LOCATION BASED DATA REPRESENTATION THROUGH AUGMENTED REALITY IN ARCHITECTURAL DESIGN

Faruk Can Ünal*, Yüksel Demir

Keywords
- location based data
- augmented reality
- architectural design

Abstract
Architects conduct site visits prior to a design activity to understand existing conditions. If the architect's position and orientation are known on site, and augmented reality system has access to a location based content database of the site, then augmented reality system can display the content in 3D directly upon the architect's view. Generally, architects use augmented reality as a visualization tool for presentation. It is also possible to collect data of a site and represent it in situ for architectural design. This paper is a survey of location based data representation in augmented reality systems to use in early stages of architectural design related to site. Initially, it describes the field of augmented reality including the characteristics and requirements. Then it surveys the state of the art by reviewing featured applications of location based augmented reality technology. Developments to the recent conditions from the first implementations have been revealed with components. At the same time, this paper aims to find common links between these featured applications and architectural site survey. Thus, it discusses opportunities of augmented reality to provide the needs of an architect as a site visit. However, it suggests which augmented reality components are more suitable in recent conditions for use in architectural design related to site. As a survey paper, it focuses on how location based augmented reality can be used in architectural design instead of presenting a model or an application.

*Corresponding Author's email address: fcunal@gtu.edu.tr
INTRODUCTION

Architects conduct site visits prior to a design activity to understand existing conditions. They also need typical activities that includes data gathering, managing complexity, mapping and analysing site. These activities are the main tasks to start an architectural design from first site visit to analysis (Anderson, 2011). There is a fundamental need for an architect to visit the site where the project will be located. The site will suggest a series of characteristics that affect the architectural design (Farrelly, 2007). The natural composition of a site contributes to make it a distinct place through topography, landscape, natural resources and climate. Overlaid on its natural composition, cultural context also influences the way that people use the site and gives its character. Cultural context includes all human-made factors like religion, art, history, settlement, infrastructure, surrounding buildings, use of materials, etc. (LaGro, 2008). These natural and cultural characteristics of site need to be sought and gathered by the architect who designs there. However, it is necessary to manage the complexity of data from different parameters and sources. The condition of any site as a record of natural and cultural data can be mapped for organized complexity. The mapping provides to have read the site, and thoroughly understand it via spatial relations in architectural design. Architects correlate data which is spatially represented in a map to properly analyse a site and put it to use in their own project. At this point, architectural design needs to take advantage of information technologies for location based data.

Over the last years, location based augmented reality came into prominence with the rise of the mobile devices, the increasing availability of location based data and the accessibility of mobile networks (Nóbrega et al., 2017). Location based computing makes it possible to link data to actual physical locations, thereby augmenting the real world with a layer of virtual information (Khan & Loke, 2017). Location based augmented reality systems can provide information about the contents of a place as the architect walks around the site. Therefore, an extensive study is carried out from augmented reality characteristics and requirements to featured applications of location based augmented reality. Firstly, augmented reality characteristics and requirements are investigated to use in detailed analysis of applications. Additionally, these featured applications are evaluated with components, significance in location based augmented reality and potential contribution to architectural design. This paper aims to find common links between these featured applications and architectural site survey. At the same time, it suggests which augmented reality components are more suitable in recent conditions for use in architectural design related to site.

AUGMENTED REALITY CHARACTERISTICS & REQUIREMENTS

Beginning in the 1960’s, augmented reality has progressed from first augmented reality prototypes (Sutherland, 1968), to coin as augmented reality (Caudell & Mizell, 1992), and the developments continues with enabling technologies. Augmented reality supplements the real environment with computer generated content that creates a seamlessly coexisting spatiality. The goal of augmented reality is to enrich a user’s perception and interaction with the real environment (Arnaldi et al., 2018). Combining real and virtual, interaction in real time and registration in 3D are characteristic properties of augmented reality systems (Azuma et al., 2001). These fundamental characteristic properties also demonstrate the technical requirements of the augmented reality system. An augmented reality system has to have a display that can combine real and virtual content, an interface that can provide interaction on a computer system and a tracking system that can find the position of user’s viewpoint and virtual contents (Billinghurst et al., 2015).
Combining Real and Virtual: Display Techniques & Types

In order to combine real and virtual content, some kind of display technology is needed. Depending on the display techniques and the position of the display, augmented reality display technologies are classified in two different approaches (Krevelen & Poelman, 2010). Table 1 shows display techniques, display types and display devices that emerged from the intersection of display techniques and types. Basically, there are three display techniques to visually present an augmented reality: video see-through, optic see-through and projection-based display (Verlinden, 2012).

<table>
<thead>
<tr>
<th>Display techniques / Display types</th>
<th>Video see-through</th>
<th>Optical see-through</th>
<th>Projection-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-attached</td>
<td>Head-mounted display (HMD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-held</td>
<td>Hand-held devices</td>
<td>See-through</td>
<td>Spatial</td>
</tr>
<tr>
<td>Spatial</td>
<td>Embedded display</td>
<td>boards</td>
<td>projection-based</td>
</tr>
</tbody>
</table>

In video see-through display technique, computer graphics are combined with captured video frames in real time. This type of technique digitizes the real environment scene using a video camera system, so that the image of the real environment can be composited with the rendered image of the virtual content which using digital image processing (Carmigniani et al., 2011). Video see-through display is the most widely used technique in augmented reality systems due to the ease of accessing the display devices. A wide range of devices, from smartphones to tablets, include a camera that can be used to capture video for augmented reality.

Another technique is optical see-through display that provides the virtual content with a direct view of the real environment. This technique uses an optical combiner to superimpose a computer-generated scene onto the real scene (Hua et al., 2011). With leaving the perception of real environment alone, optical see-through displays do not suffer from limitations in resolution, lens distortion, eye displacement, or time delay. It’s important for safety demanding applications that require a direct view of the real environment, such as medical or military application.

The third technique is projection-based display that projects the virtual content overlay onto real environment. While other techniques combine the real and virtual world view at the display’s image plane, projection-based displays overlay virtual content directly on the surface of the physical object of interest (Sand et al., 2016). While projection-based display could have an advantage of not requiring the user to wear anything, this could limit the display to be tied with certain locations. It requires a physical surface where the virtual content can be projected onto. Other limitations of projection-based display include being more sensitive to lighting conditions, and suffering from shadows created by other physical objects.

While augmented reality displays use different techniques to combine the real and virtual environment, they can also be categorized based on where the display is placed between the user’s eye and the physical object to be augmented (Bimber & Raskar, 2005). Displays can be arranged in three different types: head-attached, hand-held and spatial display (Peddie, 2017). Figure 1 shows where the displays are located with respect to the observer and the physical object with example of displays.
Head-attached displays refer to head-mounted displays (HMD), which can apply either of the three display techniques. Users mount this type of display on their heads, providing virtual content in front of their eyes. No other physical objects come between the eyes and the virtual content from the display, which supplies the virtual content not getting blocked by other physical objects (Aukstakalnis, 2016). The main advantage of head-attached display is its hands-free nature. These displays provide a high mobility and visually immersive experience.

Hand-held display describes augmented reality systems which can be hold by the user. With advances in mobile device technology, hand-held displays became powerful enough to process augmented reality visualization. From smartphones to tablets, a variety of devices have been used as augmented reality displays (Yusof et al., 2016). Hand-held displays are considered to be mobile and personal, besides sharable with others as needed. They are also more socially accepted compared to head-attached displays.

Projecting the virtual content directly onto the surface of physical object is common approach used for implementing spatial display (Marner et al., 2011). Compared to head-attached and hand-held displays, spatial displays are limited in mobility and are usually installed at a fixed location. As spatial displays tend to provide a larger image in many cases, they are more applicable as public displays which multiple users see. Spatial displays detach most of the technology from the user and integrate it into the environment.

**Interaction in Real Time: Interface**

One of the most important aspects of augmented reality is to create appropriate techniques for intuitive interaction between the user and the virtual content of augmented reality applications in real time. Depending on the interaction of augmented reality applications, different interfaces have emerged over time. There are five main ways of interaction in augmented reality applications. Figure 2 shows augmented reality interfaces: information browsers, 3D user interfaces, tangible user interfaces, natural user interfaces and multimodal interfaces (Billinghurst et al., 2015).

Information browsers are one of the representative types of augmented reality interfaces. In this interface, augmented reality displays are considered as a window into an information space, and the main task of the user is to manipulate this window to browse the information. Other types of interactivity common to information browsers includes choosing different information to view, filtering information shown, navigating into details of the information provided, and changing visualization style, etc. Most of these interactions can be
accomplished using traditional 2D graphical user interfaces and screen input (Langlotz et al., 2013). The interaction method provided is simple and easy to learn as the users can use their knowledge of traditional mobile user interfaces.

3D user interfaces adopt 3D interaction techniques to manipulate virtual objects through controllers (Kulshreshth & LaViola Jr, 2018). 3D user interfaces can provide good interactivity in augmented reality applications for entertainment, design, and training. Users can interact with 3D virtual objects everywhere in space in a natural and familiar way.

Tangible user interfaces use physical objects for representing virtual entities and information, and to bridge between the physical and digital worlds. While tangible user interfaces provide natural and intuitive interaction with digital information through manipulating physical objects, they can have limitations with display capabilities, either showing very limited information with different status of physical objects (Shaer & Hornecker, 2009).

Natural user interfaces provide the interaction of natural body motions and gestures. Sensors are used for tracking and recognizing body movements. With advance in computer vision technology, augmented reality systems became capable of recognizing user’s body motion and gesture in real time without requiring the user to wear any sensors (Kaushik & Jain, 2014).

Multimodal interfaces are used to provide richer interactivity in augmented reality applications. Main goal of multimodal interfaces is to combine different modalities of input. Among different combination of input modalities, speech and gesture recognition combined is one of the most widely and actively researched combinations (Lee et al., 2013). This type of interface offers a relatively robust, efficient, expressive, and highly mobile form of interaction that represent the users’ preferred interaction style for future augmented reality application.
Registration in 3D: Tracking

The registration in augmented reality is a process which properly aligns the objects in the real and virtual environments to each other. As users move their viewpoints, virtual contents must remain aligned with the observed 3D positions and orientations of real objects. The registration depends on accurately tracking the viewing pose, relative to either the environment or the annotated objects. Tracking is defined as the measurement of object position and orientation in a scene coordinate system (Yi-bo et al., 2008). Each type of tracking device has different level of accuracy that depends greatly on the type of system being developed. Tracking technology of augmented reality can be classified into three kinds: sensor based tracking, vision based tracking, and hybrid tracking techniques (Zhou et al., 2008).

Sensor based tracking techniques are based on sensors such as magnetic, acoustic, inertial, GPS, optical or mechanical sensors. They all have their individual advantages and disadvantages. For example, magnetic sensors have a high update rate and are light, but they can be distorted by any nearby metallic substance that disturbs the magnetic field (Pagani et al., 2016). GPS and inertial sensors are the most preferred types due to the ubiquity of mobile devices such as smart phones and tablets. These sensors are essential for detection of position and orientation in a location based application.

Vision based tracking techniques can use image processing methods to calculate the camera pose relative to real world objects. Objects are localized based on their pixel information including changes in brightness, intensity, and other local features. The advantage of vision based tracking is its high adaptability to unprepared environments. For example, a point cloud based system is able to build multiple 3D maps for an unknown environment online and the markerless tracking schemes can perform 3D registration based on image visual cues extracted from camera frames (Yu et al., 2016).

Hybrid is the most common type of tracking for augmented reality systems by combining a few complimentary tracking techniques to comprise the advantages of both and support the disadvantages of the other. Hybrid tracking systems gain data from multiple sensors to add additional degrees of freedom, enhance the accuracy of the individual sensors, or overcome weaknesses of certain tracking methods. For example, GPS tracking systems are often combined with inertial sensors and vision based tracking in order to obtain pose estimation due to their low accuracy and only providing positional information (Singh & Mantri, 2015).

LOCATION BASED DATA REPRESENTATION IN AUGMENTED REALITY SYSTEMS AND ITS POTENTIAL CONTRIBUTION TO ARCHITECTURAL DESIGN

Augmented reality allows for an on-site representation of information that is registered to the physical environment. As computers increase in power and decrease in size, new wearable and mobile computing applications became feasible, promising users access to online resources always and everywhere. Significant improvement has been obtained by new generation smartphones and tablets, which are equipped with GPS, inertial sensors, and fast network connections (Shatte et al., 2014). With these opportunities, at the same time representation of spatial data sets has become important via location based services. The ability to supply location based data to users is a key aspect to make augmented reality more practicable (Pierdicca et al., 2016). The merge of location based services and augmented reality provides a valuable addition towards the presentation of data in the real world at the
location of interest (Santana et al., 2017). Location based augmented reality facilitates a greater awareness and better understanding of the environment (Riera et al., 2014; Pereira et al., 2018).

In architectural design, site visit is a fundamental need for an architect to understand existing conditions. Site visits provide clues about how to produce a design response. Architects spend time at the project site and make visits to experience the site’s context. The architect’s main efforts on the site focus on data gathering and absorbing the sense of place. However, it is necessary to manage the complexity of data from different parameters and sources. For this reason, the condition of any site can be mapped to have read the site, and thoroughly understand it via spatial relations in architectural design. Architects correlate data which is spatially represented in a map to properly analyse a site and put it to use in their own project (Figure 3). At this point, location based augmented reality can be used to map a site, and investigate it.

Figure 3. An example of site analysis through mapping (Source: Site analysis, 2017).

The use of location based augmented reality has become common with different applications in architectural design field (Freitas & Ruschel, 2013; Sato et al.,2016; Miyake et al., 2017). It makes possible a new class of applications that exploit surrounding contents of a place as the architect walks around the site. Thus, developments from the first implementations to the recent conditions have been revealed in location based augmented reality with featured applications. The sample applications included in this survey were selected based on their outstanding characteristics and the improvements they have made. Potential contributions of these applications to architectural design are reviewed, whilst also providing an insight into attitudes towards utilising these technologies within the architectural site survey.
MARS

MARS project, acronym of “Mobile Augmented Reality System”, was one of the first outdoor projects. Feiner et al. (1997) combined wearable computers with GPS tracking to produce a number of location based augmented reality interfaces for showing information in place in the real world. The touring machine was an early prototype of an outdoor MARS that presents 3D graphical tour guide information to campus visitors. The touring machine allows users to walk around the university campus and access information via a tracked see-through display and hand-held display. The main theme of their work was presenting contextual information of the university visually connected to the physical world by combining multiple display and interaction technologies. The user is tracked through a combination of satellite-based, differential GPS position tracking and magnetometer/inclinometer orientation tracking. As the user looks around the campus, the see-through head-attached display overlays textual labels on campus buildings. When selected, each of them sends a URL to a web browser running on the hand-held computer. The browser then presents information about the campus, the user's current location, a list of departments, and a list of buildings, respectively. Besides GPS, two additional means of determining position are often employed in MARS, mostly as part of hybrid tracking systems: inertial sensors and vision based approaches. With developing researches in MARS, 3D model of a building that once occupied Columbia University campus, was overlaid on its former site. This application also presents a situated documentary of the history in Columbia campus via showing the model of a historical building at its original location (Höllerer et al., 1999).

Figure 4. MARS project as an augmented reality information guide (Source: Höllerer & Feiner, 2004).

Figure 4 shows a more recent version of the MARS, annotating restaurants in the Columbia University neighbourhood. This prototype of MARS provides an interface to a database of the restaurants in New York City. Information about restaurants is provided either via an overview 3D map, so that the user can be guided to a specific place of own choices, or as direct annotations of the actual restaurant locations themselves. Having selected an establishment, the user can bring up a popup window with further information on it: a brief description, an image of the interior, restaurant’s menu and reviews (Höllerer & Feiner, 2004).
Archeoguide

Archeoguide offers personalized augmented reality tours of archaeological sites. It uses outdoor tracking, mobile computing, 3D visualization, and augmented reality techniques to enhance information presentation, reconstruct ruined sites, and simulate ancient life. Archeoguide project aims to develop new interactive methods for accessing cultural heritage information. Site information servers administer a multimedia object database storing 2D images, 3D models, audio and video clips, and text objects on the archaeological site. These objects are organized in a hierarchical tree structure, enabling grouping according to the information they represent. Mobile units provide all information stored in the central database to the touring users and incorporate a hybrid system that contains GPS, inertial and vision based tracking for identifying the user’s view. The system filters the information through user’s position and orientation. The system automatically personalizes the tour according to its user’s profile, entered prior to the tour’s start. Based on parameters like age, interests, education, and archaeological knowledge, the system draws up a basic tour and enriches it with corresponding information. Moreover, the proposed interface allows choosing between several themes and media. Archeoguide especially provides an opportunity to visualize the 3D reconstructed damaged site (Vlahakis et al., 2002), see Figure 5.

![Figure 5. Visualization of a cultural heritage on-site (Source: Vlahakis et al., 2002).](image)

VIDENTE

With the advent of augmented reality applications running on hand-held computing devices, VIDENTE project aims to develop a mobile augmented reality solution to visualize subsurface characteristics. Unlike conventional solutions, augmented reality provides a more intuitive interface to access complex underground utility network data in the field. Users no longer have to transform map space into the real world since they obtain an integrated view of both at a time. From user’s localization, it is possible to visualize in real time 3D representation of networks of cables and pipes hidden underground. Figure 6 shows the hidden pipelines superimposed as a computer graphics overlay on the road surface in front of the user. The rendered augmented reality scenes are adjusted continuously as the user moves around. The platform comprises a GPS module and an inertial measurement unit for respective position and orientation tracking. Geospatial objects originating from an operational location based database are delivered to the client application in offline or online.
mode. The application converts the delivered geospatial data into a corresponding three-dimensional computer graphics data structure. Scenes are assembled as a video see-through at the hand-held device in real time by merging continuously streamed video footage with location based computer graphics considering the client’s currently tracked position and orientation. By means of this application, users are enabled to visualize both hidden underground objects such as cables, pipes and joins and abstract information such as legal boundaries or safety buffers (Junghanns et al., 2009).

Figure 6. Presentation of the subsurface infrastructure via VIDENTE project (Source: Junghanns et al., 2009).

CityViewAR

CityViewAR is a mobile outdoor augmented reality application for providing AR information visualization on a city scale. As an information browser, the main function of the CityViewAR application is to allow the user to efficiently access geo-located information. The application takes advantage of built-in sensors on smart phones (e.g., GPS, electronic compass and accelerometer) to provide information based on the user’s current location. To meet different needs of the users, CityViewAR shows information using different visualization methods, including AR, interactive digital map, and list views. These three views are used as the main interfaces with which user could browse through the content and information provided (Figure 7).

The application is designed to start with the Map view which is more accessible independently from the user’s location. Map view gives enough spatial context, and provides a familiar starting point. The users can easily switch into the other browsing views using icons located at the bottom right screen corner, and then access various content including historical information, images and panorama pictures (Lee et al., 2012). In the AR view mode, the application shows virtual information overlaid on a live video camera background, making the virtual content appear in the real world. This type of application shows information on point of interest (POI) in the real world. In most cases, geographical information is shown as virtual bubbles with text and images of the related POI. In addition to providing historical information about buildings, the CityViewAR application is also designed to provide onsite AR visualization of the buildings, allowing users to see a virtual 3D model of the building on the real site where it once was. This application shows that making such information easily accessible to the public in a number of formats could help people to have richer experience about cities.
Alongside development of smart mobile devices, numerous concepts, techniques, and prototypes have been introduced, focusing on basic implementation issues of augmented reality mobile applications. Geiger et al. (2014) focus on the efficient implementation of a robust mobile augmented reality engine, which provides location-based functionality. They denote this engine as AREA (Augmented Reality Engine Application). Their work deals with the development of a generic mobile application, which enables location-based mobile augmented reality for realizing applications. In order to enrich the image captured by the smart mobile device’s camera with virtual information about POIs in the surrounding, basic concepts enabling location-based calculations are developed. Figure 8.a shows the algorithm realizing the location view.

AREA has been integrated with several mobile applications such as LiveGuide. LiveGuide can be used to provide residents and tourists of a German city with the opportunity to explore their surrounding by displaying points of interests stored for that city (e.g., public buildings, parks, places of events, or companies). When realizing such mobile applications on top of AREA, it turned out that their implementation benefits from the modular design and extensibility of AREA. In particular, when developing the LiveGuide application type, only the following two steps were required: First, the appearance of the POIs was adapted to meet the user interface requirements of the respective applications. Second, the data model of AREA was adapted to an already existing one. Figure 8.b shows user interface elements in the context of the LiveGuide application and originally implemented for AREA.
BIM based AR

An advanced form of documentation is building information models (BIM), which may contain spatial information, construction schedule, and lifecycle analysis etc. Architects still have to rely on their spatial awareness to map the 2D drawings or 3D projections into the context of real 3D space, e.g. to use that information during the construction of 3D buildings on the construction site. Researchers tried to facilitate the process of mapping 2D design documentation to 3D real-world construction reality by mixing virtual information with the real environment. Meza et al. (2014), focused on how to use the BIM information and feed it into augmented reality systems. They implemented a BIM based AR system that consists of four activities: creating building information model, creating schedule, creating augmented reality model, and using augmented reality model on site (Figure 9).
Table 2: Evaluation of featured location based augmented reality applications (Source: Authors).

<table>
<thead>
<tr>
<th>Location Based Augmented Reality Applications</th>
<th>Display Technique / Display Type</th>
<th>Interaction Type</th>
<th>Tracking Type</th>
<th>Significance</th>
<th>Contribution to Architectural Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARS</td>
<td>Optical see-through display / Head-attached + Hand-held display</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+DGPS+ Magnetometer+ Inclinometer+ Vision based tracking)</td>
<td>First use of augmented reality for the exploration of urban features</td>
<td>Representation of site information</td>
</tr>
<tr>
<td>Archeoguide</td>
<td>Optical see-through display / Head-attached + Hand-held display (Pen-tablet+ Palmtop)</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+DGPS+ Inertial Sensors+ Vision based tracking)</td>
<td>Use of different data representations and enhanced database structure</td>
<td>Visualization and simulation of former condition</td>
</tr>
<tr>
<td>VIDENTE</td>
<td>Video see-through display / Hand-held display</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+Inertial Sensors)</td>
<td>Direct up to date data about the subsurface utilities</td>
<td>Presentation of hidden underground objects &amp; legal boundaries</td>
</tr>
<tr>
<td>CityViewAR</td>
<td>Video see-through display / Hand-held display</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+Inertial Sensors)</td>
<td>Information visualization on urban scale</td>
<td>Presentation of data on a city scale</td>
</tr>
<tr>
<td>AREA</td>
<td>Video see-through display / Hand-held display</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+Inertial Sensors)</td>
<td>Engine application for location based augmented reality applications</td>
<td>Editable application layout for architectural applications</td>
</tr>
<tr>
<td>BIM based AR</td>
<td>Video see-through display / Hand-held display</td>
<td>Information Browsers</td>
<td>Hybrid Tracking (GPS+Inertial Sensors)</td>
<td>Building information modelling and augmented reality system integration</td>
<td>Visualization and simulation of 4D content (Information with a time component)</td>
</tr>
</tbody>
</table>

These featured applications included in this survey were evaluated on their augmented reality components, significance in location based augmented reality and potential contribution to architectural design (Table 2). It shows that some of the components seem more appropriate to location based augmented reality systems. Hand-held displays that use video see-through display technique are mostly preferred type of display. It depends on widespread access to hand-held displays instead of head-mounted displays. On the other hand, head-mounted displays can be preferred as a natural platform with hands-free working environment in the future. This survey showed that information browsers are the most suitable representative types of augmented reality interfaces. These interfaces are designed for basic interaction tasks to view the visualized location based augmented reality scene and browse the information provided. Hybrid is the most suitable type of tracking systems to use in location based augmented reality. Reviewed applications showed that hybrid tracking based on GPS and inertial sensors is sufficient with the development of tracking technology. Furthermore, hybrid tracking can be enhanced with vision based tracking. For systems to be successful in architectural design, developers need to take into account that augmented reality components need to be compatible, widely used, natural to interact with and precisely detectible.
MARS is the first use of augmented reality with location based data for the exploration of urban features. It makes it possible to collect data of a site and represent it in real place for architectural design. This kind of application promises to make easier the design process by bringing the architect into more direct contact with the building site. They can enable architects to not only interact with surrounding contents throughout site visit, but carry out design analyses while on site.

Archeoguide introduces innovative approaches to organize multimedia objects in database for different data representations. In addition to that it can show historical information on archaeological site by use of 2D images, 3D models, audio and video clips, and text objects. It can make contribution to architectural design about visualization and simulation of former condition on site, such as older versions of buildings in view, or pictures of past events. It can also inform an architect to protect the archaeological areas on site.

VIDENTE converts location based data to three-dimensional computer graphics on a hand-held device. It provides direct up to date data about subsurface utilities. By means of this application, architects are enabled to visualize both hidden underground objects such as infrastructures and abstract information such as legal boundaries. It may allow architects to gain an immediate check of a site’s surroundings for finding the best place for architectural design.

CityviewAR is an essential application for the demonstration of information visualization on urban scale through smartphones. The main function of this kind of applications is to allow the user to efficiently access location base data in a city. It can enable a greater appreciation of a site’s context for architectural design. Most of the information needed to understand a site’s constraints and assess its merit can be provided to architect.

AREA is an engine application developed to enable location based augmented reality applications to be easily developed on smartphones. It can present information registered directly to places with point of interests (POIs). Information of POIs comes in a variety of forms, such as text, image, video, audio, or 3D model. It provides editable application layout for architectural applications.

BIM based AR focus on how to use the BIM information and feed it into augmented reality systems. The most familiar use of these applications is to overlay a real site with an intended virtual design at full scale. It can be used to present information with a time component via visualization or simulation of 4D content. This kind of application encourages architects to consider and evaluate their project site across a range of timeframes, and from multiple viewpoints. Given the data rich nature of BIM, it can be possible to perform site analysis in-situ at full scale.

Location based augmented reality systems require that the user actually be at the place where the task is to take place. Being at the place is essential in architectural site survey. In a site visit, architects do not see these locations with comprehensive information. They have to collect site data from different sources and mediums. Then all collected data needs to be managed on maps that analyze the site. It is a long process that takes time and work-force. Use of location based augmented reality systems can provide data presentation of locations as they are current condition. If a database of the environment is available, an augmented reality application can track data representations. With the use of augmented reality, an architect looks at project site and sees data directly overlaid on the site. Architects walking around the site with augmented reality systems would gain a much better understanding of
the site. The power of augmented reality systems lies in their ability to visualize normally hidden or abstract features, such as infrastructures and boundaries. In addition to that augmented reality systems can show historical information of site. By providing information in a BIM format, location based augmented reality systems provide significant contributions to site analysis in scale with surroundings.

CONCLUSION

In this paper, we have surveyed how location based augmented reality can be used in an architectural site visit. To understand the importance of location based data in architectural design, this survey is an extensive study from augmented reality characteristics and requirements to some featured applications of location based augmented reality. As can be seen, the main idea under the research is supporting architects with opportunities of location based augmented reality. Location based augmented reality has become increasingly popular in recent times due to the minimal hardware requirements, improved computational power of consumer devices, and the ubiquity of mobile devices. From this study, we have seen that hand-held devices are mostly preferred type of display with hybrid tracking. Information browsers are the most representative types of location based augmented reality interfaces. These display, interaction and tracking types can be used to design a location based augmented reality system for architectural design.

MARS, Archeoguide, VIDENTE, CityViewAR, AREA and BIM based AR projects are surveyed as a state of the art by reviewing features. We have tried to find common links between these featured applications and architectural site survey. Therefore, this paper is intended to be a first step towards establishing a model which supports architects in a site visit. An architectural design study conducted using such a location based augmented reality system shows favourable response because the users think it is easy to understand a project site than a usual visit. On the other hand, the use of location based augmented reality can make a decisive contribution to surveying project site. Location based augmented reality provides a platform to enable novel types of architectural design applications.

ACKNOWLEDGEMENTS

We acknowledge The Scientific and Technological Research Council of Turkey (TUBITAK), The Department of Science Fellowships and Grant Programs for financially supporting.

REFERENCES


