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Clock-maker's Work-space: Tangible Mixed Reality for 3D Design in the Peripersonal Space

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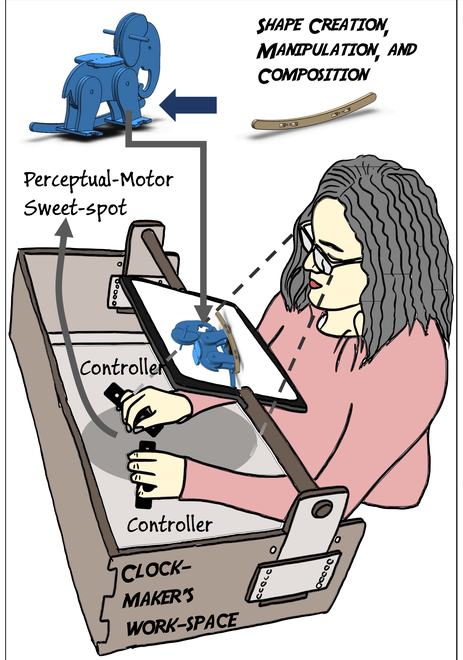
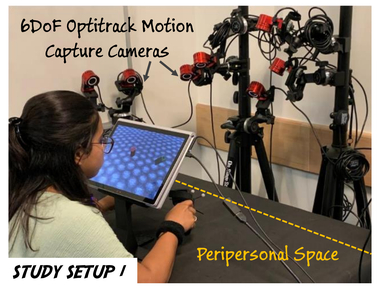
Clockmaker's Workspace

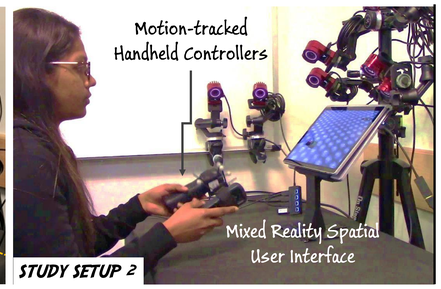


❖ **Motivation**
- Investigate precise spatial manipulation of virtual objects to facilitate 3D digital design
- Manual tasks such as sculpting, or assembly of parts involve close, careful, and precise handling of tools and work-pieces
- The space where precise action takes place is co-located with the space where action is perceived
- There is a need for methods in Extended Reality (XR) systems that capture the physicality of real-world interactions into virtual design tools to explore form and functionality of design ideas

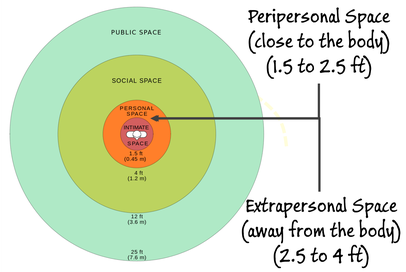
❖ **Idea**
- Perceptual-Motor Sweet-spot that follows ecological psychology and action-specific perception [Gibson1966] to capture the essence of physical interactions into virtual design tools

Preliminary Approach: User Study





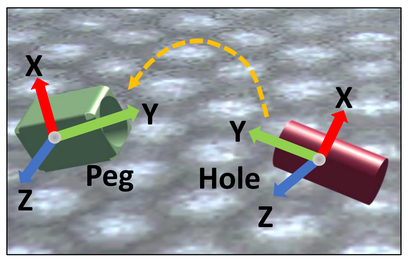
Mixed Reality (MR) interfaces (Millgram, 1994) to investigating precise spatial interactions in the peripersonal space after (left) and before (right) the screen



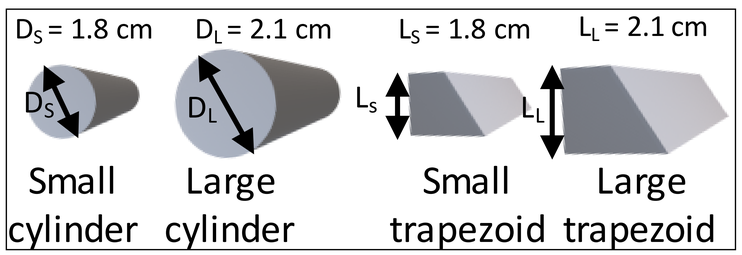
Proxemics (Hall,1966) chart depicting interpersonal distances around the body

❖ **Objective:** To investigate how spatial interactions designed for the peripersonal space affect fine motor and action-specific perception for uni-manual and bi-manual interactions
❖ **Study Setup1:** Eyes-Screen-Hands
❖ **Study Setup 2:** Eyes-Hands-Screen
❖ **Task:** Peg-and-hole docking
❖ **Evaluation Metric:** Accuracy-Time Bivariate Analysis (Piya, 2016), Path Deviation & Co-Efficient of Performance (Wang, 2018), and Average Path Length

Experiment



Peg-and-Hole Docking Task



Two shapes: Cylinder and Trapezium based on rotational symmetry/ asymmetry and Two sizes: Small and Large for peg-and-hole docking task

Uni-manual (one-handed) and Bi-manual (two-handed) hand-tracked 3D printed trapezium, cylinder, and controllers

❖ **Experiment 1:** Uni-manual vs. Bi-manual peg-and-hole assembly using controllers for both MR interfaces
❖ **Experiment 2:** Comparison between bi-manual MR interface with controllers and 3D printed counterparts of the task shapes --- cylinder and trapezium
❖ **Data Collection:** Peg-Hole alignment accuracy, task completion time, user-trial videos, NASA-TLX (Hart, 1988), pre- and post-interview questionnaire

Results & Discussions

Results

❖ **User Performance**
- Bi-manual interactions performed better than uni-manual interactions
- Users performed better in Study Setup 1 than Study Setup 2 with
- Users in Study Setup 1 using 3D printed shapes as input modes performed better than controller-based input (expected results due to direct visuo-tactile perception)

❖ **Qualitative Feedback**
- **NASA-TLX:**
  - Users expressed higher mental, physical and temporal demand for Setup 2 than Setup 1
  - Setup 1 using 3D printed shapes as input showed the least mental, physical and temporal demand of all three SUIs
- **User Feedback:**
  - Most users found the Eyes-Screen-Hands configuration intuitive and semi-immersive seconding a co-located visuo-motor space

Discussion
- Further research is crucial and viable to draw new interaction design and setup guidelines for enabling precise spatial manipulation in XR systems

External Funding

❖ **NSF CISE IIS CHS, Small: The Clock-Maker's Work-Space: Where the Action Really is for Design, PI: Vinayak Krishnamurthy; Co-PI: Shinjiro Sueda, Francis Quek, $500,000**