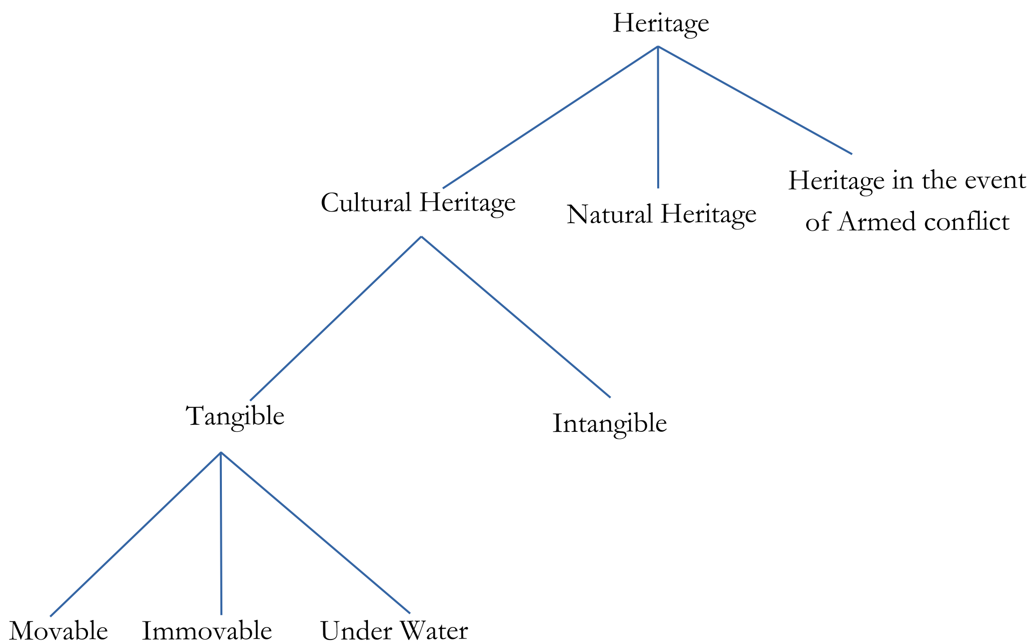

Figure 1: Classification of Heritage

Tangible CH refers to those significant places that advocate the country's history and culture and is having three types. Whereas intangible CH refers to those aspects of a country that cannot be touched or seen i.e. oral traditions, performing arts, rituals.

Movable CH is the cultural artefacts that may move from one place to another place such as paintings, sculptures, coins, manuscripts. Immovable CH like monuments, archaeological sites, and so on, can't move, and Underwater CH [61] like shipwrecks, underwater ruins, and cities. On the other hand, n**atural heritage refers to** natural sites with cultural aspects such as cultural landscapes, physical, biological or geological formations, and Heritage in the event of armed conflict.

There are huge importance and significance like historical, social, aesthetic, and scientific cultural heritage in our life. It is a great part of the tourism industry, which will earn revenue for a country. So if we can enhance the user's view, they can learn easily about the heritage and get entertained. With that more revenue will be generated as well as CH will be preserved. That is also much necessary for both the tangible and intangible cultural heritage perspective. So is there any technology by which we can enhance, reconstruct the CH site? Yes, the answer is Augmented Reality.

By mixing up the virtual object with reality AR in the modern era, the cultural heritage like the historical site [58], buildings, and artefacts and which were damaged to be reconstructed, enhanced, and preserved. It increases the user perception and people easily view and learn unknown ruined historical site and which is practically and physically almost unavailable. Moreover, this will entertain all users.

The next important things are the interactive device. Is there any single, lightweight, portable device that can be used for input, output, and has the processing capability to view and interact with the ARCH system? This is the smartphone. So the App based or web-based ARCH is run on a single mobile device. So the Mobile ARCH (MARCH) is an interesting area for the researcher.

The main objective of the paper reviews the current state of the art of MAR application in the field of Cultural Heritage. We also go for a comparative study of the existing framework and the difficulties and the limitations of the existing technology which will show the future direction of work. Thus we will provide the state of the art of the application of MAR in cultural heritage, comparative analysis and find the difficulties and limitation which will help the researcher to know the future scope research of this field. The remainder of this paper is as follows: section 2 describes the literature review, section 3, 4 and 5 gives an overview of fundamental issues (registration. Tracking, interaction interface and display) regarding MARCH. A detailed comparative study of the existing framework is given in section 6, section 7 describes the discussion of current issues and future scope of work, and ends with a conclusion in section 8.

2 Literature Review

The main motto of this paper is to review the research work published in the field MARCH (Mobile Augmented Reality in Cultural Heritage). From the survey we found, many papers published in this field. Broadly we can have categorized it in three perceptive: enhancement [14] of CH site, reconstruction of it, and combination of reconstruction and enhancement.

The concept of AR comes from virtual reality. In 1994, the Virtuality Continuum tried to differentiate between the virtual, real, and augmented environments [2]. The first outdoor AR application system is developed by Steven Feiner et. al. They developed a prototype system for University campus information called **T**ouring Machine(TM) that replaces the real world with augmented reality [6]. In this work Authors emphasizes combining the different display and interacting devices, presenting the combined information (real and virtual) in 3D real space, and help the outdoor users for moving the large campus in their footsteps. A head-tracked, see-through, head-worn, 3D displays and an untracked, opaque, handheld, 2D display with stylus and track-pad are used. The system uses COTERIE software.

A few years later, another system, called MARS was developed for navigating and delivering location-based information [7]. This system is an advancement of the previous one(TM). Compare to the previous system it uses the see-through and hear-through head-worn display and map-based hand-held display and a stylus-operated computer. This application was for indoor and outdoor users. It overlays not only the text(TM) but also audio, static images, video, 3D graphics, 360-degree surround-view images, and Java applets in the real world. The 3D color clear view was available whereas in TM the 3D view was gray and brightness was low.

Augmented Reality-based Cultural Heritage On-site GUIDE(ARCHOGUIDE) is the first project that had done in the field of cultural heritage in 2001[12]. The main objective was to on-site help and Augmented Reality reconstructions of ancient ruins, based on user's position and orientation in the cultural site, and real-time image rendering for applications ranging from archaeological research [27] to education [66], multimedia publishing, and cultural tourist. They also recreated the roman athlete of the ancient Olympic game competing in the stadium.

In 2005 F. Fritz, A. Susperregui, and M.T. Linaza developed a system called PRISMA for enhancing Cultural Tourism experiences with Augmented Reality Technologies in which the users can view the multimodal information of monuments and historical buildings in the city through the video-through display [9]. ARToolkit [35] software framework and OpenGL graphics Library is used. VRML is used to import the 3D, 2D, and animation from the database.

In the same year Develop LAMP3D (Location-Aware Mobile Presentation of 3D content) system for tourists, they can easily obtain information on the objects they see in the real world by directly selecting them in the VRML world by using a pointing device [11]. The position and the orientation are calculated by GPS.

In 2006 in IEEE Workshop an AR framework is proposed in which all the components in the outdoor are merged to a single portable device called PDA [10]. So the tracking, input, output, the processing is embedded in a single device. The device processing speed, Battery power, and weight were adequate. The touch screen of it is very useful for the untrained user. After that, the true MAR (mobile AR) comes into the scenario. In this paper, they build a library called Klimt which is having many missing features of OpenGL and WGL for 3D rendering in PDA. Marker-based tracking is done by the built-in camera and the system is run in ARToolkit. Next in 2009 [13], 2010 [59], and 2012 [62], an AR system is developed for presenting remote cultural heritage sites in a museum. The remote excavation site with its artifact enhanced by AR information superimposed on a large-scale photograph of the original site [13]. They use two video-through devices to view the information overlay in the background image.

In 2012 location-aware historical tour guide is developed by MAR with historical photographs and information of Trondheim [20]. The information is accessed by POI, clicking on the photo and from the map. One of the main features of the system is to access the detailed information of a picture and can impose a timeline as a filter i.e. for a particular decade. Over it, they also build a Technology Acceptance Model with five features, perceived usefulness, perceived ease of use, perceived enjoyment, behavioral intention, and individual behavior. A survey done by many questionnaires found that the MAR is an interesting technology and well excepted by the users.

A reconstruction procedure of a ruins cultural heritage site of the historic city center of Bruno (Czech Republic) is described in 2016 with the help of mobile augmented reality from its past photos and historical paintings (church and administrative buildings) [15]. Real-time tracking is done by both computer vision techniques and sensor-based. Zang's algorithm is used for camera (pinhole) calibration [22] [21] and distortion estimation. By the Levenberg-Marquardt optimization algorithm, the minimal re-projection error is computed. The features from the frame are detected by Oriented FAST (Features from accelerated segment test) and rotated BRIEF (Binary Robust Independent Elementary Features) (ORB). Next, the texture and the triangulated mesh [23] [24] [25] is generated. Now from a series of photographs 3D model is generated by photogrammetry software. The sensor-based technique used GPS. By comparison, it is found that the Sensor-based approach is more accurate than the computer vision technique. Lastly, they evaluated the system by surveying with users and found the system is the ease of use, ease of learning, satisfaction, interaction is good and the system is more attractive to the female user than male.

In the next year with the help of virtual and augmented reality, a system is developed to view the Roman Theater at Byblos by reconstructing it from its existing structure [17]. In this procedure they first create a 3D computer model of the existing structure by extracting a 3D point cloud, fitting geometric primitives to it, and texturing. Since the existing structure was abolished the well-known Vitruvian model is used to recreate the structure. And it is having similarity to Roman and Greek theater. By comparing the existing structure with other similar structure a digital computer-aided structure of Byblos Theater, including details regarding the cavea, scaenea Frons, pulpitium, niches, columns, and doors are formulated. Rhinoceros 3d software is used to create the 3D model of Byblos theater. The exact reproduction of the existing ruins is done by the pose tracking method and parallel tracking and mapping method. They used Unity3D software for creating the virtual theater and then it will be superimposed on the existing structure and then Oculus Rift is used to view the entire region. A* path planning algorithm is used to guide the user.

In 2018 to view the gradual change in the city center of Basel they design an application called GoFind[19]. It is having an AR interface by which the user can retrieve the location-based historic data of the city. Through the interface, the user can give a Spatio-temporal query and view the augmented seen. Users can also move freely through the city and when he reaches the vicinity of a historic place it gives notification about the place. The user can view the semi-transparent historic image overlay on the scene capture by the user's smartphone camera or it can view the historic image in the real space. The retrieval is done by the vtrivr retrieval engine and used Unity3d for virtual abject and Google ARcore2 as AR platform.

Publius Ovidius Naso(Ovid's) was an ancient great Roman poet. In 2019 a system is designed to recreate his life with virtual content and superimposed in the physical space where he had lived [28]. It representing the 3D model of Ovid in three stages of life, (a) as a child in Sulmona, where he born (b) as a famous poet in Rome where he spent most of the time in his life, and (c) as an exiled person in Tomis, where he died. Google Tango [43] technology is used for motion tracking, area learning, and depth perception [50]. The virtual 3D characteristics of Ovid's model in a different phase of life-based on his physical structure is created by MakeHuman and Blender software, and Adobe Maximo is used for animation. Photogrammetry and Autodesk 3D Studio Max software are used to create the Roman house for placing them in the actual position of historic ruins Roman houses. These virtual models are integrated into MAR by using Unity3d software. The view of the MAR is consisting of (a)he is writing the poem by sitting in the room, (b) he is walking in front of his house in childhood and reciting a poem, (c) he is wearing the Roman cloth in adult and reciting a small part of his work. The system is an evaluation done and found the overall performance is satisfactory.

In 2018 a MAR system is designed and develop for Recreating some of the lost treasures of Malolos City, particularly some selected lost buildings of the Kamestisuhan District [19]. It uses three types of markers for tracking, environment, object, and image. When the marker is scanned by a smartphone camera 3D virtual object will align in its position. A different model is used to recreate the buildings, like range based modeling, image-based modeling, photogrammetric technique, and combination technique. Then registration of virtual objects, rendering, or animation is done. Finally, the position and orientation are done. SketchUp software is used to recreate the model of the building. The system runs on Vuforia, an AR SDK that uses Computer Vision technology to recognize and track planar images and simple 3D objects in real-time. For evaluating the system, they take the feedback of several users of different sex and depending on questionnaires its proves that the system is efficient for AR view in real-time.

In 2016 a game-based tour guidance system called MAGIC-EYES on historic relics based on MAR is designed in the relic park of Yuanmingyuan [16]. There are eight scenic spots and the system will guide the tourists to move freely in all spots. The user's location is determined by the plaques, stone tablets, patterns of buildings, and geographical location information. which is then combined with AR-based interactive games and users can become familiar with the geographical environment and have a touch on the traditional Chinese cultures. The camera, gyroscope, and GPS are used to identify the images of recognizable objects, the viewing direction of tourists, and the geographical location information respectively. The system is evaluated by 12 users and they agree that the system is useful for guiding them.

3 MAR in cultural Heritage

The application of the AR in the CH field started with many heavy devices that have to be carried by the user. But with the advancement of technology these different devices merge into a single, lightweight portable device, i.e. smartphone, tablet, etc. Presently the smartphone is having high processing power. It is embedded with many tracking sensors like cameras, IMU (Inertial measurement unit). It is having good battery life and it is used as input as well as output devices. So the ARCH is converted to MARCH. Again most people are carrying the smartphone for their purpose and they are familiar with how to operate it. So in place of many devices used earlier, converge into single, smart, interactive devise. Over it there are many issues that we found in the literature survey which are related to MARCH are as follows

3.1 Registration

In AR the virtual contents are overlaid on the real-world objects. So proper positioning of the virtual content in the real object is very much important when the user's viewpoint remains fixed. The process by which the computer-generated virtual content is aligned in a proper place in the real world is called registration [5]. In this process, the key features of the image in the physical world are identified to align the synthetic contents. It is the task of computer vision technique. Registration also can be done by pixel-based and phase correlation methods. In this case, a sufficient number of the calibrated image are stored and indexed in the database [52] [32].

3.2 Tracking

It is a technique by which the virtual contents are properly aligned in a real scene when the user viewpoint is continuously changed [32]. Two types of tracking are there, Position Tracking (x, y, z) and orientation tracking (R, P, Y). Position tracking is done by Differential GPS [26]. The orientation tracking is done by the inertial sensor (accelerometer, gyroscope, magnetometers), Magnetic tracker, optical tracker, ultrasonic tracker, and mechanical tracker. Figure 2 shows a different tracker. The tracking in the field of cultural heritage is mainly done by the optical sensors [30] [31] [32] and sometimes by the hybrid sensor (inertial sensor and optical sensor). The inertial sensor and accelerometer is a solid-state sensor, used to measure the acceleration in three orthogonal directions (OD), gyroscope used to measure the angular velocity to three OD, and magnetometer senses the earth's magnetic field in three OD [55].

3.2.1 Optical sensor-based tracker

Optical tracking is very much useful for AR in cultural heritage application because the images of the environment are needed for augmenting it [33]. The same image once taken for augmenting will be used in tracking. The smartphone is having an inbuilt camera and video-through display. It provides precious alignment of video and the virtual content. It can track the different features of the environment by using many computer vision algorithms that respond in real-time. There are different types of optical tracking systems as shown in figure 2.

3.2.1.1 Marker-based tracking

A distinctive static image that can be recognized by scanning through the camera via AR application is called the marker. A marker is an image that is used to determine the pose of the camera [55] [56]. In this tracking after recognizing this image by computer vision algorithm, all the virtual contents will appear and align perfectly in the real scene in real-time. It can also be done by cloud-based, like a square marker in ARToolkit.

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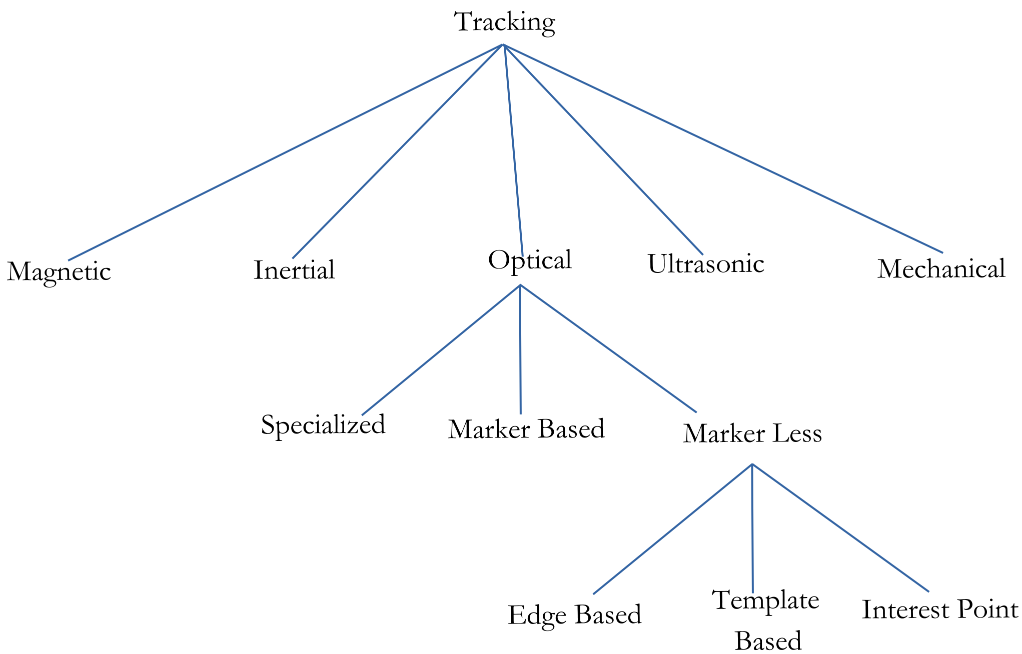

Figure 2: Type of tracking

3.2.1.2 Marker-less tracking

In this method, the tracking is done by recognizing known features of the environment [53]. No predefined marker is not used. In this case, the features must have the texture so that these can be easily recognized by the computer vision algorithm. This can be done by edge-based, Template-based, and Interest point-based. This type of tracking is done in the Vuforia platform.

3.2.1.3 Unprepared/specialize tracking

This tracking is done in an unknown environment. This tracking is much more difficult. For correct alignment of the virtual content, it demands accurate measurements of the six-degree of freedom (6DOF) of camera pose, three-degree of freedom (3DOF) for the position, and three for orientation relative to the world coordinate system. So the hybrid tracking system is best suited in an unknown environment [55] e.g. SLAM tracking [17]. Next, we want to discuss inertial tracking and hybrid tracking which are also useful in this context.

3.2.2 Inertial tracking

This tracking is done by mainly two sensors, (a) an accelerometer, which is a motion sensor, and (b) a gyroscope, which is a rotation sensor. By using this sensor, the position, orientation, and velocity of the moving object can be determined. This tracking method has high update rates with low latency and it is inexpensive. But it suffers from measurement errors when the rotational changes are very small. So it alone cannot track accurately. By combining other tracking methods, it will give a better result. And then the hybrid tracking system comes into the scenario.

3.2.3 Hybrid tracking

The sensor of a single type is not well suited for tracking. But if we combine their function then we get a good result. Hybrid tracking has many groups like (a) GPS, electronic compass, and inertial sensors (b) inertial and optical sensors [Azuma et al., 1999], (c)magnetic and vision-based [Auer and Pinz, 1999]. The smartphone which is used now a day in the MARCH field uses many types of sensors. Among them, the combination of optical and inertial sensor is best suited for hybrid tracking in MARCH.

4 Interaction technique

The next important aspect in MARCH is the interaction technique ie how users will interact with an object in the AR environment more naturally.

4.1 Tangible interaction

This is an interaction technique by which users can interact with the physical form of digital information in MARCH by touching or grasping the object. The tangible user interface (TUI) is now capable of seamless coupling of the physical objects and the virtual data. TUI is connecting the digital with the physical world. One example is the touch screen. The MIT Tangible Media Group, headed by Hiroshi Ishi is continuously developing and experimenting with TUIs including many table-top applications [collected from Wikipedia]. The usability (easy to learn and easy to operate) and the user experiences (user can interact physically with the virtual object) are much better in TUI.

4.2 Collaborative Interaction

When multiple users want to share simultaneously the real world around them and the virtual contents then collaborative interaction is required. The main issue here is the precious registration of both worlds and the multi-users.

4.3 Sensor-based interaction

Sensors devices are used in interaction. The user intends to go to the system through the sensor and no direct command or touch is not needed. Speech recognition, gaze tracking, etc. are the example of that kind.

4.4 Device-based interaction

Some devices like mouse, gamepad, etc. are used to interact with the system.

4.5 Hybrid Interaction

Here the different mode of interaction is combined to increase the user experience and the usability. Which modes will be combined that are applications specific.

5 Display

There are many display units suited for the field of MARCH. These are body-worn display devices and handheld display device. The head-mounted display(HMD), eyeglass, head-up display(HUD), contact lens, virtual retinal display, EyeTap are the example of the body-worn display. The mobile phone is an example of a handheld display.

6 MAR framework/SDK:

Presently there are many Open sources and commercially available software development kits/frameworks run in different OS platforms and suited for MARCH. These are the core software engine by which the MARCH applications are created and developed. Each SDK has its features and functionality. So it is important to choose the best one for a specific application of CH. Presently discussed frameworks are used to create the application in Android, iOS as well as Windows. For helping the researcher, we will make a comparative study depending on their available features in Table 1.

ARKit [46] is developed by Apple, runs in Apple Platform, and utilizes Visual Inertial Odometry to track the real environment with enough accuracy. It can detect horizontal and vertical planes with basic boundaries. It combines different algorithms for fast and stable motion tracking, SLAM tracking, ambient light estimation.

ARCore [34] is Google's augmented reality SDK. It is running on Google smartphones and tablets. It also supports iOS and Android platforms. The most significant features are light estimation, motion tracking, and the size and location of the vertical, horizontal, and angled surfaces detection. Vuforia [44] is an AR SDK where

Algorithms of computer vision technology are used recognition and track a wide variety of images and 3D objects in real-time. It also supports markerless tracking. Localized occlusion detection is also be done. It provides APIs in Java, C++, etc. via the Unity engine. Wikitude[45] is one of the best platforms for designing MAR apps and prototypes. 3D model rendering, location-based AR, and video overlay can be done easily. It uses SLAM technology for robust object tracking, recognition, and marker-less tracking. It focuses entirely on a location-based approach to creating augmented reality applications for cross-platform MAR development and smart eye-wear devices.

Table 1: *Comparison of different SDK/framework used in MARCH application*

Table 1a:

	Vuforia	**ARCore**	**Wikitude**	**Kudan**	**EasyAR**	**Maxst**
Type	SDK	Framework	SDK	SDK	SDK	SDK
Price	Free, Comm.	Free	Free, Comm.	Free, Comm.	Free, Com	Free, Comm.
Platform Support	A, iOS, W	A, iOS	A, iOS	A, iOS	A, iOS, W	A, iOS, W
Latest Version	9.4	1.20	8.5.0	1.6.0	4.1.0	5.0.2
Developer	Vuforia	Google	Wikitude	Xlsoft Corporation	EasyAR	MAXST
SLAM	---	---	Yes	Yes	---	Yes
Sensor	IMU, Camera	Camera, IMU	Camera, GPS	Camera, IMU	IMU, Camera	Camera, IMU
Smart Glass Support	Yes	Yes	Yes	---	---	Yes
Cloud Recognition	Yes	---	Yes	—	Yes	Yes
Unity3D	Yes	Yes	Yes	Yes	Yes	Yes
Geo-Location/ Geo Augmented Marker	—	—	—	—	—	—

Table 1b:

	ARKit	**Onirix**	**Pikkart**	**Layar SDK**	**Lumin**	**AR.js**
Type	Framework	SDK	SDK	SDK	SDK	Framework
Price	Free	free, Commercial	free, Commercial	free, Commercial	free, Commercial	Free
Platform Support	iOS	A, iOS, W	A, iOS	A, iOS	Lumin OS	Web
Latest Version	4.4	2.10	1.4	8.4.4	0.24	3.0
Developer	Apple	Onirix	Pikkart	Layar	Magic Leap	Freecodecamp
SLAM	--	Yes	--	Yes	Yes	--
Sensor	Camera	Camera	Camera	GPS, IMU	Camera	Camera
Smart Glass Support	Yes	--	Yes	--	Yes	--
Cloud Recognition	--	Yes	Yes	Yes	Yes	Yes
Unity3D	Yes	Yes	Yes	Yes	Yes	--
Geo-Location/ Geo Augmented Marker	--	+	+	+	--	--

EasyAR SDK [39] is available to developers for free i.e. EasyAR SDK Basic. It helps the developer to develop the AR application in different platforms like Android with Java API, iOS with Swift API, and Windows OS. Video playback, transparent video playback, QR code scanning, and comprehensive Unity integration are the main features of it. EasyAR SDK Pro is a commercial product used by the business user. On the other hand, the EasyAR Pro package is having extra features like SLAM, 3D object tracking, screen recording, and simultaneous detection and tracking for multiple types of targets.

Kudan AR SDK [40] is a platform that supports both marker-based and markerless location and tracking requirements. The core engine is developed in C++ and possesses architecture-specific optimizations developed. The Kudan AR SDK's support native platform APIs, iOS and Android. It also has cross-platform support for the Unity game engine. By combining AI and artificial perception the surrounding world can be sensed and interact by both the eyes and the brains like a human.

Onirix platform [47] is a mobile AR development platform, developed mainly for AR-enabled smartphones and tablets and offers to the developer a fast and intuitive experience. It supports the cloud-based platform and so uses optimal resources and performance. It is having the ability to add specific POI based on location, routes, and wayfinding. This SDK is tightly integrated with native iOS and Android apps. The SDK provides utilities and libraries for simple and quick application development for Unity, iOS, and Android. This includes support and documentation for iOS, Android, associated ARKit, and ARCore libraries, with support for Magic Leap and HoloLens.

The MaxST[41] is a comprehensive cross-platform and smart eyewear products. This supports Android, iOS as well as Windows platform. It provides instant tracking for detecting horizontal/vertical planes, visual SLAM for the smartphone camera to create a 'virtual map' of the surrounding area. It also provides object tracking to import map files created by visual SLAM, image tracking for superimposing 3D content, videos and images, marker tracking and, and QR/barcode scanning functionality.

The Pickard SDK enables developers to create AR apps. It is a lightweight, simple-to-use, quick, robust, and computationally inexpensive product used for on-device detection and tracking. It will not support the Windows platform. It also enables developers to add geolocated augmented markers to develop integrated navigation services.

The Magic Leap One HUD [49] is the world's most develop AR framework. It overlays 3D synthetic imagery on top of real-world objects by projecting a digital light field into the user's eye, it is called Lumin SDK. It includes a new platform under the build window to specifically target Magic Leap's Lumin OS. Besides, the native plugins can be created by a build/packaging system.

AR.js [48] is a very fast, standard, open-source, web-based framework. It is a version of ARToolkit designed for the web browser. All web browsers having WebGL and WebRTC has supported it. Image tracking, marker tracking, and location-based AR are the main feature. By scanning the AR-Code user can reach the content without installing any app.

7 Discussion

In MARCH still, much work has been done. But up to that, many different difficult challenges have to overcome for enhancing, exploring, and reconstructing the damaged cultural site.

The MARCH application is a data-intensive, online, real-time application. As well as it needs perfect alignments of the virtual object in the real scene. The interactive interface should be very easily operable. The carried device for outdoor application should be lightweight as well as high processing capability. The generic MARCH architecture is as shown in figure 3. The different challenges are processing speed challenges, network bandwidth challenges, alignment challenges, portability challenges, interaction interface challenges, Visualization challenges, and the challenges on the battery life of the mobile device.

The real-time performance of the MARCH application demands a very high processing speed. There are many high complexity vision-based algorithms as well as image processing algorithm runs to achieve the output. Which will slow down the real-time performance and introduce delay. So it needs to develop an efficient algorithm to overcome this challenge.

The processing speed can be increased by incorporation modern computing like cloud computing, edge computing. But it demands high network speed. So the data bandwidth needs to be high. Again in the MARCH system, the mobile unit communicates with other units through wireless communication. Which in turn needs high bandwidth, uninterrupted Wi-Fi connectivity.

The next important issue is the proper alignment of the virtual content to the object of the real environment. Error in the registering and tracking cause incorrect rendering of synthetic content in the real-world object. So the problem of registering, tracking as well as calibrating will decrease the user perception. And in turn, it fails our motto. So vision-based algorithms need to be developed more accurately for proper alignment.

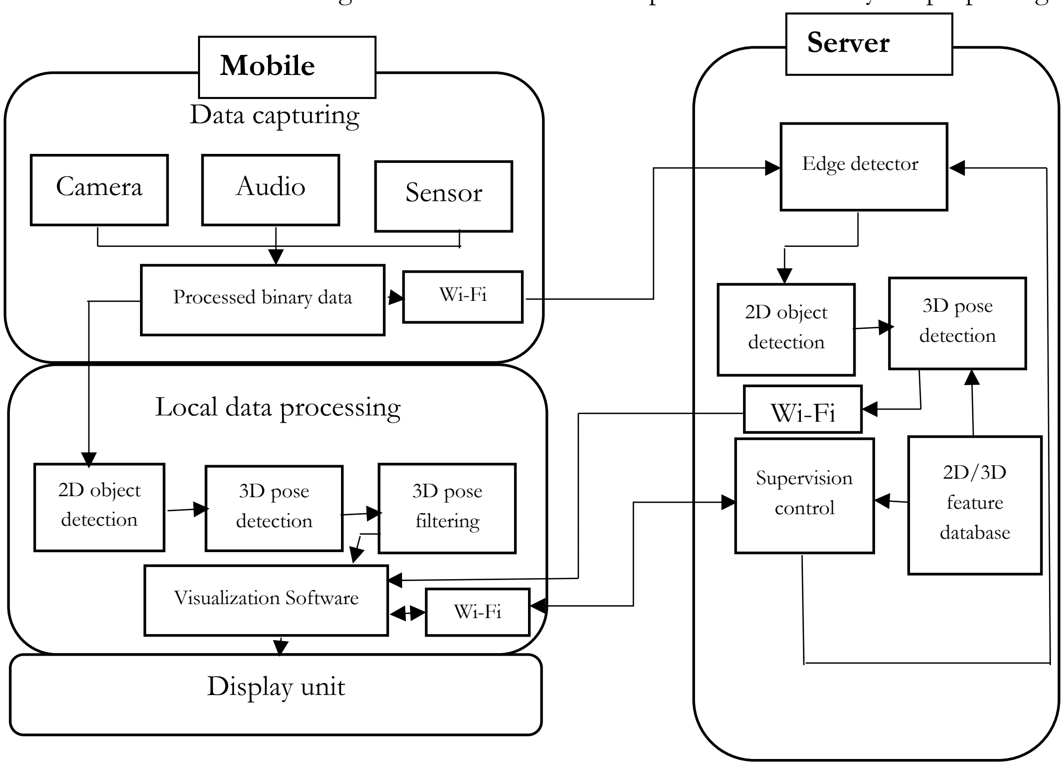

Figure 3: Generic architecture of MARCH

The introduction of the smartphone or tablet in place of heavy backpack computer, etc. in the field of ARCH reduces the portability challenges. But along with it introduced the low computational power as well as the low battery life of the device. So these challenges should be addressed.

The user interaction with the virtual and the real object simultaneously is the next challenging issue. From the survey we have seen there are many interaction interfaces like visual, tangible, haptic, acoustic, gaze, and text-based for interacting with the virtual object. The user interaction interface must be designed in such a way that it will be easy to use and it should be aesthetic. So that the user can easily interact and give their input as they want and will get their desire output. The interaction technique still suffers from many problems that have to be solved.

The next problem is visualization. The display used in MARCH monitor-based or HMD based as discussed in section 5. The contrast, brightness, resolution, field of view, etc. are the issues over here. So the illumination feature must be the same for both the real and the virtual object for the user's correct perception. Another important thing is the occlusion error. The occlusion is the process that will determine whether a part of a certain object will be visible or not in a certain viewpoint. So this is also very important for perfect perception.

8 Conclusion

In this paper, we have surveyed the many related works in the application of MAR in CH. We have discussed the main functionality like tracking, registering of virtual content, a different system like indoor/outdoor, interaction interface. We demonstrate the number of main challenges for creating the MARCH system. Also, we have discussed the different framework/SDK which is available and suited for MARCH. This survey will help the researcher to get a clear idea about MARCH. The challenges discussed in the previous section will give an idea of the future scope of work in this field.

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