VR Illusion Project Final Report

Siyuan Peng/ Zongxia Li

Project Overview

To investigate the relationship between the neural activity and human locomotion, we designed a psychophysics controlled experiment and compare the strength of visual illusion in a virtual environment setting

Experiment Design

Two Experiment Setup:

- Standing with HMD to view a series of illusion
- Walking on a treadmill with HMD to view a series of illusion.

Experiment Procedure:

- After orientation session, participants will be randomly assign one of experiment setup.
- A standardized break will be given
- The participants will experience the alternate condition.

The strength of the illusion will be determined and recorded.

Determining Illusion Threshold

To prevent habituation error and anticipation error, we use

Staircase Method

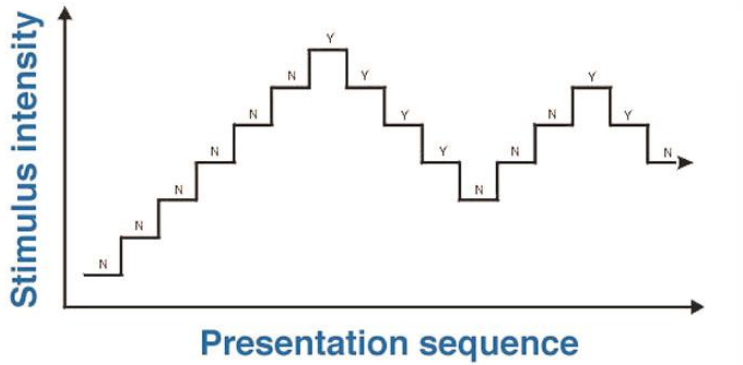


Figure 12. Staircase method. Y = Yes, the stimulus can be seen and N = No, the stimulus cannot be seen.

for illustration purpose only

Virtual Environment

Overview:

Welcome Scene:

- For participants preparation, familiarize themselves with VR equipment and practice illusion tuning.

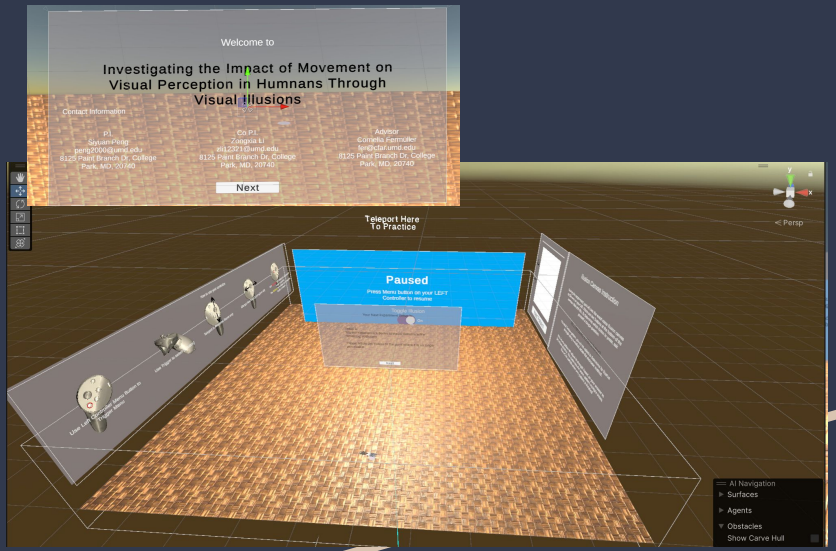
Moving Scene:

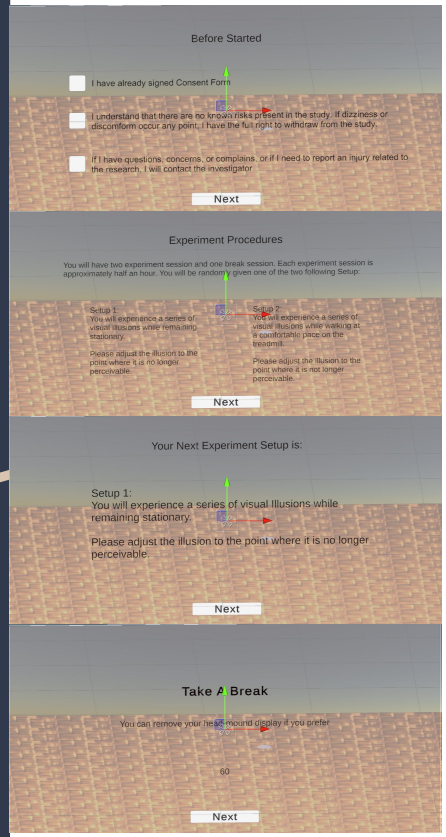
- Forever running scene: low-poly texture forest environment with a straight path in the middle of the scene

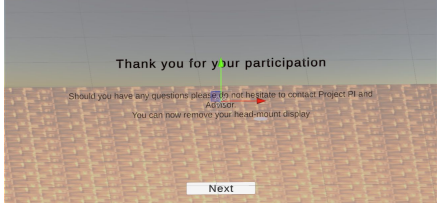
Stationary Scene:

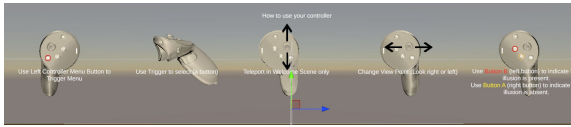
- Stationary scene: same low-poly texture forest with a path

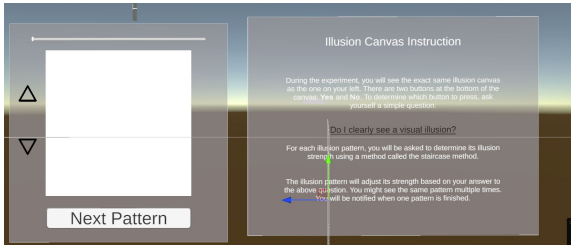
Welcome Scene



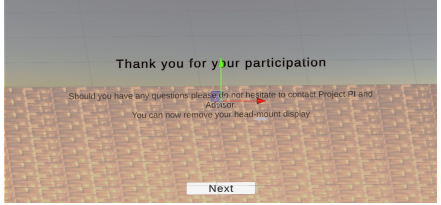


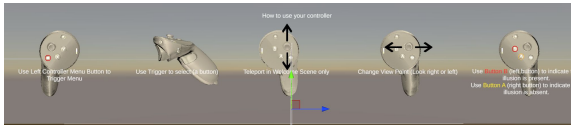


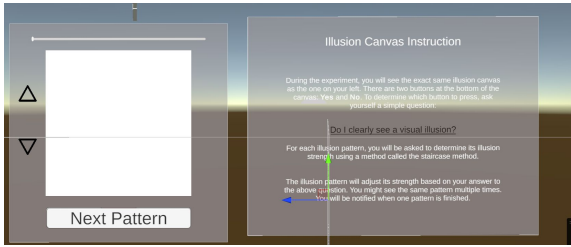


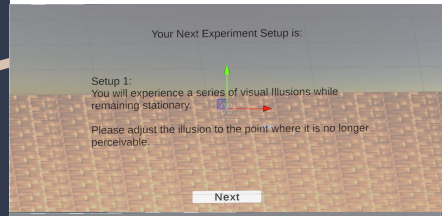


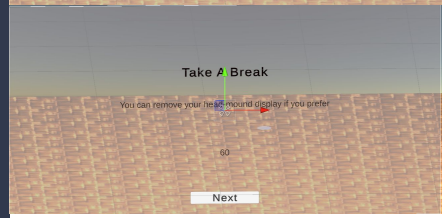
Welcome Scene

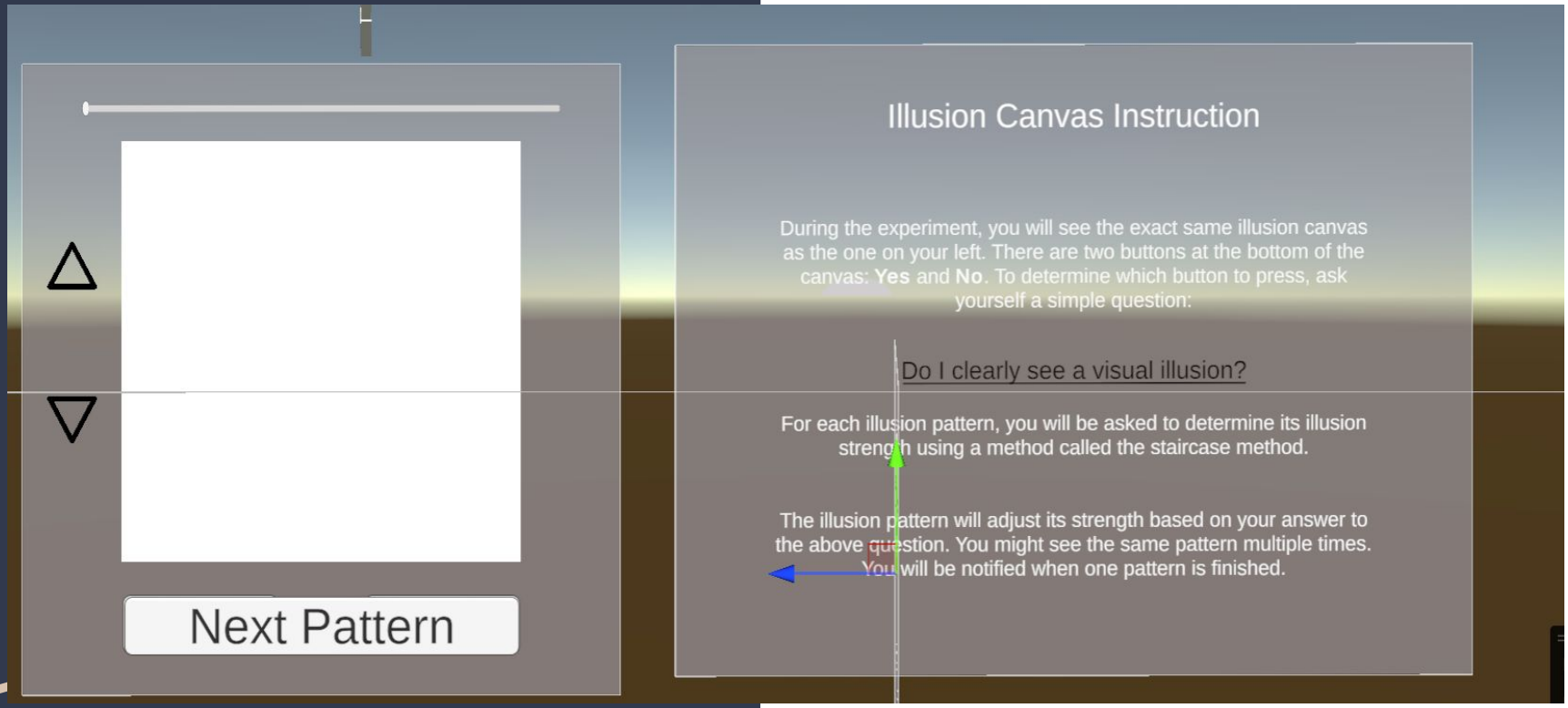




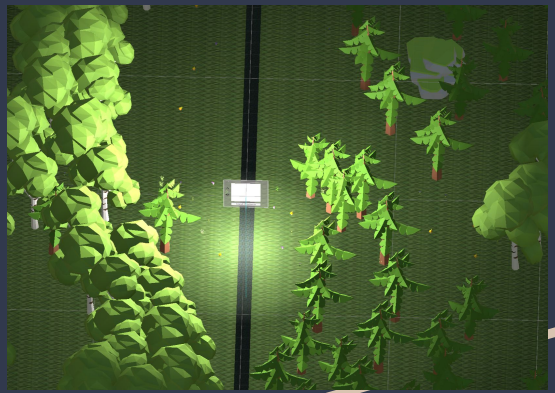


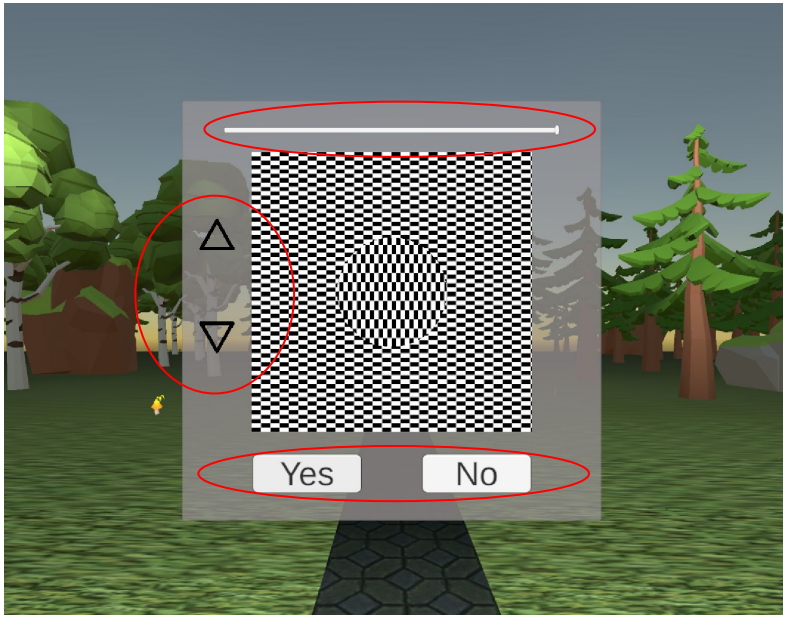


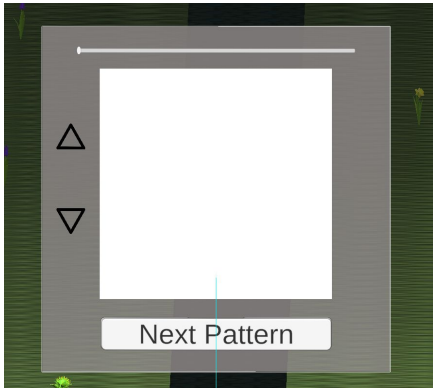


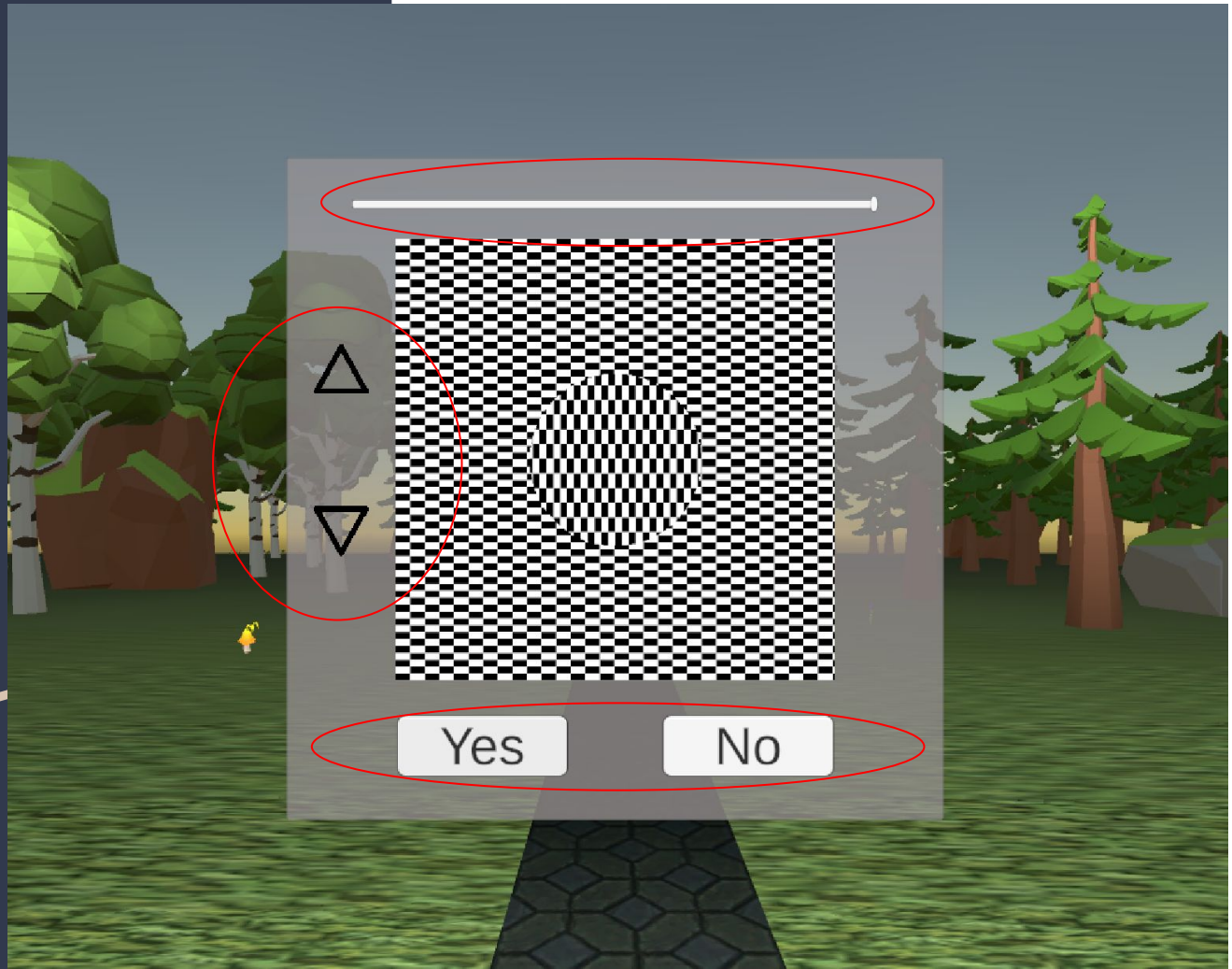

Next Pattern
Illusion Canvas Instruction
During the experiment, you will see the exact same illusion canvas as the one on your left. There are two buttons at the bottom of the canvas: Yes and No. To determine which button to press, ask yourself a simple question:
Do I clearly see a visual illusion?
For each illusion pattern, you will be asked to determine its illusion strength using a method called the staircase method.
The illusion pattern will adjust its strength based on your answer to the above question. You might see the same pattern multiple times. You will be notified when one pattern is finished.

Stationary Scene

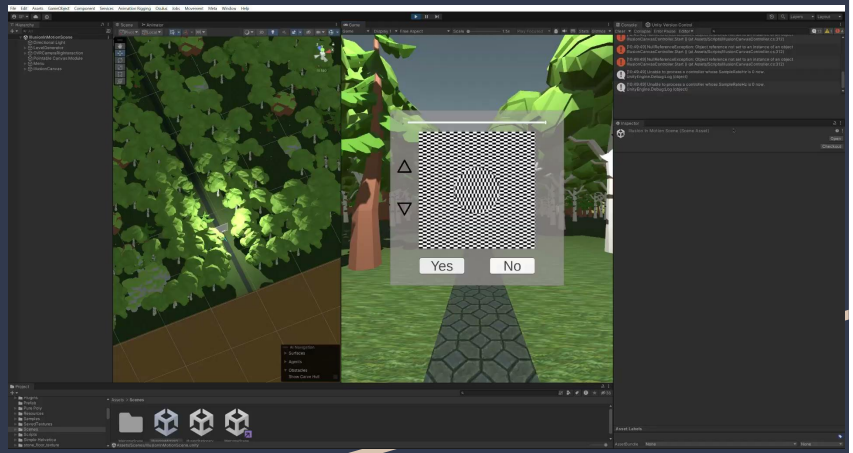


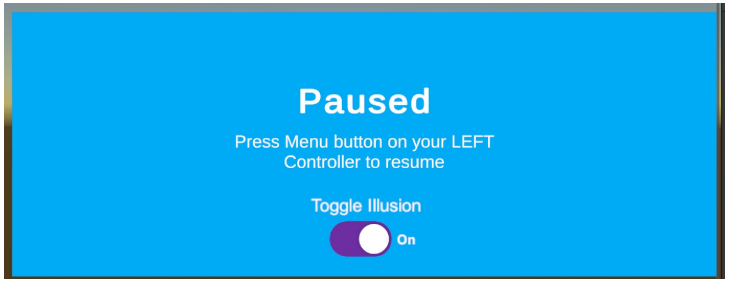





Yes
No

Moving Scene





Physical Protection

In order to conduct experiments in a moving setting, we are able to borrow a treadmill from Snehesh (Thank you!)

Thanks to the support from Dr. Cornelia, we are able to purchase the gym rack and other safety equipment.

Experiment/safety equipment:

- Treadmill
- Gym rack
- PVC DIY sets
- PVC tube cutter
- Harness vest
- Protective foams
- 5m USB to type Oculus cable

Safety Measurements

- First guard: PVC frames
- Second Guard: Treadmill safety key
- Final Guard: harness vest

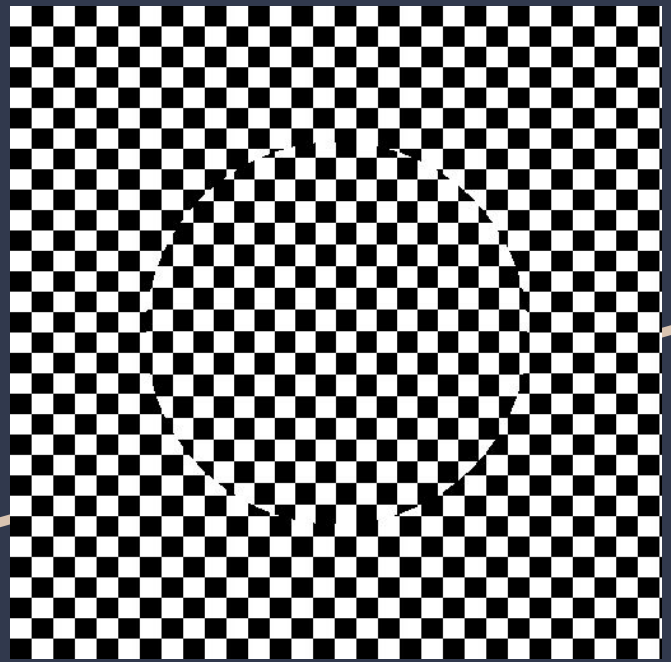
(We actually considered hanging the harness vest over the ceiling)

Illusions

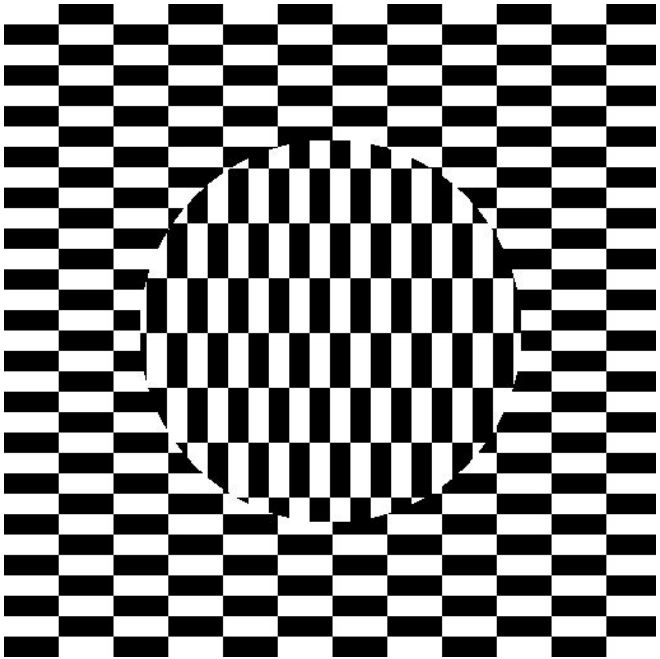
- Illusion Types and geometry
- Contrast, Size Ratio
- Step Size
- Used Pre-computed Illusions of various step sizes to reduce real-time computation

Ouchi Illusion (length Contrastive)

Least contrastive Illusion (0.0)

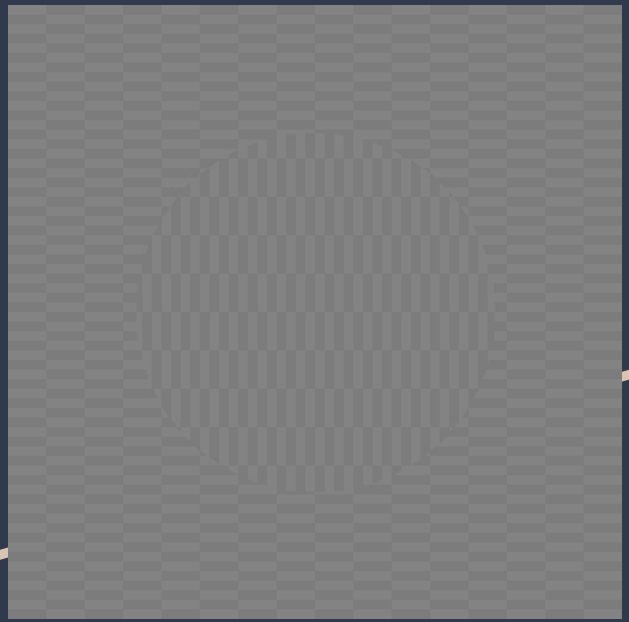


Most contrastive Illusion (1.0)

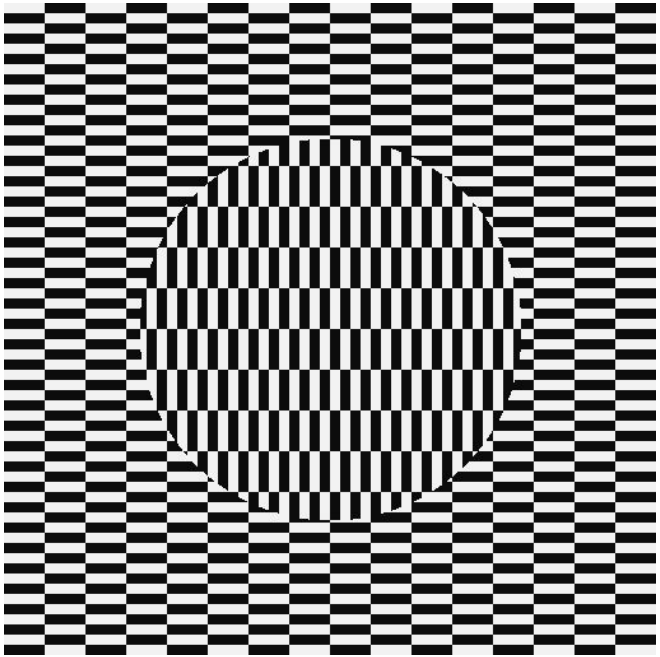


Ouchi Illusion (Contrastive)

Least contrastive Illusion (0.0)

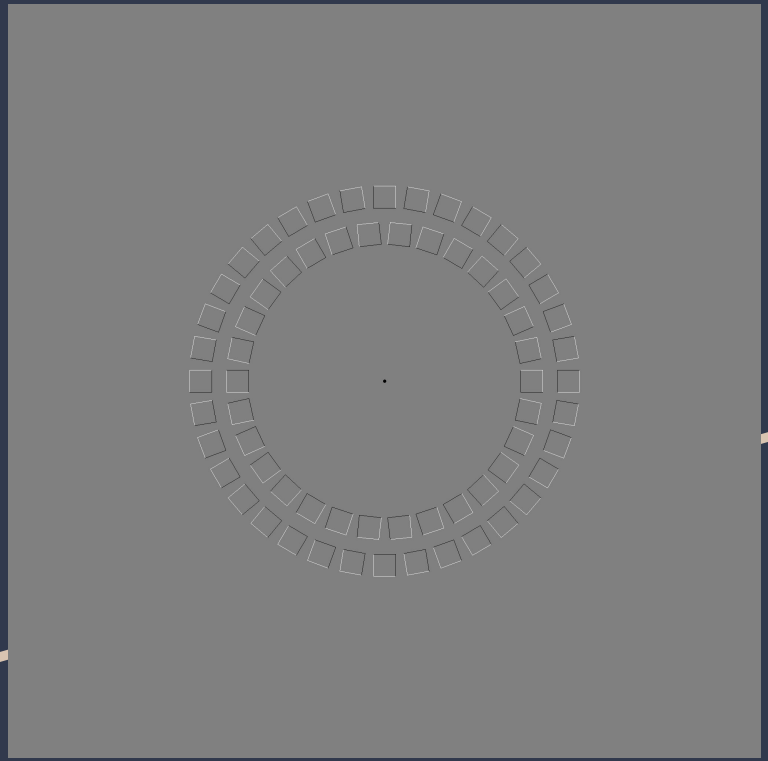


Most contrastive Illusion (1.0)

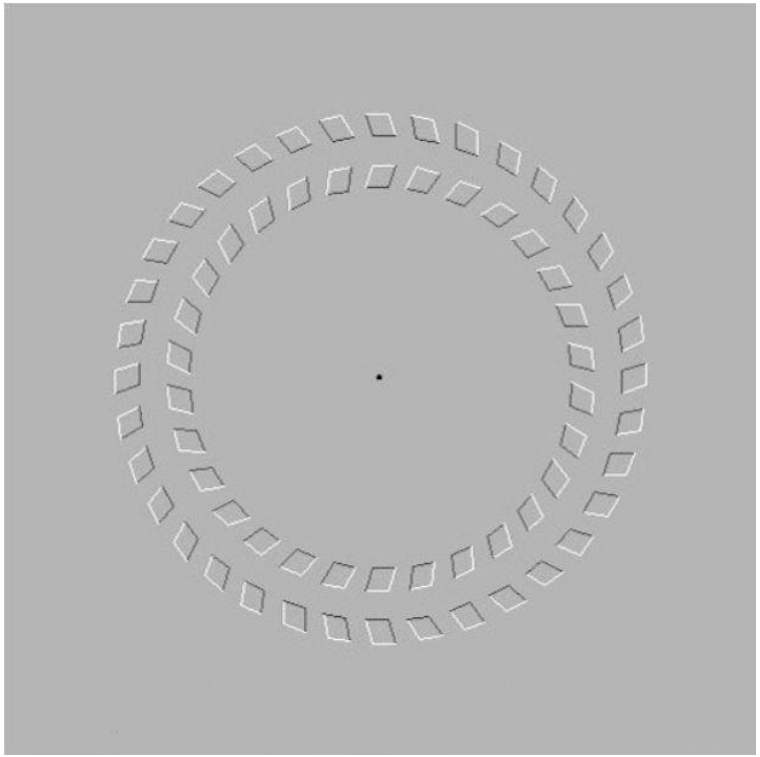


Pinnacle Illusion

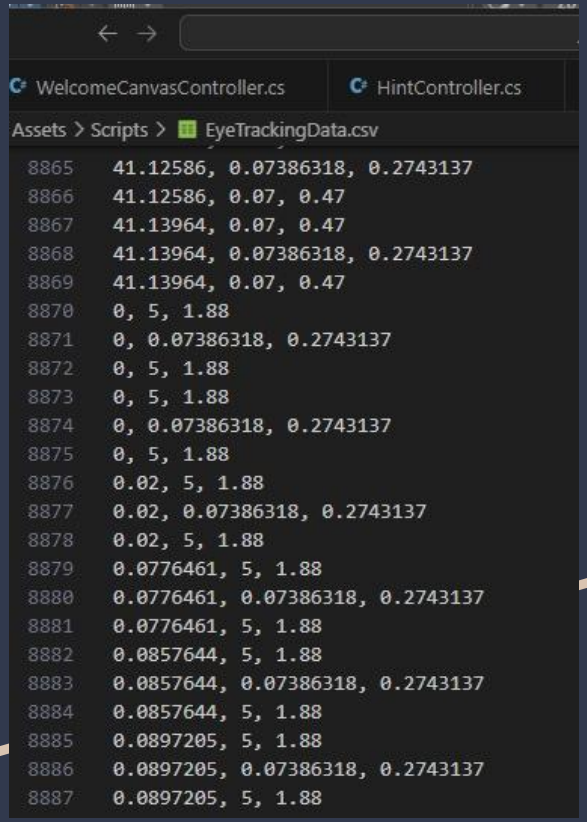
Least Contrastive (0.0)



Most Contrastive (1.0)

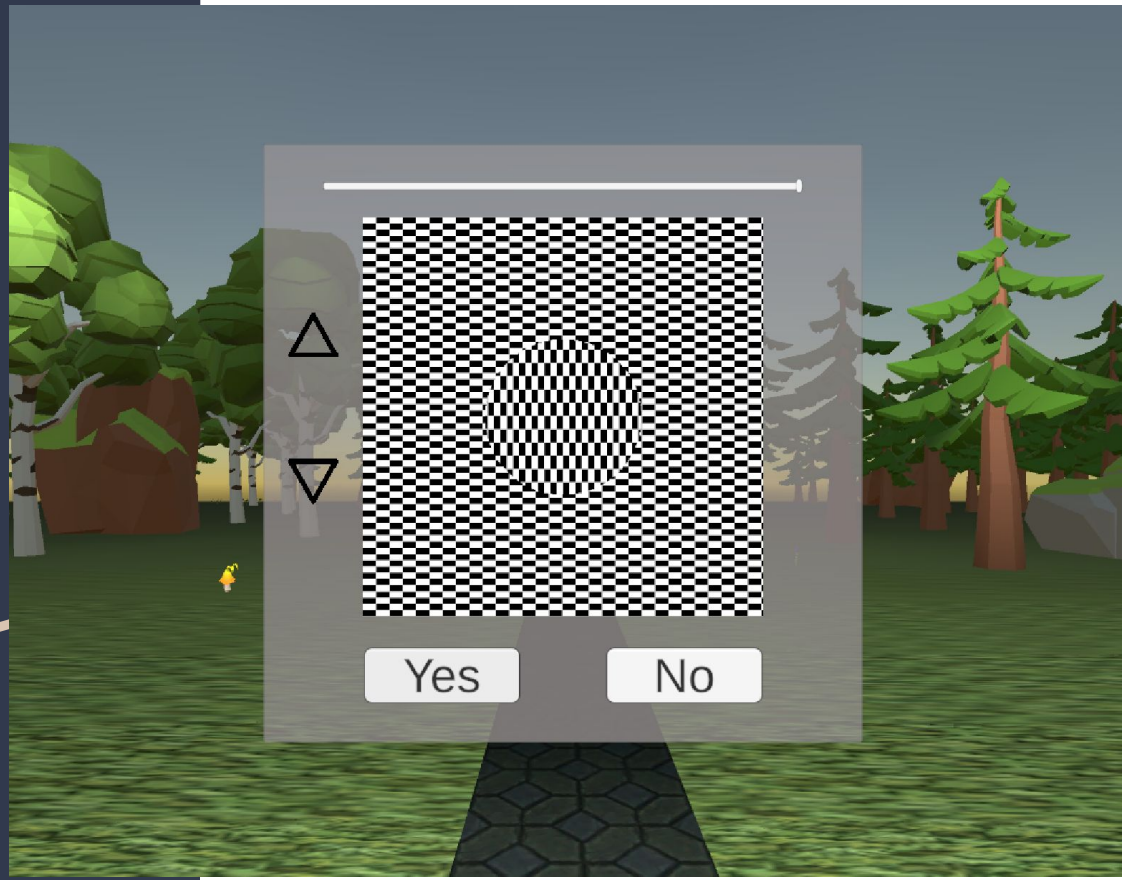


Eye Tracking



- Tracks left and right eyeballs' movement, vibration for illusion vs. time
- Hope: can detect users' eyeball vibration frequency when viewing illusions under different conditions.

User Study Procedures



Results

- **Collected Data for Four Participants. Each participant needs to experiment each pattern three times, then take the median for each pattern.**
- **Eye Tracking feature was not able to catch small movement/vibration of the eyes, can only catch eye movement in large angles.**
- **Resolution of illusion patterns in the VR display not high enough compared with monitor**
- **Participants say illusions more obvious on monitor than in the VR display.**

Illusion	Moving	Stationary
Ouchi Length	0.9-0.13	0.9-0.11
Ouchi Color	1-0.15	1-0.11
Wheel Length	1-0.17	1-0.13
Wheel	1-0.3	1-0.37

Conclusion

Next step:

- Make the illusion stronger by moving the canvas in specific directions.
- Tuning step size
- Recruit 30 Participants, collect data, and run statistical analysis
- Adding more illusions

Although we are not to collect any meaningful data, as there are still improvements needed for the illusion pattern, I'm satisfied with progress of the final project. I've spent more than 30 hours on this project, and I will invest more during the summer to complete it.

Thanks for the support of Dr. Cornelia, Snehesh, Ian and Roger from IMD lab, and Prof. Ming.

Thanks for all participants. They provides invaluable improvement advice on our design.

Siyuan's Contribution

Development of the Welcome Scene:

- Environments: floor, lighting, materials
- Locomotion: TP and hotspot (I have to say Meta's documentation is really confusing. I even ask a friend who's working in meta and specifically in the VR. He couldn't help me with the TP issue.)
- Main instruction panel: Welcome Page, Before started Page, Instruction Page, Assignment Page, Break Page, Thank you Page.
- "How to Use Controller" Panel: find controller's 3D model and make it 2D with text instructions
- Illusion Canvas user instruction
- Self-rotation 3D text: "Teleport here"

Development of the Stationary Scene:

- Building of the stationary scene: low-poly assets and actually "plant" them (trees, rock, flowers) on the ground
- Building of "the road", and lighting
- Building of the Illusion canvas:
  - Slider used to indicate the illusions strength
  - Up arrow and down arrow (previously used to indicate increasing the ratio and decreasing the ratio) now used to indicate the staircase method's phase.
  - Raw image that's used to load illusion pattern
  - "Yes", "no", "next" pattern button
- First loading mechanism of the illusion pattern
  - We wanted to load the illusion pattern on the fly -- meaning when the participants click Yes or No, the algorithm need to calculate the pattern during runtime, and then load it to the canvas. However, we figure out that it would have performance issue in the moving scene (very low FPS). We then switched to offline generation

Siyuan's Contribution

Development of the Moving Scene:

- We used a unity asset called forever to create this scene. I spend two nights to read documentation, create a toy example and creating the actual moving scene.
- The logic behind is that I created three independent segments. Scene Controller will randomly load one of them, thus creating a forever moving scene

TimelineController.cs : Used to determine "timeline" i.e. what's next.

Designed Timeline:

Welcome Scene => Stationary (or moving) Scene => Welcome Scene (for standardized break) => Moving Scene (or stationary scene) => Welcome Scene (For thank you page)

I figured out how to use AsyncLoading for pre-loading each scene to prevent freezing.

This Timeline controller also controls the "main instruction panel": determining what's next page. It pre-render the panel before coming back to the welcome scene from other scenes.

It's also responsible for controlling the break room timer.

Siyuan’s Contribution

DataSaver.cs

I tried to use PlayerPref to save data. Problem: it cannot be stored into multiple files.

I have to create my own data saving class.

It’s really pain to figure out where and how to save a simple txt file in the context of Oculus and Unity.

MenuController.cs

This is designed to pop up when participants feels dizzy.

IllusionPatternAbstractClass.cs

I design this interface class to designate what each illusion pattern generator needs to implement. I was hoping each IllusionPattern class can inherited this class and defines its own method, (I wrote the on-the-fly generation script for Ouchi length and color Illusion. However, as we changed to offline generation, this one only serves as data loading purpose.

IllusionPatternLoader.cs: Responsible for loading the pattern

IllusionCanvasController.cs: Responsible for controller the UI element on the canvas

Siyuan’s Contribution

Pilot Study at Snehesh’s house

Thanks for Snehesh for allowing me to conduct pilot study on this treadmill in his house.

Others:

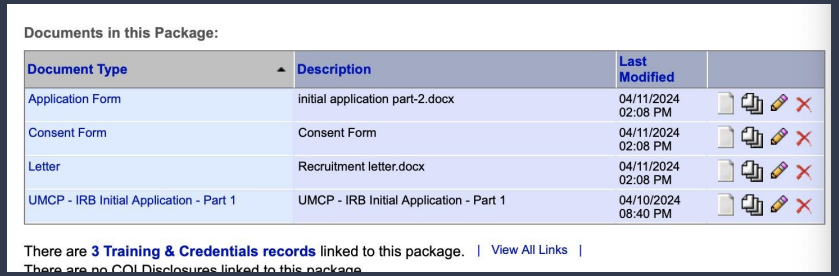
Order experiment equipments.

I drove to Rockville to purchase and carry the gym rack back to school. (I got a 100$ citation for parking in lot GG1 when offloading the rack.)

Construction of the gym rack and PVC frame (which took me another two nights)

IRB Initial Draft and Final Draft

Zongxia's Contribution



Documents in this Package:

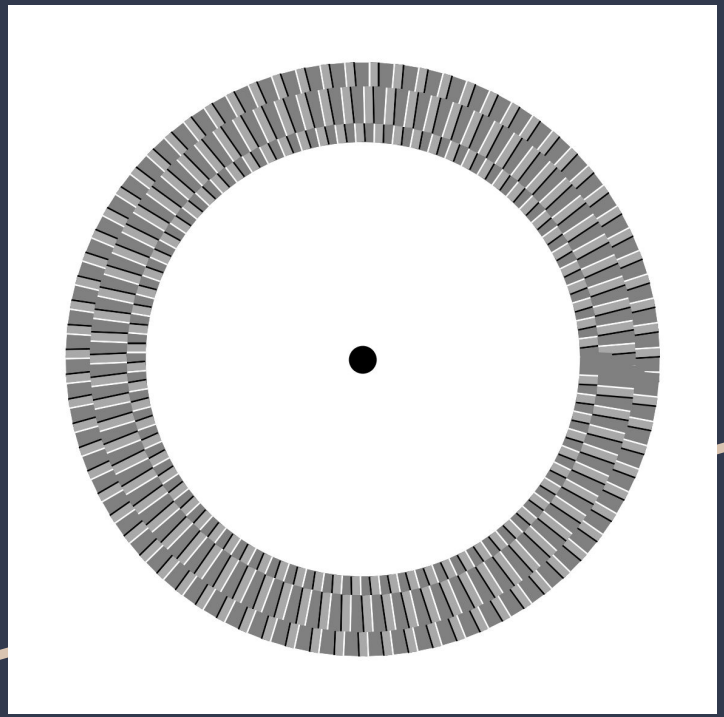
Document Type	Description	Last Modified
Application Form	initial application part-2.docx	04/11/2024 02:08 PM
Consent Form	Consent Form	04/11/2024 02:08 PM
Letter	Recruitment letter.docx	04/11/2024 02:08 PM
UMCP - IRB Initial Application - Part 1	UMCP - IRB Initial Application - Part 1	04/10/2024 08:40 PM

There are **3 Training & Credentials records** linked to this package. | View All Links |

There are no COI Disclosures linked to this package.

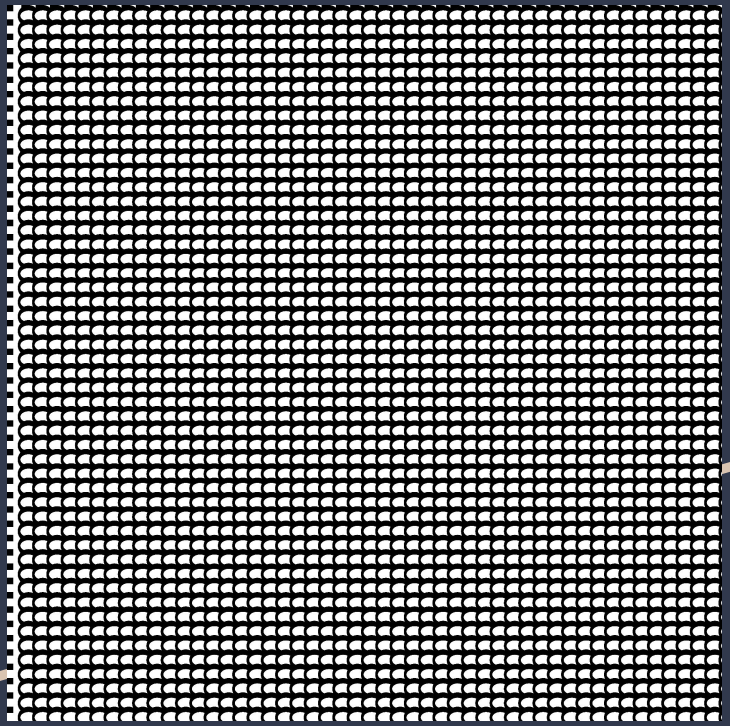
- IRB initial draft and revision. Wrote initial draft for Consent form, Initial applications, recruitment letter.
- Scripts/Coding: proposed pre-computation of Illusion images method to increase real-time experience.
- Implemented ouchi illusion, pinnacle illusion scripts to draw illusions.
- Test out illusion contrast ratios, range, step size for the user study

Zongxia's Contribution



- Eye tracking Features: Implemented eye movement tracking script.
- Eye tracking data saver: saved eye tracking data to files.
- Actually coded more illusion patterns than we used in the user study, but considering user mental load, only used four conditions.

Zongxia's Contribution



- Hire participants for user study: schedule time, print out consent forms.
- Conduct user study. Read them instructions, ask them questions during user study.
- Collect user study data.
- User study feedback and results analysis.
- Paper abstract, experiment, pattern, diagram, data analysis, conclusion sections.