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Assessment of Differences in Human Depth Understanding in Cube Displays Using Light-Field Displays

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About Me

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- **Research Interests**
  - 3D Imaging
  - Virtual/Augmented Reality
  - Light Field Displays

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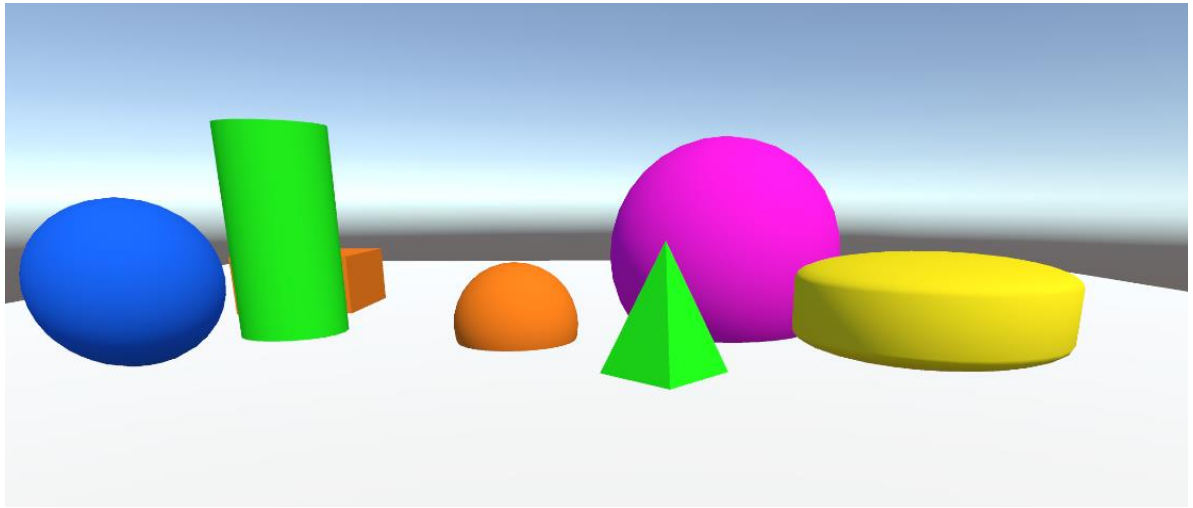
Agenda

- Background
- Research Aim
- Tools Used in This Study
- The Experiment
- Results
- Conclusion
- References

■ Background

Drawbacks of 2-Dimensional Screen

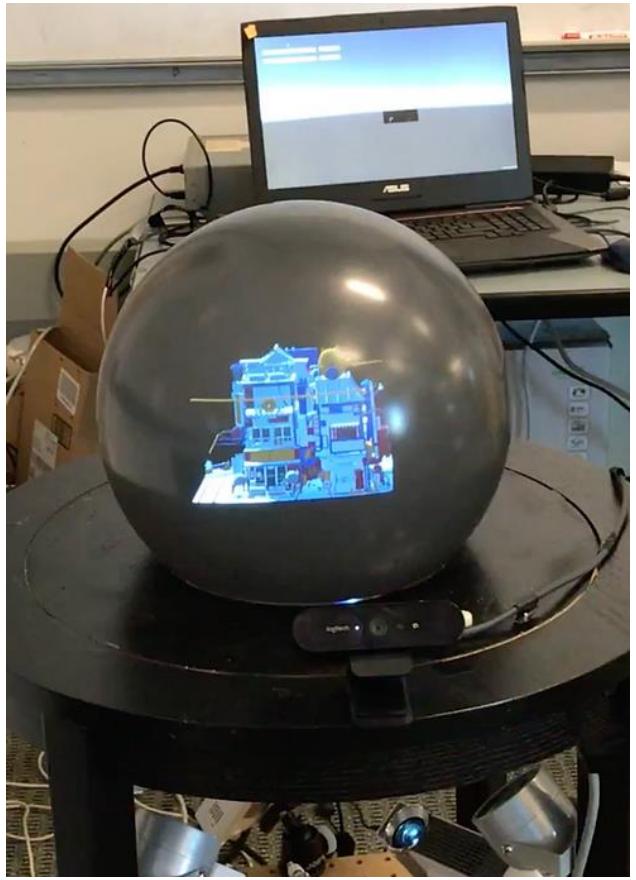
- A 2-Dimensional (2D) screen does not show actual depth. [1]
- It can be hard to understand where objects are within the scene.
- 2D screens are limited in what 3-Dimensional (3D) depth cues it can portray.



What object is closest to the viewer?
It is difficult to tell.

Background

3D Displays



SpheriCul, a sphere display [2]

- Fishbowl VR
  - Can be many different shapes
  - Has real depth
  - Does not create stereoscopy naturally

Background

Stereoscopic Displays

Apple Vision Pro by Apple [3]

- VR and AR
  - Creates Stereoscopy with screens inside the headset
  - Use trackers to create 3D environments

■ Background

Stereoscopic Displays

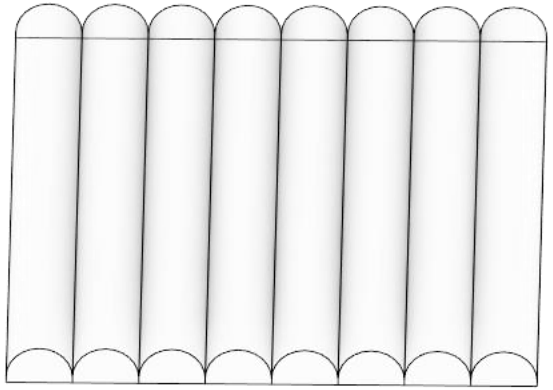
- Light Field Displays (LFDs)
  - Displays multiple views at once
  - No user or device trackers needed

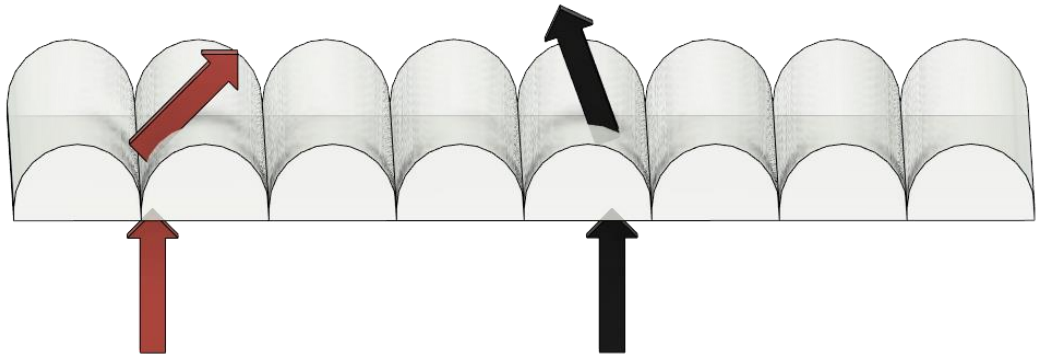
Looking Glass by Looking Glass Factory [4]

Background

Lenticular Lenses

- Curved lenses
- Bends the light of the images displayed behind the lenses
- Allows for multiple images to be placed behind the lenses
  - Each eye sees a different image
- Stereoscopy is achieved





Background

Pros and Cons

VR headset

Pros

- High resolution
- Realistic feeling 3D
- Highly interactable

Cons

- Requires headset
- Some use external sensors
- Might need dedicated space

LFDs

Pros

- Displays multiple views at once
- No devices attached to the user
- Potential for multiple users

Cons

- Lower resolution than VR
- Operating window
- Complexity

■ Research Aim

The aim of this research was to analyze the benefit of adding stereoscopic depth cues to a cube display by way of an LFD.

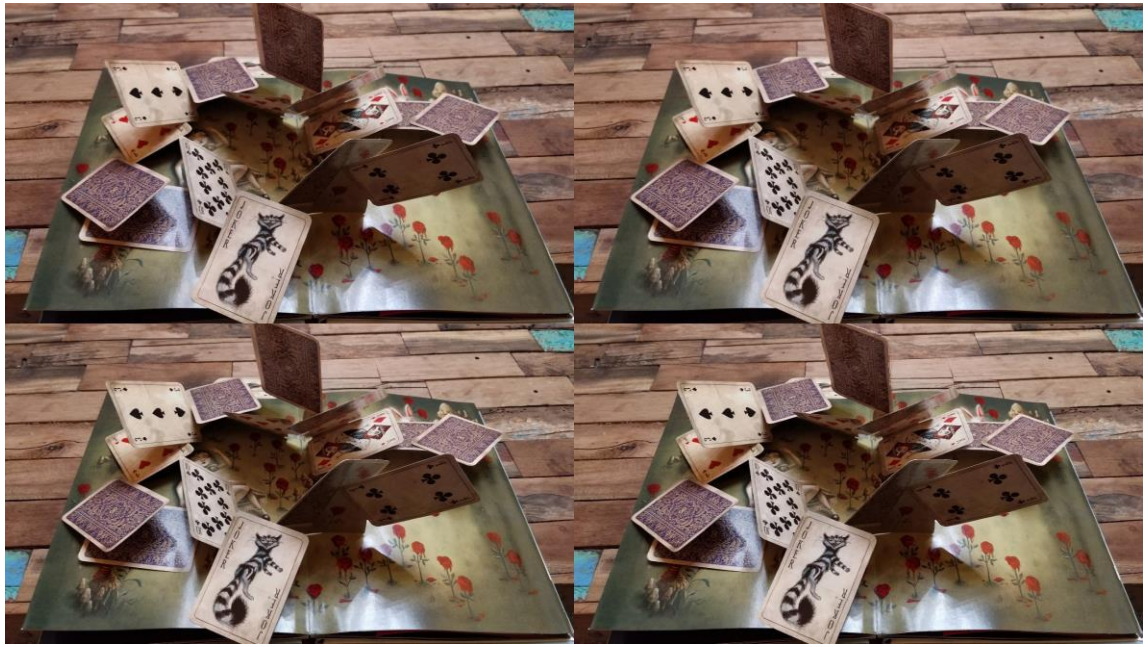
- Lume Pad by Liea Inc. [5]
  - The Lume Pad is both an LFD and a standard tablet.
  - It can operate as a stereoscopic display as well as a 2D display.

■ The Tools used in This Study

Lume Pad by Leia Inc.

- LFD Tablet
- Four images

- More compact than many other LFDs
- Developer support



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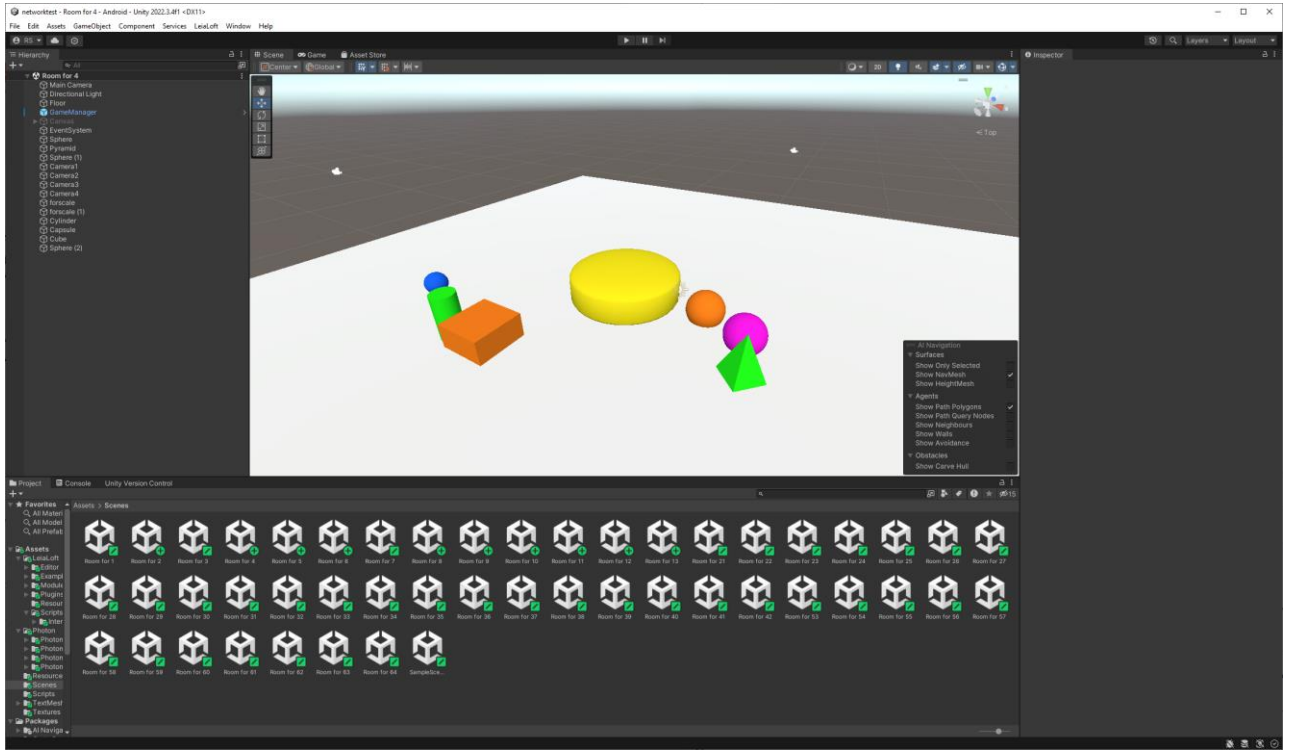
The Tools used in This Study

Software

- **Unity**
  - Allows for straight forward set up of experiments.

- **Lume Pad SDK [6]**
  - Built in Lume Camera handles LFD effect.
  - LFD effect can be switched on and off as needed.

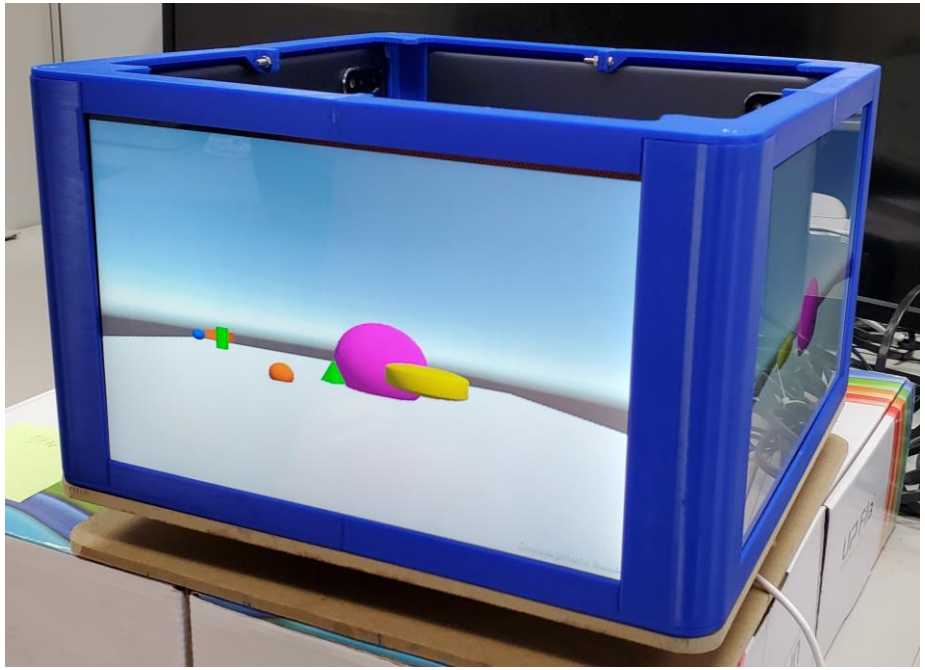


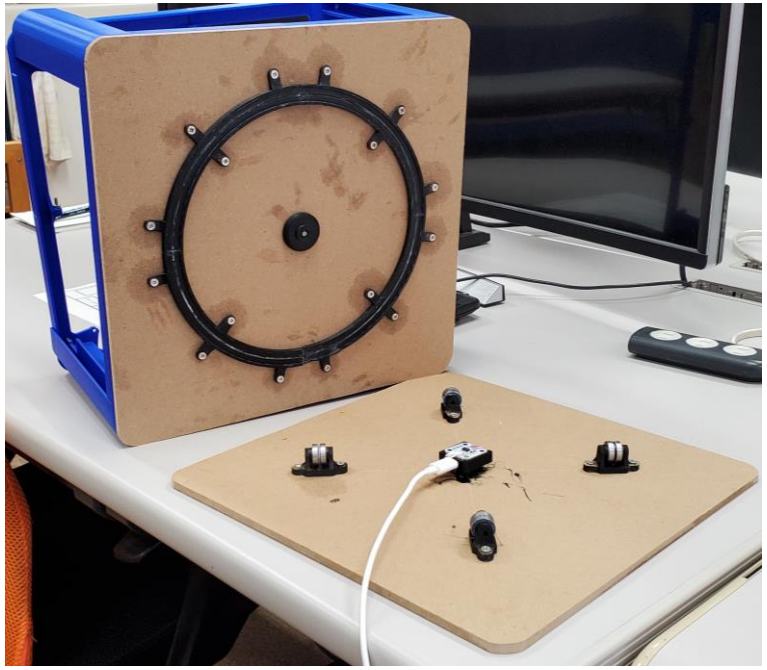
■ The Experiment

Concept

Dice

- 4 Lume Pad tablets
- Magnetic Encoder



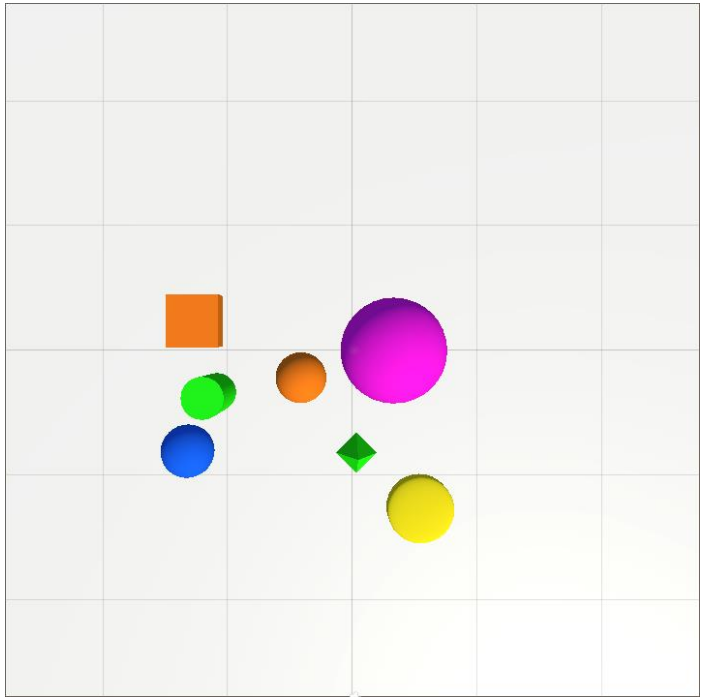


The Experiment

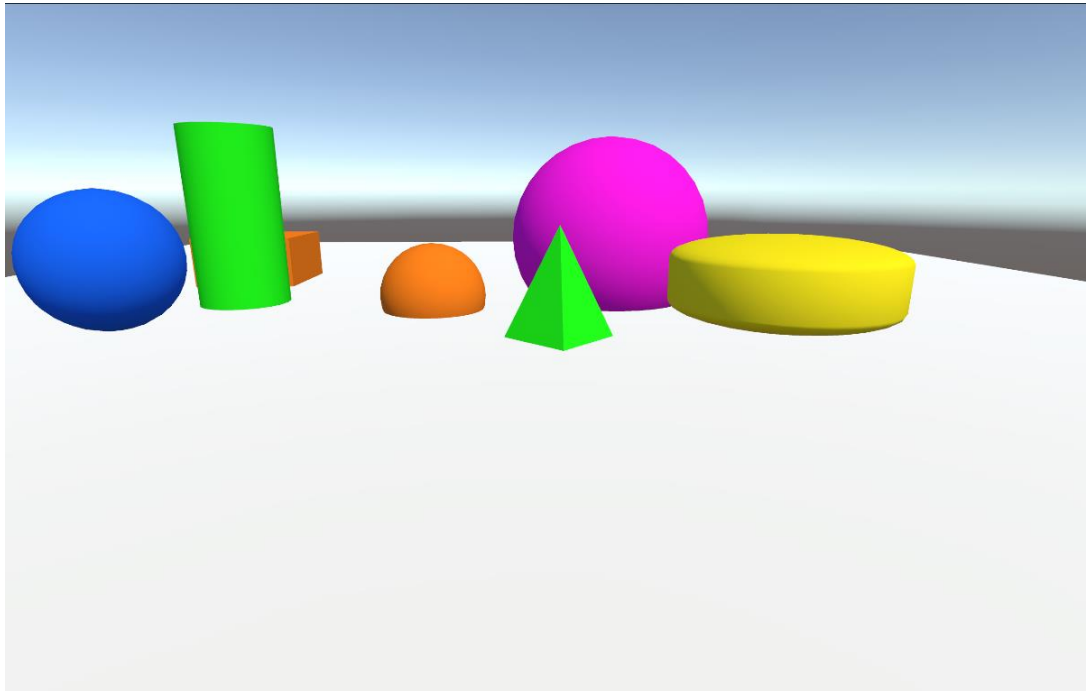
Concept

Subjects were asked to pick the object closest to the green cylinder and the green pyramid.

As the subjects could not see a top-down view, only a side view, they needed to rely on many depth cues.



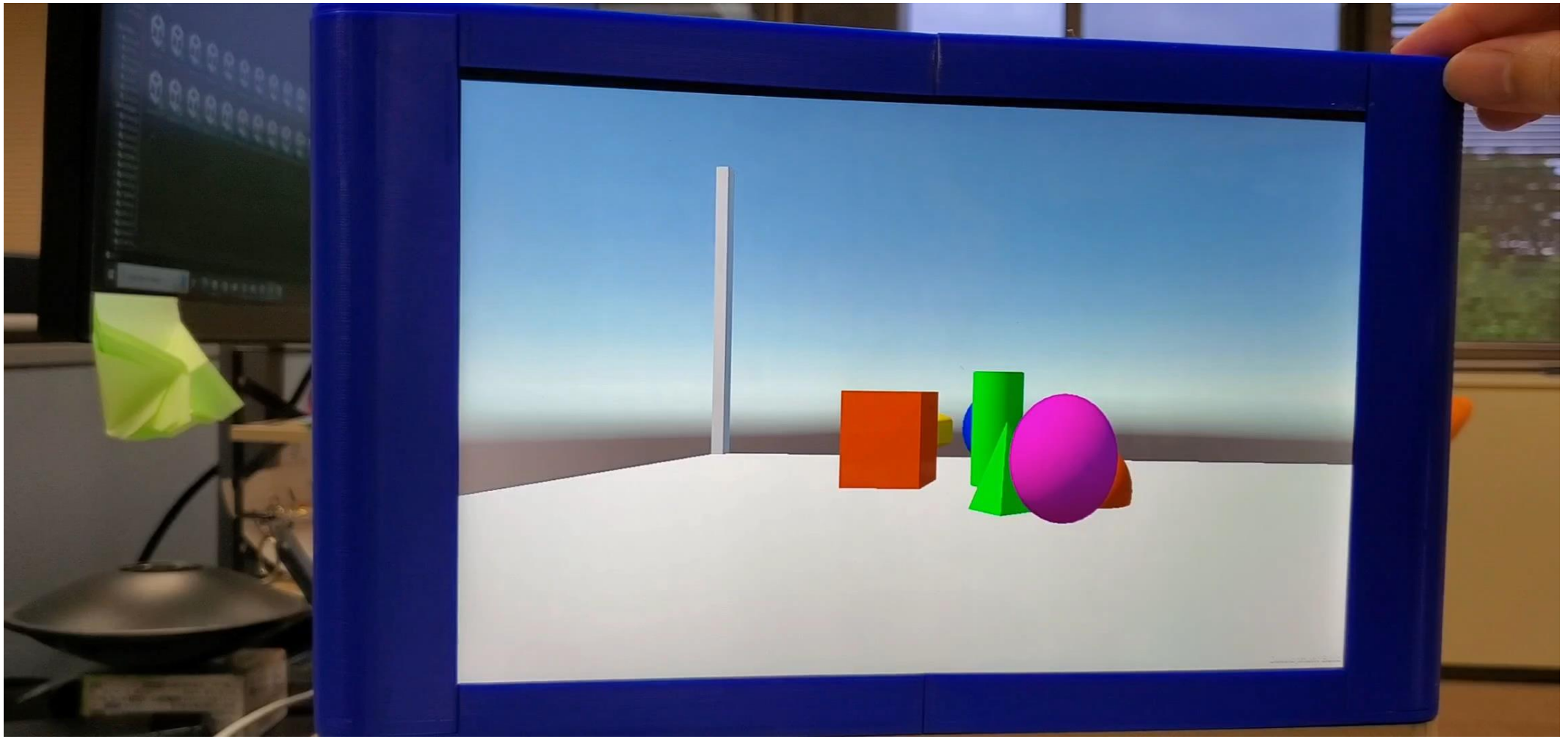
Sample scene as seen from a top-down view in Unity.



Sample scene as displayed on one side of Dice.

■ The Experiment

Dice



Results

Experiment

- A total of 60 tests
  - 30 tests were performed with the LFD
  - 30 tests were performed without the LFD

- LFD error rate: 7% (2 errors)
- W/o LFD error rate: 17% (5 errors)

■ Results

Test Subject feedback

- Users felt unconfident in both modes.

- The users felt more confident with the stereoscopic depth cues of the LFD, but still were not confident.

- Objects were too far away. The scale of the objects in the experiment needs to be increased.

Conclusion

Achievement

- Our research showed interesting, if inconclusive, results.
- The questionnaire showed that the tests need to be reconsidered.

Future work

- Improve the camera.
- Redesign existing tests to better work with the display.
- Design tests to emphasize stereoscopic depth cues.
- Obtain a larger sample size.
  - This should help achieve conclusive results.
- Investigate additional ways to interact with Dice. [7]

References

[1] Faubert, J. (2001, February). Motion parallax, stereoscopy, and the perception of depth: Practical and theoretical issues. In *Three Dimensional Video and Display: Devices and Systems: A Critical Review* (Vol. 10298, p. 1029809). International Society for Optics and Photonics.

[2] SpheriCul: A New Perspective on 3D Displays, https://www.sphericul.com/ [Retrieved on 6 May 2024]

[3] Apple Vision Pro, https://www.apple.com/apple-vision-pro/ [Retrieved on 22 April 2024]

[4] Looking Glass Factory: The Hologram Company, https://lookingglassfactory.com/ [Retrieved on March 2024]

[5] 3D Lightfield Experience Platform, https://www.leiainc.com/ [Retrieved on 21 March 2024]

[6] SDK and Developer Resources, www.leiainc.com/sdk. [Retrieved on 10 February 2024]

[7] I. Stavness, B. Lam, and S. Fels, “pCubee: A Perspective-Corrected Handheld Cubic Display,” Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1381-1390, 2010.

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