**MOHAMMAD HOSSEIN SALIMIAN RIZI**
**BSc (Computer Science), Sharif University of Technology, 2005**
**MCSc (Computer Science), Dalhousie University, 2010**

**FACULTY OF COMPUTER SCIENCE**

**TITLE OF THESIS:** EXPLORING THE IMPACT OF ASYMMETRICAL INTERFACES ON PRESENCE AND GROUP AWARENESS IN MIXED REALITY COLLABORATIVE ENVIRONMENTS

**TIME/DATE:** 11:00 am, Thursday, December 6, 2018

**PLACE:** Room 3107, The Mona Campbell Building, 1459 LeMarchant Street

**EXAMINING COMMITTEE:**

Dr. Mark Hancock, Department of Management Sciences, University of Waterloo (External Examiner)

Dr. Qigang Gao, Faculty of Computer Science, Dalhousie University (Reader)

Dr. Bonnie MacKay, Faculty of Computer Science, Dalhousie University (Reader)

Dr. Derek Reilly, Faculty of Computer Science, Dalhousie University (Co-Supervisor

Dr. Stephen Brooks, Faculty of Computer Science, Dalhousie University (Co-Supervisor)

**DEPARTMENTAL REPRESENTATIVE:** Dr. Raghav Sampangi, Faculty of Computer Science, Dalhousie University

**CHAIR:** Dr. Margaret Walsh, PhD Defence Panel, Faculty of Graduate Studies

## ABSTRACT

Mixed Reality (MR) can be used for mixed presence collaboration by connecting physical and virtual worlds to create an integrated space: remote collaborators connect virtually to a physical workspace inhabited by collocated collaborators. While a “What-You-See-Is-What-I-See” (WYSIWIS) approach holds benefits for group awareness in traditional desktop collaborative systems, WYSIWIS is made problematic by the fundamental asymmetry of many MR configurations. This thesis examines the relationship between interface asymmetry, group awareness, and a sense of co-presence in MR collaborative spaces.

We conducted a user study with three scenarios involving hiding and sharing blended physical-virtual documents around a fused physical-virtual tabletop. The remote collaborator was presented to collocated collaborators as an avatar in a VE in tableside and circumambient display conditions. Collocated collaborators actively sought information about how the physical and virtual environments were mapped chiefly when this was relevant to the tasks, although the circumambient displays generated more curiosity than a single tableside display about how the spaces were connected. Most participants felt that keeping documents away from the tabletop was sufficient to hide them from the remote collaborator, but indications that remote participants could somehow “see” around the physical environment in WYSIWIS fashion led some participants to trust the integrated physical-virtual environment less.

We further investigated how the nature of WYSIWIS abstraction in a collaborative MR environment impacts collaborators’ awareness and feeling of co-presence, specifically for tasks involving 3D artefacts. Collocated collaborators used a tabletop display, while remote collaborators used either a tabletop display or a head-mounted display and physical proxy table to work on tasks involving 3D object manipulation. The results of the study suggest that an immersive VE significantly increases group awareness and the feeling of being co-presence for both remote and collocated collaborators in comparison to a pure WYSIWIS tabletop configuration. Presenting 3D models in front of the remote participant above the virtual tabletop (Hover) or within the virtual tabletop (Fishtank) did not yield significant differences in group awareness or presence, despite Fishtank providing a more WYSIWIS experience. In addition, a significant percentage of remote participants preferred presentation over the virtual tabletop.

The lack of toolkit support for our research motivated us to combine the software technologies and algorithms used in our work to create a Unity toolkit for rapidly prototyping immersive mixed reality collaborative environments (IMRCE). The IMRCE toolkit helps developers to add five components to their systems: hand tracking (visualized and synchronized on all clients), position tracking, touch gestures, virtual reality interaction, and creating client/server applications. We evaluated the usability of our toolkit by conducting an A/B comparison between IMRCE and common Unity libraries. The results showed that the IMRCE toolkit made a significant improvement in time to completion, lines of code, number of features, and number of bugs in comparison to development without IMRCE