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課題番号 ：P-4

Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices

[1] Organization

Leader: *Bill Kapralos* (Faculty of Business and Information Technology, University of Ontario Institute of Technology, Canada)

Representative at RIE: *Hiroshi Inokawa* (Research Institute of Electronics, Shizuoka University)

Participants:

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Robert Allison (Department of Computer Science and Engineering, Faculty of Engineering, York University, Canada)

Patrick Hung (Faculty of Business and Information Technology, University of Ontario Institute of Technology, Canada)

Julita Vassileva (University of Saskatchewan, Canada)

Magdalina Todorova (Department of Computer Science, Faculty of Mathematics and Informatics, Sofia University, Bulgaria)

Michael Vynnycky (Department of Mathematics and Statistics, University of Limerick, Ireland)

Karen Collins (Canadian Centre of Arts and Technology at the University of Waterloo, Canada)

Adam Dubrowski (The Hospital for Sick Children Learning Institute, and Department of Pediatrics, University of Toronto, Canada)

Andrew Hogue (Faculty of Business and Information Technology, University of Ontario Institute of Technology, Canada)

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Sanshiro Sakai (Graduate School of Informatics, Shizuoka University)

Kamen Kanev (Graduate School of Informatics, Shizuoka University)

[2] Progress of the research

The purpose of the 2013 Cooperative Research Project (Research Institute of Electronics, Shizuoka University), was to continue and expand upon an ongoing research collaboration between researchers from Japan and Canada that is examining various aspects of tabletop computing displays and virtual simulation for e-learning applications. Within the scope of the current funding, our work focused on the development of an innovative, unique, strategy-based, learner-centered, interactive, virtual learning environment (VLE) for IPE in pediatric critical care (see (2,6) for a discussion on the use of virtual simulations and serious games for health professions education and training). The VLE will provide a safe environment whereby trainees apply and practice IPE-specific skills in a remote (online), multi-user setting thus eliminating the need, and problems associated with, bringing together health professionals of various disciplines to train at one location. In addition to its use as a training tool for health professionals, the VLE will be developed as a research tool that will permit the altering of various simulation parameters (e.g., audio and visual fidelity). This will allow us to examine multi-modal interactions and simulation fidelity on learning and explore questions such as the following: Do higher fidelity visual and auditory cues lead to a greater transfer of knowledge? How do changes in audio/visual fidelity affect students'/trainees' ability to perform specific tasks? Is a scaffolding approach whereby fidelity is increased in proportion to trainee level, effective? What effect does stereoscopic 3D viewing have on immersion, engagement, and ultimately learning (see (8))? What effect does spatial sound have on learning? Answering such questions and developing a greater understanding of multi-modal interactions has implications for virtual reality

applications in general (including virtual simulations) given that despite the great computing hardware and computational advancements over the last decade, real-time, multi-modal rendering of complex virtual environments is still beyond our current reach; having a good understanding of multi-cue interaction will allow us to take advantage of perceptual-based rendering whereby the rendering parameters are adjusted based on the perceptual system (typically vision), to limit computational processing.

Although this is a long-term goal, significant progress has been made towards this ultimate goal within this funding period. More specifically the following milestones were reached:

- A scenario outlining a pediatric patient and critical care response team was developed.
- A series of experiments that examined audio-visual interactions and more specifically, the effect of contextual auditory cues on visual fidelity perception were conducted (4,7).
- A novel game-based calibration method that allows users to customize/individualize the virtual environment before they begin using was developed (4).
- Continuation and expansion of the Japan-Canada research collaboration with additional research members.

Greater details regarding each of the above milestones is provided is the following section.

[3] Results

(3.1) Research results

Below, greater details regarding the four areas of progress over the last project year are provided.

(3.1.1) Pediatric Patient Scenario

Patient history: Johnny is a 7 year old, male patient admitted to an emergency room in a tertiary children's hospital. Upon admission, his parents report that he has been complaining of dizziness and nausea. While at the emergency room, Johnny loses consciousness and stops breathing.

*Simulation Protoco*l: Within this scenario, a computerized mannequin, that is known as the Human Patient Simulator (HPE), plays the role of Johnny. The emergency nurse calls "code blue" and the Critical Care Team (CCT) is mobilized. The CCTs are fundamental components of most hospital patient safety infrastructure designed to assist with critically unstable patients. The CCTs consist of multi-professional teams consisting of nurses, respiratory therapists and physicians. The team is expected to respond according to strict protocol that dictates actions, sequences, timing and coordination with other team members. The HPS-Johnny is capable of providing the team with vital signs, such as breathing, oxygen saturation, heart rate, just the way a real patient would. His chest rises as he breaths and he can communicate with the team using voice. The simulation event is similar to role-playing exercise, where the teacher plays the role of the patient. She can adjust the vital signs, rhythms etc. and talk to the team. She follows an algorithm developed based on real clinical experiences.

(3.1.2) Audio-Visual Interaction Experiments

Previous work has shown that sound can affect the perception of visual fidelity. This work expanded upon our previous work by examining the effect of contextual sound cues (i.e., sounds that are related to the visuals) on visual fidelity perception through a user-based study. Results suggest that contextual sound cues do influence visual fidelity perception and, more specifically, our perception of visual fidelity increases with contextual sound cues. These results have implications for designers of multimodal virtual worlds and serious games that, with the appropriate use of contextual sounds, can reduce visual rendering requirements without a corresponding decrease in the perception of visual fidelity. Greater details regarding this study can be found in (7).

(3.1.3) Game-Based Calibration Method

Given the large variation observed across individuals with respect to the perception of audio-visual fidelity and with the respect to the effect of audio cues in the perception of visual fidelity (see (4)), we have recently begun examining the customization (individualization) of a virtual environment by each individual user through the use of a game-based calibration method. Customization of the audio and visual interface is accomplished using a simple game-based approach, making the process interactive and far more engaging. Our approach is inspired by standard testing methodologies employed by optometrists to determine the optimum properties of corrective lenses in order to overcome a variety of visual deficiencies. The calibration game presents the user with a split screen with the same game running in each window but under different fidelity/realism settings with a single background sound. The player chooses the screen they prefer by clicking a button just above the corresponding window. Their choice will be registered and the audio-visual fidelity of the game running in the

other window will change (increase or decrease). This process is repeated over a number of cycles (the total number of cycles can be easily modified), until the optimal fidelity level is reached (greater details are provided in (4)).

(3.1.4) Expanding and Building-Upon the Japan-Canada Research Collaboration

Recently, an international team of interdisciplinary researchers across several institutions in Japan, (Dr. Kamen Kanev from Shizuoka University), and from Canada (Dr. Michael Jenkin from York University, Dr. Bill Kapralos from the University of Ontario Institute of Technology, Dr. Adam Dubrowski from Memorial University, and Dr. Karen Collins from the University of Waterloo), have established an international collaboration to investigate various problems and issues related to tabletop computers. Their independent and collaborative efforts have examined a range of issues related to the development of effective tabletop computer display technology. Emphasis has so far been placed on spatial sound generation and localization and our work to date has focused on the generation (and localization) of spatial sound for tabletop computers and has led to some novel results and innovations including the following: i) development of two spatial sound (amplitude panning) techniques for tabletop computers, ii) the use of video games for evaluating human-computer interaction and in particular, for conducting usability tests to examine various loudspeaker configurations and amplitude panning techniques for tabletop computers, iii) distributed audio over mobile devices, and iv) developing novel hardware and using the hardware to conduct a series of experiments that investigated sound localization for both virtual and actual sound sources positioned on a horizontal surface.

Overall, our work has shown that sound localization on a horizontal surface (inherent with a tabletop computer), is erroneous irrespective of the techniques used to generate the sound or the loudspeaker. Developers and designers of applications for tabletop computers must account for this and not necessarily rely on accurate sound localization as a primary method conveying information. Rather, they may exaggerate placement when sound source positions correspond to positions with large error. It has been shown that sound source localization varies with frequency and changes in frequency, sounds that have more formants/overtones are easier to localize than sine waves, and reverberation also aids sound source localization. These are all potential areas that warrant further investigation. Furthermore, images tend to "magnetize" sounds to a specific location and it can therefore be assumed that some errors can be corrected through the visualization of sounds.

Our most recent efforts have focused on building upon and expanding our current progress and are primarily focused on i) collection of reference data for audio-visual table top displays, ii) incorporating visual cues in audio-visual interactive displays (including tabletop computers), and examining the interaction of audio and visual cues in enhancing the user experience, and iv) development of an innovative, unique, strategy-based, learner-centered, interactive, virtual learning environment (VLE) for interprofessional education (IPE) in pediatric critical care that employs a table-top display to leverage its inherent collaborative nature (described further below). The funding received from the Cooperative Research Projects fund (Research Institute of Electronics, Shizuoka University) titled "Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices" was used to directly support our ongoing work. More specifically, the funds were used to support the visit to Shizuoka University by three Canadian researchers in December 2013 to meet with their Japanese colleagues/partners with regards to their ongoing collaboration. The researchers included existing collaborators Dr. Michael Jenkin, and Dr. Bill Kapralos in addition to a (new) researcher, Dr. Patrick Hung from the University of Ontario Institute of Technology.

During the visit to Shizuoka University in December 2013, the visiting Canadian researchers participated in a Cooperative Research Workshop titled "Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices" held on Friday December 13, 2013. The workshop was organized by Dr. Kamen Kanev and held at RIE, Shizuoka University. It included the following presentations by the Canadian visiting researchers to describe their current work and further collaboration (exchange) opportunities for students and faculty members between Shizuoka University and the University of Ontario Institute of Technology.

- Dr. Michael Jenkin: A Model for Interaction through Augmented Surfaces.

- Dr. Patrick Hung: Evidence-based Technology: MaxIt Systems.
- Dr. Bill Kapralos: Interprofessional Critical Care Training – Interactive Virtual Environments
- Dr. Patrick Hung: Possibilities for Joint Research Collaboration and Exchanges between University of Ontario Institute of Technology and Shizuoka University.

In addition, the visit by the Canadian researchers coincided with the International Conference on Humans and Computers 2013, Hamamatsu, Japan, December 17, 2013. Dr. Kapralos presented an invited presentation titled "Virtual Simulation and Serious Gaming: Audio-Visual Interactions, Perceptual-Based Rendering, and the Implications". In addition, the project members presented the following works:

- Dr. Patrick Hung: Evidence-based Technology: Case Studies and Interactions
- Adam Dubrowski, Bill Kapralos, Michael Jenkin and Kamen Kanev: Interprofessional Critical Care Training: Interactive Virtual Learning Environments and Simulations.
- Kamen Kanev, Itaru Oido, Patrick Hung, Bill Kapralos and Michael Jenkin: Augmented Reality Toys: Applications and Future Works.

Additional activities included "Japan-Canada meet and greet" on Friday, December 13, 2013 (Takayanagi Museum Building from 18:00 – 20:00) and organized by Dr. Valerie Wilkinson. The three Canadian researchers attended the "meet and greet" where they had the opportunity to talk to various students and faculty from Shizuoka University and other guests.

(3.2) Future Work

We are continuing to build-upon and expand our Japan-Canada collaboration. More specifically, Dr. Kapralos submitted a proposal to the Japan Society for the promotion of Science (JSPS) January 15 to support a visit to Japan (Shizuoka University) for 60 days (January 15 2015 – March 15 2015) to continue ongoing work that is examining multi-modal interactions and tabletop computers (decision to be made in May 2014). In addition, researchers from the University of Ontario Institute of Technology (UOIT) and Dr. Kamen Kanev are in the process of preparing and submitting a multi-million grant proposal to the Canadian Foundation of Innovation (CFI) 2015 Innovation Fund for infrastructure to support a User-Centred Informatics Research Space (UCIRS). The UCIRS will contains state-of-the-art visualization, computing, and sensing capabilities layered in a modular manner in order to design and test evaluate user interaction with medical, simulation, training and entertainment informatics via brain-body sensing and natural user interfaces for collaboration and affective user sensing, two-way holographic/volumetric video conferencing, in the NICU and user-centered informatics context . The facility will incorporate high quality stereoscopic 3D projection, full body motion capture and tracking, computer vision systems for creating 3D representations of the environment in real-time, and state of the art observational recording for behavioral and physiological analysis. One of the projects to be investigated includes developing the control room of the future. The CFI application has already passed the internal UOIT review process and was selected (amongst two other proposals) to proceed with the next stage (development of the Notice of Intent) CFI. The Notice of Intent is due Friday March 28, 2014 while the full proposal is due Friday June 27, 2014.

With respect to publications, currently Drs. Hung, Kanev, Jenkin, and Kapralos are completing an article (book chapter) that will appear in the book "Mobile Services for Toy Computing" that will be published by Springer in late 2014. The article is titled "Augmented reality (AR) toys" (1). Furthermore, Drs. Dubrowski, Kapralos, Jenkin, and Kanev are preparing an article titled "Interprofessional Critical Care Training: Interactive Virtual Learning Environments and Simulations". Kapralos and Kanev are also preparing an article titled "Spatial Sound for Virtual and Augmented Reality Environments: Problems, Limitations, and Implications for Mobile Devices" that will also appear in the book "Mobile Services for Toy Computing" (3). The article will provide an overview of spatial sound with an emphasis on the generation of spatial sound for mobile devices. The article will be submitted to the Medicine Meets Virtual Reality 2015 conference (deadline is July 2014) and summarizes progress to-date regarding the work done by the authors that is examining the use of a virtual learning environment (simulation) for interprofessional education IPE for pediatric critical care teams using a tabletop computing platform coupled with novel image-based sensing technologies. This will allow for collaboration and interaction amongst a group of trainees while promoting a learner-centric learning approach where the simulation is tailored specifically to the needs of each trainee.

[4] Publications

(1) P. Hung, K. Kanev, M. Jenkin, and B. Kapralos. Augmented reality (AR) toys. In *Technologies of Inclusive Well-Being*. In P. Hung (Ed.), Mobile Services for Toy Computing, Springer, to appear 2014.

(2) B. Kapralos, F. Moussa, and A. Dubrowski. An overview of virtual simulations and serious games for surgical education and training. In *Technologies of Inclusive Well-Being*. In A. Brooks, S. Braham, and L. Jain (Eds.), *Springer Series Studies in Computational Intelligence*, Heidelberg, Germany, Chapter 14, pp. 289-306, 2014.

(3) Kapralos, and K. Kanev. Spatial sound for virtual and augmented reality environments: Problems, limitations, and implications for mobile devices, In P. Hung (Ed.), Mobile Services for Toy Computing, Springer, to appear 2014.

(4) B. Kapralos, R. Shewaga, and G. Ng. Serious games and virtual simulations: Customizing the audio-visual interface. *Well-Being, Rehabilitation, and Healthcare: Serious Games, Alternative Realities, and Play Therapy* Parallel Session at the *6th Int. Conference on Virtual, Augmented and Mixed Reality, HCI International 2014*, Crete, Greece, Jun. 22-27, 2014 (to appear). Invited paper and presentation.

(5) J. Lam, B. Kapralos, K. Collins, A. Hogue, and K. Kamen. Amplitude Panning-Based Sound System for a Horizontal Surface Computer: A User-Based Study, *ACM Computers in Entertainment* (to appear, 2014).

(6) S. de Ribaupierre, B. Kapralos, F. Haji, E. Stroulia, A. Dubrowski, and R. Eagleson. Healthcare training enhancement through virtual reality and serious games. In M. Ma, L. Jain, and P. Anderson (Eds.), *Virtual, Augmented Reality and Serious Games for Healthcare 1*, Springer-Verlag (to appear 2014)

(7) D. Rojas, B. Cowan, B. Kapralos, K. Collins, and A. Dubrowski. The effect of contextual sound cues on visual fidelity perception. *Medicine Meets Virtual Reality 2014*, Manhattan Beach, CA, USA, Feb. 20-22, 2014. Also appears in *Studies in Health Technology and Informatics*,196:346-352, 2014.

(8) M. Tawadrous, A. Hogue, B. Kapralos, and K. Collins. An interactive in-game approach to user adjustment of stereoscopic 3D settings. In *Proceedings of Stereoscopic Displays and Applications XXIV*, February 3-7, 2013, San Francisco, CA, USA, pp. 1-6.

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Traveling Report

Name:	Dr. Bill Kapralos
Affiliation:	Faculty of Business and Information Technology
Period of time:	December 8 – 19, 2013
Destination:	Shizuoka University, Japan
Purpose:	i) to discuss the ongoing Japan-Canada research collaborations and project organization, ii) to schedule future work, iii) to participate (provide a presentation) at the “Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices” workshop held on Friday December 13, 2013, and iv) to participate (present research and an invited presentation) at the International Conference on Humans and Computers 2013 held on December 17, 2013 (Shizuoka University).
Name of receiver:	Dr. Kamen Kanev

Name:	Dr. Patrick Hung
Affiliation:	Faculty of Business and Information Technology
Period of time:	December 10-20, 2013
Destination:	Shizuoka University, Japan
Purpose:	i) to discuss the ongoing Japan-Canada research collaborations and project organization, ii) to schedule future work, iii) to participate (provide a presentation) at the “Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices” workshop held on Friday December 13, 2013, and iv) to participate (present research and an invited presentation) at the International Conference on Humans and Computers 2013 held on December 17, 2013 (Shizuoka University).
Name of receiver:	Dr. Kamen Kanev

Name:	Dr. Michael Jenkin
Affiliation:	Department of Computer Science and Engineering
Period of time:	December 8-14, 2013
Destination:	Shizuoka University, Japan
Purpose:	i) to discuss the ongoing Japan-Canada research collaborations and project organization, ii) to schedule future work, and iii) to participate (provide a presentation) at the “Promoting Collaborative Interprofessional Education for Critical Care Teams with a Table-Top Computer-Based Virtual E-Learning Environment Engaging Advanced Imaging Devices” workshop held on Friday December 13, 2013.
Name of receiver:	Dr. Kamen Kanev