TranslucentAR: A Novel AR Based System to Display Translucent Object

Wankui Liu
School of Optoelectronics,
Beijing Institute of Technology
100081 Beijing, China
wan_kui@126.com

Yue Liu
School of Optoelectronics,
Beijing Institute of Technology
100081 Beijing, China
liuyue@bit.edu.cn

Dongdong Weng
School of Optoelectronics,
Beijing Institute of Technology
100081 Beijing, China
crgj@sohu.com

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Abstract

Translucent historical relics such as porcelains and jades are common exhibits in modern museums. However, because of its preciousness, visitors are not allowed to touch and take a closer look to appreciate it. In order to solve such problems, this paper presents *TranslucentAR*, a novel display system that is realized with motion capture device (PhaseSpace), head-mounted display (HMD) and an imitation of the real historical relic which is installed with a few cameras and LEDs. The proposed system allows its users to enjoy translucent visual experiences of the precious historical relics. Owing to the precise tracking data from PhaseSpace, the position detail of the imitation of cultural relic can be obtained. 4 cameras which are fixed inside the imitation of cultural relic are used to acquire the texture of the outside environment. After combining panoramic texture with that of the original object surface, the translucent effect is rendered on the 3D model surface, which enables its users to see the environment at the back of the imitation. The implementation of the prototype and the future improvements are also discussed in this paper.

Author Keywords

Head-mounted display; translucent objects; augmented reality; motion capture

Figure 1: Examples of translucent cultural relics

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces – Graphical user interfaces;

General Terms
Design, Human Factors

Introduction
Porcelains and jades are common exhibits in most modern museums, however, it is impossible for visitors to touch and take a closer look at these historical relics because of their preciousness and fragility. This inspires us to develop an AR based system which is named as TranslucentAR, the aim of which is to enable its users to see the background through an imitation of historical relic and enjoy its translucent beauty. With an HMD worn on the user's head, the surface of imitation held in the user's hand can be combined with the textures of historical relic as well as that of the back environment to generate a translucent effect. A user can rotate, move the imitation and enjoy the visual impacts of the translucent relic. Considering that the virtual image is shown on the surface of complex object, this novel design makes it possible to display any specific image effects on the surfaces of any shape.

Related work
In order to make the image shown on the right place, the imitation must be moved or rotated, thus tracking is one of the key technologies in the proposed system. There have been many previous works on motion tracking such as electromagnetic tracking [2], acoustic tracking [3], mechanical tracking (BOOM display) and optical tracking [4]. Each technology has both advantages and disadvantages. Electromagnetic tracking system is very responsive but the same as acoustic tracking system, its stability depends on surrounding environment, which makes it impossible to be applied in such complex environments as museums and exhibition centers etc. Mechanical tracking system is fast, however, user's range of motion will be limited. In an environment as a museum, there are so many people and emergencies that stability and accuracy is the key issues. Active optical motion capture can meet such requirements, and therefore PhaseSpace [1] is chosen.

Few researchers perform intensive studies on the display of translucent objects in augmented reality system. Jin Zhou et al. proposed a framework which can render translucent objects interactively based on precomputed light transport technology [5]. Chunhui Yao and Bin Wang combined translucent shadow maps with a new adaptive sampling strategy achieving real-time rendering [6]. Lensch, H.P.A. et al. made use of illumination map and obtained local and global response respectively [7]. None of the above-mentioned technologies can be directly applied in TranslucentAR because for TranslucentAR, a model texture must be shown on the surface of 3D imitation model.

There are many researches on display interfaces in augmented reality system for museums, such as HMD [8], projector [9] and desktop devices [10] etc. But few of them are concerned with the display of translucent objects. Projector and desktop devices are immovable, while the immersed feeling of users is lower than that of HMD. Therefore, HMD is chosen to display translucent textures.

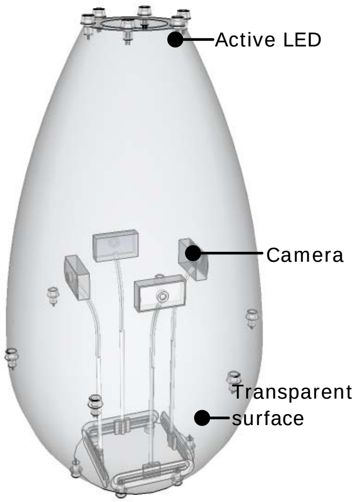

Figure 2: The structure of the imitation of historical relic. This vase-shaped object consists of 4 cameras, 18 active LEDs and transparent surface. The cameras are installed around the center of the vase in order to get the panorama view of the surrounding environment.

Based on the above-mentioned research, our approach for the representation of translucent objects takes a different way. TranslucentAR display system is realized with motion capture device (PhaseSpace), head-mounted display (HMD) and an imitation of the real historical relic which is installed with a few cameras and LEDs. Four cameras inside the imitation are used to capture the outside environment and produce a panoramic image, which could be used to synthesize translucent textures indirectly. At last, the translucent textures shown on the HMD are rendered on the surface of the imitation.

Implementation

Active optical motion capture system PhaseSpace is used in our system to provide highly accurate, real time data with the minimum occlusion and dropout errors. PhaseSpace consists of cameras, LED controllers, active LEDs and server computer. The cameras are used to detect the positions of LEDs at 480/960 Hz. The LED controller and an RF transceiver, which utilizes an onboard microprocessor to control up to 72 LEDs, is used to control the LED at certain frequency with a unique digital ID. The LEDs are placed along the edge of the imitation which can be captured by cameras and sent to the server computer for the calculation of real world coordinates.

The imitation can be any proper shape such as vases (as shown in Fig. 2), jades, Buddha statues etc. The inside of the imitation of cultural relic is fixed with four cameras and covered with transparent surface, the reason of which is to make the cameras inside the imitation have a clear view of the surrounding environment. Because the imitation might be taken up and examined, wireless cameras are more suitable.

The proposed System has two pipelines running in parallel. In one pipeline the position data of LEDs are obtained with PhaseSpace and the 3D model of the imitation is built hereafter. In the other pipeline the surrounding environment is captured by the cameras inside the imitation and a panoramic image is drawn. A constant factor is used to synthesize panorama into the original relic object texture. After rendering a translucent texture, the 3D model and the translucent texture are combined together as shown in Fig. 3.

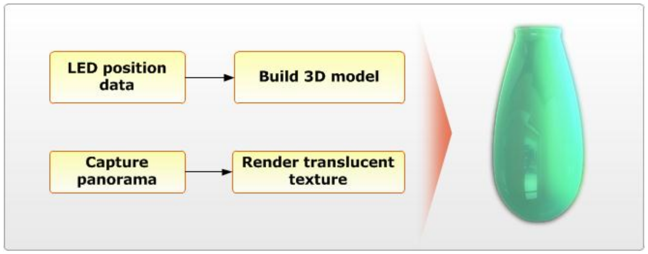

Figure 3: The software structure of TranslucentAR. The vase texture combines the panorama texture with original color (jade) of the vase. The right picture shows that a window is behind the vase.

Usage Scenario

In the proposed system the user will wear an HMD to enhance its feeling of immersion (as shown in Fig. 4) and is able to enjoy the beauty of historical relic by moving or rotating the imitation. With the lighting on the imitation of the historical relic from a torch held in the user's hand, a user can also judge the value of the relic by checking the luster, transparency of the imitation [11]. At the same time, some text information about the history and the evaluation of the historical relic can also be displayed on the HMD. In this way, the

Figure 4: Effect drawing of TranslucentAR. The man wearing HMD is observing an imitation of vase. In his visual field, he can see the translucent relic and extra text information about the history of this relic. Now he is using a torch to appreciate the translucent vase. With high brightness and penetrability of the torch light, the internal structure can be observed carefully to check cracks and flaws of the jade. The torch light is captured by the cameras in the imitation of vase.

user can enjoy the excellent translucent visual experience and learn more about the historical relic.

Conclusion and Discussion

The TranslucentAR system proposed in this paper enables its user to have a strong immersed feeling of translucent historical relics. Early results indicate that this system can draw the museum visitors' attention and enhance their understanding of historical relics such as porcelains and jades. However, this system is still in the initial stage. We would gather the feedbacks from its users and try to improve its performances based on the analysis of them.

Since there are still shortcomings with the rendering pipeline, e.g. the synthetizing of translucent texture is not very accurate, in the next step, we will take account of diffuse scattering and bidirectional surface scattering reflectance distribution function [12]. The proposed system also fails to consider the complex illuminations which include sunlight, fast moving light sources etc. and these problems will be tested and thoroughly studied in the future.

Acknowledgements

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