Southern Illinois University
CARBONDALE

SIU-CAVE: Cave Automatic Virtual Environment

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Introduction

A cave automatic virtual environment (CAVE) is a form of virtual reality that allows for an immersive, multi-user experience without limiting one's spatial awareness or mobility.

A typical CAVE system consists of:

- Five screens that form a cube
- Five projectors that project synchronized-stereoscopic images to the user(s)
- PCs networked together to run the application synchronously on all screens
- Input devices and motion sensors synced for localization and input signals

Purpose

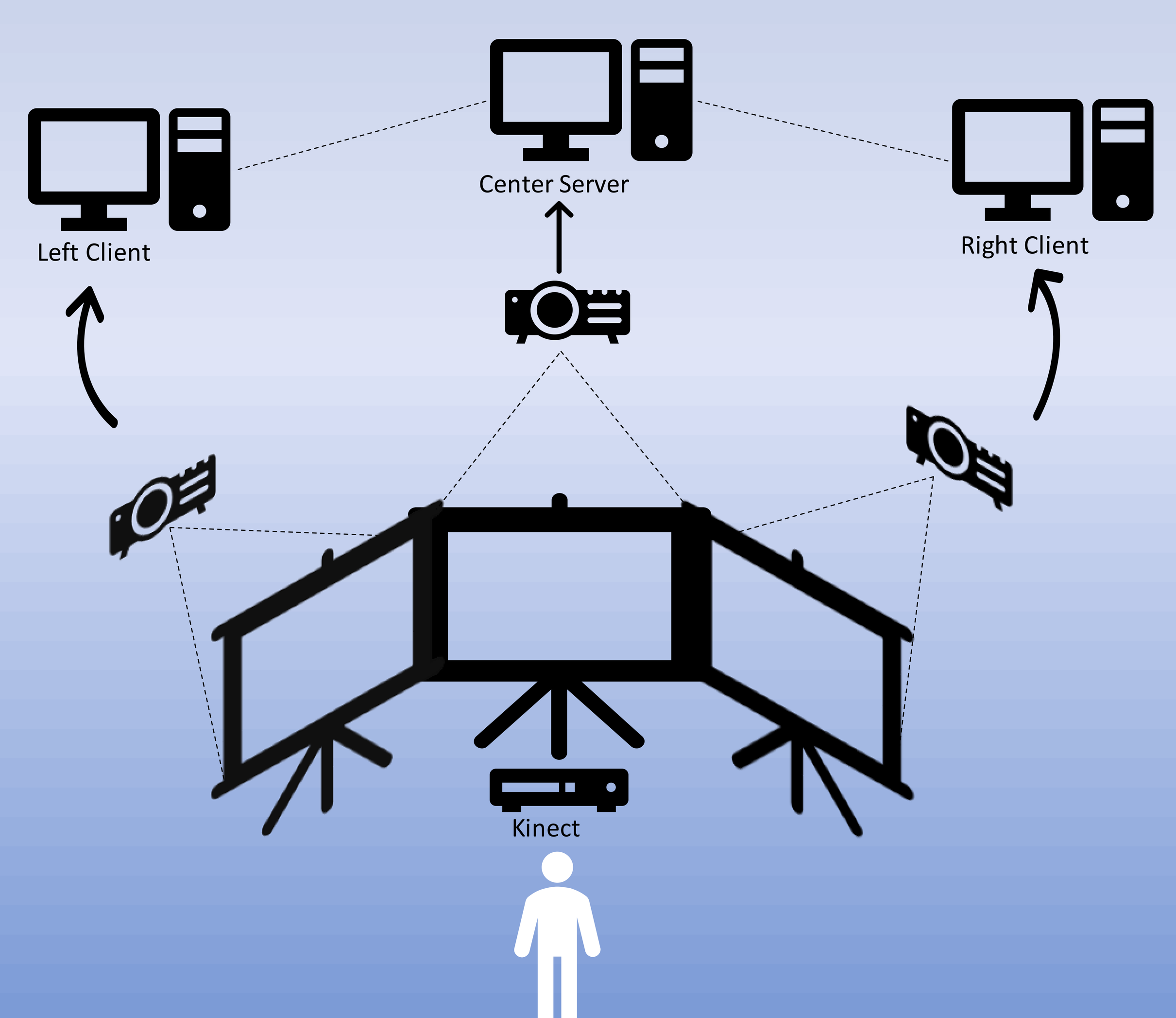
Create a prototype CAVE system to better analyze and demonstrate the features of CAVE's, as well as provide an initial platform for developing CAVE VR technologies at SIU.

High-end CAVE systems are incredibly expensive and complex, reaching upwards of $20,000. Our CAVE prototype aims to illustrate the benefits of these systems while being cost-effective.

Challenges

The complexity of the project stems from the compatibility and interaction of different types of hardware and software, including:

- Collecting and localizing the user's input data
- Synchronizing and calibrating viewports
- Determining and optimizing the user's field-of-motion and field-of-view



Methods

ARCHITECTURE DESIGN:

- 3 Screens constructed at 60° angles to form a C-shape
- 3 Projectors behind the screens at a distance of six feet
- 3 PC's connected to their own projector, and then networked together; two clients and one server
- Rear-projection screen material to eliminate shadows
- Screen and projector stands
- Kinect motion sensor placed underneath the middle screen and a Wiimote held by the user
  Total cost: ~$630

SOFTWARE DESIGN:

- Unity Game Engine for application development
- MiddleVR is a plugin used for camera calibration, networking, and input-device communication with Unity
- VRPN is a tracker for input data used with the Wiimote
- Kinect SDK: is a tracker for input data used with the Kinect

INPUT DESIGN:

- The Kinect tracks the user's yaw movement; when you turn left or right the cameras adjust accordingly
- Rotating the Wiimote modifies the user's Z and Y-axis independently; simulating moving forward, backwards, and fine-tuned turning
- A sense of localization is achieved while using both inputs

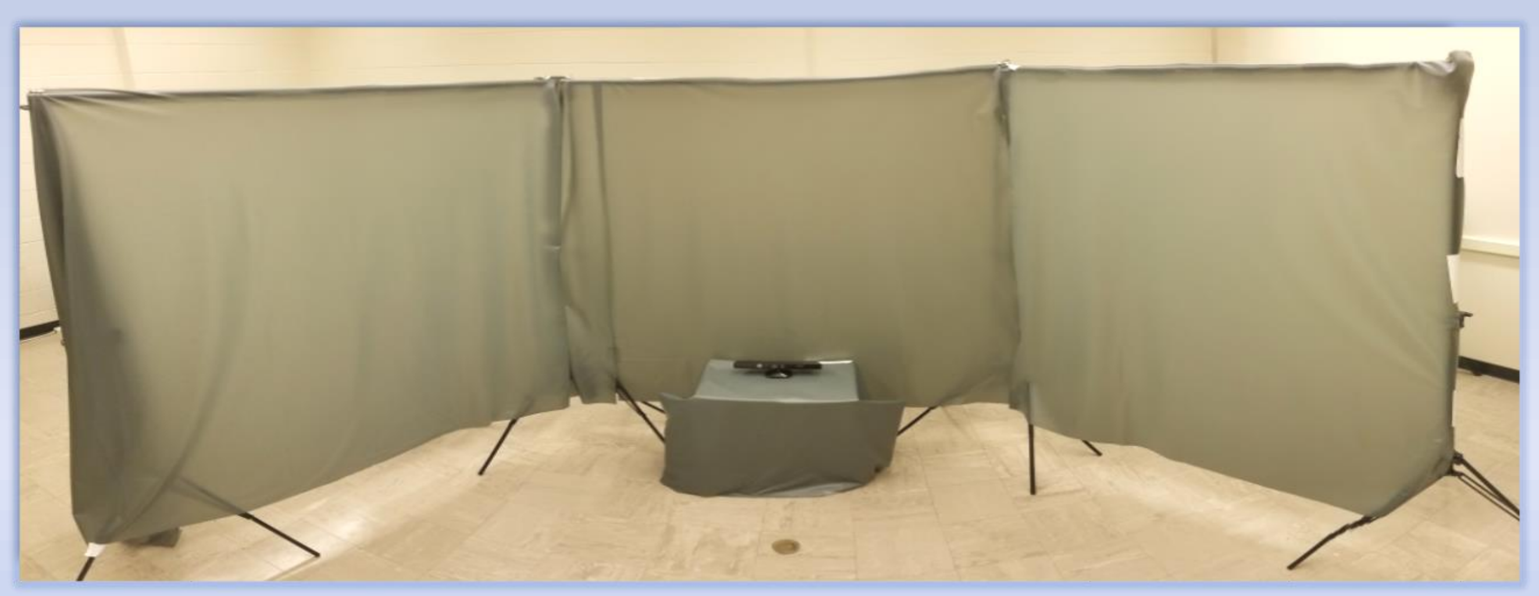
Development Environment

Unity Game Engine:

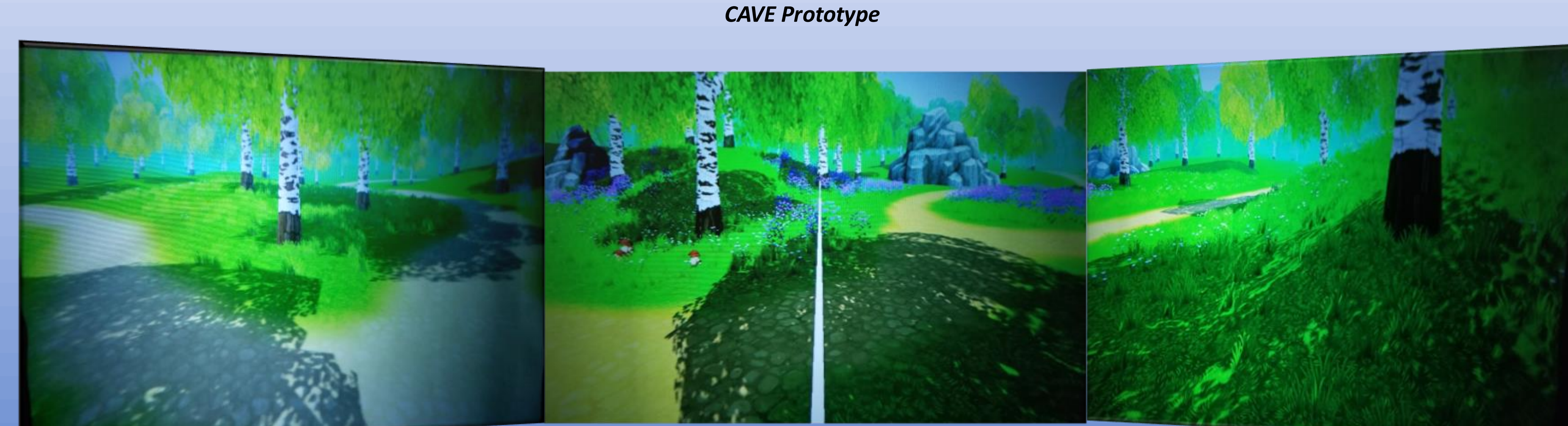
- Platform chosen for application development, compatible with MiddleVR plugin
- MiddleVR's plugin is used to further edit settings within the project

MiddleVR:

- Creates a configuration file with viewports, cameras and input devices settings.
- The configuration file is imported into the Unity application
- Cluster daemons run on each computer in order to synchronize instances
- An instance of each project is then ran on each machine via the network



CAVE Prototype



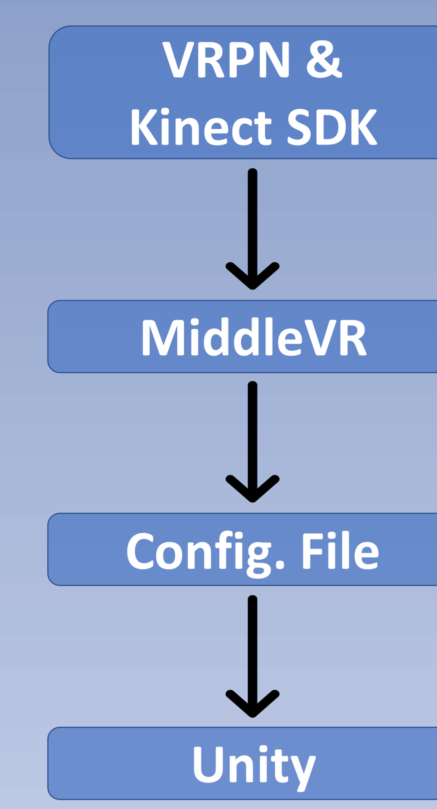
CAVE Demo

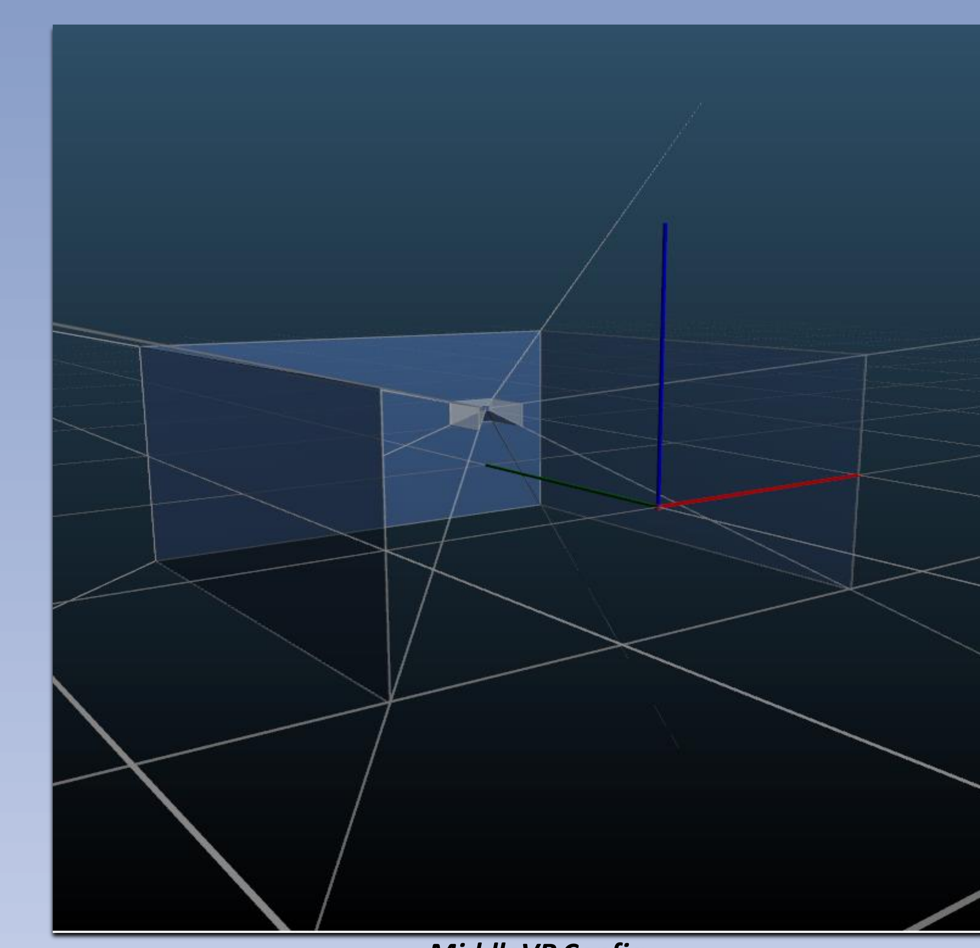
Discussion

The real value of a CAVE system is the variety of applications it can be used for. These are some of the current fields benefiting from CAVE technology:

- Automotive and aerospace engineering
- Medicine
- Architecture
- Education
- Media and entertainment
- Military
- Real estate

At SIU, an application for a CAVE system can be designed to utilize the multi-user functionality and the virtual environment. The CAVE can be used as a virtual lab that would enable students to practice high-risk scenarios that would otherwise not be feasible, such as medical operations.





MiddleVR Config

Conclusion

With limited funding, we successfully created an entry-level CAVE that demonstrates the key features of high-end systems. For developing the CAVE further, we recommend the following investments and adjustments:

- Additional screens for the floor and ceiling of the CAVE to improve immersion
- Develop SIU's own calibration software to improve CAVE-application flexibility
- A larger room for CAVE development minimizes calibration and field-of-motion issues
- Improve hardware
  - Projector's throw distance needs to be minimized for high-quality, large images
  - Screens need to be seamless, large, and of high quality to improve fidelity
  - High-performance GPU's for improved framerate
  - Input devices with three-dimensional tracking

Acknowledgements

We would like to thank the department for the budget to do our project as well as Michael Barkdoll and his GA's for their technical assistance. Also a big thank you to Professor Mousas and Professor Hoxha for their guidance and support!

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Senior Project, Team JBU, 2017-2018