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Controlling Viewpoint from Markerless Head Tracking in an Immersive Ball Game Using a Commodity Depth Based Camera

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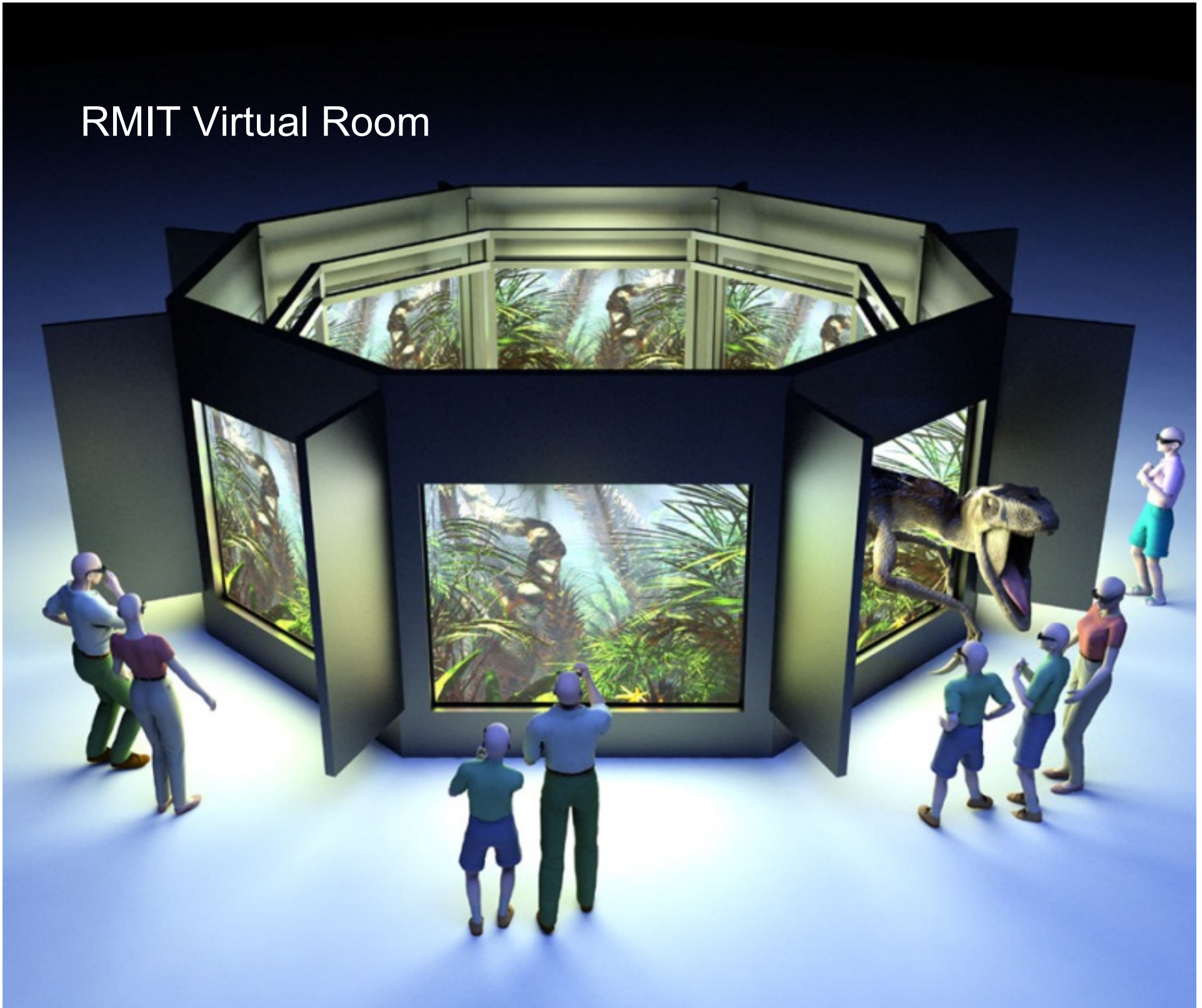
Controlling Viewpoint

- Getting the gamer out if the chair
- Perspective of the gamer into the virtual world often not taken into account
- Stereoscopy is more talked about than viewpoint update
- Parallax is a stronger cue to gauge distances over a greater range
- Motion tracking in front of large display surfaces remains hard to achieve
- Microsoft Kinect for Xbox 360 can be used for head tracking
  - Calibration is easy and take seconds
  - Cost of the device proved within the budget of home gamers

Approach

- Is the quality of a commodity depth based camera sufficient for a ball game where players needed to move from side to side?
- Latency (Nausea or Disorientation)
- Accuracy (Game Success)
- Enjoyment
- Difficulty
- Immersion

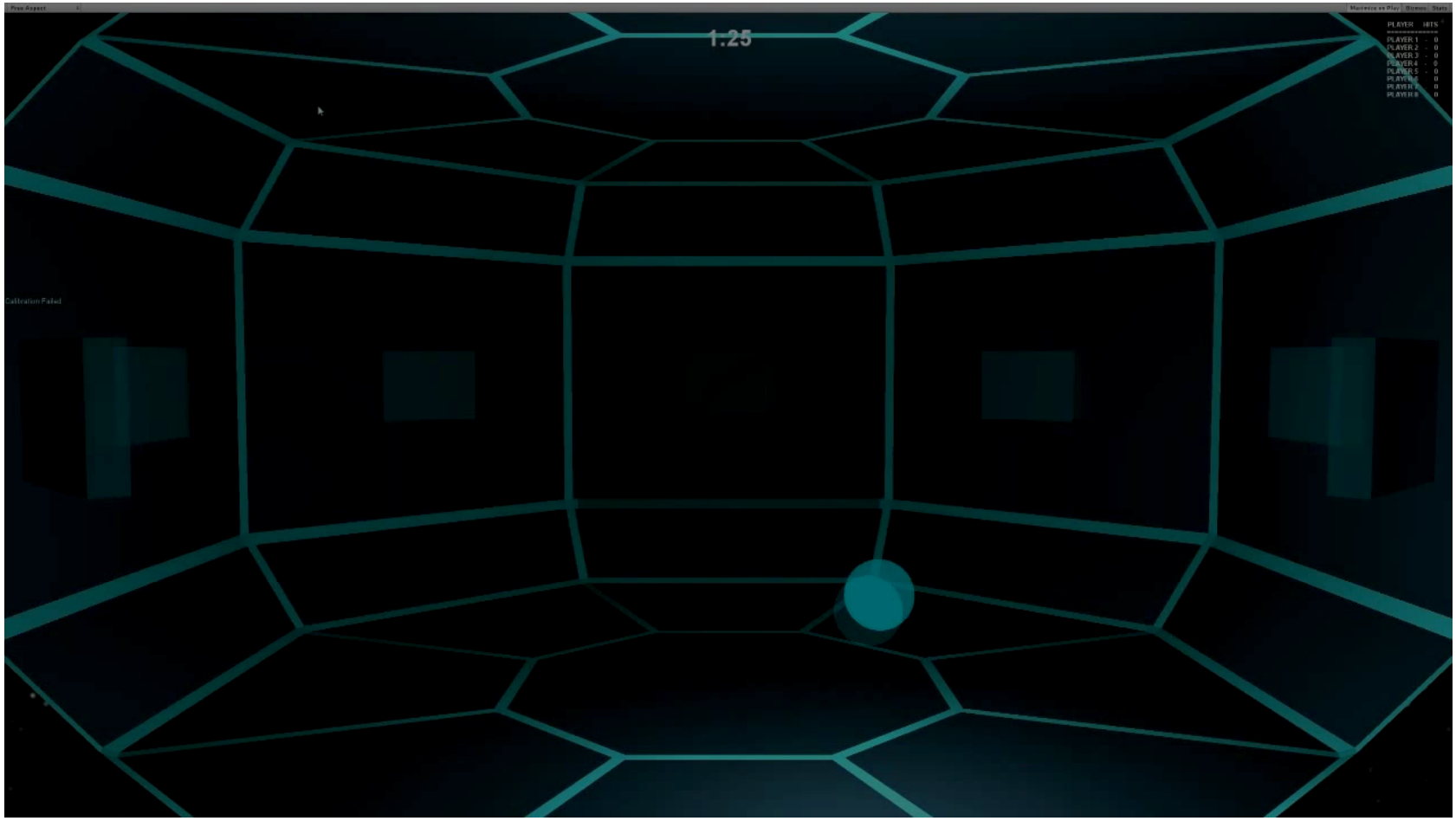
RMIT Virtual Room



The game

- VROOM consists of 8 active rear projected screens
- Game Designed for 8 players
- Virtual Environment contains virtual ball that bounces around
- Players control a paddle to deflect incoming balls via hand movements
- Visualisation is stereoscopic
- Paddle hits and paddle misses were recoded
- The winner is determined by the lowest number of screen hits (paddle miss)
- Ties are won based on the highest number of paddle hits wins

The Game



Experimental Design

- Entire visualisation system was built with commodity hardware and Unity
- User performance and experience measured for three randomly allocated viewpoint conditions:
- Condition 1, 'Laptop Experience'
  - Participants controlled the x and y position of a paddle with a mouse
- Condition 2, 'VR Hand Tracking Experience‘
  - Stereoscopy + hand tracking
- Condition 3, 'VR Hand and Viewpoint Tracking Experience'.
  - Condition 2 + viewpoint tracking, which and rotated and translated the display of the virtual scene accordingly

Experiment Procedure

- Two participants per experiment at opposite ends
- Ball movement was restrained to only bounce between the two players
- Random test of three conditions
- Instructions and practice followed by 90 seconds game
- Questionnaire with Likert-like scale from 1-7 after every game
- Repeat until every participant experienced all three conditions

Players Competing in the Ball Game

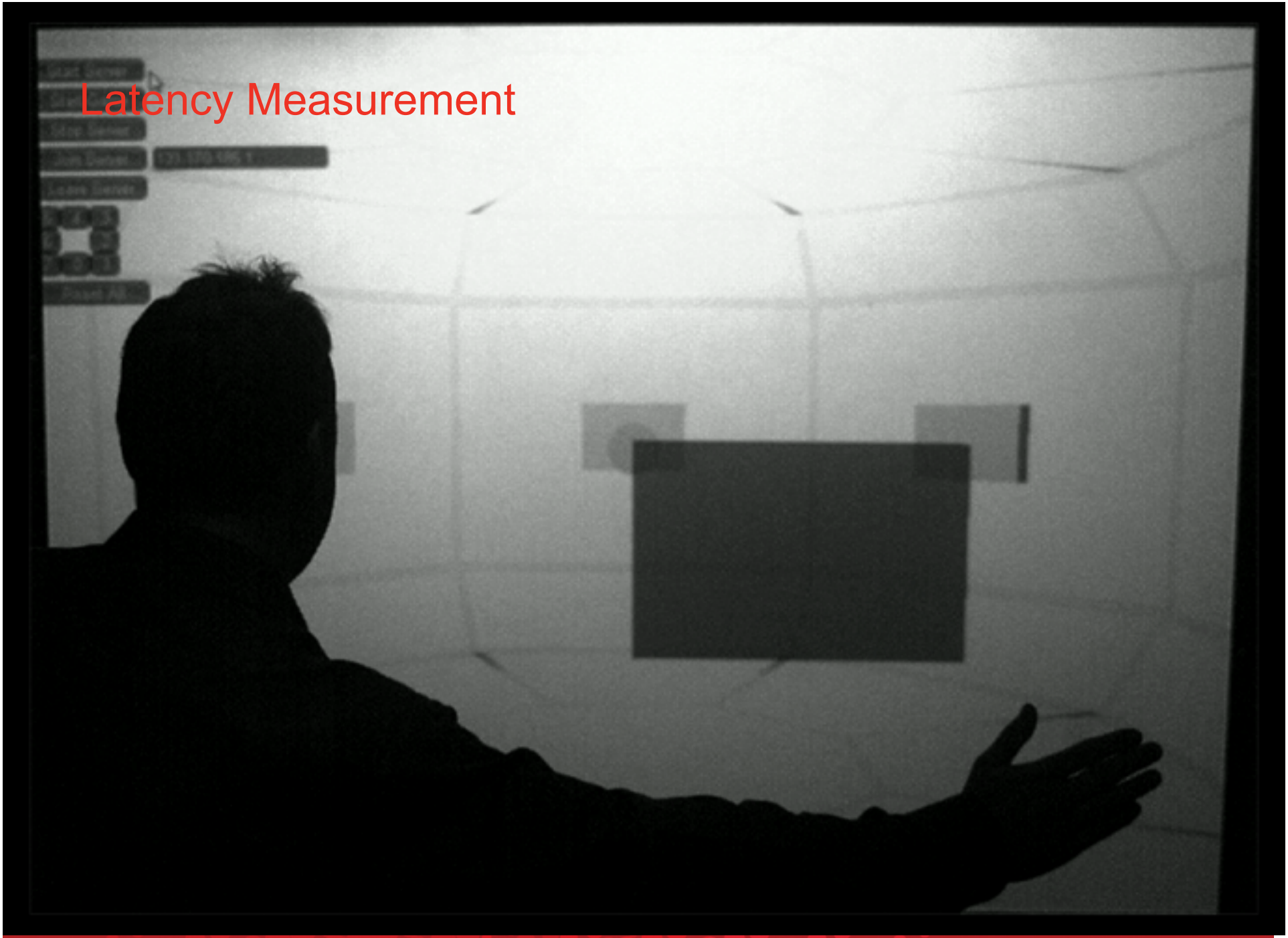
Participant Profile

- Game was designed for a wide audience
- Participants selected indiscriminately of age and gender
- 12 participants, mainly young adults
- Mixed gender (4 female, 8 male) ranging from 22 to 45 years.
- The mean age was 31 years (SD = 7.324), median age was 30 years.

System Latency

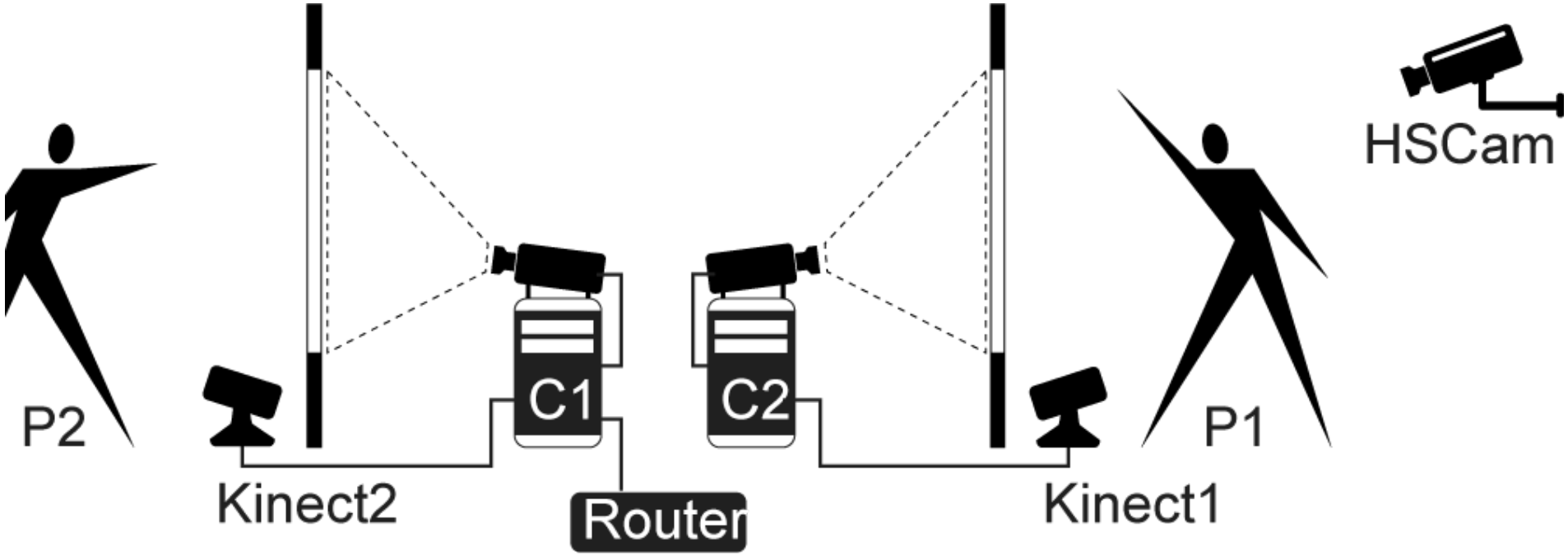
- Time between user input and the system's response to the input
- Frame by frame analysis of video footage recorded at 240 fps
- Video camera placed behind the player and directed towards the screen
- Hand and head movements compared against movements of the virtual paddle as well has changes in viewing angle
- Local Measurement
  - Hand Movement Left. Right
  - Hand Movement Up, Down
  - Head Movement Left, Right
  - Head Movement Forward, Backward
- Remote Measurement
  - Hand Movement Left. Right
  - Hand Movement Up, Down

Latency Measurement



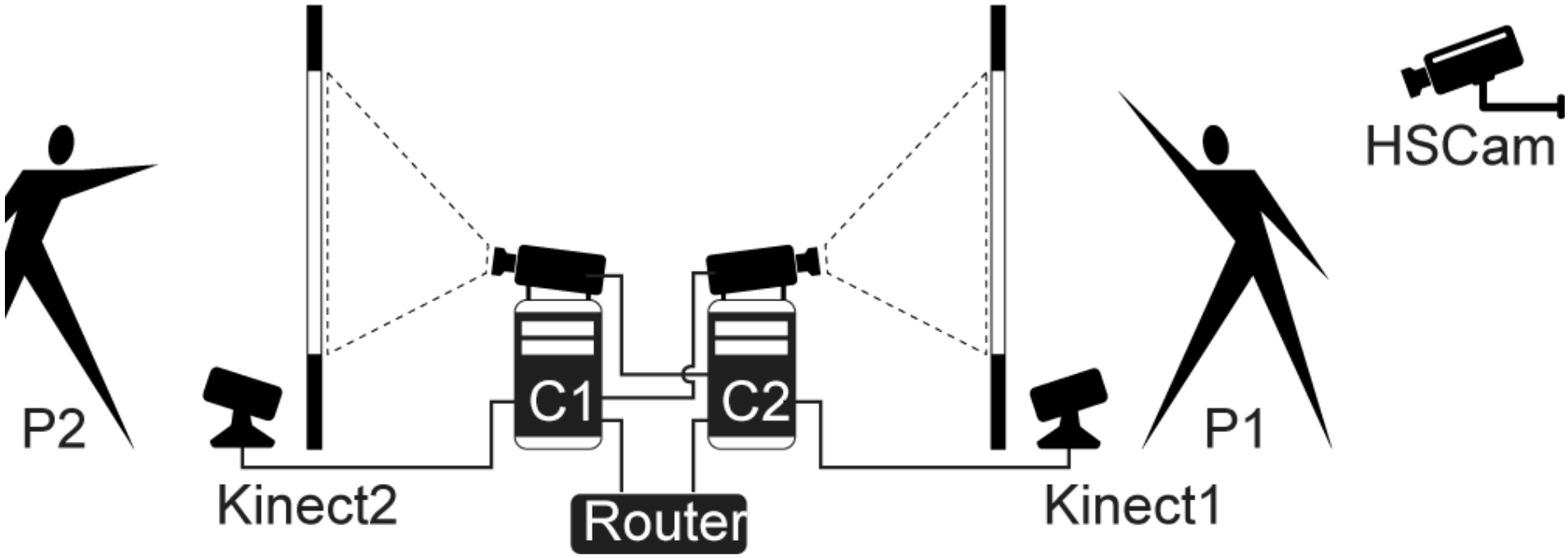
Local System Latency Results

- Average latency between start and local screen movement 130ms
- Average latency of subsequent movements 33ms



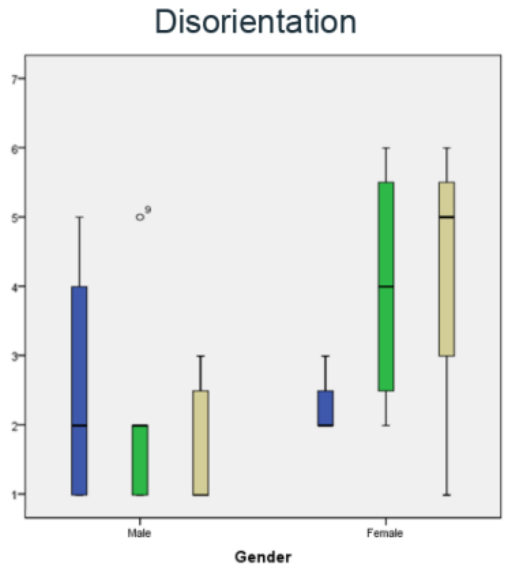
Remote System Latency Results

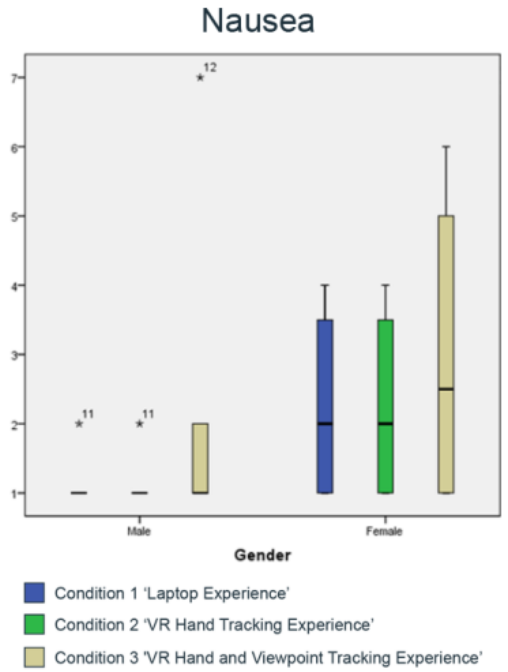
- On average 3ms above local update



Nausea or Disorientation

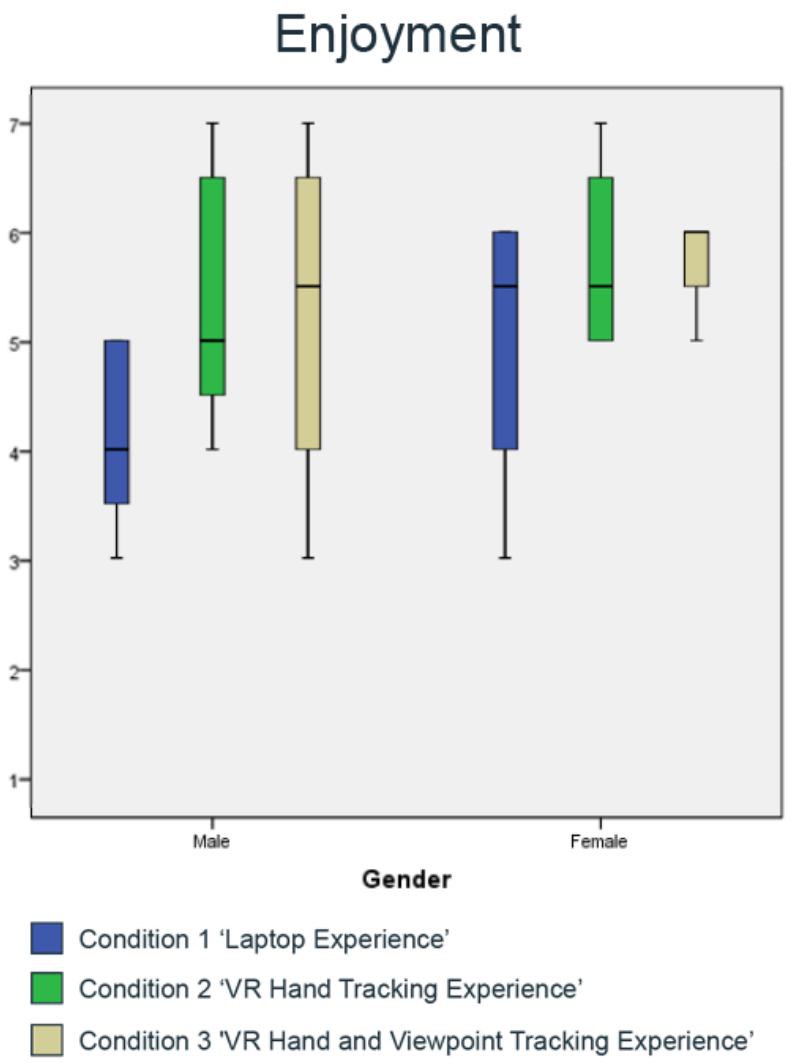
- No significant difference in Nausea or Disorientation
- 12 participants commented on the lag between the hand movement and the paddle response





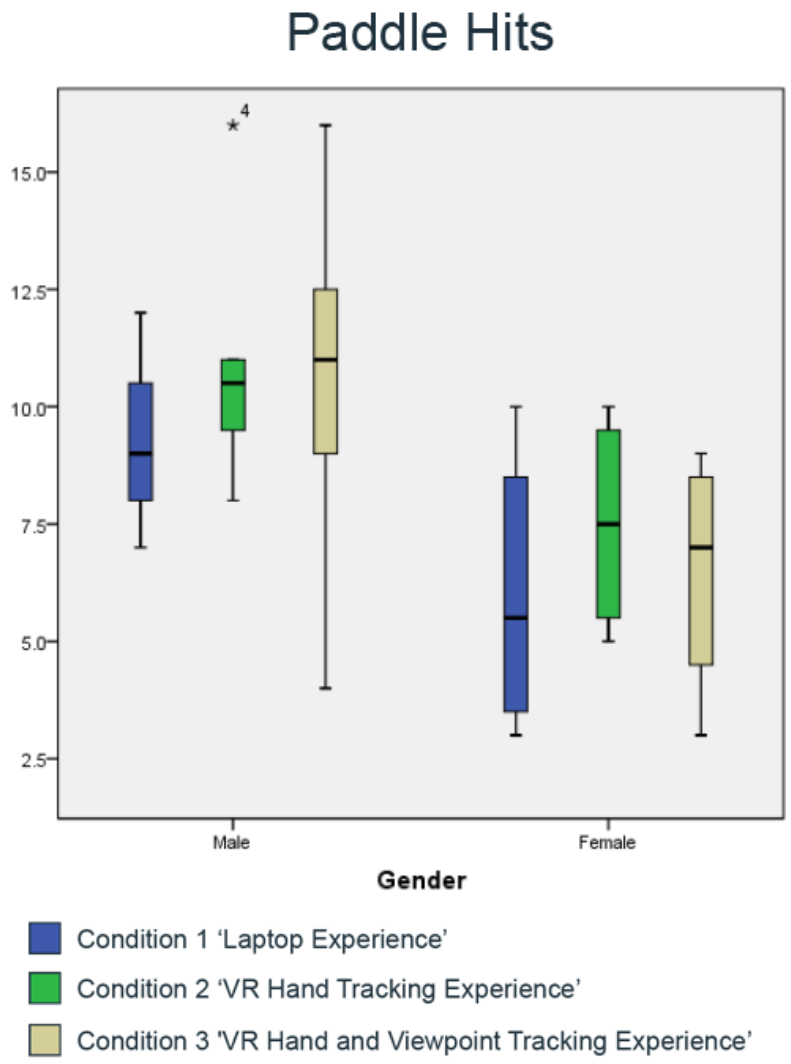
Enjoyment

- No significant difference among the three tested conditions



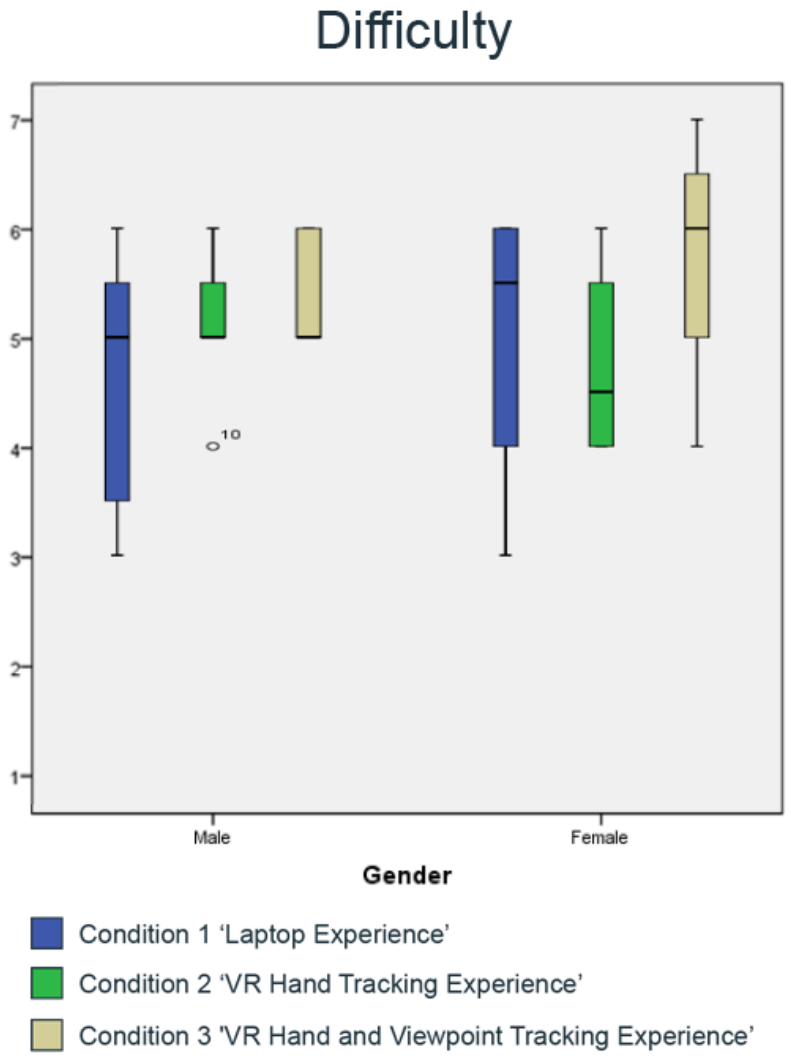
Game Success

- Means analysis on hit and miss scores
- Marginally higher, but not significant paddle hit and lower paddle miss rate in the hand tracked VR environment as opposed to the mouse controlled laptop version of the game



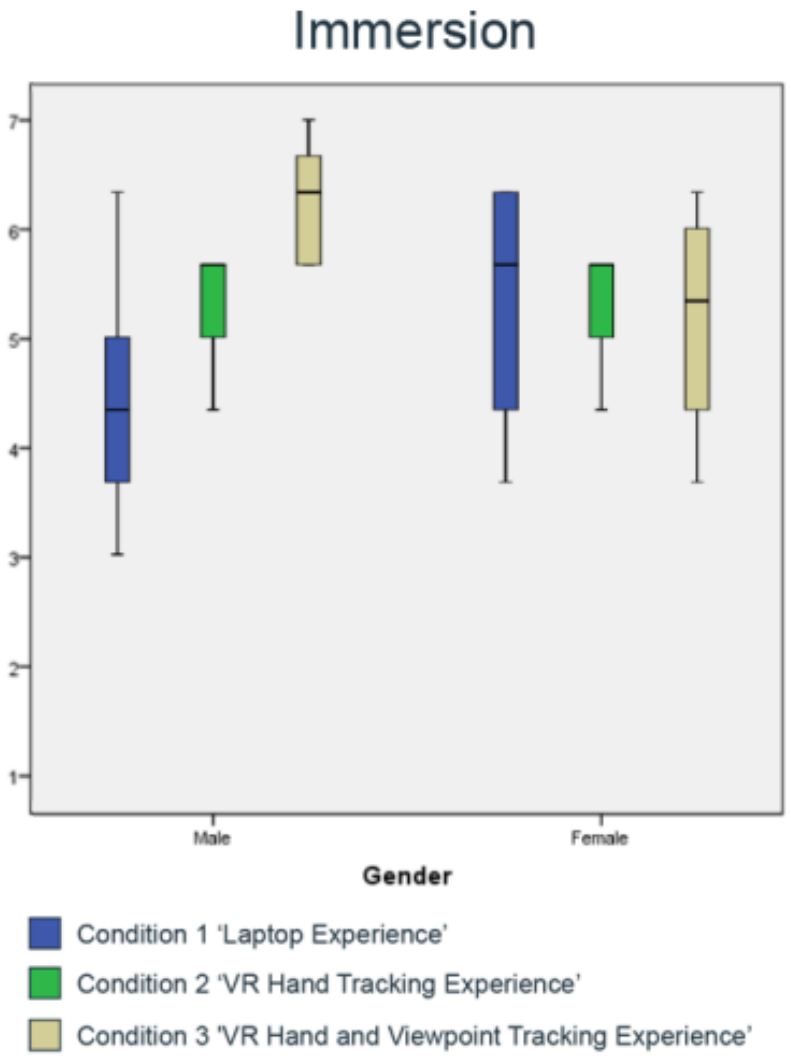
Difficulty

- Significant difference between VR Hand Tracking Experience and VR Hand and Viewpoint Tracking Experience after adjusting for gender
- Participants found the ball was harder to hit with Viewpoint Tracking
- Wilkes Lamda = .625, F(2, 12) = 2.700, p = .045



Immersion

- Users felt more immersed in the head tracked VR environment
- Significant difference was found between the Laptop Experience and VR Hand and Viewpoint Tracking Experience
  - Wilkes Lamda = .411, F(2, 12) = 6.457, p = .009.
- Marginal significance between Laptop Experience and VR Hand Tracking Experience with p = .056.



Discussion

- Head tracking had no significant effect on enjoyment and game success and made the game seem harder to play
  - Implementation problem, inexperience of viewpoint update
- No significance in nausea or disorientation despite latency
  - Participants noticed the initial latency
  - Not constant occurrence
  - Short exposure time
  - Analysis of Kinect accuracy could reveal if inaccuracy causes problems
- Approach seemed suited to home systems
  - Accuracy may be a problem
  - Simple, calibration procedure compared to marker and transmitter/sensor systems
  - Developers get head tracking working in a matter of hours

Conclusion

- Low cost immersive multi-player ball game using depth cameras
- Recorded latency was higher at points when a trajectory changed
- No significant difference in performance of gameplay across the conditions
- Two significant differences found in the perception of gameplay
- Viewpoint update was found to improve feelings of presence but made it harder to hit the ball
- Understanding why people found it harder to hit the ball with viewpoint update strongly calls for further research.

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THANK YOU