Increasing the Learning Performance via Augmented Reality Technology

A Case Study of Digital Image Processing Course

ChinLun Lai[1(✉)] and YuFang Chu[2]

[1] Department of Communication Engineering, Oriental Institute of Technology, Taipei, Taiwan
fo001@mail.oit.edu.tw

[2] Education Resources and Publishing Center, National Academy for Educational Research, Taipei, Taiwan
yufang@mail.naer.edu.tw

Abstract. In this paper, an innovative teaching model to reinforce the teaching performance of teachers and the learning performance is proposed. Based on the digital image processing courses, an interactive teaching method containing immediate image retrieval, visual analysis and processing, imaging control, theoretical narration, and the extensive applications using AR technology and wearable devices is designed. This method converts the mode from teacher's traditional theoretical lectures and the student's passive learning behaviors into immediate and dynamic operations, immersive observations; changing combinations; and bi-directional interactions, exchanges, and discussions. It is expected that this method can improve student's interest and motivation in learning and help them comprehensively understand the abstract concepts of course content and technology theories, as well as the skill in practical application, through real-time and immersive surrounding observations and interactive interface operations, thereby can enhance the learning performance.

Keywords: Augmented reality · Engineering education · Digital image processing · Wearable device · Video analysis

1 Introduction

Augmented reality (AR) refers to the integration of real-world objects with virtual graphics or images and the rendering of these composite images on electronic displays. Therefore, AR is a type of technology that emphasizes the interaction between the real and virtual worlds. The development of AR began in the 1900s. It has since been expanded into the medical, industrial, and entertainment domains amidst the advancements in computer technology. Although viewing the effects of AR requires the use of specialized devices, technological improvement has made these devices smarter and easier to use, which consequently enhances the convenience and broadens the application of AR. One of the popular examples is the game 'Pokemon Go'.

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AR is particularly useful for abstract explanation since it deed present the phenomena processing or events observing. Therefore, it can be applied in the education domain to facilitate learners in observing 3D objects and animation created for AR and learning the occurrence of phenomena, thereby achieving learning objectives through AR field observations [1–9]. AR contains several features and affordances thus can be served as attributes for learning aids. (1) It can render course content in 3D to help students develop and understand 3D spatial concepts, such as producing a 3D representation of 2D plants revolving around the image of the sun. (2) Specific scenarios can be incorporated into collaborative learning, where students can engage in indoor/outdoor scenario-based AR learning using mobile devices, as well as cooperation and interaction through information retrieval and analysis. (3) It provides immediate sensory feedback thus the students can immersive themselves in AR and gain immediate feedback through human-machine interaction. (4) It facilitates the digital visualization of invisible objects. AR can virtually represent objects that students cannot see with the naked eyes, such as chemical molecules within a 3D space to highlight molecular arrangement. (5) It links classroom lessons with outdoor learning. For example, AR can link campus environments with science material when teaching campus flora and fauna.

On the other hand, AR combines physical objects with virtual graphics and then presented as an operable interface on a display to help students transcend original sensory learning methods and impart understanding of the knowledge and information both in quality and quantity. In course learning, the physical and microscopic elements of multi-dimensional and special learning processes can become interchangeable through design, such as zooming into a crystal structure to present its molecular arrangement. To explain in further detail, AR can serve as an auxiliary tool to enhance the practical, cognitive, and affective domains of learning. In terms of the practical domain, AR provides a way for hands-on learning, facilitating scientific comprehension through result observation of the real-time operation. In terms of the cognitive domain, the association of macroscopic, microscopic, and symbolic scales; the operation of abstract expressions; and the integration of time and space through AR can be employed to build scientific models to facilitate comprehension. In terms of the affective domain, collective learning using mobile technology can promote peer interaction and communication and stimulate positive attitudes and interest towards course learning.

In the recent years, some novel concepts are proposed to enhance the teaching, training, and learning performance in a diversity fields and courses by using the AR technique as well as the mobile devices [10–12]. Some of the important advantages of using these tools include: (1) It increases the learning interest, especially for those courses with profound theory or taught by teacher's lectures only. (2) It makes the students comprehend the course contents more quickly and deeply by live scene observation. (3) It significantly reduces the time for a learner from beginner to profession. For example, in the field of digital image processing, there are thousands basic image processing functions should be practiced and acquainted for the beginner where such process may takes several months to years. After that, it is possible for them to make the correct decision in which processes they should take once a live image processing problem occurs. The aforementioned learning process is necessary for a learner who interests in image processing and the related advanced techniques such as computer vision or pattern recognition. However, it takes a long time to familiar with the basic image processing functions by studying, programming, and experiments, thus know how to apply them correctly for the corresponding cases. By the help of App aids, learner can be experienced quickly by observing the real-time captured images and the corresponding processing results at the same time, thus understand the effect of operating image processing function.

Accordingly, this paper try to proposes an innovative teaching model as well as teaching aid system to reinforce the teaching performance of teachers and the learning performance of students. Based on digital image processing courses, an interactive teaching method containing immediate image retrieval, visual analysis and processing, imaging control, theoretical narration, and the extensive applications using AR technology and wearable devices is designed. This method converts the mode from teacher's traditional theoretical lectures and the student's passive learning behaviors into immediate and dynamic operations, immersive observations; changing combinations; and bi-directional interactions, exchanges, and discussions. It is expected that this method can improve student's interest and motivation in learning and help them comprehensively understand the abstract concepts of course content and technology theories, as well as the skill in practical application, through real-time and immersive surrounding observations and interactive interface operations, thereby can enhance the learning performance.

2 The Research Methodology

To achieve the aforementioned objectives, a course APP for mobile devices will be designed and implemented. The APP can be used in conjunction with Google CardBoard to achieve a more immersive experience. An interactive interface will be de signed for the APP to control different display modes, providing learners with different selections and operations. Such modes include the instant scene mode, which displays real-world images using the camera on the mobile device; operation processing mode, which displays images processed through video processing; and tile display mode, which displays the original image and the processed image simultaneously.

In the initial App design, there are 20 popular image processing functions, among the digital image processing techniques such as listed in Tables 1 and 2, will be implemented for users to select and use, including thresholding, edge extraction, color coordinate conversion, high/low pass filters, contrast adjustment, median filter, spectrum space conversion, and morphological processing, among numerous others. Some of the implemented processes are similar to running the MATLAB programs in desktop PC as shown in Figs. 1 and 2, where educators largely adopt abstract introductions to impart these basic theories. They may also provide experiential courses to enable learners to write their own programs or operate existing applications, thereby presenting images before and after processing and facilitating learners understand theories of processing functions. The proposed interactive APP enables learners to capture images of the real world using the cameras on their devices, and then selecting a processing function to view processing outcomes immediately. The ability to dynamically change operating parameters, observing images change before and after

Table 1. Some popular basic image processing functions and its descriptions (MATLAB Image enhancement and deblurring)

imadjust	Adjust image intensity values or colormap
imcontrast	Adjust Contrast tool
imsharpen	Sharpen image using unsharp masking
histeq	Enhance contrast using histogram equalization
adapthisteq	Contrast-limited adaptive histogram equalization (CLAHE)
imhistmatch	Adjust histogram of image to match N-bin histogram of reference image
decorrstretch	Apply decorrelation stretch to multichannel image
stretchlim	Find limits to contrast stretch image
intlut	Convert integer values using lookup table
imnoise	Add noise to image
deconvblind	Deblur image using blind deconvolution
deconvlucy	Deblur image using Lucy-Richardson method
deconvreg	Deblur image using regularized filter
deconvwnr	Deblur image using Wiener filter
edgetaper	Taper discontinuities along image edges
otf2psf	Convert optical transfer function to point-spread function

the processing, and analyzing numerical differences allows learners to gain a greater understanding of the various functions in different display mode such as shown in Figs. 3 and 4. Moreover, the application of real-world images and content enhances the liveliness of learning. Learners are more able to resonate with the content, thus

Table 2. Cont., Some popular basic image processing functions and its descriptions (MATLAB Image transforms)

bwdist	Distance transform of binary image
bwdistgeodesic	Geodesic distance transform of binary image
graydist	Gray-weighted distance transform of grayscale image
hough	Hough transform
dct2	2-D discrete cosine transform
dctmtx	Discrete cosine transform matrix
fan2para	Convert fan-beam projections to parallel-beam
fanbeam	Fan-beam transform
idct2	2-D inverse discrete cosine transform
ifanbeam	Inverse fan-beam transform
iradon	Inverse Radon transform
para2fan	Convert parallel-beam projections to fan-beam
radon	Radon transform
fft2	2-D fast Fourier transform
fftshift	Shift zero-frequency component to center of spectrum
ifft2	2-D inverse fast Fourier transform
ifftshift	Inverse FFT shift

Fig. 1. Matlab script example of image enhancement processing

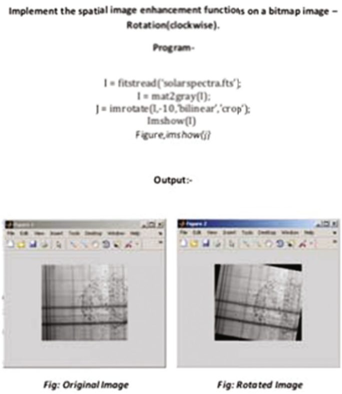

Fig. 2. Matlab script example of image rotation processing

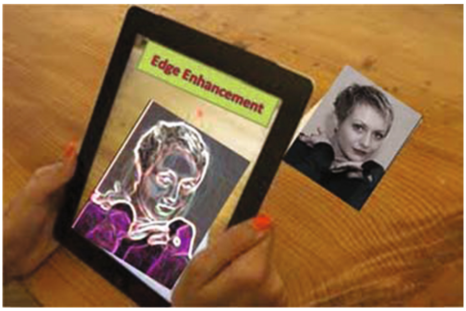

Fig. 3. Display Type I: mobile device

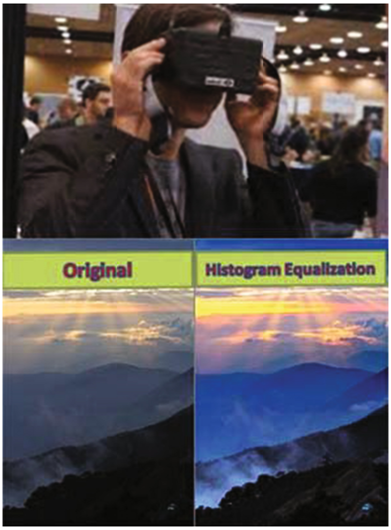

Fig. 4. Display Type II: AR device

increasing their learning motivations and interests. In future, an infinite number of image processing functions can be added into the teaching APP. Adjustment to the operations or displays modes can also be made depending on course content to reinforce extended application capabilities, thereby expanding the applicability of the proposed APP in different professional courses.

3 Conclusions

Currently, teachers primarily used slides, animation, video examples, journals, and books as teaching materials for science and technology subjects. Interactive technology device is seldom applied in science and technology teaching. Thus, learning performance relies heavily on students' learning motivation and their ability to comprehend abstract concepts. Appropriate implementation of technology applications can embody the abstract of theories hence effectively attract the interest of students and enhance their understanding of figurative expressions. Among various technological applications, wearable devices and applications for course teaching should be widely developed and promoted including 3D structure imaging, AR experiment operation and training, interactive comparative observations, and instantaneous operation and display. The present study investigated a teaching method and teaching aids which use the AR technology in designing the course aids App to try to improve the teaching/learning performance. However, implementation of the App needs cooperation of interdisciplinary experts including course teacher, image processing engineer, and the App designer/programmer. It is expected that after empirical research test in the teaching scene once the App is completed, the innovative teaching method/aids will be proved to satisfy the aforementioned teaching resource requirements and achieve learning performance goals. That is, the experiment results will be applied to field courses test to collect feedback data from students thus to verify the effect of the proposed teaching method. Moreover, the method proposed in the present study can be extended to other professional subjects. Future scholars endeavoring to develop of similar teaching materials should invite more teachers to provide their teaching needs, which would facilitate developers in creating teaching aids that meet site demands and enhance teaching content and learning materials, thereby improving learning performance.

References

1. Lee, K.: Augmented reality in education and training. TechTrends **56**(2), 13–21 (2012)
2. Zhung, S.-K.: Design an Augmented Reality Teaching System with Concept Mapping Technique. Master thesis of Industrial Design of National Cheng Kung University (2006)
3. Azuma, R.T.: A survey of augmented reality. Presence: Teleoperators Virtual Environ. **6**(4), 355–385 (1997)
4. Kaufmann, H., Schmalstieg, D.: Mathematics and geometry education with collaborative augmented reality. Comput. Graph. **27**(3), 339–345 (2003)
5. van Krevelen, D.W.F., Poelman, R.: A survey of augmented reality technologies, applications and limitations. Int. J. Virtual Reality **9**(2), 1 (2010)
6. Dunleavy, M., Dede, C., Mitchell, R.: Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. J. Sci. Educ. Technol. **18**(1), 7–22 (2009)
7. Liarokapis, F., et al.: Web3D and augmented reality to support engineering education. World Trans. Eng. Technol. Educ. **3**(1), 11–14 (2004)
8. Schmalstieg, D., et al.: The studierstube augmented reality project. Presence: Teleoperators Virtual Environ. **11**(1), 33–54 (2002)
9. Starner, T., et al.: Augmented reality through wearable computing. Presence: Teleoperators Virtual Environ. **6**(4), 386–398 (1997)
10. Gogula, S.K., Gogula, S.D., Puranam, C.: Augmented reality in enhancing qualitative education. Int. J. Comput. Appl. **132**(14), 41–45 (2015)
11. Parmar, D., Pelmahale, K., Kothwade, R., Badgujar, P.: Augmented reality system for engineering graphics. Int. J. Adv. Res. Comput. Commun. Eng. **4**(10), 327–330 (2015)
12. Onime, C., Abiona, O.: 3D mobile augmented reality interface for laboratory experiments. Int. J. Commun. Netw. Syst. Sci. **9**, 67–76 (2016)