MU ITC: Interdisciplinary Innovations Fund 2015/2016 Report for

Development of 3D Virtual Reality Environments for Medical Education

Project Leaders:

- Bimal Balakrishnan, PhD: Department of Architectural Studies, College of Human Environmental Sciences
- Julie Marshall, MD: Department of Anesthesiology, School of Medicine

The goal of our team collaboration for this project is to create a 3D virtual reality operating room, which can provide the complex detail found in real patient care environments while providing adaptability, accessibility, and affordability for medical education.

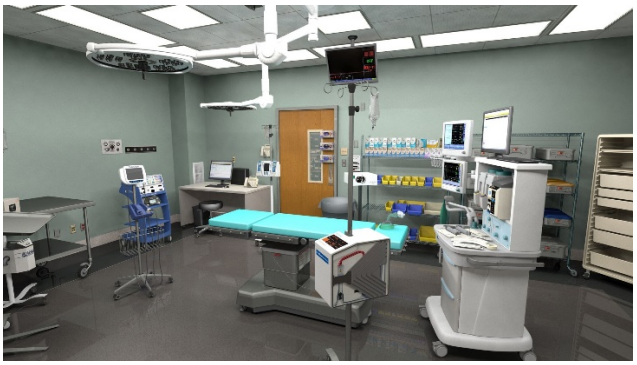
The progress to date has included completion of the following components as outlined in the initial proposal:

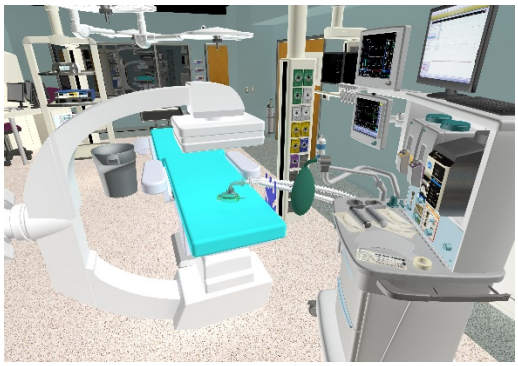
Phase 1 – **Detailed documentation of operating rooms at the University of Missouri Hospital.**
(December 2015 to February 2016)

- In this phase, we gathered highly precise measurements of medical furniture, equipment and other peripherals in the operating rooms using photographs, laser measuring tapes, digital calipers, 360 stills and videos and 3D scanning along with references such as product specification sheets from manufacturers, and digital catalogs. These measurements were taken of the trauma operating room and the hybrid operating rooms in the University Hospital.
- Acquisition of measurements was completed by graduate students Zhaleh Khosravi, Benjamin Schrimpf and Ehsan Naderi and were assisted by undergraduate students Hannah Schultz and Rachel Liberty under supervision of Dr. Balakrishnan
- Dr. Marshall provided expertise in cataloging key components of the trauma operating room and hybrid operating rooms, guidance of critical components during environmental measurements, and obtaining access to the operating room suites.

Phase 2- Development of virtual reality models of operating rooms
(February 2016 – August 2016)

- Models were developed using 3D modeling tools Solidworks and 3D Studio Max and exported to Unity3D software for building interactivity and deployment on virtual reality platforms. This was led by graduate students Zhaleh Khosravi and James Hopfenblatt under the supervision of Dr. Balakrishnan. Dr. Marshall with medical students Michael Moore and Matt Mooberry, along with resident Ryan Farmer, MD provided continuous input with evaluation meetings to ensure a high level of accuracy for the VR environment.
- Created 360^{O} 3D virtual images of the trauma operating room with ability for 3D viewing with low cost VR devices, including Google cardboard and View-Master
- Interactive capabilities were evaluated to determine the optimum user interface. Joystick interaction has been configured for initial interactive capabilities with continued evaluation into the ability to use full body motion capture system.

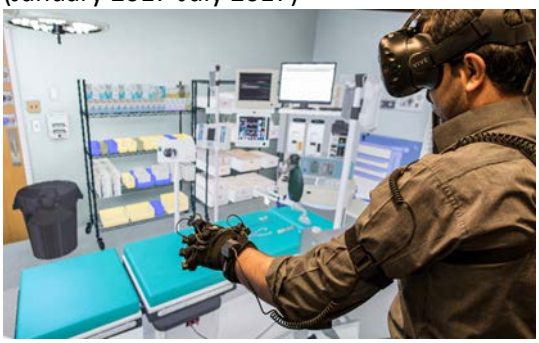




Phase 3 – **Usability evaluation for education of students and residents**
(September 2016 – December 2016)

- During the week of September 26th, 2016, graduate student Zhaleh Khosravi under the supervision of Dr. Balakrishnan, along with Matt Mooberry and Ryan Farmer MD under the supervision of Dr. Marshall, led evaluation sessions for the virtual reality operating room using screen based display and Oculus Rift systems by faculty anesthesiologists, anesthesiology residents, and certified registered nurse anesthetists.
- We collected detailed feedback from 31 participants regarding the level of realism, ease of interaction, its potential for use as a training environment, and their suggestions for which clinical scenario to integrate with the VR environments. The virtual trauma surgery room and the hybrid operating room were presented to participants using Oculus Rift and a projector. They interacted with the virtual environment and explored it using joystick controllers.
- Evaluation plans were developed by Dr. Balakrishnan and Dr. Marshall focusing on:
    - Ease of user interaction with the virtual OR environment
    - Experiential congruence with equivalent real-world OR environment
    - Preference of interactive systems for learners.
- Evaluation of the learning system was conducted with IRB approval as a Quality Improvement project.
- Survey data was evaluated to determine best user experience.

Project Completion:
(January 2017-July 2017)



- National presentation by the resident, medical student, and graduate students on the development of this system and user sense of realism.

- Obtained precise measurements of the hybrid operating room to demonstrate usability of varied clinical environments for virtual reality.
- Labeled equipment and critical medical devices in the operating rooms for independent student orientation to the environmental space.
- Data analysis resulted in reconfiguration of the interface to allow movement and orientation for realism and to decrease a reported sense of disorientation by some users.
- Integration of motion capture gloves to allow basic interaction with the virtual environment
- Focused evaluation by faculty and residents to refine the system interaction
- Fully interactive virtual reality environments for trauma and hybrid operating rooms are ready to be deployed. These two training environments will allow residents and medical students to explore and familiarize themselves with these operating rooms.
- We are continuing our work to develop training simulations for various medical procedures and seeking additional funds from external sources. Dr. Balakrishnan and Dr. Marshall's Anesthesia Immersive Reality Simulation (AIR-SIM) project based on the foundation laid by this IIF project was a finalist for the MU Coulter Boot Camp. We have filed an invention disclosure for the training simulation and working to seek a provisional patent.
- An agreement to establish a virtual reality learning space within the Russell D Sheldon Simulation Lab by November 2017 following proper installation and configuration of purchased equipment. This will ensure that this project will have ongoing impact on medical education at MU.

Summary

Our team has accomplished creating a highly detailed virtual reality environment and have met the benchmarks we had set for ourselves in the proposal as detailed above. We expect the project to allow for continued development of virtual reality training methods for student and resident education. Our system has potential for use in full simulation of medical scenarios which will allow a flexible learning environment for learners. We are currently exploring multiple partnerships including one with the Tiger Institute to develop our training simulations further and seek commercialization opportunities. In addition to the successful project deliverables discussed above, the project experience had meaningful impact on our student leaders. Benjamin Schrimpf who graduated this past spring semester has established his own company specializing in visualization and virtual reality.

BUDGET & EXPENSE REPORT

Current Expenditures:

GRA Support	$16,294
Unity Pro License for 2 years for ongoing development efforts for VR training	$ 1,800

Equipment for setting up VR training lab at the Russell D Sheldon Simulation Lab

Two Dell Alienware VR Desktops	$ 4,200
Two Monitors for Alienware Desktops	$ 384
Two HTC Vive VR Head Mounted Displays and Controllers	$ 1,198
Two sets of tripods for HTC Vive Trackers	$ 67
Overall Project Expenses	**$23,943**
Balance	$ 1,025