Spatial Augmented Reality on Person: Exploring the Most Personal Medium

Adrian S. Johnson and Yu Sun

Robot Perception and Action Lab (RPAL), University of South Florida, Tampa, FL, USA
asjohns4@mail.usf.edu, yusun@cse.usf.edu

Abstract. Spatial Augmented Reality (SAR) allows users to collaborate without need for see-through screens or head-mounted displays. We explore natural on-person interfaces using SAR. Spatial Augmented Reality on Person (SARP) leverages self-based psychological effects such as Self-Referential Encoding (SRE) and ownership by intertwining augmented body interactions with the self. Applications based on SARP could provide powerful tools in education, health awareness, and medical visualization. The goal of this paper is to explore benefits and limitations of generating ownership and SRE using the SARP technique. We implement a hardware platform which provides a Spatial Augmented Game Environment to allow SARP experimentation. We test a STEM educational game entitled 'Augmented Anatomy' designed for our proposed platform with experts and a student population in US and China. Results indicate that learning of anatomy on-self does appear correlated with increased interest in STEM and is rated more engaging, effective and fun than textbook-only teaching of anatomical structures.

Keywords: spatial augmented reality, self-referential encoding, education.

1 Introduction

In Spatial Augmented Reality (SAR) [1-10], projectors render graphical information onto real objects. SAR has rarely been applied to the body of humans. Recently, tracking human pose in real-time without markers has become readily available using the Microsoft Kinect [11]. Thus, dynamic projection on-person is now widely accessible, motivating study of such interactions.

Further, traditional SAR research has yet to explore specific psychological effects of using the human body as a display medium. Relating digital content and avatars with the self has been found generating a sense of ownership. Ownership is the sense of self-incorporation a user adopts for an avatar, object, or interaction they identify with personally [12, 13, 14, 17].

Once ownership is established, a psychological effect termed Self-Referential Encoding (SRE) holds that information relating to the self is preferentially encoded and organized above other types of information [15, 16]. The Spatial Augmented Reality on Person (SARP) system and application we present here differ from typical SAR research in

R. Shumaker (Ed.): VAMR/HCII 2013, Part I, LNCS 8021, pp. 169–174, 2013.

that they are designed to explore the effects of self-referential interactions. Our SARP system projects interactions onto and around a user's dynamic moving body.

A hyper-personalized avatar virtualizing the user's very own internal makeup enjoins her every move in spatial as well as temporal unity. The above referenced psychological research has laid groundwork in identifying and quantizing ownership and SRE effects. However, little work has been done to render and study such promising effects in a commonly measured context providing for more formal assessment. The Augmented Anatomy SARP application we developed for our system explores teaching anatomical structures on person to study these effects in learning a practically applicable and standardized core curriculum.

2 SARP Platform Description

A hardware platform that provides a spatially augmented game environment (SAGE) capable of rendering the SARP technique was developed (Figure 6). The hardware consists of ubiquitous technology such as a Microsoft Kinect for tracking and pose estimation, a high-lumens BenQ MX commodity projector for ambient-light resistant visualizations, and a standard computing device with a graphic processing unit to efficiently and intelligently drive the two former I/O components. Standard projector and Kinect calibration techniques provide for spatial unity of avatar and user in the physical world.

Up to two users may freely move and turn within the bounds of the SAGE while interacting with content rendered on their bodies. Anatomical structures remain in sync with the body, maintaining the user's sense of ownership.

3 Augmented Anatomy SARP Application Description

An educational game and learning analysis tool that renders the SARP technique entitled Augmented Anatomy was developed. We provided a gesture-based approach for the user to learn anatomical structures and trigger interactions. Users can turn around and see the anatomy from different angles. The student may select an anatomical structure with their hand to learn more.

During the quiz interaction, the names of anatomical structures are spoken by the computer. The user is given time to touch the correct organ. In two player competition mode, the first player to correctly identify the correct structure wins points. The correct structure highlights before moving onto the next organ to provide feedback.

Several anatomical learning modes are provided. For instance, if the player makes a muscle the muscular system triggers (Figure 3). Crossing the arms into a skull and crossbones position under the head will display the skeletal system (Figure 1). Within each anatomical system mode, the players are automatically quizzed to identify the anatomical structures visible in that system. The system verbally asks the players to "point to" structures by name or functionality based on questions modeled from standardized assessments widely utilized by schools.

Fig. 1. Two players in the "Augmented Anatomy" Spatial Augmented Game Environment

Fig. 2. Augmented Anatomy SAGE in a classroom setting

Fig. 3. The muscular system is triggered via double bicep pose

4 Results

We present statistics in the form M +/- S, where M is a mean and S is a standard deviation or ES, p where ES is an effect size and p is a probability for significance testing.

4.1 Expert Survey

Augmented Anatomy was demonstrated to k-12 teachers (n=7) to assess SARP teaching effectiveness potential in a classroom setting. Each later anonymously answered survey questions. All teachers either agreed or strongly agreed the system would be effective (M=6.71 +/- 0.45) in class and more engaging (M=6.43 +/- 0.49) than a textbook (Figure 4).

Descriptive responses included "capturing attention, high levels of on-task behavior," and an "increased level of interest." One teacher touted "fun and immediate feedback' as a cause and another mentioned 'the fact that the organs show up on the kids' shirts makes the activity personal." One expert responded "it looks fairly easy to use, and is student-centered allowing the student to take part in their learning versus listening to a teacher lecture on the topic."

4.2 Student Survey

User evaluation results (n=16) support system was more engaging (M=6.0 +/- 1.21) effective (M=5.60+/- 1.50) and fun (M=6.36+/-0.69) than learning from a textbook.

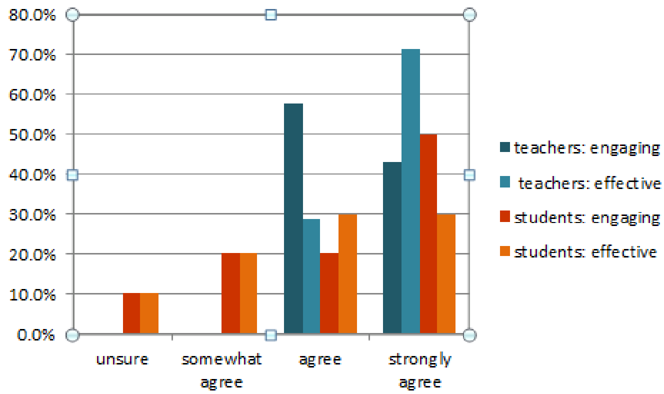

Fig. 4. 100% of teachers, 90% of students agree: more engaging and effective than textbook

4.3 Subject Interest Levels

Two groups of students participated in an online STEM subject interest survey. The first group had not seen Augmented Anatomy and the second completed the survey after seeing the system (n=81). The system had an immediate positive impact on student's interest in related STEM subjects. Results found support for an increased interest in anatomy (ES=+1.01, p<.0048) and computer science (ES=+1.16, p<.0027) with no significant change for law (Figure 5).

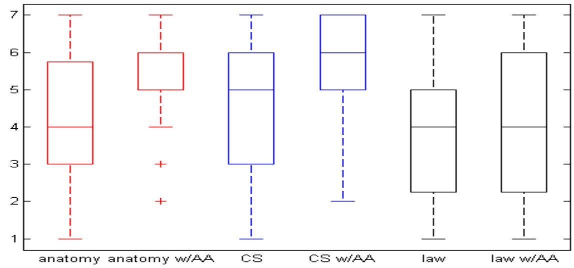

Fig. 5. STEM Interest levels significantly increased, law did not

4.4 Learning Effectiveness

We tested effectiveness on (n=50) university and high school students. The subject's education levels varied from 10th grade to Ph.D candidate and were evenly distributed among male and female. Incorrect identifications rapidly reduced during successive iterations. 100% identification occurred on average within 2.1 iterations.

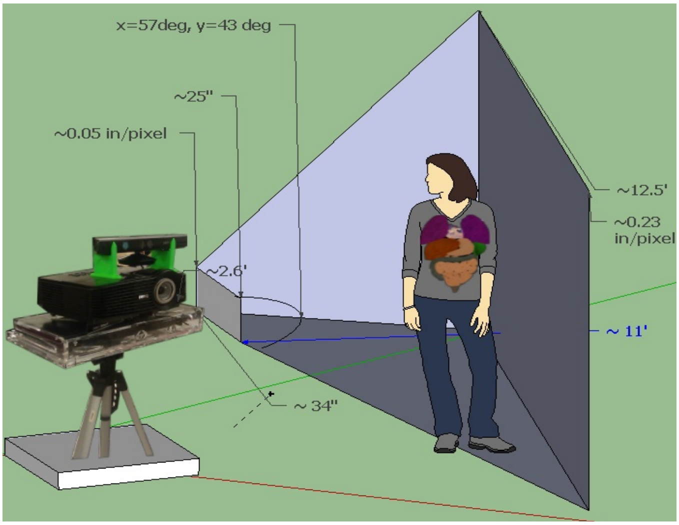

Fig. 6. Our interactive learning setup and practical ranges using Kinect, projector and laptop

5 Concluding Remarks

Here we proposed a new system and application for exploring specific psychological effects of on-person interactions. Our studies have shown positive usability, positive expert feedback, and increase in student engagement. We are conducting tests in real classrooms to determine if SRE, as leveraged by SARP, can increase benchmark scores on standardized material.

Acknowledgements. This material is based upon work supported by the National Science Foundation under Grant No. 1035594.

References

1. Raskar, R., Welch, G., Fuchs, H.: Spatially Augmented Reality. In: First International Workshop on Augmented Reality (September 1998)
2. Bandyopadhyay, D., Raskar, R., Fuchs, H.: Dynamic Shader Lamps: Painting on Real Objects. In: The Second IEEE and ACM International Symposium on Augmented Reality (ISAR 2001), New York, NY, October 29-30 (2001)
3. Raskar, R., van Baar, J., Beardsley, P., Willwacher, T., Rao, S., Forlines, C.: iLamps: geometrically aware and self-configuring projectors. ACM Transactions on Graphics (TOG) 22(3) (July 2003)
4. Bimber, O.: Spatial Augmented Reality: Merging Real and Virtual Worlds. AK Peters (2005)
5. Azuma, R.: A Survey of Augmented Reality Presence: Teleoperators and Virtual Environments, pp. 355–385 (August 1997)
6. Drascic, D., Grodski, J.J., Milgram, P., Ruffo, K., Wong, P., Zhai, S.: ARGOS: a display system for augmenting reality. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Amsterdam, The Netherlands, April 24-29, p. 521 (1993)
7. Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., Ivkovic, M.: Augmented reality technologies, systems and applications. Multimed Tools Appl. 51, 341–377 (2011)
8. Feiner, S.: Augmented reality: a long way off? AR Week, http://Pocket-lint.com (archived from the original on March 6, 2011) (retrieved March 3, 2011)
9. http://www.t-immersion.com/trylive/trylive%E2%84%A2-augmented-reality-fashion
10. Hagbi, N., Bergig, O., El-Sana, J., et al.: Shape Recognition and Pose Estimation for Mobile Augmented Reality. IEEE Transactions on Visualization and Computer Graphics 17(10), 1369–1379 (2011)
11. http://www.microsoft.com/en-us/kinectforwindows/
12. Botvinick, M., Cohen, J.: Rubber hands' feel'touch that eyes see. Nature 391(6669), 756–756 (1998)
13. González-Franco, M., Pérez-Marcos, D., Spanlang, B., et al.: The contribution of real-time mirror reflections of motor actions on virtual body ownership in an immersive virtual environment. In: VR Conference, pp. 111–114 (2010)
14. Odom, W., Zimmerman, J., Forlizzi, J.: Teenagers and their virtual possessions: design opportunities and issues. In: CHI, pp. 1491–1500 (2011)
15. Symons, C.S., Johnson, B.T.: The self-reference effect in memory: A meta-analysis. Psychological Bulletin 121(3), 371 (1997)
16. Baddeley, A.: Working memory. Science 255(5044), 556 (1992)
17. Cunningham, S.J., Turk, D.J., Macdonaldet, L.M., et al.: Yours or mine? Ownership and memory. Consciousness and Cognition 17(1), 312–318 (2008)