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Application and effect evaluation of virtual reality technology in teacher education

Fang Ji and Kyung Yee Kim
Graduate School, The Catholic University of Korea, Gyeoggido Bucheon city, the Republic of Korea

ABSTRACT

The project is based on virtual reality to improve students' perception of engineering drawing knowledge. A 3D modelling-assisted teaching system based on a mobile terminal was constructed by integrating augmented reality technology into classroom teaching. Then, this paper uses visual overlay and reinforcement to highlight the user's subjective feelings. It aims to construct an effective transformation route between the perception-linked perspective and the entity to improve the perceptibility of abstract form. In combination with classroom teaching and guidance, students can consciously enhance the cognitive function of graphic perception in view interpretation. The function sharing is realised through the configuration of the software module, and the interaction efficiency between the modules is improved. The advantages of this method in reducing energy consumption and the signal-to-noise ratio of teaching resources are verified by comparison with existing online education platforms. This method can significantly improve the efficiency of the whole system.

KEYWORDS Engineering drawing; AR; cell phone; education system; transmission energy consumption
CONTACT Kyung Yee Kim jjingyi0301@163.com
Received 21 March 2024

1. Introduction

Engineering Drawing is an introductory course of technology in engineering colleges. Its purpose is to improve students' spatial thinking ability and practical ability. Previous studies have found a lower level of interpretation of graphics in the brain, that is, the "unconscious" encoding and decoding of the "picture sense". "Image perception" refers to a direct feeling of the image that you see. It can realise the flexible application of the principles of drawing. At the same time, it is based on image and abstract thinking and gradually develops through continuous practice. Its sensitivity to graphics is one of the main indexes to measure cartographability. So, the language of drawing to think in order to stimulate the feeling of graphics and obtain relevant information is used. Analysing the object's structure is an effective way to improve drawing ability and engineering concepts.

With the rapid development of virtual reality (VR) and augmented reality (AR), a new way has been opened up for the teaching reform of the cartographic major. From the perspective of pedagogy, the experience of virtual reality refers to the activity level of education. Some experts have established a four-step model of "plan-preparation-implement-tracking" in virtual reality, which provides a valuable reference for developing virtual reality courses (Scavarelli et al., 2021). Some scholars have applied virtual reality technology to the course of mechanical and electrical engineering drawings to strengthen their understanding of the internal and external structures of objects, processes, and assembly structures, as well as the reading and drawing of engineering drawings (Smutny, 2023). Researchers have developed a mobile teaching system for engineering drawing on Android phones based on VR. They designed the screen segmentation function according to the cognitive rules of engineering drawing teaching. The system enables the interactive display of video narration and 3D modelling on the screen (Ledwos et al., 2021). Combining 3D virtual reality and the natural world enhances the user's cognition and recognition of the real world. It has the advantages of a virtual-real combination, good interactivity, a strong sense of reality, etc. In addition, with the rapid development and popularity of mobile phones, mobile phones can also be used as an exemplary application platform for AR technology. Applying it to the educational process can form a new type of educational resource. It can be integrated with traditional educational methods to improve the outcomes (Johnson-Glenberg et al., 2021). But at present, the portability and practicality of AR technology are minimal. Some researchers have developed a virtual reality simulation platform for construction workers by analysing the data from construction sites (Al-Gindy et al., 2020). Some researchers have developed an enhanced image-based weather education system without labelling (Kolla et al., 2020). Some researchers have proposed a visual AR optical experimental platform based on Android (Alnagrat et al., 2022). Other scholars combined AR with computer vision to design a set of virtual classrooms to create an immersive interactive teaching environment (Cannavo et al., 2020). Scholars have also developed the application of AR technology in machine tool manufacturing technology training courses for a mobile terminal operating setting (Hamilton et al., 2021).

The above educational research work has established feasible experimental teaching support means, but the development work is distributed over multiple disciplines. Its lack of interaction makes it difficult to offer practical uses in colleges and universities. The research on engineering drawing is even more lacking. However, according to the above analysis, the teaching process of engineering graphics especially needs this kind of AR technology to supplement the existing teaching methods. So, this topic intends to apply AR to the teaching of engineering drawing. A multi-functional AR simulation graphics modelling system is developed based on the education mode of image perception training. This paper regards the improvement of the teaching level of cartographic courses as a critical content of auxiliary teaching. The system breaks through the limitations of time and space. It can save learning costs and be more flexible and open.

2. Methods and materials

2.1. System architecture and development scheme

This project focuses on researching the coupled superposition of virtual modelling and natural scenes in three-dimensional space based on the mobile terminal AR technology. The system should have the following essential functions: (1) Realise the rapid identification and extraction of image code and overlap it with the two-dimensional views in reality; (2) Interactive control of multi-touch 3D solid modelling, including scaling, rotation, cutting, orthogonal, etc.; (3) Video commentary for each model, which can be called and played back on a split screen at any time; and (4) The paper aims to achieve online evaluation, feedback, interaction, downloading and scoring of the model (Alvarez et al., 2024). In order to make better use of the technical characteristics of AR education, the system's resource support system is divided into three modules: model base management module, model interaction module, model discussion and evaluation module. The implementation level of the system consists of three aspects: hardware system, network cooperation system and software system. The system's overall architecture is shown in Figure 1 (image cited in the International Journal of Engineering Education 2015 Vol. 31, No. 3, pp. 713-725).

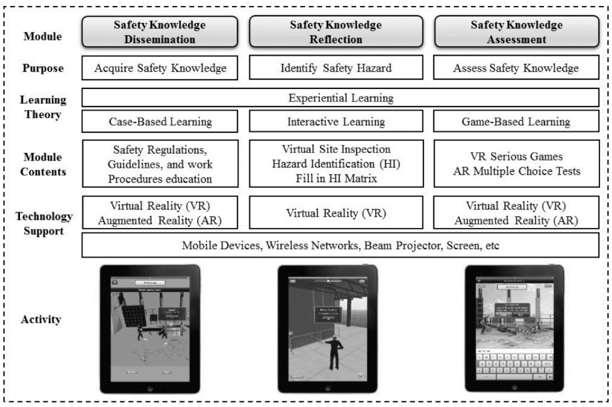

Figure 1. Overall system architecture.

The Java and Android software development kits were set up in Eclipse. The Android virtual device was created. Three-dimensional solid models were built and texture mapped in 3DMax. Using Open GLES technology, the model was introduced into the Unity3D engine to complete the force-sensing function based on Finger Gestures, combined with multi-touch technology to complete the interaction with the model (Pellas et al., 2021). The system can be divided into augmented reality display window, image acquisition module, control module, processing module, forwarding module link, controller program list, current pose estimation module, etc.

2.2. System development

2.2.1. Three-dimensional form modelling

This topic intends to study the 3D body in the textbook. Knowledge includes plane stereoscopy and cutting, surface stereoscopy and cutting and intersecting, assembly drawing and reading, representation methods, standard parts and common parts, parts drawing and assembly drawing. Currently, most virtual education systems use 3DMax as a modelling tool, then introduces Unity3D to draw. This results in a large footprint, low visibility and poor interaction. This saves the memory data transfer time and optimises the visual and interactive experience throughout the operation. Three forms of basic, composite and multilateral modelling methods have been adopted in modelling technology. The strict control of the number of modules ensures the smooth display of the software. The name and querying of the module are realised through the corresponding graph number and graph name in the textbook. Part of the model library is shown in Figure 2.

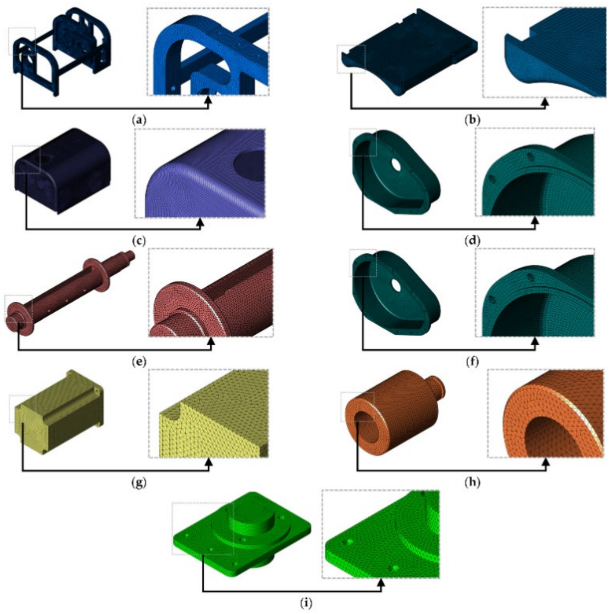

Figure 2. 3DsMax model library.

2.2.2. Target identification and tracking registration

The teaching system uses the camera on the mobile phone to scan the object and project it into the natural environment. The real-time correction of virtual object positioning is realised using machine vision tracking and registration methods. The camera is positioned and updated in the corresponding area of the picture to ensure that the relative position of the camera and the object is not changed during observation and interaction. In this way, continuous, highly realistic visual effects are achieved. Figure 3 shows what the object validates. First, two-dimensional images obtained by the camera are used. The optimal thresholds of front and back colour and background colour are obtained using the exhaustive method. Greyscale images are converted back into black and white thumbnails and then black and white thumbnails are converted into pixel matrices. In this way, models are annotated and associated with model libraries (Atli et al., 2021).

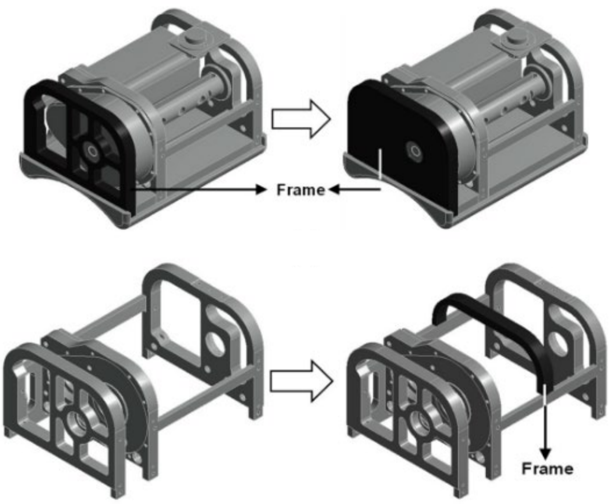

Figure 3. Process of target recognition.

The tracking registration problem of a single camera involves transforming multiple coordinate systems. The image is taken from the camera in the scene and converted into a 2D image. It is then projected onto the imaging surface of the camera. The natural space pose of the actual scene is solved in real time with each camera parameter as the given state. The mapping relationship between the camera and the actual scene is established by using the spatial coordinate transformation method. The image analysis of four-pixel points is carried out to realise the positioning of phase points. The conversion matrix of the system is obtained by using the node of the calibration coordinate system and the plane coordinates of the camera. Then, the accurate positioning of the transformation matrix completes the system's registration.

2.2.3. Coupling between presentation and interaction

The three-dimensional entity generated by Unity3D and the entity view in IDE is displayed in parallel in the scene, thus ensuring that the virtual entity always overlaps from the IDE perspective. This avoids mutual interference between actual scenes. This project takes Unity3D as the leading platform. The OpenGLES3D engine built into Unity3D realised the efficient processing of 3D models. Finally, the FBX component was used to conduct three-dimensional modelling of Unity3D. They adjusted the light intensity to achieve the object of light and shadow adjustment. The corresponding system logic was established to enable it to interact in different environments. Figure 4 shows the desired result (Harfouche et al., 2020). The Unity Player variable in the UnityPlayer Native Activity.java class was used and a plug-in was developed for Java-coupled display and interaction effects on Eclipse. It was then transferred to the Unity platform along with the profile. It was then matched to the relative position of the target scene. The model changes as the camera pose and the target scene change to achieve a more realistic augmented reality (Rogers et al., 2021).

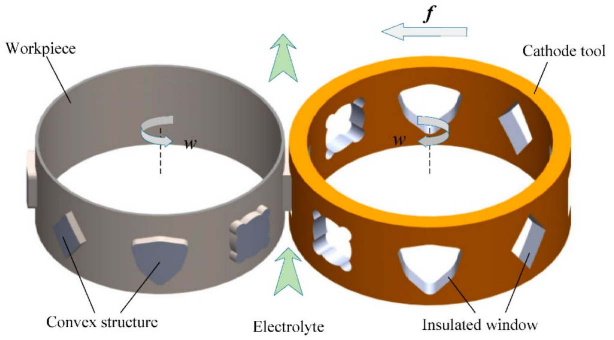

Figure 4. Coupling display and interaction effects.

2.3. System software algorithms

In the software development of this system, the problem of how to allocate various teaching resources reasonably was solved. This improves the utilisation rate of teaching resources. When sending a bit of data to node B, the energy consumption of the sending node in the online teaching system is:

$$W_\alpha(t,s)=\begin{cases}W_\alpha\cdot t+\delta_\beta\cdot s^n\cdot t\\ W_\alpha\cdot t+\delta_\gamma\cdot s^n\cdot t\end{cases}. \tag{1}$$

δs^n represents the energy required to amplify the transmitted signal. δ_β, δ_γ is the loss factor for the distribution of teaching materials. The energy for the next node to receive t bit data is:

$$W_\zeta(t)=W_\alpha\cdot t\ . \tag{2}$$

The width of the gradient of the system resource data transfer network is calculated after calculating the transmission energy loss. The goal is to allocate resource data better. The following equation calculates the gradient width of the network:

$$R_s = \frac{H}{N}\left(1 + \lambda \frac{2n - N}{2N}\right). \tag{3}$$

H is the farthest transmission distance between nodes in the network. N represents the most significant grid gradient. n stands for Network gradient. λ, μ adjusts the sending radius of competing cluster heads by calculating the gradient value. The transmission radius on a node i is as follows:

$$F(i) = \mu \cdot s_i \cdot R_s \cdot n / N. \tag{4}$$

μ refers to the emission diameter regulation factor. s_i is the radius of the initial transfer. So, for the node i, the energy return delivered is:

$$P(i) = F(i)\left[W_\kappa(i) - W_c(i)\right]. \tag{5}$$

$W_\kappa(i)$, $W_c(i)$ represents the energy received by the node and the energy consumed by it. The distribution equation of teaching resource data is as follows:

$$G(i) = \frac{1}{F(i)} - \frac{P(i)}{\max(P(i)) - \min(P(i))}. \tag{6}$$

$\max(P(i))$, $\min(P(i))$ represents the maximum and minimum operating energies of the node i. The above calculation shows the accurate distribution of teaching resources in the online education system (Abich IVJ et al., 2021).

3. Results

The results of the virtual simulation online classroom are compared and verified. The environmental parameters of the test are shown in Table 1.

Table 1. Experimental environment configuration.

Item	Disposition
Server memory	16GB
Operating system	Windows7
Teaching system architecture	B/S architecture mode
Archive	MySQL
Teaching system dynamic interaction	JSP+DAO

This paper compares the transmission energy consumption and signal-to-noise ratio of network resources. The effectiveness of the proposed method was proved by comparison with the experimental results of the study by Ebadi et al. (2022) and the study by Liu et al. (2020). A comparison of the energy consumption of the three different transmission modes is shown in Figure 5.

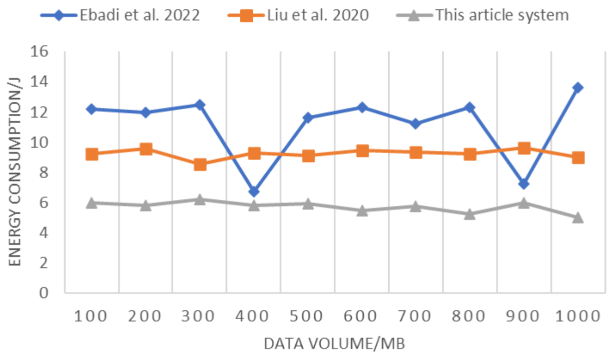

Figure 5. Comparison of transmission energy consumption.

The transmission energy of the system has been maintained at a trim level under the condition that the transmission data flow of the system continues to increase. Even at its maximum transmission capacity, it still transmits very little energy. This indicates that the data transmission energy in the system is unaffected by the data capacity. However, in the study by Ebadi et al. (2022), the energy consumption in the network also presented periodic changes due to the increase of data flow in the network. This leads to the instability of energy consumption in the network. In the study by Liu et al. (2020), although the transmission energy could be maintained relatively stable, the overall energy consumption was higher than that proposed. This shows that the designed system has a good teaching resource data transmission performance. Data comparing the transmitted signal-to-noise ratio of the three systems are shown in Figure 6. It can be seen from Figure 6 that the SNR of teaching resources transmission in this scheme is higher than that of the two comparative systems, which proves that the effect of this scheme is relatively good.

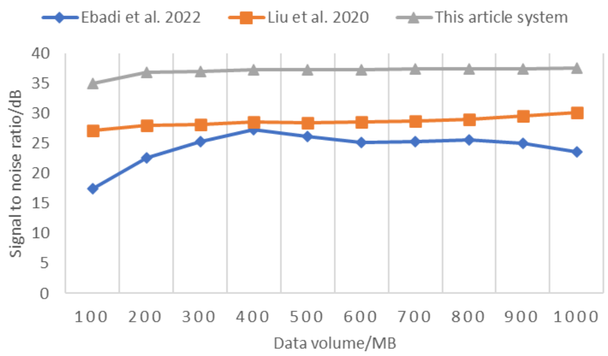

Figure 6. Comparison results of the transmission signal-to-noise ratio.

4. Discussion

This project uses the cover of the engineering drawing textbook as a recognisable image to enhance the user's convenience and intuitive feeling. The user can scan the cover of the textbook through the camera of the intelligent terminal unit. It can be loaded into the corresponding engineering graphics AR mode app. In this program, students can log into the system and begin to perform automatic identification operations. Students can scan the pre-set model view and combine it with the natural environment to overlap and display. Through the graphical touch operation model, the text can be projected. Students can perform 3D rotation operations, pre-cutting operations, model enlargement operations, model short comments, and teach video clips on the system screen display. A complete set of interactive assignments to enhance students' user experience. The system can help students construct the perception of images and deepen the understanding and cognition of the representation of views. The drawing class AR-assisted teaching system is integrated into the classroom. Combined with regular education, it can significantly increase students' enthusiasm for independent learning. In the aspects of foundation and cutting, assembly reading and expression, it can make them quickly perceive and think about images. And the ability to transform the feeling of graphics into graphics. Students' spatial thinking and discussion of answering questions have been increased significantly, enabling teachers to better grasp students' understanding and reception of patterns. This has also played a good role in guiding the teachers' teaching.

5. Conclusion

The purpose of this project was to improve graphic perception. An AR graphic teaching system based on Android and IOS mobile devices was constructed. This project combines the flat view of the workbook with the virtual 3D modelling situation to highlight the authenticity of the experience through visual overlap and enhanced interactive manipulation. This can enhance the interest in teaching and students' enthusiasm for learning. An effective conversion channel between the 2D view and a 3D entity was established, and instruction was conducted in the classroom. It can be seen that the virtual simulation teaching system designed in this paper can better realise the data transmission in online teaching.

Notes on contributors

Ms Fang Ji, born on 27 May 1988, is of Han ethnicity. She was born in Baoding, Hebei Province, China. She received her master's degree in August 2021 at the Vitebsk State University. She is currently pursuing her Ph.D. in Educational Administration of the Graduate School, the Catholic University of Korea. Her research focuses on Educational Management and Curriculum Design. With a keen interest in advancing educational practices, she aims to contribute to the field through her research endeavours.

Prof Kyung Yee Kim, a female born on 16 October 1962, in South Korea, holds a Doctorate in Culture. She graduated from Ewha Womans University in South Korea. Currently, she serves as an Associate Professor and Ph.D. Supervisor at the Graduate School, the Catholic University of Korea. Her research interests encompass Educational Management, Teaching and Learning in Higher Education, Educator Competency Development, and Education Program Design.

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