VR Ping Pong Team Design Review

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Use Case

Problem: Long distance, virtual interactions are not as personal as physical interactions. This makes digital ***social interactions less interesting and engaging*** to everyone involved.

Solution: Creating a virtual reality ping pong game to play against other people around the world in real-time. The VR aspect creates a pseudo-presence that will make the interactions more fun.

Use Case Requirements: User Experience

- Latencies
  - Ball movement latency - < 50ms to calculate ball trajectory
  - Paddle movement latency - < 100 ms
- Smooth Frame Rate
  - 30 FPS is acceptable, allows for 15 frames to show ball flight path of a professional-speed rally
- Moderate resolution (~360p)
- Paddle power lifespan
  - Allow for 1 hour of continuous, wireless gameplay
- Accurate Paddle Motion Tracking
  - +/- 3 inches in terms of position
  - +/- 7.5 degrees in terms of orientation

Solution: Virtual Reality Ping Pong Game

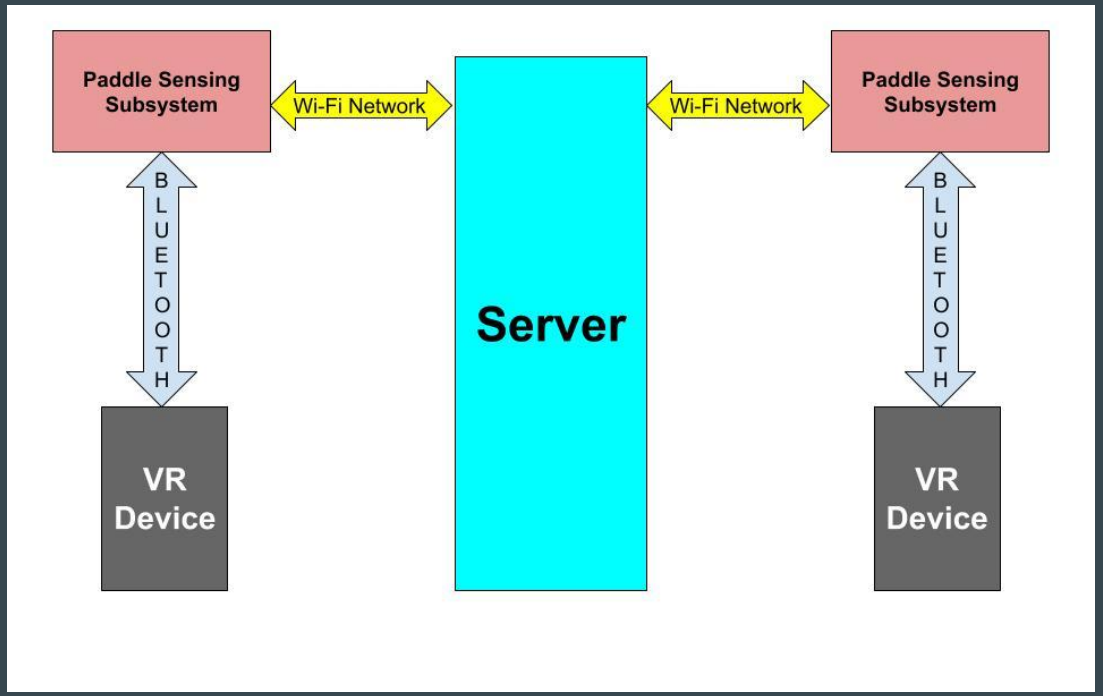
Sensing System + Device Application

- Use a combination of Inertial Measurement Units and Computer Vision for paddle motion sensing
- Sensing system will need to be connected to a microcontroller
- Use of battery to power microcontroller and sensing system
- Google Cardboard VR development kit for the VR mobile application
  - Can be done with Unity or Android Studio
  - Provide libraries for rendering graphics
  - Android libraries for Bluetooth communications as well

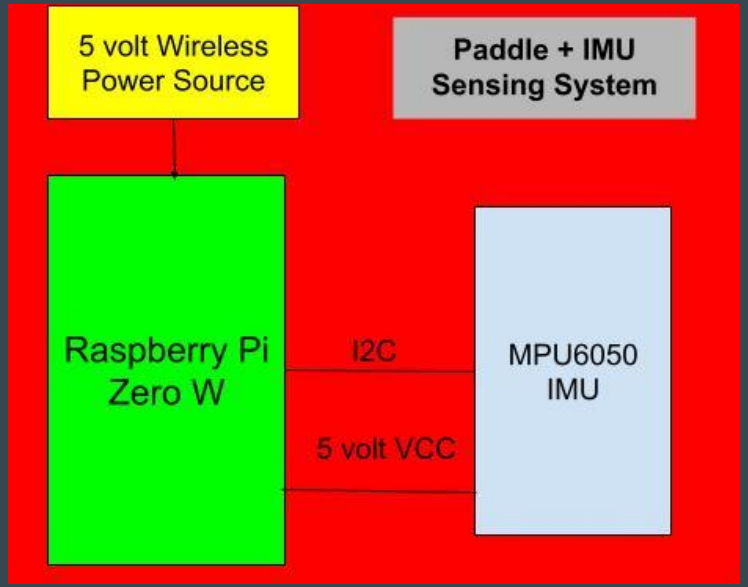
Solution Part 2: End-to-End Communications

- Sensor to Device Communication:
  - From sensor to microcontroller: wired serial communication (I2C, UART, etc...)
  - From sensing system to device: Bluetooth transmission is the obvious solution
  - Full-duplex communication between device and sensor through bluetooth
- Device to Device Communication:
  - Use networking to send data between devices (e.g. Android Sockets)
  - Potential use of a server to receive data from device and relay to other device
    - Allows for players to connect through a central server
    - Need to check how latency is affected
  - Decide what data is absolutely necessary to be sent real time, and what data is not as urgent to be sent through network, and what data can be processed locally
  - Possibly Cache some data

System Specifications



Components and Communication Protocol



Paddle System Design

System Specifications – Detailed

Paddle Sensing Subsystem

- Performs bulk of computing for the game
- Get IMU and CV data
- Perform data processing algorithms on microcontrollers to get position and orientation data
- Use the data on the paddle position and orientation and combine with data about incoming ball trajectory to determine returning ball trajectory
- Use this data and data about opponent paddle position to calculate parameters for graphics rendering

Data to Server:

- User paddle location and orientation
- Did the ball get returned?
- Returning ball trajectory data over time

Data from Server:

- Opponent paddle location and orientation
- Incoming ball trajectory over time

Graphics Parameters

- Opponent Paddle Position data
- Player Paddle Position data
- Ball Flight Trajectory data

VR Device

- Render Graphics
- Provide user application experience

Server

- Connect two players
- Keep track of game play data (e.g. scores)
- Relay data from player to player
- Perform validation of data to ensure both ends are synchronized to an extent

Components List:

Headset Components:

Purchasing:
- Google Cardboard
- Unity Assets

Downloading:
- Unity Game Engine
- Bluetooth Plugin

Developing:
- Graphics
- Gameplay
- Network communication with camera

Paddle Components:

Purchasing:
- IMU
- Battery
- Raspberry Pi/Jetson
- Camera
- Wifi Card and Antennae

Downloading:
- Bluetooth Plugin
- OpenCV

Developing:
- Object tracking
- Network communication with headset
- IMU signal processing

Server Components:

Purchasing:
- Amazon EC2 Instance

Developing:
- Code to project the ball trajectory
- Score tracking
- Network communication with headset and paddle

Testing, Verification, and Metrics

- Testing latency:
  - Get ping times for data from device to device
  - Measure delay from sensor to device
  - Different latencies for different connections:
    - Paddle - Headset
    - Paddle - Paddle
    - Paddle - Server
    - Headset - Server
  - Find latencies between each connection to find optimizations
  - Qualitative, easier success case: Realistic feeling gameplay

Testing, Verification, and Metrics

- Testing Paddle Sensor Accuracy:
  - Measure error of expected position and the actual physical position of paddle
  - Measure error of expected orientation and the actual physical orientation of the paddle
  - Measure how the ball trajectory reacts to real physical contact with a paddle compared to how the graphics simulate such reactions
    - Where the ball hits on the table
    - Location of the apex of the ball
    - Time it takes for the ball to complete its trajectory
    - Reaction of the ball to spin

Division of Labor

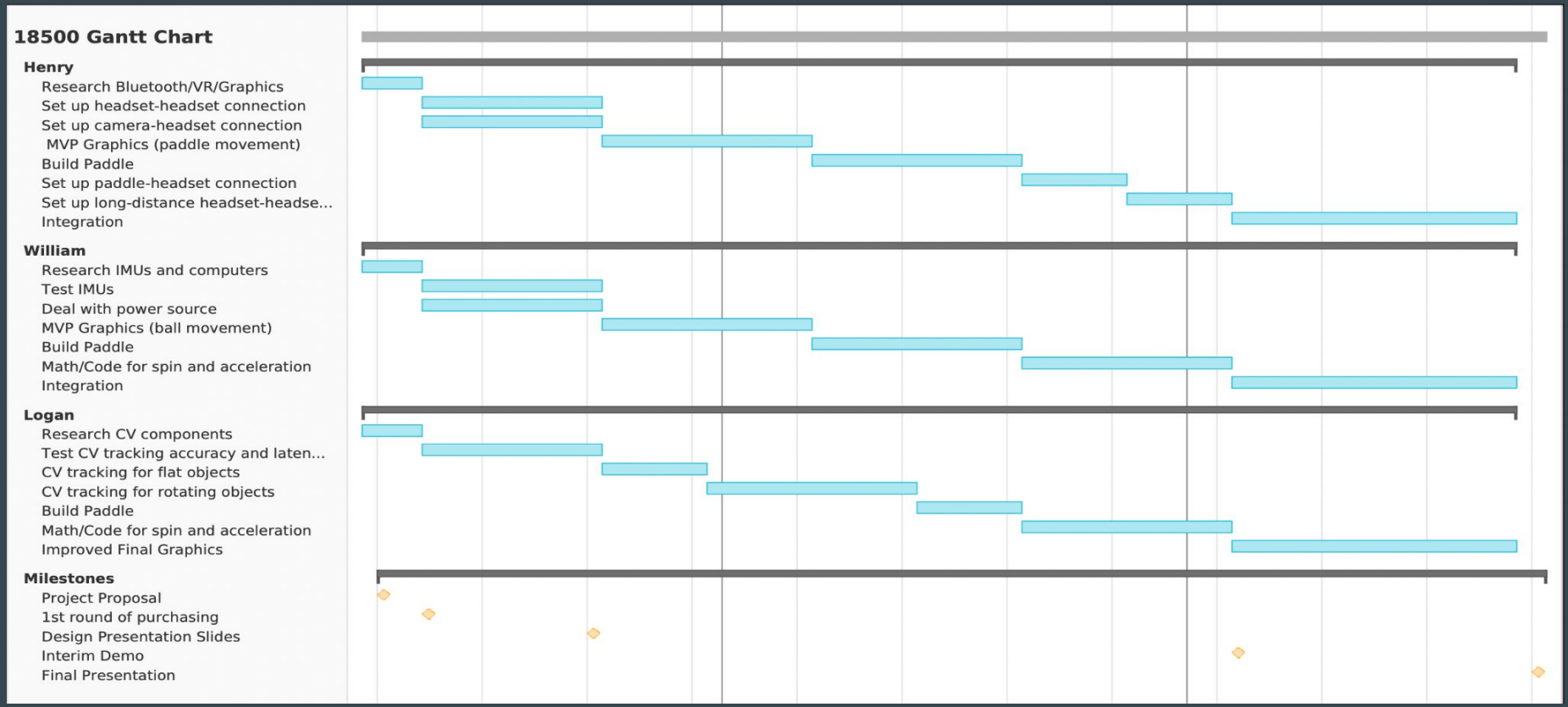
Milestone: MVP

- Computer vision tracking for flat objects and MVP graphics- Logan
- Project ball movement - William
- Project paddle movement - Henry

Milestone: Final Product

- Build paddle, Computer vision tracking for rotating objects, Final graphics - Logan
- Build paddle, Project ball movement - Will
- Build paddle, Headset-to-paddle communication, Long distance headset-to-headset communication - Henry

Schedule


18500 Gantt Chart
Henry
Research Bluetooth/VR/Graphics
Set up headset-headset connection
Set up camera-headset connection
MVP Graphics (paddle movement)
Build Paddle
Set up paddle-headset connection
Set up long-distance headset-headse...
Integration
William
Research IMUs and computers
Test IMUs
Deal with power source
MVP Graphics (ball movement)
Build Paddle
Math/Code for spin and acceleration
Integration
Logan
Research CV components
Test CV tracking accuracy and laten...
CV tracking for flat objects
CV tracking for rotating objects
Build Paddle
Math/Code for spin and acceleration
Improved Final Graphics
Milestones
Project Proposal
1st round of purchasing
Design Presentation Slides
Interim Demo
Final Presentation