Final Presentation:

Bachelor's Thesis in Informatics: Games Engineering

Smartphone-Assisted Virtual Reality Using Ubi-Interact

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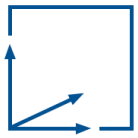

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Outline

1. Introduction
2. Related Work
3. Implementation
4. Experiments
5. Evaluation
6. Future Work
7. Conclusion

Introduction

Chapter 1

Virtual Reality

- Sherman et al.: Definition of Virtual Reality (VR) [She03]:
  - Virtual World: an imaginary space with rules and relationships
  - Immersion: the sensation of presence in an environment
  - Sensory Feedback: the feedback based on the user‘s state
  - Interactivity: responsiveness of the virtual world to the user’s actions

VR Controllers

Figure 1.1: Consumer VR Controllers
Source: [Yan]

Versatility of Smartphones

Figure 1.2: Google Cardboard
Source: [Goo]

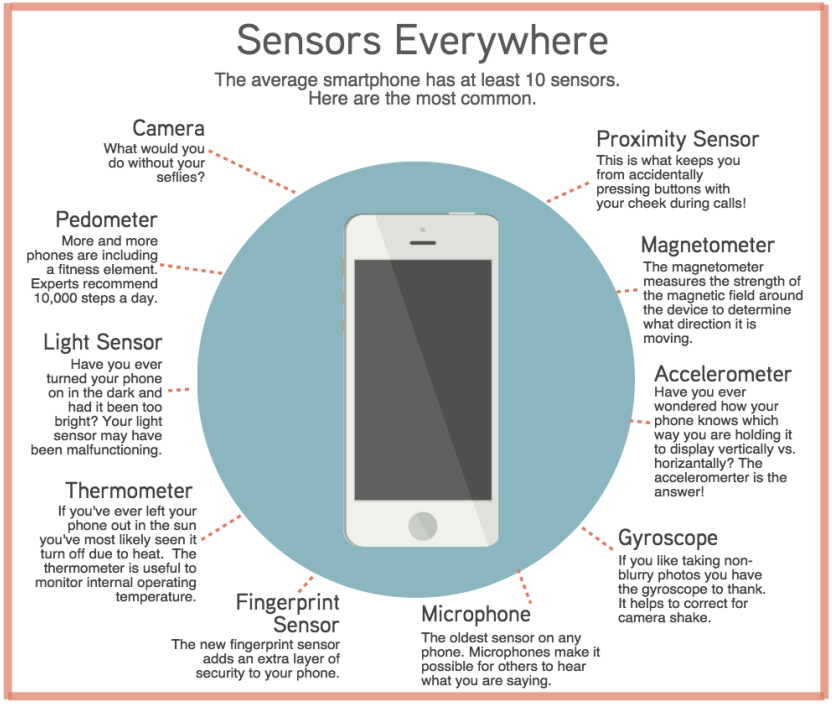

Figure 1.3: Smartphone Sensors
Source: [Mat15]

Problem Statement

- Explore usage of smartphone as interaction device
- Implement typical VR interactions
- Perform user study
  - Evaluate implementation
  - System Usability Scale (SUS) Study
- Use Ubi-Interact

Related Work

Chapter 2

Model Viewer: Katzakis et al. [Kat10]

- Uses smartphone as input device
- IMU data controls 3D object, displayed on regular display
- Compared to a mouse and touch pen: Smartphone wins in terms of time it takes to rotate to a certain pose

Figure 2.1: The model is rotated by the smartphone
Source: [Kat10]

Laser Pointer: Pietroszek et al. [Pie14]

- Uses smartphone as input device
- Ray cast to select objects
- IMU data controls ray direction
- Origin of the ray is fixed
- Select depth with touch screen
- Compared to a Wii controller: no significant difference

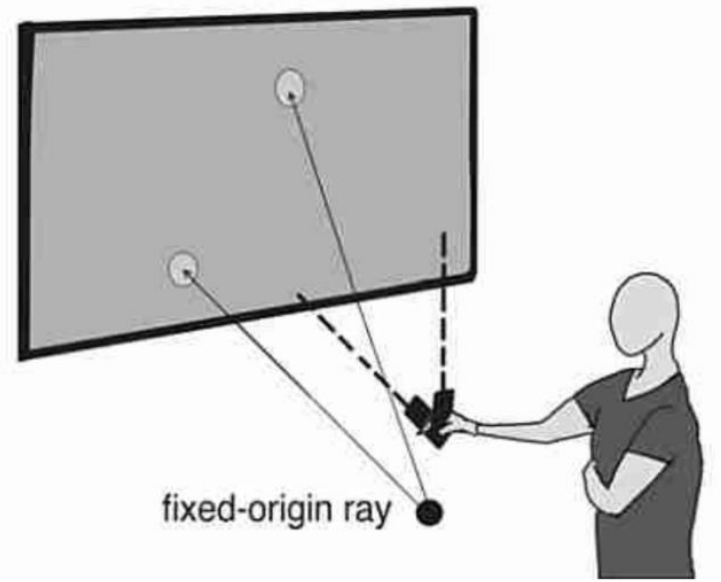

Figure 2.2: The origin of the laser pointer is fixed
Source: [Pie14]

Virtual Keyboard: Markussen et al. [Mae13]

- Keyboard is displayed on large display
- Move hand to move the cursor to aim for keys
- Use finger gesture to select a key
- => Visibility-independent text entry method:
  - user does not have to see his input device (the hand)

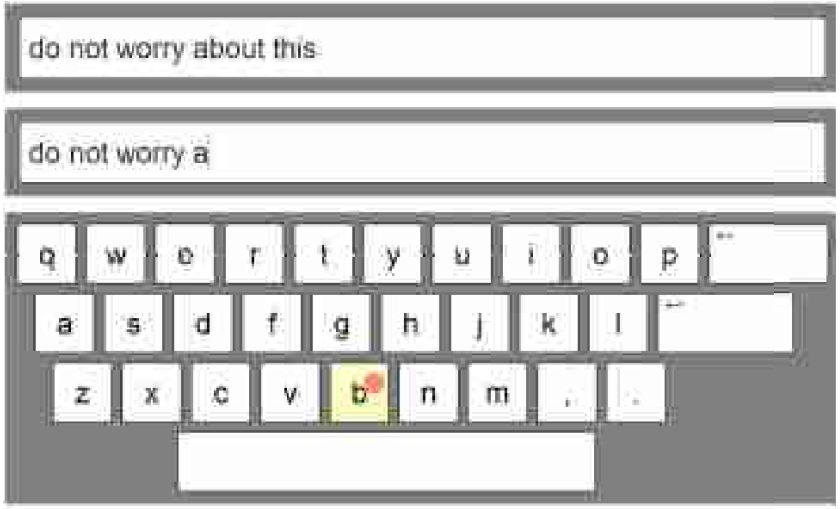

Figure 2.3: The virtual keyboard displayed on a large display
Source: [Mar13]

Implementation

Chapter 3

Technology Stack

- Web based
  - WebAPIs (Touch events, DeviceOrientation, WebVR)
  - Three.js
  - UBII Client

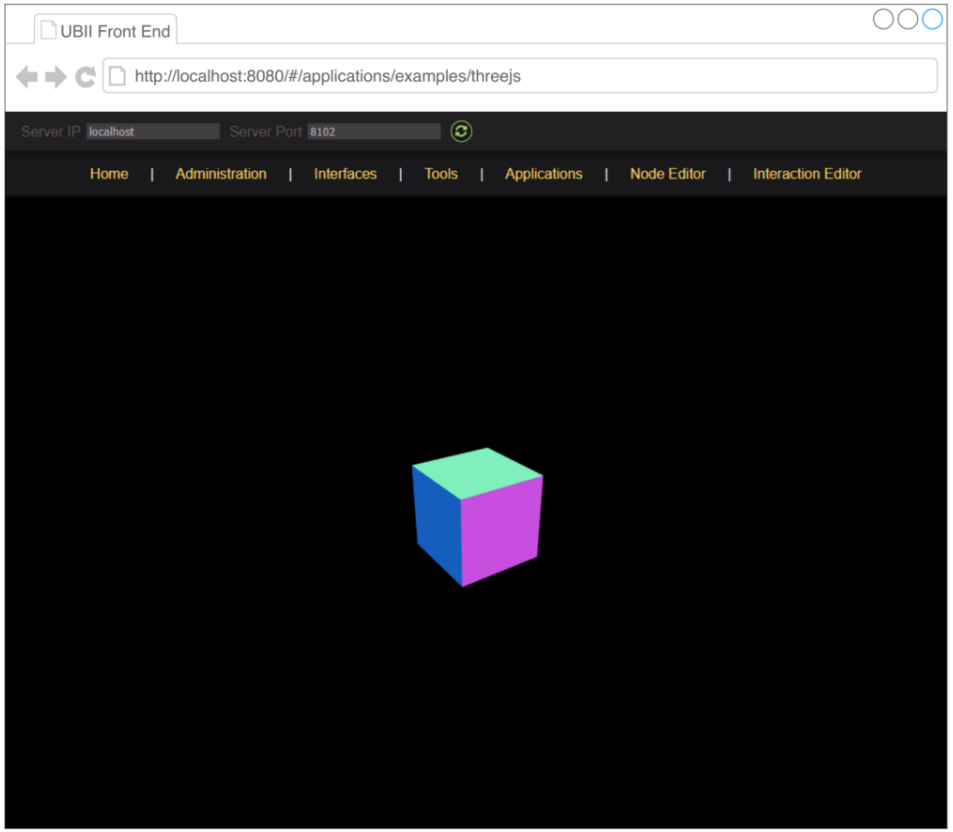

Figure 3.1: Demo application running in the UBII front end.

Ubi-Interact (UBII)

- => Networking framework for distributed applications

- Devices use WLAN to connect to UBI Server
- Devices read or post Data to “Topics”
- Logic can be abstracted in ”Interactions”
- Uses Google Protocol Buffers as Protocol

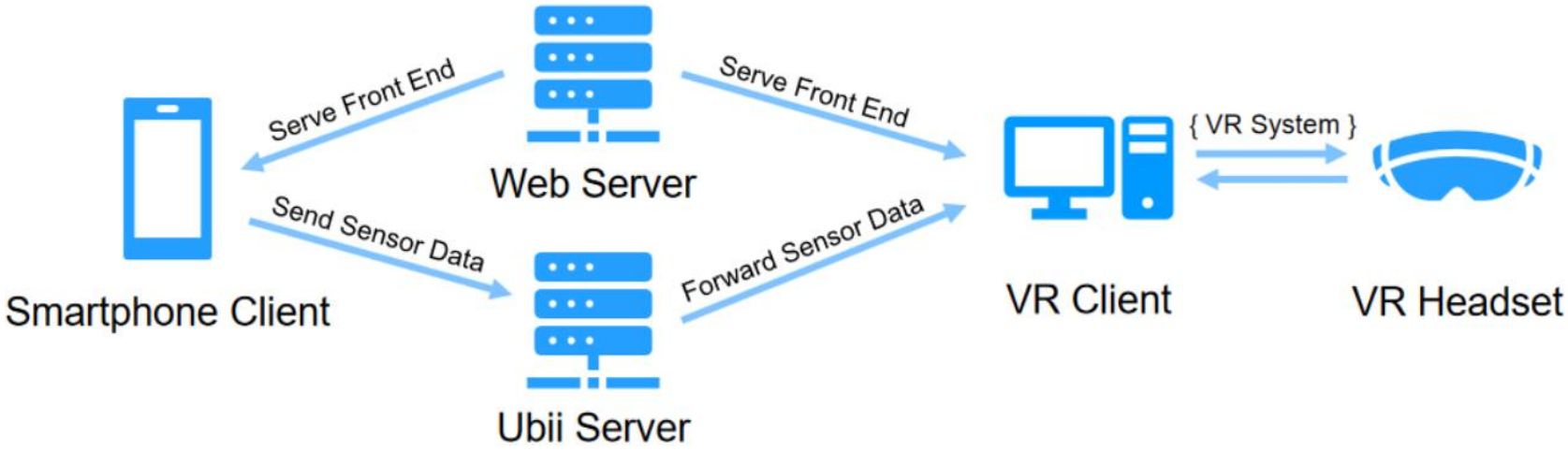

Figure 3.2: Project Architecture

Ubi-Interact: Interactions

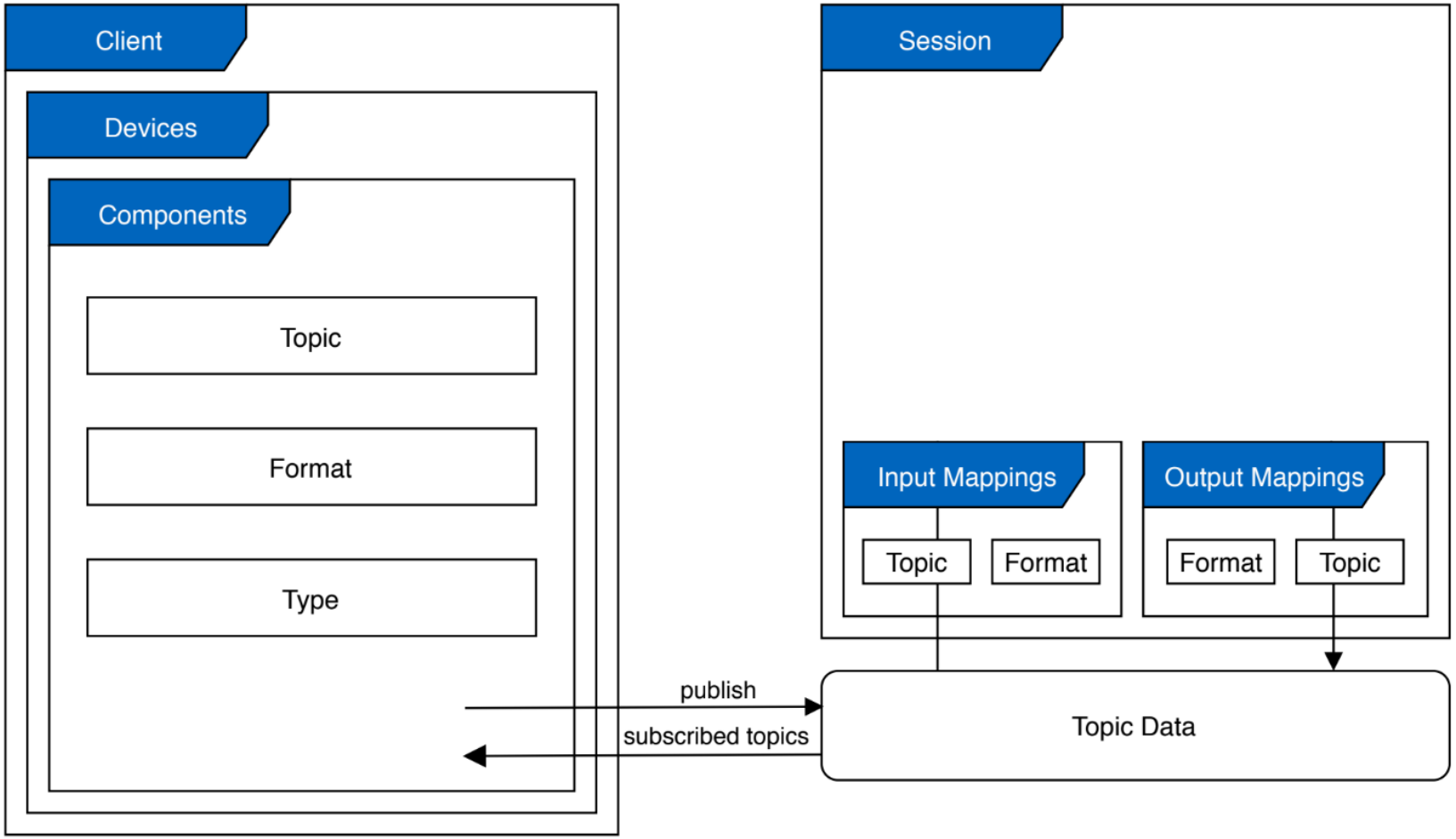

Figure 3.3: Interaction processing overview.

Experiments

Chapter 4

Model Viewer

- Each connected device spawns a model
- Orientation of the smartphone is synchronized to model
- An Interaction is used to convert degrees to radians

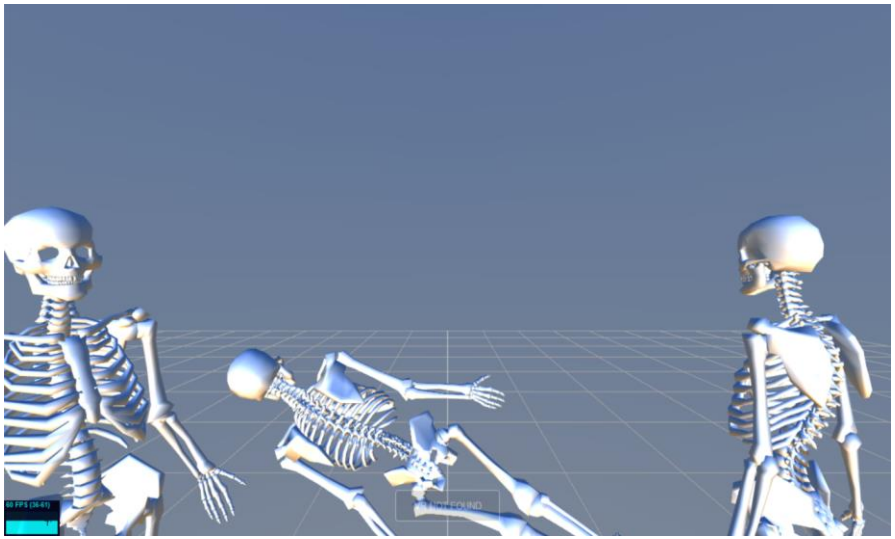

Figure 4.1: Screenshot of the model viewer experiment.

Laser Pointer

- Enables selection of 3D objects or UI elements
- Raycasting is used to determine the hit object
- Orientation of the smartphone is synchronized to model and used as raycasting direction
- Ray origin is a point relative to the user
- Touchscreen is used to trigger Selection

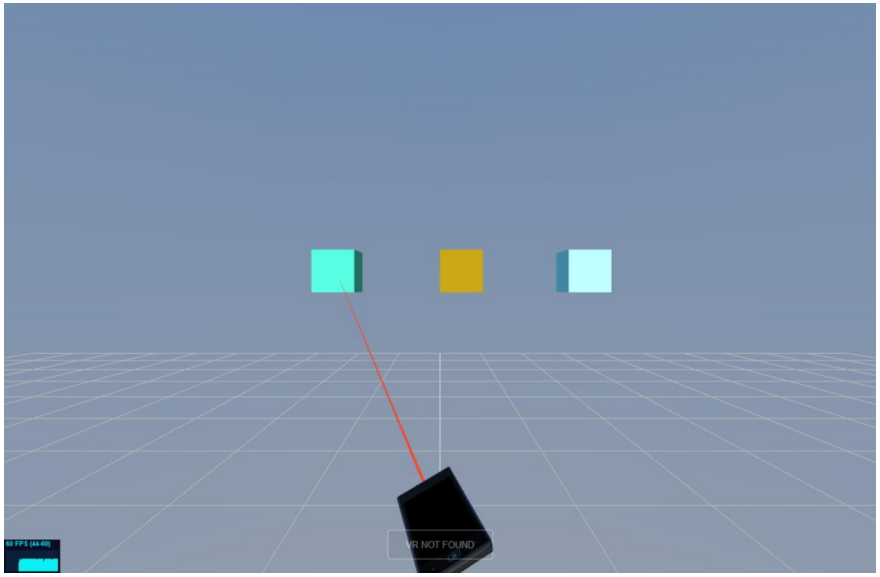

Figure 4.2: Screenshot of the model viewer experiment.

Virtual Keyboard

- Virtual keyboard is fixed in the world
- The keyboard is mapped 1:1 to the smartphone display
- Touch display to move the cursor
- Hold position for ~1 second to select a key

Figure 4.3: Screenshot of the model viewer experiment.

Evaluation

Chapter 5

Procedure

- Implemented tasks in experiments:
  - Model Viewer: Match poses of shown model
  - Laser Pointer: Hit as much objects as possible without mis-hits
  - Virtual Keyboard: Write a given sentence correctly

- System Usability Scale (SUS) Study
  - Users rate 10 usability questions on a Likert scale
  - Total scores are mapped to Grades (American system)

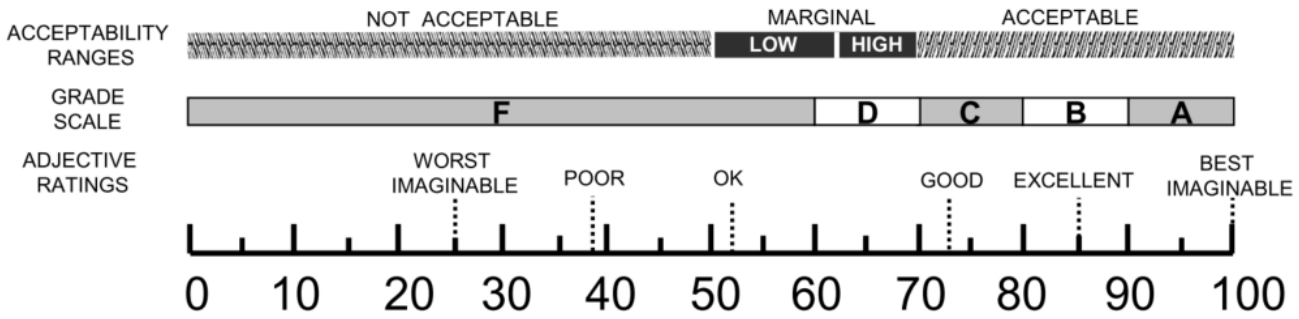

Figure 5.1: The meaning of SUS scores.
Source: [Ban09]

Preliminary Questions

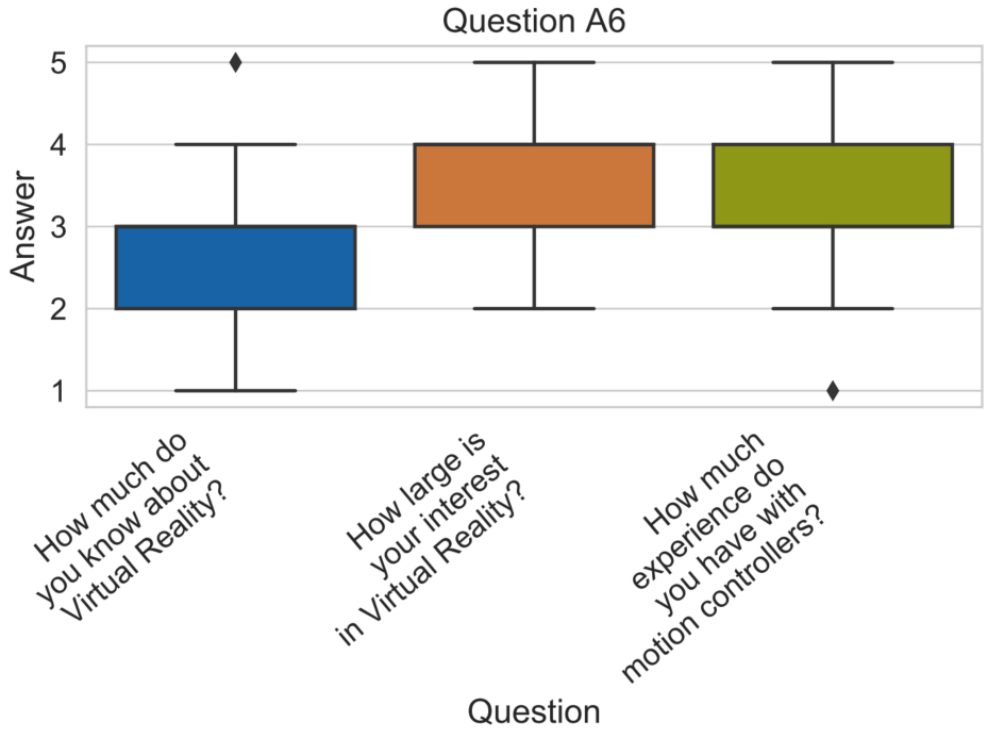

Figure 5.2: Answers to preliminary questions asking about the knowledge of VR.

Model Viewer Task

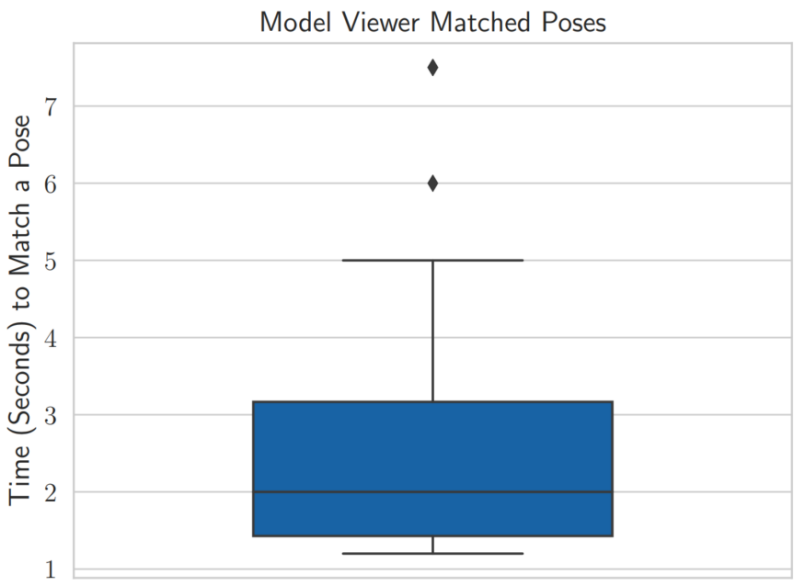

Figure 5.3: Time (seconds) it took participants to match one pose

Figure 5.4: The total SUS score of 83.04 which evaluates to grade B

Laser Pointer Task

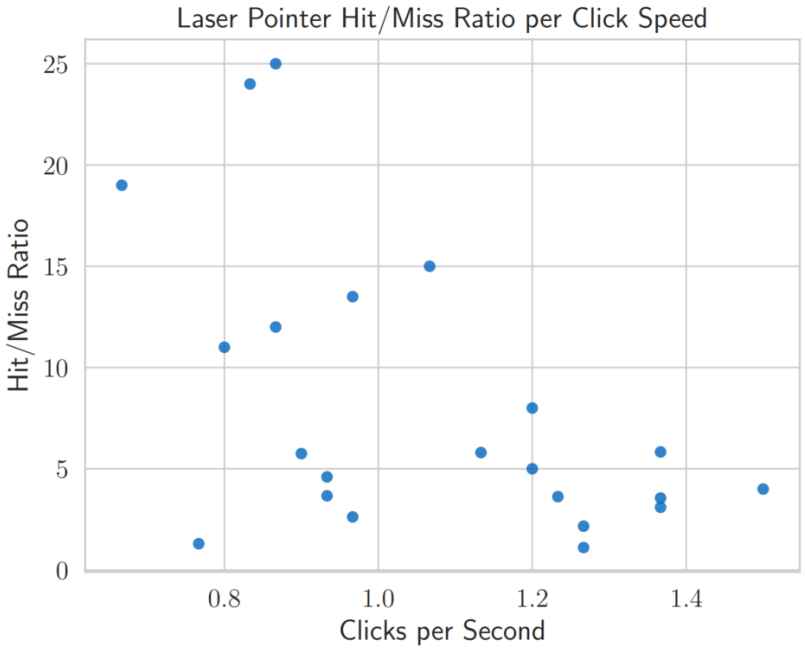

Figure 5.5: The hit to miss ratio per click speed.

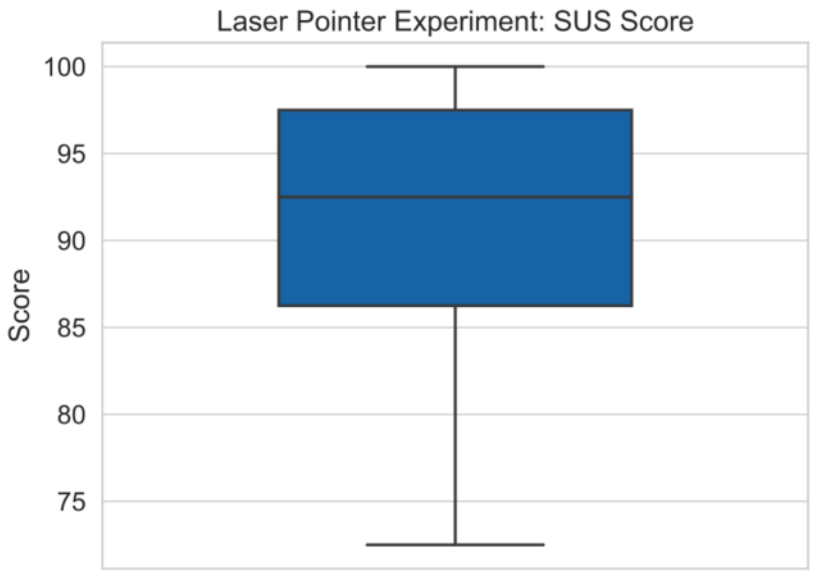

Figure 5.6: The total SUS score of 91.41 which evaluates to grade A

Virtual Keyboard Task

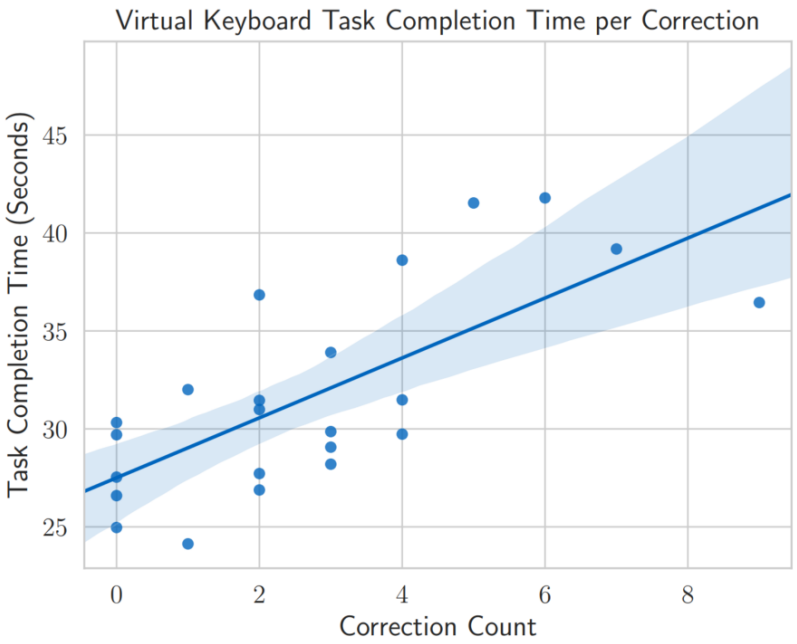

Figure 5.7: Time (seconds) it took correctly type “The quick brown fox jumps over the lazy dog!”

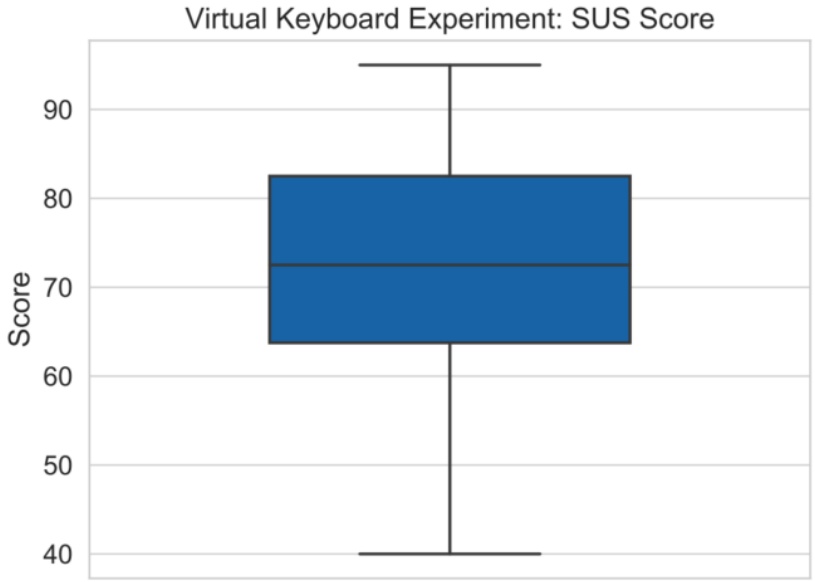

Figure 5.8: The total SUS score of 71.63 which evaluates to grade C

Future Work

Chapter 6

Future Work

- Experiments
  - Model Viewer:
    - Incorporate touch screen for object manipulation
  - Virtual Keyboard
    - Leap Motion
- Positional Tracking
  - Vive Tracker
  - Camera based

Conclusion

Chapter 6

Conclusion

- SUS Scores
  - Model Viewer: Grade B
  - Laser Pointer: Grade A
  - Virtual Keyboard: Grade C
- Feedback and Stats are Good
- Used Ubi-Interact to make system extensible

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