Design and Development of Campus Environment Display System Based on Augmented Reality Technology

Shijie Wang¹, Huaqun Liu², Hou Shu³, Xinzhe Zhang⁴ and Yu Zhang⁵

¹,²,³,⁴,⁵Beijing Institute of Graphic Communication University, Beijing, China

*Corresponding author

Abstract. With the rapid development of augmented reality technology and the continuous improvement of people's needs in various aspects, people are more looking forward to interactive, real-time augmented reality systems. In the field of physical display, Augmented Reality Technology provides a more convenient channel for people to experience various objects at zero distance, and reforms a new form of physical display. Including campus display, AR augmented reality technology creates a new display experience for users. This project uses Beijing Institute of Graphic Communication as the research model. In the early stage, the scene was modeled using Cinema 4D software. In the later stage, the scene was interactively designed using Unity 3D. The Vuforia engine was used to detect and track feature points and match them. After superimposing on the scene, we explored the optimization strategy of AR augmented reality technology in campus display applications.

1. Introduction

In recent years, Augmented Reality Technology has developed on the basis of virtual reality[1], and even has a tendency to surpass virtual reality. Augmented reality is a new technology that overlays virtual information into the real world. It mainly relies on registration and tracking technology to capture the position and angle of the identified objects so that the computer can generate virtual 3D graphic annotations based on the real world. It is real-time, interactive and immersive [2]. This technology is widely used in games, military, medical, education, tourism, cultural display, etc. [3]. This article proposes a method for developing an augmented reality campus environment display system using Unity 3D and Vuforia. This system can effectively solve the problems that parents and students in different places may have when they are familiar with a strange campus. This system can provide a comprehensive introduction to the campus from the whole to the specific, and it is also an effective channel for the school's external publicity.

2. AR Environment Display Method Based on Unity 3D

2.1. Overall Framework of Augmented Reality Environment Display System

The augmented reality environment display system to be completed in this project takes the campus scene of Beijing Printing Institute (school headquarters) as the research object, uses CINEMA 4D and 3DS Max to model the scene environment, uses unity 3D to design the scene interaction, tracks and identifies the feature points of two-dimensional target pictures (the logo of North India is the identification picture in this project) through vuforia SDK, and adopts SIFT and FAST algorithm in combination, real-time matching of augmented reality scene is carried out according to the location of feature points. At the same time, overlay virtual information, audio commentary, text commentary,
introduction video. Compared with the traditional one-way display, the interactive display can provide users with a good experience, so as to solve the problem more effectively. The overall system development process is shown in Figure 1.

![Image](image.png)

**Figure 1.** The overall development process of the augmented reality system of Beijing Institute of Communication.

2.2. CINEMA 4D Technology
Cinema 4D is a 3D drawing software developed by Maxon Computer in Germany. It contains modules such as modeling, animation, rendering, characters, particles, etc. It is famous for its fast computing speed and strong rendering plug-in. At the same time, Cinema 4D has a strong model compatibility. Project files imported from other 3D software can be used directly without worrying about problems such as broken surfaces and file loss. The models and animations produced by Cinema 4D can be directly imported into Unity 3D for post-design, so this project uses this as the main software for scene modeling, mapping and animation production.

2.3. Unity 3D Technology
More than 60% of AR / VR content on the market is developed and designed by Unity 3D. It is a lightweight and extensible dependency injection container that supports constructor, property and method call injection. The augmented reality campus display system needs to render 3D virtual scenes, and it also needs to add interactive functions. The realization of these two functions. Therefore, we chose to use Unity 3D to implement scene rendering and interaction design functions.

2.4. Virtual Image Target Recognition and Matching Method
When implementing image detection, the more complex the color of the target picture, the more the graphics change, the denser the recognition points, and the higher the accuracy of the final recognition. This project uses the school logo as the recognition target. There are only two colors, blue and white, and the recognition is difficult. Therefore, the method of combining the SIFT algorithm and the FAST algorithm of the Vuforia SDK engine was selected to improve the recognition of the target image accuracy.

2.4.1. Sift algorithm. The SIFT (Scale-invariant feature transform) algorithm is an algorithm for detecting local features of a target picture. The algorithm can obtain feature points in the target image and feature descriptors representing the direction and size of the feature points. Before describing the feature points, the gradient of a specific area of the image needs to be calculated on a certain scale area around these feature points. And these gradients are presented with some specific changes. The changed gradients become more stable and can adapt to some changes in the image or external interference. The key points obtained in this way have the advantages of scale invariance and rotation.
invariance. The generation of Sift features generally includes the following steps, as shown in Figure 2:

- Construct a scale space, detect extreme points, and obtain scale invariance;
- Feature point filtering and precise positioning;
- Assign direction values to feature points;
- Calculate transformation parameters.

**Figure 2.** Sift algorithm schematic.

### 2.4.2. FAST algorithm.

The author of FAST, Rosten et al., defined FAST corner points as: if a pixel point is very different from many points on its adjacent area, then this pixel point is a possible feature point\(^6\), as shown in Figure 3.

**Figure 3.** Fast algorithm schematic.

- As shown above, a circle with a center of pixels and a radius of 3 has 16 pixels \((A_1, A_2, \ldots, A_{16})\).
- Define a threshold. Calculate the pixel difference between \(A_i, A_9\) and the center \(A\). If their absolute values are less than the threshold, the \(A\) point cannot be a feature point and pass directly; otherwise, as a candidate point, further investigation is needed;
- If \(p\) is a candidate point, calculate the pixel difference between \(A_1, A_9, A_5, A_{13}\) and the center. If at least three of their absolute values exceed the threshold, they are considered as candidate points and then the next step is examined; otherwise, pass directly;
- If \(p\) is a candidate point, the pixel difference between the 16 points \(A_i\) to \(A_{16}\) and the center \(A\) is calculated. If at least 9 of them exceed the threshold, it is a feature point; otherwise, pass directly.
- Non-maximum suppression of images: Calculate the FAST score of the feature points (score or S value) of the feature points, determine the neighborhood (such as \(3 \times 3\) or \(5 \times 5\)) centered on the feature point \(A\), and calculate if there are multiple feature points, determine the \(S\) value of each feature point (the sum of the absolute values of the 16 points and the center difference). If \(A\) is the largest response value among all feature points in the neighborhood, keep it; otherwise, suppress; If there is only one feature point (corner point) in the neighborhood, keep it.

### 3. Overall System Design

#### 3.1. System Function Design

Based on the investigation and analysis of the various functions and advantages and disadvantages of the existing campus environment display system, according to the characteristics of the school, an AR system for environmental display of Beijing Institute of Graphic Communication was designed, as shown in Figure 4.
Figure 4. Functional diagram of augmented reality system of Beijing Institute of Communication.

Function introduction of each module:
- AR core module: Realize AR function through Unity 3D’s Yuforia engine's tracking algorithm and image matching technology.
- AR overlay fusion: Real scenes are superimposed with virtual scenes and virtual information. The virtual information mainly includes: video, animation, audio, and text in order to meet the content needs of users for obtaining information.
- Model display: Scene model imported into AR display system, real-time rendering.
- UI interface: When presenting a scene of virtual reality augmented reality, the superimposed three-dimensional scene can be viewed in whole and in part through human-computer interaction. Browse operations: click, zoom, rotate, move.

3.2. Design the Overall Process

Figure 5. Overall design flow chart.

4. Case Studies

4.1. User Needs Analysis
- School needs: Explore a more convenient way of publicity, and encourage parents and students to watch school publicity pictures and videos.
- The needs of parents and students: to find and locate useful campus information in a timely manner, to be able to understand the campus teaching building settings and the surrounding
real environment as a whole, and to understand the location and function of each teaching building on campus.

4.2. Functional Analysis
After installing a prefabricated package on the mobile phone in advance, the user can scan any school LOGO with the mobile phone, identify the marked points through image recognition, and match the scene model, and then the virtual campus can be superimposed on the mobile phone screen. After the virtual campus is displayed, users can interact with the displayed campus model. You can click on the model of any teaching building in the campus to learn more about the distribution of classrooms and offices in the teaching building, in order to achieve a comprehensive understanding of campus functions. It is also equipped with 3D campus promotional videos, introductory videos, and introductory audio. Screenshots of the final work are shown in Figure 6, Figure 7.

![Figure 6. The school LOGO and the campus model are displayed in an augmented reality view.](image1)
![Figure 7. Overlay pictures and video interface views in the system.](image2)

5. Conclusion
The Beijing University of Graphic Arts campus environment display system, developed by incorporating the Unity 3D/ Vuforia augmented reality environment display method, has been experimentally shown to be more effective in promoting user understanding and improving user acceptance. Its main advantages are: support for virtual and real overlay functions (3D models, animations, pictures, etc.), with rich interactivity (virtual buttons, rotation, zoom, etc.), to achieve rapid matching of landmarks and virtual scenes. At the same time, there is still room for further research. For example, in the later school, the campus display system can be used to better understand the needs of students' parents. In the background, the length of time users stay at each level can be used to calculate which content attracts users Greater efforts to improve campus construction in this area.

References
[1] Yuhan Liu, Zhan Qing, Xu Jie. Research on Application of Mobile Phone Based on Augmented Reality. Journal of Xiangtan University (Philosophy and Social Sciences), 2015, 39 (02): 127-130.
[2] Jian Teng, Fucheng Wan. Research on Product Design APP Design Based on Augmented Reality. Packaging Engineering, 2017, 38 (14): 219-223.
[3] Sanqiang Wei, Bing Wang. Application of AR technology in intangible cultural heritage and cultural tourism industry. Journal of Jianghan University (Natural Science), 2016
[4] Pingli Wu. On the 3D Design Software Cinema 4D. Audiovisual, 2019 (04): 258-259.
[5] LOWE D G. Distinctive image features from scale-invariant keypoints. International Journal of Computer Vision, 2004, 60(2): 91-110.
[6] Jing Chen, Yuan Sun. Augmented Reality Tracking Registration Algorithm Based on FAST Key Points. Journal of Beijing Institute of Technology, 2015, 35 (04): 421-426.
[7] Zhizhi Zhang. Educational Application and Integrative Prospects of Virtual Reality and Augmented Reality. Modern Educational Technology. 2017 (01)
[8] Miao He. *Research on the Application of AR Technology in Education*. Computer Programming Skills and Maintenance. 2017 (24)