Augmented Reality in Cultural Heritage Tourism: A Review of Past Study

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Abstract

Augmented Reality (AR) is a complex system that combines information technology into a range of fields, including health, manufacturing, education, architecture, and the gaming industry, by superimposing virtual material on the actual environment in real time. This article provides a survey of previous research on mobile augmented reality. The goal of this study is to provide a design paradigm for point-of-interest (POI) and annotation in location-based augmented reality (LBAR) mobile applications. In cultural heritage tourism, an augmented reality annotation is a note added to an AR platform with the intent of commenting on, explaining, or modifying a historical figure, item, or location. The phrase POI refers to items that capture the attention of visitors. This strategy capable of maintaining and avoiding the obliteration of cultural heritage through time. While users may enjoy an immersive experience with this augmented reality technology, researchers continue to face challenges with location accuracy and efficiency for digital material and annotations. Indoor tracking research has already been conducted utilizing a hybrid technique that combines marker-less monitoring with the sensors found on current cellphones. This article will examine how to design an augmented reality annotation for POI and how to improve the hybrid tracking approach on an outdoor platform for cultural heritage tourism, where technical challenges such as unexpected temperature and weather conditions, as well as environmental conditions, will be encountered. The outcomes of hybrid tracking approaches can improve the efficiency of augmented reality digital material while also increasing location accuracy.

Keywords: *Augmented Reality, Location Based AR, Cultural Heritage Tourism, AR Annotation, Point of Interest (POI)*

1. Introduction

AR is a technology that expands our physical world by adding a layer of digital information to it whether in the form of voice, video or graphics, it changes the view of the real-world physical environment by incorporating computer -generated displays that change the perception of reality we have to enhance the user experience [1]. In an AR environment, the user is presented with a real-time view that is artificially augmented with information generated and superimposed by a specific computer system, such as

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digital images, videos, texts, sounds, GPS location data, tactile vibrations, and other similar information [2]. The information about the world could become more interactive and manipulable. Compatibility between mobile operating systems is the reason why not all mobile devices can access the AR platform. This is because each operating system has its own applications developed by different companies. Three-dimensional models were created with a description of the object and a point of interest that contains information about unusual symbols or features [3].

The AR application has been used in many fields such as healthcare, architecture, education, industry and robotics, entertainment, military, and many others that required training on the job. A more recent study exploring the flexibility of AR applications in everyday human applications, limitations and also a survey of the future direction of AR [4]. The long-term cultural, historical, social, environmental, and economic consequences of tourism site destruction are well known [5]. Technical specifications on mobile phones allow digital content to be rendered with a combination of camera inputs, so applications for Android mobile phones can be developed, offering real-time, on-site 3D depiction, and visualization of historical monuments [6]. The actual world and a completely virtual environment are at opposite extremities of this continuum, with Mixed Reality (MR) in the middle [7] . Figure 1 shows Milgram's Reality-Virtuality Continuum.

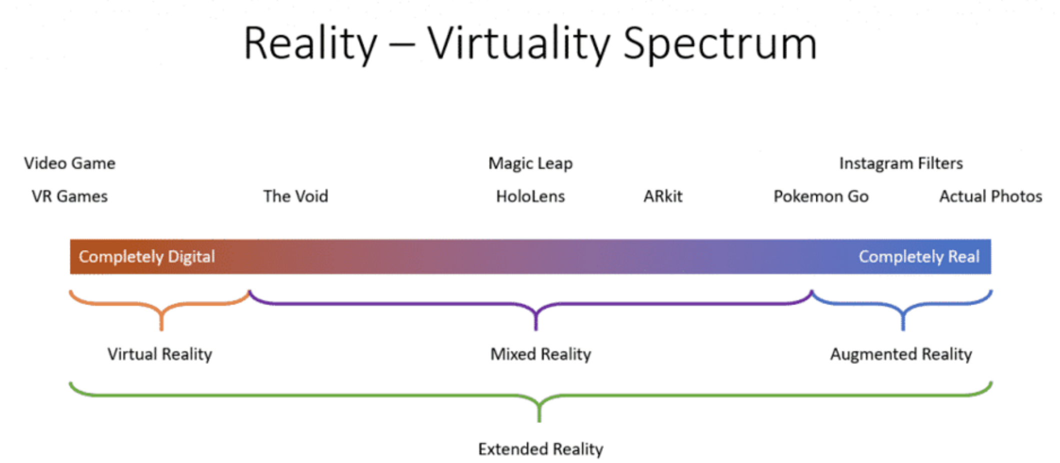

Figure 1: Milgram's Reality-Virtuality Continuum

2. AR In Cultural Heritage Tourism

AR has the potential to enhance the tourist experience by supporting them in accessing critical information, hence increasing their awareness of their visiting destination while also increasing levels of user amusement. A compelling incentive to investigate the possibilities afforded by digital technology is the preservation of cultural heritage [3]. When it comes to artificial intelligence in the context of cultural heritage, there is a significant body of work that has been done, notably in areas such as education, learning, and the enhancement of the visitor experience. Chris Panou et al. [6] has developed a framework for creating mobile outdoor augmented reality experiences for heritage sites that are located in historical locations. Even though outdoor mobile augmented reality presents a number of obstacles in terms of localization and registration, it provides a unique experience to a broader demographic. It is now feasible to construct a trustworthy augmented reality experience that aids in the understanding of historical facts because to the general availability and improvement of contemporary smartphone technology [8].

The KnossosAR application makes use of the Android AR Framework to enable the projection of AR views as well as the implementation of several desired features such as a visual metaphor of a 'radar' to identify the position of POIs in relation to the user's location and direction [9]. This technology has tremendous promise for promoting and preserving cultural heritage items. The public has begun to adopt AR technology, and they desire a communal and collaborative experience that blends education and entertainment [10]. The fundamental objective of AR technology in cultural heritage is to restore old buildings, monuments, or artefacts in 3D and bring them to life in today's society. [6]. Figure 2 shows the geolocating of the 3D model using Google Sketchup software.

Increased knowledge and usage of modern technology has transformed how visitor seek information, make decisions, purchase travel items and services, and look for and read reviews. The line between the tourist experience and everyday living has been increasingly blurred as tourism's usage of technology grows [11]. Examining the use of AR in the context of cultural heritage tourism from the perspective of internal stakeholders, for example. The study of AR has the potential to provide value by optimizing existing performance depending on visitor experience. This might mean introducing something more enticing to the market while keeping the current one [2].

For instance, examining the application of AR in cultural heritage tourism from the standpoint of internal stakeholders. AR research has the ability to provide value by optimizing existing performance in response to visitor experience. This may entail presenting a more tempting product to the market while maintaining the current one. According to [12], the enhancement of the user experience in AR interactions is composed of three major components, as seen in Figure 3. These components are the user, the user interface, and the virtual content. An AR system may be used by a single user or by a group of users (collaboratively). It is contingent upon the system's user base. The passive user will interact with the virtual contents but will not participate in them. The active user will interact with virtual contents through the user interface. The user interface defines both the ability to engage with virtual material and the manner in which that engagement occurs. [13].

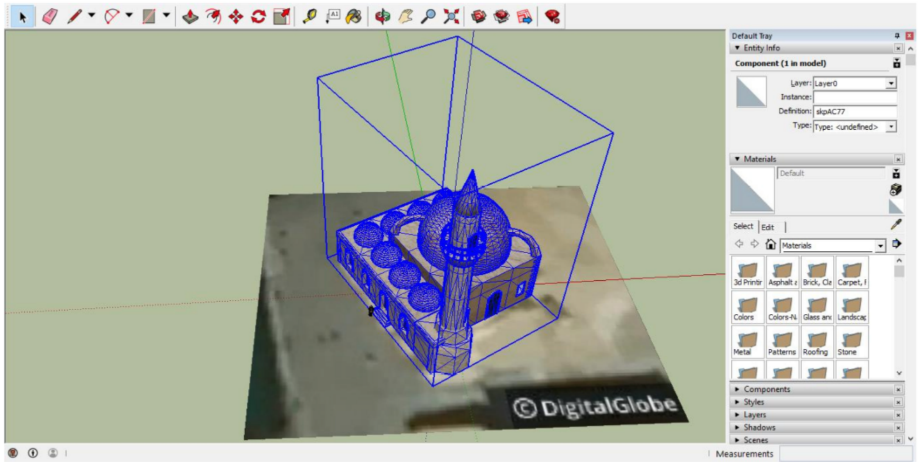

Figure 2: Geolocating Model Using Google Sketchup

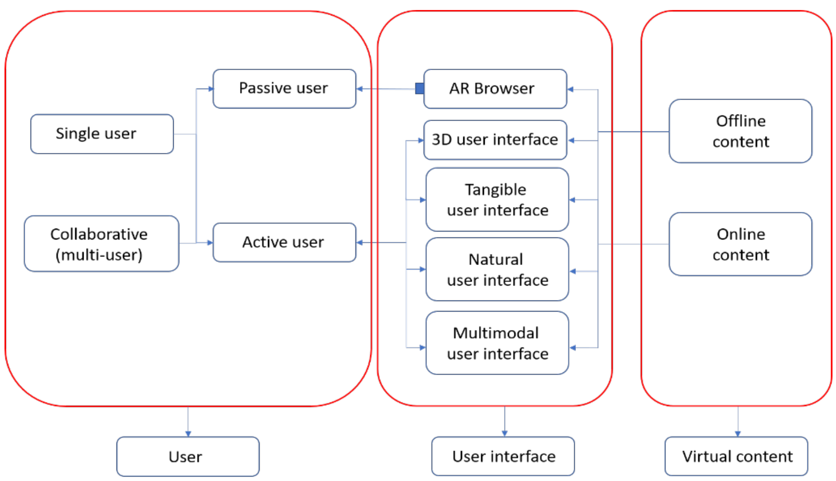

Figure 3: AR Interaction Aspects

3. Annotation in AR

Annotating AR is an attractive solution to provide individuals with more information about their location [14]. Although knowledge-based information systems are used to manage documentation operations, they do not openly or directly utilize the geometrical and visual properties of 3D data [15]. On the other hand, a number of 3D techniques make it possible to annotate the reality model [16], but make no mention to the complicated connections that exist between information and interpretation [17]. Contextualized knowledge is more fascinating and easier to comprehend, which boosts its total usefulness. The ability of AR technology to contextualize and find virtual information is a huge benefit. As a result, annotations account for a sizable portion of all AR material [18]. As demonstrated by interactive guide systems, AR annotations may be valuable in a variety of ways. Users may create, display, and preserve significant parts in this 2D or 3D annotation system by editing fundamental spatially oriented 2D images centered around a dynamic 3D representation [15].

The digitization of cultural assets typically requires the researcher to travel to the site and collaborate with the museum or cultural heritage specialist to verify that all data is captured appropriately. The data was surveyed using photogrammetry and then analyzed using Structure from Motion (SfM) software and modified to make it accessible and available. [3]. Due to the instability of an inertial sensor over time, techniques of localization based on it are inadequate [19], and location-based systems based on GNSS data would need systematic localization of projects [15]. However, this approach has a number of disadvantages, including measurement drift over time, which is associated with error accumulation inside the incremental method [8], it may impair alignment precision; on the other hand, because the photos are not geolocated, the resultant poses are stated only in a local reference system.

Heritage artefacts are an integral aspect of a country's identity. As a consequence, [20] laser scanning technology provides a cutting-edge form of data processing for cultural heritage preservation in this research on the necessity of protecting and conserving legacy assets. In the field of cultural heritage, augmented reality applications are largely concerned with mediation and dissemination. These applications, which are mostly used for tourism or virtual museums, need the preparation of digital information in advance, typically in a controlled or known setting. Consistent visualization of learning can result in superior performance to pupils who are actively engaged in learning activities. This technique has been studied by [21] and found that the passive technique will have minimal educational value when used to tourism, as the information supplied will not engage visitors in learning activities. Thus, by annotating locations of interest in augmented reality, such information visualization approaches can increase the efficacy of learning and continue to engage people in active learning. The annotation model illustrating their past condition will be exhibited in full scale and superimposed on their actual position; it must be proportional to their surroundings. This will include archival pictures, historical data, and expert estimations. As a result, exact measurements of the monument or artefact associated with the construction are necessary. If no technical drawings or plots are available, the shape and height of the structure can be estimated utilizing internet mapping libraries. [6].

The advantage of AR over books or other offline data sources is that data may be shown alongside the thing to which it belongs. The development of the mobile tour application was intended to accomplish not only tourism guide software that enables people to navigate within a specific area of interest (site-specific feature), but also to incorporate multiple items associated with POIs in order to achieve spot-specific features via augmented reality components. [21]. Annotations is a notes added to text or illustrations to clarify or remark on certain points. Applications developed by [1] can be used to annotate the digital content of cultural heritage objects by providing a menu option that enables the user to manipulate and choose elements of the item in order to modify incorrectly transcribed words. This will aid archaeologists in their future research, education, and outreach on cultural heritage assets. For public usage, it enables individuals to contribute their expertise by annotating 3D models. By navigating across geography and time in a historical location, augmented reality annotation enables users to investigate the idea of narrative mobility. Figure 4 show the MAAP Annotate application, which interacted with digital information using hand gestures.

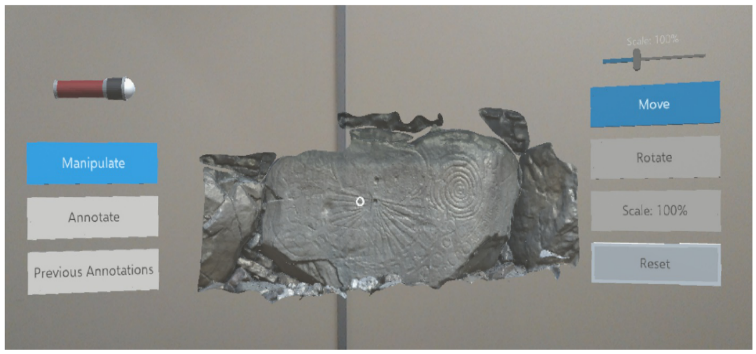

Figure 4: MAAP Annotate Application Used Hand-gestures

4. Point of Interest (POI)

One of the most effective strategies for resolving the aforementioned issues is to increase tourist knowledge by tracing their unique profiles utilizing the most pertinent and distinct data, such as physical and psychological problems, personal preferences, and likeness to others. According to [22], a point of interest (POI) is a site (for example, a restaurant, park or a monument) that is of interest to people [23]. Tourism recommendation systems may be crucial in improving user experiences and, as a result, a destination's impressions. The findings may be generated from a mix of user information and a complete description of each POI, which enables the mentioned systems to provide suggestions capable of avoiding or at the very least lessening the impact of tourist limitations or impairments throughout their tourism experience. In terms of computer representation, a POI can be described and categorized in a variety of ways [24]. The most popular methods are feature-based or functional-based.

This concept strives to improve the travel experience for physically or mentally challenged people. This is performed by specifying the functionality/accessibility thresholds required to offer tailored POI suggestions periodically. According to [24], it is possible to preserve pertinent information about visitors (and so provide an acceptable POI proposal) only if the tourist is understood in three separate contexts: a) the society context; b) the tourist context; and c) the POI context. The two primary types of entities are users and points-of-interest (POIs). Users are connected with POIs, denoted in figure 5 as l1, l2,..., l6, via their "check-in" activities, which often represent the users' preferences for certain POIs. To provide customers with POI recommendations, earlier user check-in behaviors are plainly critical [25].

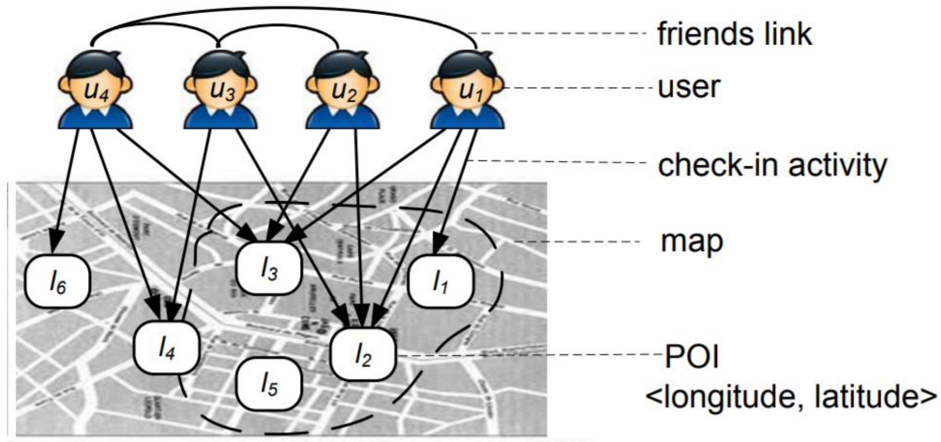

Figure 5: Graph Representation of User-User Friendship and User-Location Check-In Activity

5. Design Point of Interest (POI) Annotation

The purpose of this component of the study is to look at the tracking mechanism and design of the augmented reality annotation. This study expands on prior research on the use of annotations to engage individuals via an augmented reality platform. Some use hand gestures to engage with the object, while others employ the scan the object approach. [26] conducted research on the interaction of AR and the hand-gesture approach. Hand movements are classified into two categories: sketching in the air and drawing on the surface. It will be used to educate the augmented reality application via 3D annotations. The study's findings indicate that users prefer to operate the interface using the rotate, scale, and reset buttons. While virtual reality aims to augment a person's presence through a mix of interaction and immersion in a virtual environment, this does not mean that the digital environment accurately mimics the fictitious world [2]. Rather than that, researchers have used virtual reality and 3D data collection techniques such as photogrammetry and laser scanning to develop applications for a variety of cultural heritage users, such as virtual museums, virtual reconstruction, virtual exploration, and cultural heritage training. Virtual reality's technical and experiential qualities have added to the definitions' variety. However, virtual reality was appropriately characterized as an advanced technology that generates a digital environment in which users may interact and become entirely immersed [13]. Immersion and interactivity, as a result, are important components of a virtual reality experience. In a more restricted sense, because visual input is prioritized over other senses, immersion suggests that the visual component of the experience is the ultimate sensory consequence of VR.

A completely immersive virtual reality experience engages all of our senses and enables natural interaction with the virtual environment – just as we do in the real world. Due to the fact that processing capacity is required to view the augmented reality annotations of POI's cultural assets in an aesthetically pleasing manner, remote rendering is a frequently used technique for seeing these models on less powered devices. The application called Olympia VR demo developed by [27], demonstrates that this approach is appropriate for public cultural institutions such as museums by bridging the divide between mobile and desktop VR, thereby combining the benefits of mobile AR with the benefits of desktop VR in terms of maintenance, usability, safety, rendering performance, and graphics-quality. Users may see the high-resolution 3D scans and annotations from a new angle in this application, as well as insert virtual signs and audiovisual content adjacent to the object or structure to offer historical context. Users can save their discoveries in the application's database or share them with a colleague. Annotations such as virtual signs and audiovisual information can help individuals have a better understanding of historical artefacts and assist scholars in conducting in-depth studies on cultural heritage.

According to [28], MULTIRAMA is the foundation for a low-cost, comprehensive means of expressing digital heritage using augmented reality technology. It is a software application that was developed in 2013 by the MIT ARC (Architecture Representation Computation) Group. Three phases comprise this method: documentation, data processing and modelling, and presentation (see Figure 6). It has an augmented reality interface for representing objects or structures, as well as an easy-to-use interface and visualization tool that enables archaeologists to assess their work in 3D rather than 2D drawings. Additionally, the application gives visitors with a unique perspective on ancient architecture when visiting archaeological sites, a simple and educational medium with a user-friendly interface for youngsters and students with an interest in archaeology. Figure 7 illustrates how a POI may be navigated using an augmented reality application.

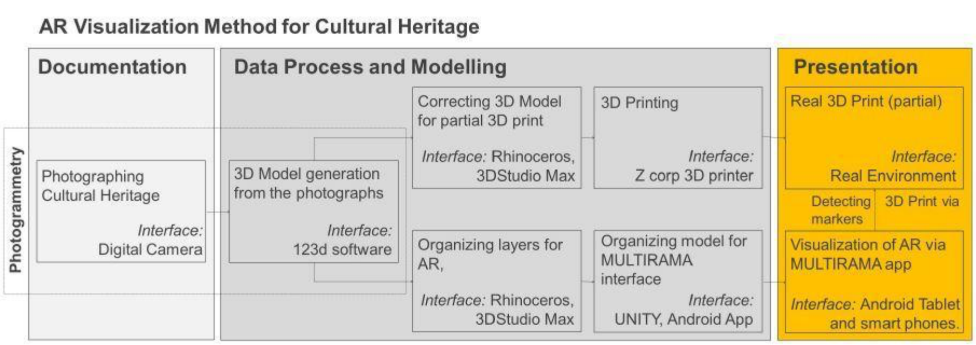

Figure 6: MULTIRAMA method application process

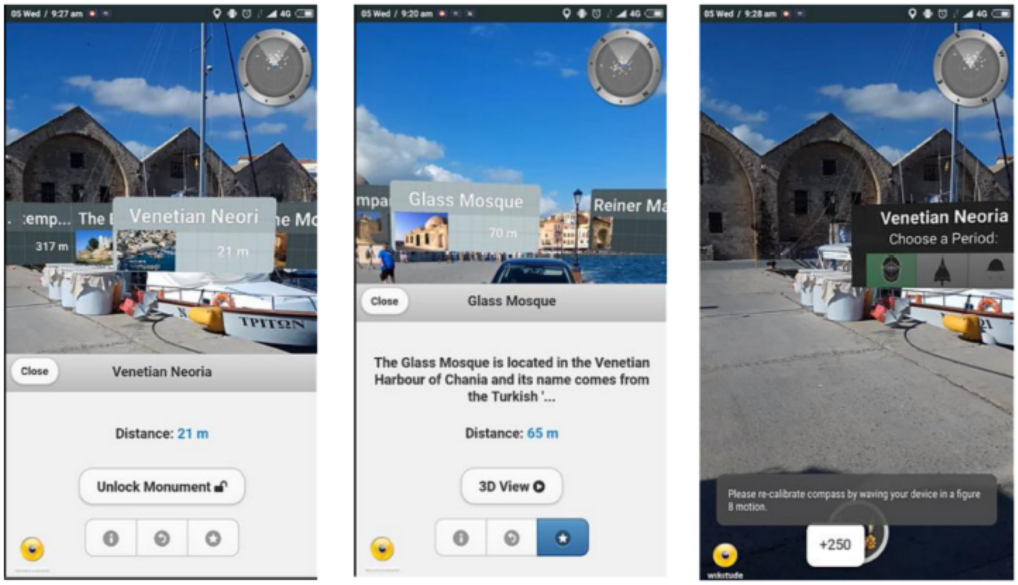

Figure 7: Navigation of POI in AR application

6. Discussion

Annotations for POIs in cultural heritage tourism are the best method in AR technology to interact with visitor's interests. It can make it easier for visitors to make a choice based on the information in the annotation provided [1]. While mobile AR has the potential to transform the way we discover POIs and interact with our surroundings, this vision is currently distant from reality due to the limited information contents supporting location-based resource discovery and route planning [22]. The majority of solutions represent POIs solely using name and category labels, allowing for only precise finding. A retrieval attempt cannot make use of more thorough POI descriptions to filter out and rank resources based on their relevance. Additionally, the type of annotation permanence employed in an application may vary depending on the program's design needs. While these dimensions are beneficial for differentiating one type of annotation from another, they are ineffective for establishing bigger patterns within the annotation space [14].

6.1 Two (2) Main Components of POI Annotation Model Development

6.1.1 Location

Increased precision of the location with the use of computer vision software, GPS coordinates, and ARCore for Android. The annotation is placed directly above the identified item, along with its height, using the software's relative ground approach [6]. This can assist in resolving the issue of annotations or objects remaining precisely in place and within a radius chosen by the user.

Direct annotation is a compilation of static data about a particular physical item. This sort of annotation, which is shown in the work on providing directions for bundling wires, appears to be most prevalent in construction maintenance and tourist applications, both of which frequently include general informative annotations [14]. This sort of annotation can be rather complicated in terms of location, but often has minimal mobility due to the fact that the information is about individual objects. Moreover, the semantic relevance is generally high, as the annotation's original purpose is to offer further information about the object [10].

6.1.2 Real-time Information

By utilizing interactive design techniques, problems associated with real-time information may be minimized. Users can access the information immediately by clicking on the annotation or button, which will open the display in the same AR application. Users don't have to use other search engines in order to obtain the basic information. Real-time information may be obtained through the use of interactive methods in which data is funneled through deep semantic ways. When an annotation is clicked, real-time and exact location information is provided without having to quit the AR application. There are 2 sub-components required to facilitate real-time information for augmented reality applications, namely:

6.1.2.1 Design

While it is crucial to have a workflow that involves all development phases, it was difficult to convey the full effect of the location-based augmented reality application's user experience [29]. Due to the industry's novelty, determining what customers desire from these applications and if they are effective at increasing the watching experience proved challenging. Defining the user engagement in an application interface is significantly more difficult than it is in conventional systems [10]. AR user interface (UI) displays an interactively manipulable menu using buttons or icons [30]. This button acts as an annotation that will display information regarding the POI and will interact to the user personalization [29]. By using the annotation method as a new way of presenting information, aspects of the user experience need to be taken into account. Many AR applications in the market have annotations but only focus on 2D text or image and it is not interactive. Annotations that have a 3d navigation theme make users feel more immersive in exploring historical materials [31].

6.1.2.2 Manipulate

It was important to enable users to view annotations in augmented reality applications from a variety of angles and to interact with them in a more natural manner. The fundamental manipulation methods supported are moving, rotating, and scaling [1]. Three of them are determined by the user's location. This is defined as the difference between the user's current position and the annotation scale's location. The translation is performed by projecting the mobile device's movement onto all of the user's axes and following it accurately. While translating, the menus are hidden to provide the user with an unobstructed view. When the AR application determines the proper position through GPS coordinates, the annotation is projected on the user interface. Regardless of how the mobile device is rotated, the annotation will remain attached to the POIs in the user interface [14].

By combining annotations with semantic-based technology, more articulated descriptions of POI locations may be created. Its formal machine-comprehensible meaning enables enhanced location-based resource identification via appropriate conclusions [14]. In fact, annotations can not only be used to clarify and expand sources of information with personal observations, but annotations can also be used to convey and share ideas to enhance collaborative work processes [15]. Additionally, annotations serve a variety of purposes, ranging from elucidating and augmenting sources of information with personal observations to conveying and sharing views and knowledge on a subject. Thus, annotations can be tailored not only to the way an individual works and a particular research method, but also to a particular method of conducting research. Figure 9 shows the design model of the annotation for POI in AR application.

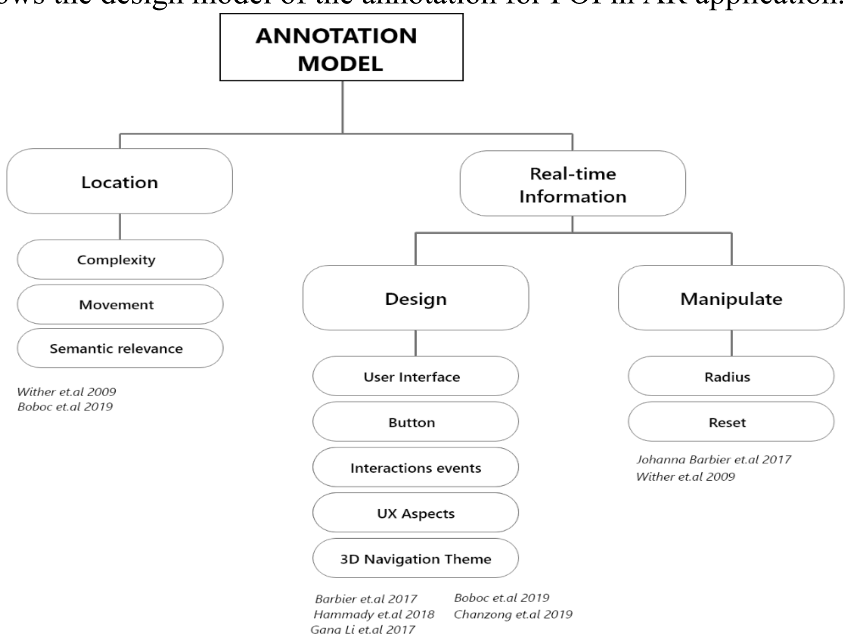

Figure 9: Model Component for Annotation Development in AR Application

7. Conclusion

This paper highlights prior research on cultural heritage tourism in relation to AR and their implementation. Visitors can travel through space and time (an immersive experience), and technology plays an important educational role by enabling instructors to easily explain and show complex facts and concepts. The combination of facts and graphics that the user may adjust interactively, as well as an in-depth experience. When users explore archaeological sites, the AR program gives a unique perspective on old buildings and perhaps a method of rebuilding previous construction. The impact of the initiative will be reinforced by its distribution among academicians, students, and professionals in related disciplines of digital cultural heritage. Along with aiding users in accessing necessary information, the augmented reality application saves the user time through the use of location-based techniques. By combining technology, users may communicate before to, during, and after a visit. This includes online and offline access, management and maintenance of virtual feeds, as well as marketing and training tools. Massive digital preservation projects have been enabled by computer graphics and media technologies, assisting in the preservation of both intangible cultural legacy and an equally crucial intellectual history. It placed a premium on user experience and usability when building a guided system for cultural assets on mobile devices. Through a series of visual cues, the results are given in increasing degrees of detail. Future developments will consolidate customizing aspects into a single engine, manage more expressive POI descriptions, integrate augmented reality more completely using computer vision technologies, and support for voice-based semantic searches via speech-to-text annotation.

8. Acknowledgement

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