ASYMMETRIC INTERACTION BETWEEN HMD WEARERS & SPECTATORS WITH A LARGE DISPLAY

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INTRODUCTION

MOTIVATION

- HMDs provide a highly immersive experience to a single user, but they make it difficult to communicate with spectators in the real world.
- It is often not feasible to implement a multi-HMD solution just for spectating purposes.
- Display mirroring (the default solution) fails to convey the feeling of presence from VR.

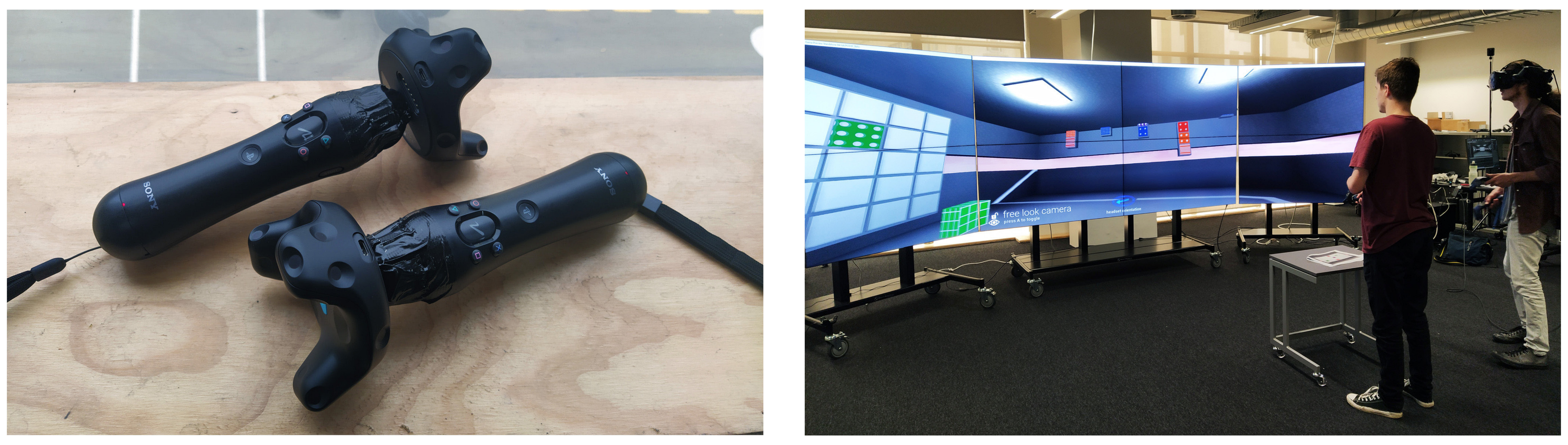
GOALS

- Create a better spectator solution which is easy to add to an existing single-player project and works with audiences of any size.
- Elevate the spectator's feeling of presence.
- Allow the the spectators to interact with the virtual world in order to communicate and collaborate with the HMD user. Useful for demonstrations, collaborative projects, and training scenarios.

IMPLEMENTATION

IMMERSIVE DISPLAY

- The large-scale display was configured to maximise its immersive properties.
- This was accomplished by arranging the eight 55-inch displays in a 4×2 grid, increasing the spectator's horizontal field of view.
- The displays were also arranged on a slight curve, which has the benefits of increasing spacial presence and reducing viewing angles [1].



Left: The spectator's motion controllers (HTC Vive Trackers taped to PS Move controllers).
Right: Two participants in the user study interact with the system.

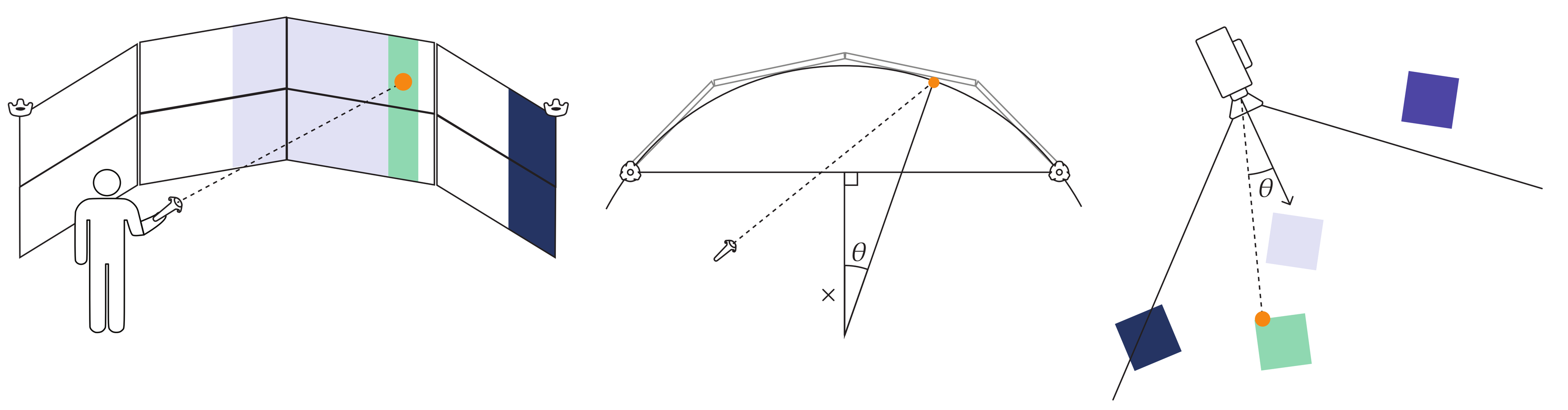
SPECTATOR CAMERA CONTROL & VIRTUAL INTERACTIONS

Camera Control

- When the spectator holds down the trigger on their left controller, the virtual camera's orientation is mapped to the orientation of the controller in the real world.
- This is called the "eyeball-in-hand" control metaphor [2].
- The large button on the controller toggles free-cam mode. If free-cam mode is disabled, the camera snaps back to follow the VR user's perspective when the spectator releases the trigger. If free-cam mode is enabled, the camera stays where the spectator left it.
- This allows the user to perform ratcheting motions to turn the camera around without having to maintain an uncomfortable hand position.

Interactions

- If the spectator holds the trigger on the right controller and points it at the display, a marker is spawned in the virtual world at the position they are pointing at.
- This means the motion controller can be used like a laser pointer into the virtual world.

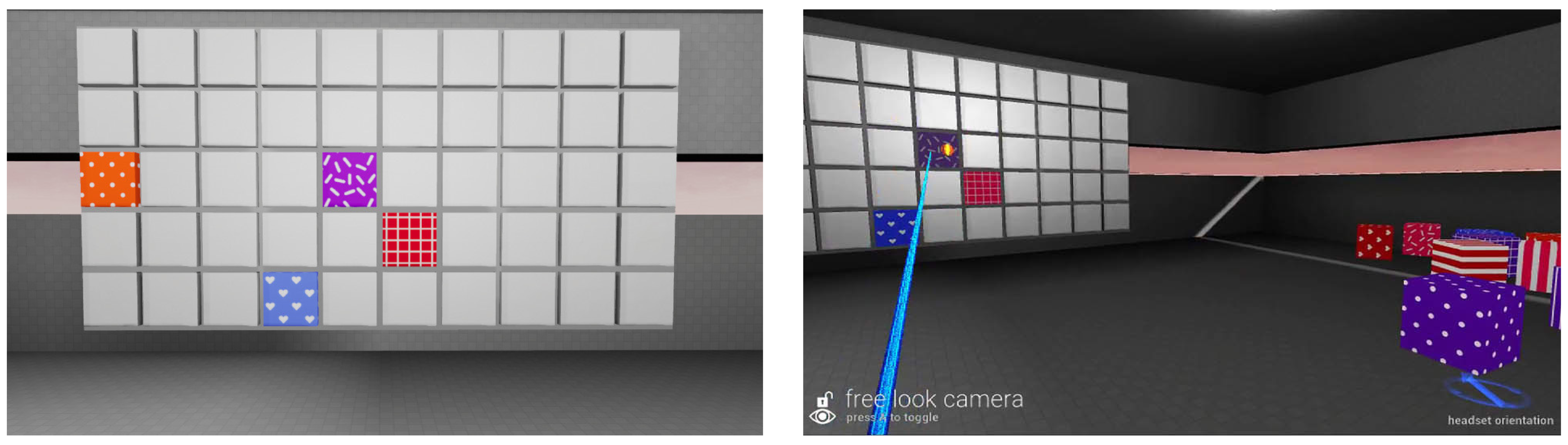


The pointing tool projects a marker into the virtual world by calculating the angle between the spectator camera and the marker. This requires the position of the display to be mapped into the virtual world – which was achieved using Vive Trackers.

EVALUATION

TASK DESIGN

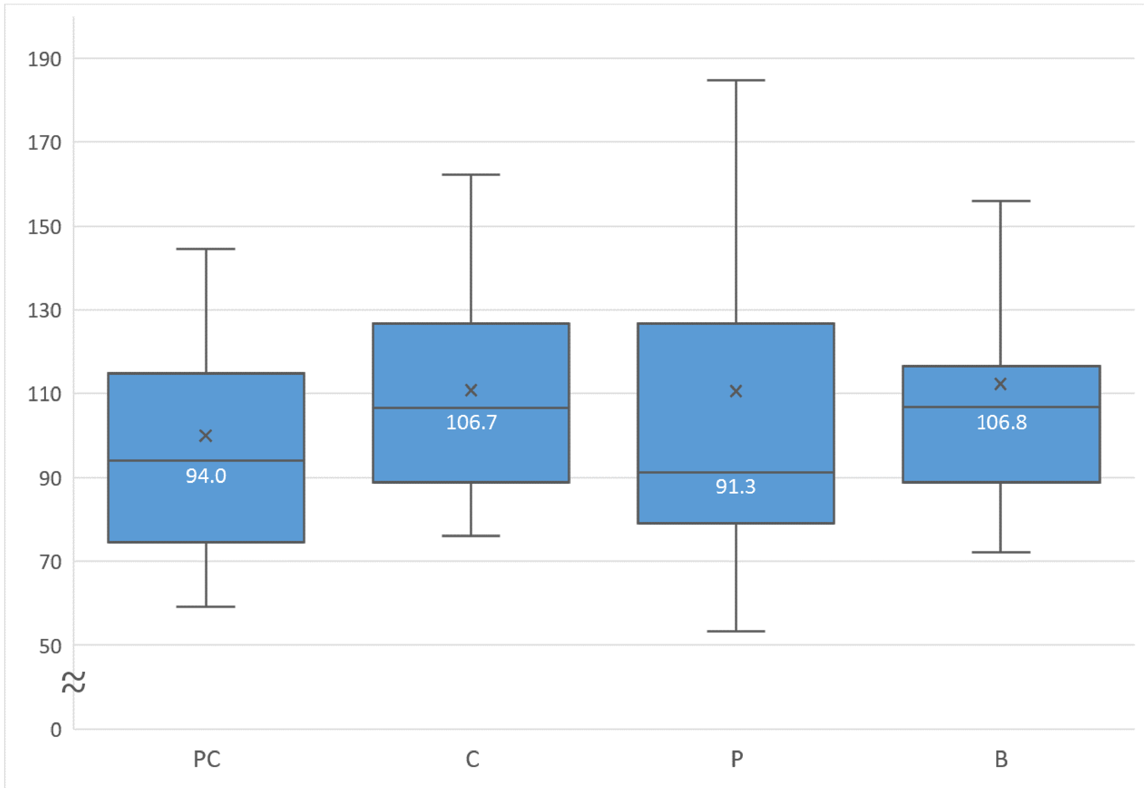
- We designed a task to be completed by a HMD user and a spectator to measure the effect the system has on efficiency in collaborative tasks.
- The virtual test environment contains 40 unique cubes have been randomly placed on the walls. They slowly move in and out of view.
- The VR user is able to put these cubes in the large grid on the wall. The spectator is provided with a printed screenshot of a solution: a grid with several cubes in it.
- The goal for the subjects is to find the cubes which are displayed in the solution and place them in the grid in the correct locations.



Left: An example of a solution grid which was given to a spectator.
Right: The HMD user places a cube into the grid.

RESULTS

- We measured the duration of each trial and how much each tool was used. The study had 24 participants (75% male, age range of 20-30 except one above 30).
- There were two independent variables which were either enabled or disabled in each condition: the spectator's independent camera (C = enabled) and the pointer tool (P = enabled). In the baseline condition (B) the spectator used basic display mirroring. Each participant completed one trial for each condition in each role.
- We found that users were able complete the task on average 13% faster when the pointer tool was enabled. We also found that users put the available tools to use, averaging at 31% of the time (7% standard deviation) throughout all conditions.
- We asked the users to complete a qualitative survey after each trial, and the responses showed that the tools were considered to be useful from the perspective of both spectators and HMD users.



CONCLUSION

- We presented a spectator system in an asymmetric VR scenario with a single HMD user. The spectator can freely look around, decoupled from the HMD user's view. They can also point and place virtual markers to communicate with the HMD user.
- Our study showed that the system enabled effective communication, allowing each user to focus on different areas of the environment to complete a collaborative task.
- In future work, we will further explore the user interface with the aim of increasing each user's awareness of where their partner is looking.

REFERENCES

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