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# Utilizing "Augmented Reality" Technology to Illustrate Residential Open Space Greenery

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**Abstract**

Displaying visually assistant for research in architecture is a necessity and importance of using new technologies in this matter is inevitable. One of the main assistant for them could be analyzing the effect of non-built environment on human behavior. Also some studies use VR to analyze human behavior but all of them are implemented in lab environment and until now no study tries to examine the human behavior in a real urban context. So this survey diverse underestimated wide range of new technologies with the three-dimensional structure, and finally "Augmented Reality" is chose. Due to the implementation of AR in open spaces, some successful methodologies have been tested for accuracy of registration and City 3D-AR is selected as a practical test. Therefore, environmental factors, according to the characteristics of desired visual have been simulated and virtually laid out in Open Space of Residential Complex. Simulated factors with information of their latitude and longitude, by an interface (API), entered in the Android version of this software. By putting the smartphone in a location and angle that environmental factors have been laid out, these factors have been integrated with its surroundings and through the vent of screen mobile phone is visible. The results of the practical test show that augmented reality technology is a convenient and ideal way to visual characteristics of environmental factors in residential complexes with unique privileges such as freedom of polled individuals; a clear transition of issues and maximum similarity of the area of covered the test.

**Keywords**: Augmented Reality, Design Pattern, Sense of Community, Open Space of Residential Complex, Environmental Factors.

## INTRODUCTION

A significant increase in growth of housing by economic and social reasons was accompanied by reducing the area of residential open space. So that in metropolises such as Isfahan, Iran, 12 percent of homes and residential units below 75 square meters and about 80% of them have less than 150 square meters (URL1). By reducing the area of apartments, open space of residential complexes for performance and recreation reasons have been addressed by residents. Environmental psychologists believe that environmental factors have an indisputable effect on residents' feelings and comforts and propose that these factors should be designed in a way to be harmonized with mental and physical conditions of residents and encourage them to longitudinal residing (Kim, 2004).

Results of previous researches suggest that there is a significant relationship between environmental factors and a sense of community of residents (Kim,2001), as well as the factors of public green space, trees location, height and amount of shading of trees and stops (places to sit and talk) have more effects on the social feeling of residents. Research has focused on the environmental factors affecting social sense, but visual characteristics of these factors, as well as a variety of species and sizes and the way of putting these factors together, have not been studied. Why not check the visual features can be found in the lack of a suitable method for this purpose as saying. More conventional approaches usually have a structure of interview or questionnaire or their visual expression is a two-dimensional structure. These methods limit the identification of environmental factors and their way of a design pattern (which may also differ by a different impact on the social sense) (Seichter, 2005). Finding the effect of visual features of environmental factors on people feeling needs to find a practical way.

The dramatic developments of new technologies which are three-dimensional structure, daily discover new valves to researchers in various disciplines, including architecture. Now with the advancement of technology, the question is discussed that how visual characteristics and layout pattern of the sense of community of the environmental factors can test? In response, a way is required with three-dimensional structure and the potential ability for displaying the visual characteristics. This study seeks to examine a wide range of these technologies, to set a practical approach to the visual study of architecture and environmental psychologists. New

technologies are based on more virtual space. Influencing of the virtual world on the daily lives of people that are surrounded by cities and buildings cannot be hidden. One of the manifestations of this impact that is called "Augmented Reality" (AR) technology, has been little noticed among the architects who are experts in this field.

This paper by introducing the function of augmented reality technology in architectural studies attempts to use this technology to present visual characteristics and environmental factors and their effects on the sense of community of residents. In this section, first the notions and literature review in the area of augmented reality technology is presented and then a practical example of using this technology and its function than other common methods is discussed. Finally, the function of augmented reality technology to present collected environmental characteristics and its generalizability to other areas of architecture and environmental psychology is also discussed.

## LITERATURE REVIEW

Nowadays, the present era has named digital age (Mahmudi, 1383), an era in which architecture studies use new technologies (izadie, Fazel 1393). This approach requires a different definition of Human-Computer Interaction (Jourabchi, 1384). Changes in human-computer interaction in the context of entertainment, commerce, advertising and mass media are proposed (Chen, 2009; Zhanpeng, 2015). Many industries (IBM, Intel, Sony, Nokia, HP) that work in this field, have focused enhancing of human-computer interaction by investing heavily in the augmented reality technology (Figure 1), and they have mentioned it as a pioneer of new technology (Anders, 2007; Algfoor et al, 2015; Kolivand and Sunar, 2013).

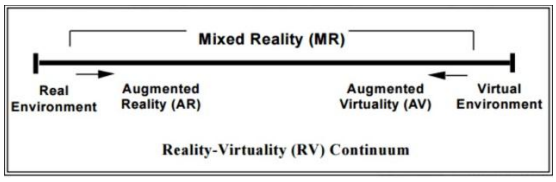


**Figure 1:** Mixed Reality (Milgram and Kishro,1994)

This technology unlike virtual reality technology which replaces the real world with the simulated environment (Steuer, 1993), attempts to combine as normal and live the real and virtual environment and create a mixture of similar to the real environment. Augmented Reality by using its developed tools adds components or information from the virtual world that is understandable to humans by computer processing (Metz, 2012) to the real environment. In order to create the perception of a camera to photograph the natural environment, powerful processors for adding digital elements and visual means to show the real environment and digital elements is required (Figure 2). In the past, in order to make this process, relatively large equipment was needed, but with advances in technology it possible in many smartphones has been placed. It consists of two main parts: hardware and software. The hardware's task is imaging, processing and displaying environments like the real environment and soft wares attempts to coordinate visual characteristics of virtual factors with their real environment.

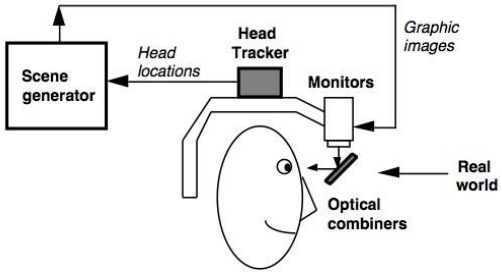


**Figure 2:** Optical see through him (Azuma,2009)

By the emerge of Augmented Reality technology in the industry of smartphones, the investment on it has increased so that the benefits of this technology exceeded $ 12 billion in 2020. Given the huge investment, academic research in this field is increasing. Including academic disciplines that have shown interest in AR technology can refer to in the fields of architecture and civil engineering (Shin, Duston, 2009). The first effort in the area of using AR in the field of architecture has been done by Sutherland (Sutherland,1968). Other researchers continued his method and they used AR for adding digital elements to the created environment. Done researchers in this field can be divided into four categories as follows according to Figure 3:

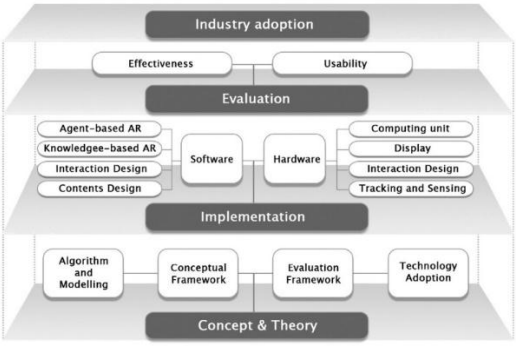


**Figure 3:** Architectural Framework of AR (Wang, 2013)

### Theory and Idea layer

Researches that are located in this layer are utilized AR technology to solve particular problems of architecture. The results of the researchers in this layer have remained on the introduction of the idea (Myers et all, 1992), and practical solutions are not provided. (Carpenter, Oloufa995). The basic properties of AR technology can be an algorithm at this stage

(Webster, 1996) that causes integration of real and virtual environments (Richards, 1994). It should be noted that Theory and Idea layer is divided into four classifications of modelling, theoretical framework, the framework of evaluation and compliance with technological (Kerr, 2011).

**Implementation Layer**

Researches that are located in this layer, in addition to introducing new ideas, practice tests are also discussed (Lee, Shin, 2010), (Chen, 2008), (Zhu, Mutka, 2005). One of the major objectives of this study is concordant with the hardware and software characteristics of augmented reality with cited architecture studies(German,2006) (Behzadan, 2007), (Yeh, 2010). The hardware includes displays, inputs, followers, and calculations (Behzadan, 2009) and the software covers the intelligent, knowledge bases and interactive design (Chen, 2009).

**Evaluation Layer**

Selected studies in this layer, after proposing and concept and impellent it in real experiment, ties to evaluate them in a sample groups (Hong, 2009), (Kamat, 2007), (Trung, 2011). Thus, this layer can provide new methods for testing the feelings of residents to specific space (Petzold, 2007), (Salim, 2011). This stage is divided into two parts, the effeteness, and usability (Dai, Dong, 2010).

**Marker Base Augmented Reality**

In this method find a location for putting the digital elements in the real world a two-dimensional pre-defined is required. After that the camera or webcam identified the given screen in a real environments, rather than this screen can add a virtual element on the screen. As a result, by rotating the screen in different directions on the screen will shift the virtual object (Figure 4). This method is much less use in mobile because of the need too many processing.

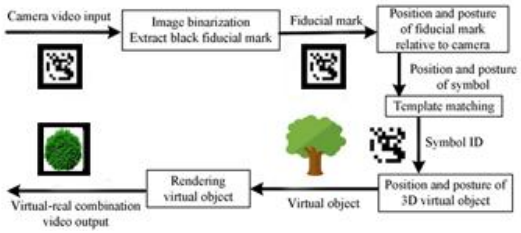


**Figure 4:** Marker Base Augmented Reality Procedure

**Marker less Augmented Reality**

In this method, unlike the followers' method, a two-dimensional pre-defined screen is not needed and to add digital elements to the real environments, the spatial information is used. This method according to the nature of out of its construction; the most interest is the researchers and developers of architectural science that is visible in Figure 5.

Figures and presented subjects by developers of architectural science have been remained mostly as an idea so that the current research attempts to come near to the reality and use them in architecture research.

**Figure 5:** Sample of AR in Built Environment (httpwww.edudemic.comaugmented/reality-in-architecture)

**Sense of community**

The word 'sense of community' refers to the common feelings of a group of people who are in a geographical location or members of a group, (Herek, 1995). Hummon (1992) states sense of community is a familiarity process of a human with a place, so that the person begins to understand and feel about the place, receives the senses about the environment and fresh feelings appear among them. Urban designers and architectures define' sense of community' as the emotions of the aesthetic characteristics of the environment, (Cross, 2001). Designers also think that a sense of community is associated with attachment of location and they believe that human beings by cultural beliefs, practices, and habits of specific events connect with place (Jackson, 1994). Topophilia is a strong sense of the place that in some cases it is applied by identity between the individuals of community and dependence on specific features of a given location (Tuan, 1977). There is a direct relationship between environmental factors and a sense of community, researchers concluded (Kingston, Mitchell, Florin, & Stevenson, 1999) and environmental features of public green space have more influence on a sense of community of residents (Duany, Plater- Zyberk, & Speck, 2001).

**RESEARCH METHODOLOGY**

Because current study ties to propose and idea and implement it in real context, it belongs to implementation layer. Those

studies with this approach must use tools that are capable of displaying and combining the three-dimensional structure of visual characteristics of environmental factors (virtual) in the context of open space of residential complex (real). First classification tools (non-followers) that act on the basis of image processing are more efficient in outdoors and short distances. But to achieve the aim of this study should benefit the tools that can be used in open space and long distances. After examining four tools from second classifications it was found that City3D-AR is more consistent with the objectives of this study, making it easier and more freedom for researchers to work.

According to this tool, first, the environmental factors (for example, a tree that is selected) are simulated in 3D Max software. The simulated tree in the centre of the residential complex of Moshtagh in the city of Esfahan is located with 32630869251 and 735622418 geographical longitude and latitude. The following output file of software and its location are linked by an interface (API) in a library in Android version; City 3D-AR software is imported.

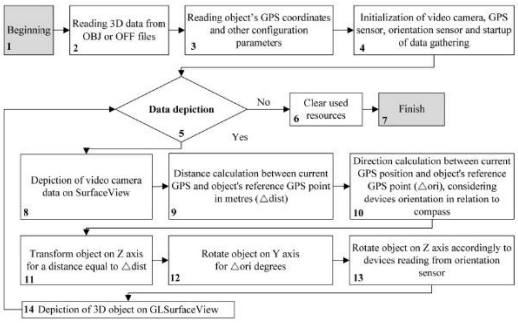


**Figure 7:** 3D-AR flow chart

After entering data, City 3D-AR software requires a reference to calculate and lay out environmental factors (Figure7). In the first stage observer's location was consistent and thus the location of reference of environmental factors was determined as an offer in Farvardin complex.

In the second stage and by moving the observer, the reference location of environmental factors must also be changed. So the reference location, the position of the smartphone was considered to update constantly the visual characteristics of environmental factors with the movement of the person that one of the important characteristics cabs is referred to the distance and the angle of person's view to the environmental factors. To calculate the distance (d) the observer was used with the following environmental factors of the key formula (Veness, 2002):

$$a = \sin^2(\Delta\omega/2) + \cos(\omega 1) * \cos(\omega 2) * \sin^2(\Delta\lambda/2)$$

$$c = 2 * \text{atan2}(\sqrt{a}, \sqrt{(1\ a)})$$

$$d = R * c$$

In this formula latitude, ω is the geographical latitude, Δ as a geographical longitude and R is the radius of the Earth (6371 km).

In order to calculate the angle of rotation and the way of attitude to environmental bodies, the north direction than the smart phone was considered as reference and the following code to calculate deformation, direction, and scale of these factors were used (Calo, 2015).

After the carried out process in accordance with Figure 8, the user by moving among open space of Moshtagh residential complex enters the centre of the space in which the simulated tree is placed by designer decision City 3D-AR software after receiving the spatial information and the rotation angle of the observer person and after doing the necessary processing, composed the given tree of the smartphone's screen with the real environment that is understandable and observable for the observer (Figure 8). It should be noted that user can observed the tree from different angles, locations and directions.

**Figure 8:** Case study of Augmented Tree to Housing Open Space

## DISCUSSION

As you can see, this technique uses augmented reality technology and its related tools attempt to provide maximum similarity between environmental factors (virtual layer) and open space of residential complex (real layer). So that the observer feels him/her inside the space and the gap between added virtual and the real environment is hidden from him/her. This happens if the autonomy for the observer is the same in augmented reality with the real environment. More autonomy observer is when the person moves easily between open space and environmental elements and rotates and the angle view of 360 degrees to the space to be created for him. So that the user can easily interact with their surroundings and to discover the witnesses in virtual space or like a real space.

This method makes the user to be questioned in real environments. Being the tested person in a real environment

unlike the laboratory environment that causes ignoring confounding factors such as temperature, sound, etc., will cause the user to get an experience quite similar to his daily activities. The same experience causes to obtain much more accurate and reliable results. In architectural studies, the similarity of the environment and natural state of the user during the test with his everyday life is important to evaluate and try to create a maximum environmental likelihood in the time of the test (Ellard, 2008).

In the conventional methods, the transmission of concept and purpose of the researchers was through the conversation that makes different images to be created and the intentions of researchers do not transfer well.

## CONCLUSION

The success of this approach and understanding of the presented topics is concluded that this technology has several advantages compared to existing methods. So that a user does not feel limitation by space and movement angle and there are no boundaries between the virtual and real elements of his vision. Another advantage of this method can be referred to be easily and accurately convey the intention of the researcher to the user. This faith makes to prevent the personal interpretations and mental of polled person exactly the given issue of researchers to be transferred to him/her, and all the variables that every day effects on his behaviour be the same in the test and makes obtaining results accurately and precisely so that so far this method is the most similar feeling to the real life of humans.

Augmented Reality technology not only can be used for presenting the visual patterns from the elements of open space of residential complex but also can be developed to other architecture spaces like the design of instructional spaces that need the test of visual characteristics. New technologies and especially augmented reality offer a suitable experience from attitude to the future researchers of architecture. Experience shows that this method can evaluate the eternal characteristics of environmental factors on the feeling of residents and create the practical knowledge in architecture area. This method helps architects to join three-dimensional virtual elements to the recreated space and uses the benefits of research and design.

It is concluded that augmented reality technology has a potential ability for production in other architecture research and can evolve the professional and research future of this area.

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