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Development of a Novel Tabletop and Mobile Imaging Device Based System to Facilitate Learner-Centric Education

［1］Organization

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［2］Research Progress

The purpose of the 2015 Cooperative Research Project (Research Institute of Electronics, Shizuoka University), titled *Development of a Novel Tabletop and Mobile Imaging Device Based System to Facilitate Learner-Centric Education,* was to continue and build upon an ongoing collaborative research initiative between researchers from several institutions in Japan, Canada, United States, and Colombia, that is examining various aspects of novel multi-modal display technologies including tabletop computing displays that will be used to facilitate unique and novel education, e-learning, and training applications. In addition to their use in education and training applications, the novel multi-modal displays will also be used to examine the effect of multi-modal interactions on engagement,

immersion, knowledge transfer, and retention.

Within the scope of the funded project, our work has focused on improving and building upon our novel display approach that couples a tabletop display with mobile devices to allow for learner-centric education and content delivery.

Below is a summary of the progress made during this funding period:

- Replication of the novel tabletop-tablet display that was previously developed at Shizuoka University (March 2015) in collaboration with York University (Michael Jenkin), and University of Ontario Institute of Technology (Bill Kapralos).
- Members of the team have developed a novel mobile application ("app") to support cardiac auscultation training. Although the app is currently intended for mobile devices (e.g., mobile phones and tablets), in the future, it will be modified to work with (and take advantage of), the novel tabletop-tablet display.

[3] Results

(3－1) Research results

Replicating the Novel Tabletop-Tablet Display at Multiple Locations: Tabletop computers/displays when coupled with a mobile device (e.g., tablet or mobile/smart phone) provided to each of the users may provide an effective physical infrastructure for promoting learner-centered medical education whereby the information delivered to users is customized for each user to account for the individual levels of learning (e.g., beginner, intermediate, advanced) and is presented on a as-needed basis. This provides for novel learning opportunities in areas such as teaching human anatomy to medical students and medical-based virtual interprofessional education training [Dubrowski et al., 2015]. Recently, at Shizuoka University, researchers from Japan (Kamen Kanev), Canada (Michael Jenkin, and Bill Kapralos), and Colombia (Alvaro Uribe Quevedo), developed a framework that coupled a tabletop display and mobile devices (tablets and/or smartphones), to facilitate multi-user teaching and collaborative education and training [Uribe-Quevedo et al., 2016]. An initial application of this framework was for facilitating eye anatomy education. An article outlining the novel framework and its application to eye anatomy education was prepared, submitted to an international conference, and is currently under review (see [Codd-Downey et al., 2016]). In addition, Bill Kapralos was invited to present this work as part of the *Department of Anatomy and Cell Biology Weekly Seminar Series*, Schulich School of Medicine and Dentistry, University of Western Ontario, London, Canada, on October 2, 2015.

In order to ensure greater flexibility with the work on the tabletop-tablet display, we have replicated it at York University (in Michael Jenkin's laboratory) and the University of Ontario Institute of Technology (in the laboratory of Bill Kapralos and Andrew Hogue) so that now, we have three such displays and can work on each display simultaneously.

Development of the Cardiac Auscultation Application (app): Auscultation refers to the act of listening, either directly or through an instrument (commonly, a stethoscope) to sounds within the body as a method of medical diagnosis to evaluate the frequency, intensity, duration, number, and quality of sounds associated with various parts of the body (typically the heart, lungs, and intestines). Cardiac auscultation allows for the examination of the mitral, tricuspid, pulmonary, and aortic valves to obtain information regarding the heart's rate, rhythm, location timing, intensity, quality, and shape. Identifying heart anomalies on time can help reduce the number of annual cardiac related deaths (according to the World health Organization, 17.5 million estimated in 2012). A variety of audio libraries, websites and mobile apps that help familiarize trainees with the sounds of the heart under normal and diseased conditions are available. More recently, virtual reality and manikin-based simulators have become widely used for training as they allow trainees to practice in controlled scenarios where several procedures can be configured. After analyzing cardiac auscultation tools, we identified a gap between available tools limited to presenting concepts and sound in a digital form (including websites, apps and VR), and the training provided by physical simulators where

practice and assessment takes place. Attempting to close this gap, we believe that a game-based mobile application to learn auscultation skills will connect the traditional information presented with videos and animations promoting only the memorization, and hands-on practice with manikins where they develop and test their auscultation skills. Within the scope of this funded project, team member Bill Kapralos, Alvaro Uribe Quevedo, and Adam Dubrowski (along with other researchers including cardiac surgeon Fuad Moussa from Sunnybrook health Sciences Centre in Canada and Norman Jaimes from the Faculty of Medicine, University Mil. Granada in Colombia), have developed a novel game-based mobile application ("app") for auscultation training. Our app takes advantage of the widespread use and user familiarity with smartphone devices to provide a low fidelity multimodal VR-based auscultation examination tool. The app uses low fidelity graphics, and presents a realistic auscultation setup where the trainee is required to diagnose a virtual patient. The app allow us to examine the effects of VR environments (i.e., multimodality, fidelity, and gamification), on the acquisition and development of auscultation skills.

Fig. 1. GUI, virtual patient, and sound colliders.

The app was developed using the Unity3D game engine and incorporates a 3D model patient with heart sounds (see Fig. 1). The first step is to characterize the cardiac examination. The procedure requires the trainee to inspect, palpate, and auscultate the chest overlying the heart. The examination allows visual inspection and auscultation by moving a virtual stethoscope around the chest. Collisions with the points of interest result in the reproduction of heart sounds and pop-up questions about it. The goal in this early stage is for the user to auscultate the virtual patient by identifying rate, rhythm, and sound location, and to determine whether it's a normal or pathological sound. To challenge and engage the user, game elements (e.g., challenge, procedure, score and time) are employed to increase difficulty and reward the user. Healthy and diseased sounds are randomly presented across the chest to encourage users to pay attention rather than just memorize the same sound in the same position with time constraints associated to the sound intensity level. An article outlining the auscultation app will be presented at the *4th International Conference on Serious Games and Applications for Health* in May 2016 (see [Uribe-Quevedo et al., 2016]). We have also recently conducted a preliminary study with human participants (medical students in Colombia) to examine the effectiveness of the app. The results are being analyzed and an article will be prepared and submitted to a journal shortly.

(3－2) Ripple effects and further developments

We are continuing to build-upon and expand the innovative work and progress that was made during this particular funding period. Work will continue simultaneously at three locations where the displays are currently available: Shizuoka University, York University, and University of Ontario Institute of Technology. The work to be done will involve continuing to improve the novel tabletop-tablet display that we have developed. More specifically, we will examine the incorporation of spatial sound to the display, taking advantage of our previous work that has developed various spatial sound techniques for tabletop displays relying on amplitude panning. We have previously shown (via human based "ground truth" experiments) that localizing a real (actual) sound source on a horizontal plane is difficult and error prone [Lam et al., 2015]. Here we will examine whether the inherent sound localization errors can be reduced with the addition of graphical cues (a review article outlining audio-visual interactions and fidelity was recently published by team members Bill Kapralos, Karen Collins and Adam Dubrowski [Kapralos et al., 2016]). We will also examine methods to couple and synchronize the spatial sounds on the tabletop display to the mobile device.

Future work will also include continuing the development of the auscultation app. This will include conducting a Delphi study with the

stakeholders of the mobile application (e.g., medical educators) to gather information of the key components/elements that should be included to make the application a useful learning tool. Once we have reached agreement consensus through our Delphi process, we will use this information to refine the development of the app. Once the application has been developed, it will go through a validation process to verify that the use of the newly developed tool provide the knowledge we intended to reach. This will include conducting formal usability experiments with medical students.

［4］Achievements (List of Publications)

（1） R. Codd-Downey, R. Shewaga, B. Kapralos, A. Uribe-Quevedo, K. Kanev, and M. Jenkin. A novel tabletop and tablet-based display system to support learner-centric ophthalmic anatomy education. Submitted to *3rd International Conference on Augmented Reality, Virtual Reality and Computer Graphics (SALENTO AVR 2016)*, Otranto, Lecce, Italy, June 15-18, 2016 (currently under review).

（2） A. Dubrowski, B. Kapralos, K. Kanev, and M. Jenkin. Interprofessional critical care training: Interactive virtual learning environments and simulations. In *Proceedings of The Sixth International Conference on Information, Intelligence, Systems and Applications* (IISA 2015), Corfu, Greece, July 6-8, 2015.

（3） B. Kapralos, F. Moussa, K. Collins, and A. Dubrowski. Levels of fidelity and multimodal interactions. In P. Wouters and H. van Oostendorp (Eds.) Techniques to Improve the Effectiveness of Serious Games, Springer *Advances in Game-based Learning* book series (to appear 2016).

（4） J. Lam, B. Kapralos, K. Kanev, K. Collins, A. Hogue, and M. Jenkin. Sound localization on a horizontal surface: Virtual and real sound localization. *Virtual Reality*, Special Issue on *Spatial Sound in Virtual and Augmented Reality*, 19(3):213-222, 2015.

（5） A. Uribe-Quevedo, B. Kapralos, A. Hogue, K. Kamen Kanev, M. Jenkin, and R. P. Barneva. A multi-user tabletop display with enhanced mobile visuals for teaching and collaborative training. In *Proceedings of the Consortium for Computing Sciences in Colleges — Northeastern Region 2016 Conference*, Clinton, NY, USA, April 29 – 30, 2016 (to appear).

（6） A. Uribe-Quevedo, D. Rojas, M. Usman, B. Kapralos, F. Moussa, A. Dubrowski, and N. Jaimes. Cardiac auscultation serious game approach. In *Proceedings of the 4th International Conference on Serious Games and Applications for Health*, Orlando, FL, USA, May 11-13, 2016 (to appear)

（7） Barneva, R., Kanev, K., Kapralos, B., Jenkin, M., Enhanced student engagement using cell phones and tabletop computers or smart boards, In *Proceedings of 25th CIT 2016 Conference on Instructional Technologies*, Potsdam, NY, USA, May 31-June 3, 2016 (to appear).

Travelling Report （Mention each travel by CRP budget.）

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Affiliation：
Period of time：
Destination：
Purpose：
Name of receiver：