

Authoring Augmented Reality as Situated Multimedia

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Abstract: Augmented reality (AR) is an enabling technology for presenting information in relation to real objects or real environments. AR is *situated multimedia* or information that is positioned in authentic physical contexts. In this paper, we discuss how we address issues in creating AR content for educational settings. From the learning theory perspective, we explain that AR is a logical extension of multimedia learning theory. From the development perspective, we demonstrate how AR content can be created through our in situ authoring tool and our platform for handheld AR.

Keywords: augmented reality, authoring tool, multimedia learning, situated learning

1. Introduction

Augmented reality (AR) is an emerging technology for educational settings. Our review (Santos et al. 2014) provides a useful summary of AR prototypes applied to learning. Currently, researchers have varying definitions for AR, depending on which of its features are emphasized. We define augmented reality learning experiences based on Azuma's (1997) definition of AR – "3-D virtual objects are integrated into a 3-D real environment in real time". This is a conceptual definition that is independent from enabling technologies. The "objects" mentioned are more understood as inserting computer graphics and aligning it to a video feed of the real environment. However, Azuma et al. (2001) explained that AR can potentially apply to all senses.

Although there are many AR prototypes for learning, researchers do not usually use the most important feature of AR – showing an explicit relationship between the virtual learning content and real objects found in the natural environment. There are many definitions for AR. As a technology for education, we propose to define AR to be *situated multimedia*. In other words, AR is multimedia (text, sound, images, animations, etc.) that is displayed in relation to the real environment. Thereby, the real environment becomes the "authentic context" of learning that is characteristic of situated learning (Herrington & Oliver, 1995). From this formalization, we then discuss our implementation of authoring tools that teachers can use for creating such situated multimedia.

2. Extending Multimedia Learning Theory to Augmented Reality

Previous research works have described AR to offer contextual learning (Specht et al., 2011) and ubiquitous learning (Dede, 2011). Indeed, AR has several benefits because it applies situated cognition (Wu et al., 2013). In this paper, we take a step back and explain that AR is essentially multimedia. As such, multimedia learning theory applies. In this theory, multimedia refers to pictures and words. It assumes dual-channels, limited capacity, and active processing (Mayer, 2009). First, humans have two separate channels for perceiving visual and auditory information. Second, humans have a limited capacity of information that they can attend to. Lastly, learning only takes place if learners actively make sense of incoming information using their prior knowledge. AR visualization can reduce cognitive load, thereby, allowing students to allot more effort to actively processing

information. In a previous study (Fujimoto et al., 2012), we have shown that using AR visualization enables better memorization of abstract symbols. This result is consistent with the prediction of spatial and time contiguity principles of multimedia learning.

Multimedia learning is learning with *pictures* and *words* (both written and spoken). This theory applies to AR if we make the following logical substitutions: The real objects or the real environment is the *picture*. The virtual texts, symbols and pre-recorded sounds are the *words*. A *new picture* is created when real objects, real environment and the *original picture* are combined.

3. Authoring Augmented Reality Content

One of the difficulties for adapting situated multimedia is the lack of authoring tools to make educational content. Currently, several authoring tools exist. However, they do not address the needs of teachers for a simple but flexible tool for everyday use. Software libraries like the ARToolkit (Kato & Billinghurst, 1999), Vuforia¹ and PointCloud SDK² are authoring tools for programmers.

MacIntyre et al. (2004) and Hengel et al. (2009) developed desktop-based systems for non-programmers so that they can author AR content. On the other hand, Langlotz et al. (2012) created a system for handheld-based authoring. Although handhelds have less processing power than desktops, it has the key advantage of mobile authoring at any place in any time. Currently, Langlotz et al. (2012) draws basic 3D shapes and other features such as copying, deleting, etc.

3.1 Simple In Situ Authoring for Teacher's Use

For the purposes of teachers, it is enough for them to download pictures from the internet, and then place it on a real environment. As such, we implemented an authoring tool that enables teachers to download a picture, and perform affine transformations. Our prototype uses the ARToolkit running on iPad 2 (dual-core A5, 512MB DDR2 RAM, 32GB, 601 grams, 9.7 in display, 1024-by-768 at 132 ppi).

Figure 1 shows the interface for our simple authoring tool for teachers and a sample use case. In this example, teachers can download any image from the internet. This image is converted into a texture on the screen. Using gestures like swipe, pinch, and so on, the teachers can modify the appearance of the image. In this example, it is desirable to scale and position the lungs correctly on the body.



Figure 1. Simple Authoring Tool (left); Sample Use of the Authoring Tool (right)

3.2 Handheld AR Platform for Situated Multimedia

Currently, authoring tools focus on rendering fast and beautiful graphics on a real world scene. There are few authoring tools that emphasize on the use of sounds and text. For educational settings, teachers use a combination of image, sound and text to facilitate learning. As such, we developed a handheld AR platform for presenting images, sound and text onto real objects.

We implemented the whole platform on iOS7 running on iPad 2. Figure 2 shows the package diagram and a sample application for vocabulary learning. The main part of the platform is the Controller, which has access to learning contents. It receives the marker ID and camera view matrix

¹ <https://developer.vuforia.com/>

² <http://developer.pointcloud.io/sdk>

from the Tracker and uses these information to specify the behavior of the on-screen display. The Tracker was built using ARToolkit, and the Renderer was built on OpenGL ES 2.04. In the sample use case, students can learn the word “pindutin” (Filipino for “to push”) by animating a hand which pushes a real button. This is an example of situated multimedia because it shows explicitly the relationship of the animation with real objects such as a coffee maker found in the learner’s natural environment.

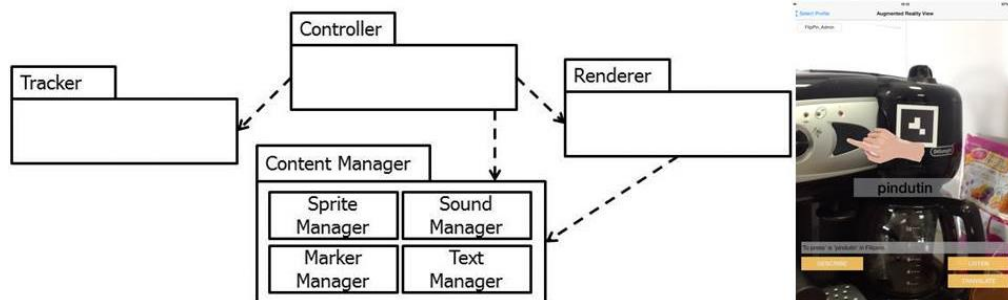


Figure 2. Package diagram of handheld AR platform (left); Sample Interface using the platform (right)

4. Conclusion

We defined augmented reality as situated multimedia. For the first time, we point out that AR could be better understood and designed by applying multimedia learning theory. Aside from graphics, sound and text is also required for creating AR learning materials. As such, we implemented two prototypes for authoring situated multimedia content namely, in situ authoring and our handheld AR platform. Currently, we are conducting evaluations of the interface with teachers. Educators can benefit from this research because it will enable them to design educational content in authentic contexts.

References

- Azuma, R. T. (1997). A survey of augmented reality. *Presence*, 6(4), 355-385.
- Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001, Nov). Recent advances in augmented reality. *Computer Graphics and Applications, IEEE*, 21(6), 34-47.
- Dede, C. (2011). Emerging technologies, ubiquitous learning, and educational transformation. In *Towards Ubiquitous Learning* (pp. 1-8). Springer.
- Herrington, J., & Oliver, R. (1995). Critical Characteristics of Situated Learning: Implications for the Instructional Design of Multimedia. In J. Pearce, & A. Ellis, *Learning with technology* (pp. 235-262). Victoria: University of Melbourne.
- Fujimoto, Y., Yamamoto, G., Kato, H., & Miyazaki, J. (2012). Relation between location of information displayed by augmented reality and user's memorization. *Proceedings of the 3rd Augmented Human International Conference* (pp. 7:1--7:8). New York, NY, USA: ACM.
- Kato, H., & Billinghurst, M. (1999). Marker tracking and hmd calibration for a video-based augmented reality conferencing system. *International Workshop on Augmented Reality, 1999.(IWAR'99)*
- Langlotz, T., Mooslechner, S., Zollmann, S., Degendorfer, C., Reitmayr, G., & Schmalstieg, D. (2012). Sketching up the world: in situ authoring for mobile augmented reality. *Personal and ubiquitous computing*, 16(6), 623-630.
- MacIntyre, B., Gandy, M., Dow, S., & Bolter, J. D. (2004). DART: a toolkit for rapid design exploration of augmented reality experiences. *User interface software and technology*, (pp. 197-206).
- Mayer, R. E. (2009). *Multimedia learning*. Cambridge University Press.
- Santos, M., Chen, A., Taketomi, T., Yamamoto, G., Miyazaki, J., & Kato, H. (2014, March). Augmented Reality Learning Experiences: Survey of Prototype Design and Evaluation. *Learning Technologies, IEEE Transactions on*, 7(1), 38-56.
- Specht, M., Ternier, S., & Greller, W. (2011). Mobile augmented reality for learning: A case study. *Journal of the Research Center for Educational Technology*, 7(1), 117-127.
- van den Hengel, A., Hill, R., Ward, B., & Dick, A. (2009). In situ image-based modeling. *Mixed and Augmented Reality, 2009. ISMAR 2009. 8th IEEE International Symposium on*, (pp. 107-110).
- Wu, H. K., Lee, S. W., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49.