ILLUMINATION TECHNIQUES IN AUGMENTED REALITY FOR CULTURAL HERITAGE

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ABSTRACT
Augmented reality technology is becoming important in developing visual representation of virtual environment. In augmented reality environment, the most difficult problem is to render the virtual object with illumination which is consistent with the illumination and shadow of the real environment. Without the consistent illumination, the realism of augmented reality environment will be reduced. Recently, a lot of researchers developed new techniques to improve the quality of illumination in augmented reality. This paper presents an overview of the available illumination techniques in augmented reality environment. Three classification techniques were presented which is common illumination, relighting and inverse illumination. The used of the techniques depends on input requirement of the user that appropriate with the projects.

Keywords: Virtual Reality, Augmented Reality, Illumination, Cultural Heritage

1 INTRODUCTION
Recently, a high technology of computer hardware is required in the field of research and development dwelled in interactive computer graphics. One of these technologies is augmented reality. Augmented reality is a technology that combines real and virtual object in same space in different proportions to achieve a level of immersion. This technology becomes feasible in multidisciplinary areas of application such as in simulation, education, cultural heritage, entertainment, medical and game.

Augmented reality technology is significance on the re-enact of historical monuments to reproduce on site historical places as in the golden period [1]. In virtual heritage, this technology is very useful to improve the visitors’ experience of cultural heritage site. Meanwhile, cultural heritage is the legacy of artifacts of a cluster that are inherited from earlier period, including buildings and historic places, monuments and artifacts that are considered valuable of protection for the future. It is important to maintain all of these in the present and bestowed for the advantage of future generations.

In augmented reality technology for cultural heritage application, the illuminations techniques become an important aspect to produce realistic environment and to improve level of immerse. Virtual objects in real environment must have reliable shadow configuration and look natural and believable with the real world environment. Thus, this paper will briefly discuss the illumination techniques in augmented reality system.

The rest of the paper is organized as follows. In Section 2, we briefly describe the augmented reality technology applied in cultural heritage. Section 3 will explain about available illumination techniques in augmented reality system and illumination discussion in section 4. Finally, in Section 5, we present the conclusion and discussion related with the topic presented.

2 AUGMENTED REALITY IN CULTURAL HERITAGE

Mixed reality is one of the technologies that encompass all the fields of reality, namely physical reality, augmented reality, augmented virtuality and virtual reality. The concept of virtuality continuum is defined by Milgram and Kishino [2] as illustrates

![Milgram’s Reality-Virtuality Continuum and examples of each fields of reality](image-url)

Figure 1. Milgram’s Reality-Virtuality Continuum and examples of each fields of reality
in Figure 1. The concept relates to the mixture of classes of objects presented in any particular display situation.

At the left side, virtuality continuum defines the environment consisting of real object or real environment. Meanwhile, at the right side, the continuum presents the virtual environment, also known as virtual reality that consists of only a virtual element. Virtual environment allows user to interact with a computer-simulated environment where the user can experience either real or imagined one.

Augmented reality and augmented virtuality are two technologies in the mix reality area. Augmented reality is a combination of real object and computer-generated data where virtual object are blended into the real world. Meanwhile, augmented virtuality environment is mostly in a virtual space, where physical objects are integrated and interacted with the virtual world in real-time.

With the interactive, realistic and complex augmented reality system, it can enhance, motivate and stimulate users’ understanding of certain events, especially for the traditional notion of instructional learning that has proven inappropriate or difficult [3]. With the increasing of development current technologies, lots of projects related with augmented reality technologies are present, for example in virtual heritage application.

Papagiannakis et al. [4][5][6] described mixing virtual and real scenes in the site of ancient Pompeii. This project is based on 3D reconstruction of ancient frescos-paintings for real-time revival of their flora and fauna, featuring groups of virtual animated characters with artificial life dramaturgical behaviors in an immersive. The project was performed in a mobile and wearable e setup with markerless tracked camera and was implemented in real-time.

Ruiz et al. [9] developed the virtual reality for archeological Maya Cities. Their project is based on reconstruction of Calakmul’s archeological site located in the State of Campeche, Mexico. Augmented reality technology is used in this system to give the visitor two different sights of the same situation. At one sight, the system will present a state of the funerals in which it is physically reproduce. Another sight, the system can present accordingly with laboratory test, which is theoretically virtual superposition of the elements of Calakmul as depicted in Figure 4.

F. Fritz et al. [1] were presented the PRISMA project. The purpose of this project is to design, develop and implement of new 3D visualization device based on augmented reality technologies that incorporates with a tourist application. The concepts of this combination are known as tourist binoculars with augmented reality system, which multimedia personalized interactive information can enhance the real scene in order to increase the user experience. With these technologies, the user can retrieve interactive multimodal information about monuments and historical buildings.
Although a lot of augmented reality projects were developed, certain project is not considered in the illumination aspect. As a result, it will reduce the realism of the image in augmented reality environment. Currently, many researches focus on illumination techniques in augmented reality system as an effort to create a realistic and believability real-synthetic world integration environment. The available illumination techniques in augmented reality will be discussed in the next section.

3 ILLUMINATION IN AUGMENTED REALITY

As discussed in previous sections, augmented reality is a technology to merge between two worlds, real and virtual. The main step to achieve photorealism of this technology is a seamless integration of virtual objects with real scene. In [10], three aspects have been identified to achieve a high quality of augmented reality system, namely geometry, illumination and time. Consistency of geometry is referring to the correct position of virtual object in the real scene location. Meanwhile, the consistency of illumination is matching the shading of virtual object with other object in the real scene and the virtual object must cast a correct shadow. Lastly, synchronized the real world and virtual world to facilitate smooth interaction is a consistency of time.

The pioneered of superimposed between virtual and real scene with real illumination was done by Fournier et. al [11]. In augmented reality environment, the illumination is one of the important aspects to get the realistic of environment. In [12], three illumination techniques have been identified to increase the quality of mixed reality environment especially augmented reality. There are common illumination, relighting and inverse illumination. These techniques have different feature of the illumination.

3.1 Common illumination

In common illumination technique, mixed reality environment present a high level of realism when light exchanges between real and virtual objects are integrated in the mixed reality environment. The operation of this technique requires precise modeling of the real object to obtain the complete 3D information [13]. In this technique, the present illumination on the environment cannot be changed. Cinematographic storytelling is a part of movie industry that used common illumination technique in their applications. To make the movies look more realistic, some of special effect can be applied with combination between lighting effects and reflections [12][14]. Examples of movies with luminous graphical effects are King Kong, Star Wars I, Harry Potter and The Lord of the Rings.

Sato et. al [10] proposed a new technique for merging computer generated image onto a real scene with considering the radiance distribution of the environment. In this technique, the camera calibration algorithm and omnidirectional images have been used. The camera calibration algorithm is used for harmonizing geometry between virtual objects with the real world. Meanwhile, omnidirectional images are used to compute the radiance distribution of the environment. With this technique, the computer generates images with convincing shadings and shadows are merging into the real world.

Agusonto et. al [15] improve photorealism for rendering virtual objects in augmented reality using image-based and hardware-based approach. Their project developed augmented reality system using current technique of image-based lighting, environment illumination maps, and a simple yet practical multi-pass rendering framework.

3.2 Relighting

Relighting techniques are technique that virtually alters the illumination of presented environment. These techniques actually allow the user to change the original illumination of the environment that will be affecting the emergence of real and synthetic objects. The relighting techniques become popular in partially applications such as in architecture, investigation and others. The lighting condition can change virtually depends on the situation of events such as lighting in the new building and the time of the crime [12].

Drettakis [13] develop a new common illumination framework for interactive computer augmented reality. Their framework based on three steps: i) camera calibration and modeling, ii) common illumination updates and iii) rendering. The aim of the project is to develop a system that can update the computation common illumination at interactive rates. A hierarchical radiosity technique
Loscos et al. [16] focuses on virtually modifying real light source intensities and inserting virtual lights and objects into a real world. This technique involved three steps: i) used semi-automatic vision-based techniques to recreate a simplified representation of real scene geometry, ii) perform a preprocessing step to create unoccluded illumination textures based on the radiosity system and iii) perform an interactive process to compute new illumination with modified real and virtual light intensities. The outcome of the project is to enable virtually relight real scenes interactively, including modifications and additions of virtual light source and objects.

### 3.3 Inverse illumination

Inverse illumination is a technique of illumination for relighting or common illumination develops to provide more realism in computer graphics. This technique can provide a precise result which is based on more complex estimations of reflectance (bidirectional reflectance distribution function or BRDFs) in the environment. The aim of inverse illumination technique is to make accurate approximation of the photometric properties of the object in the real world [12][17].

Yu and Malik[18] develop a technique that allows relighting for outdoor environment based on inverse illumination. Two images that have dissimilar lighting conditions of surface are used which captured from the local model. From these two images, two pseudo-BRDF values are expected per surface. The first one relates to the illumination from the sun and the other one relates to the illumination from the integrated scene. Three parameters control the sky intensity: i) scale factor is applied when simulating sunrise and sunset, ii)second parameter adjusts the intensity of the sky depending on the position of the mesh on the dome and iii) the last parameter controls the sky intensity depending on the sun’s position. Then, the global illumination on the local environment reproduces using the radiance values and the pseudo-BRDFs.

### 4 ILLUMINATION DISCUSSION

Based on study of the several projects that related with augmented reality, there are still have problems need to be highlight especially in illumination problems. The system that has been proposed by Papagiannakis[14] has concentrating on how to improve the illumination consistency mainly in real-time simulation of dynamic virtual characters in augmented reality scene. The author enhances the latest development in low-frequency Precomputed Radiance Transfer models by its application to virtual characters in augmented reality.

In ARCHEOGUIDE [7][8], the system reconstruct the ancient ruins using augmented reality technology with real-time image rendering. However, the limitation of their system is not considered the illumination consistency as a real scene. Hence, the virtual object that is presented not looks realistic. This situation is same with virtual Calakmul [9]. Some improvement in illumination aspects must be done to increase the level of realism in the system.

Thus, the available illumination techniques are important to inspire the researchers to improve the quality of augmented reality system. Many researchers have already implemented their technique in different sight of problem in illumination. The classification of the techniques that presented in this paper will guide the developer to decided the appropriate technique to used in their system.

### 5 CONCLUSION

In this paper, several projects related to augmented reality in cultural heritage developed by previous researchers have been discussed briefly. However, several problems occur when merging the virtual object with real scene. The first problem is geometry consistency that is to calibrate the position of virtual object in the real environment. The second problem is illumination consistency which is focused in this paper. The illumination problem concerns with how to illuminate the virtual object with the original light of the real environment.

A brief discussion of illumination techniques have also been highlighted in this paper. The illuminations techniques are important to add the realistic and level of realism in augmented reality environment especially in cultural heritage application. In cultural heritage, the precise illumination is required to make a realistic environment and to improve level of immerse.

As a conclusion, the study will be useful for the augmented reality system developer and therefore, contributing to the computer graphics community. Nonetheless, this will bring benefits especially for academic purposes and in research fields related to augmented reality system.
REFERENCES


