Step

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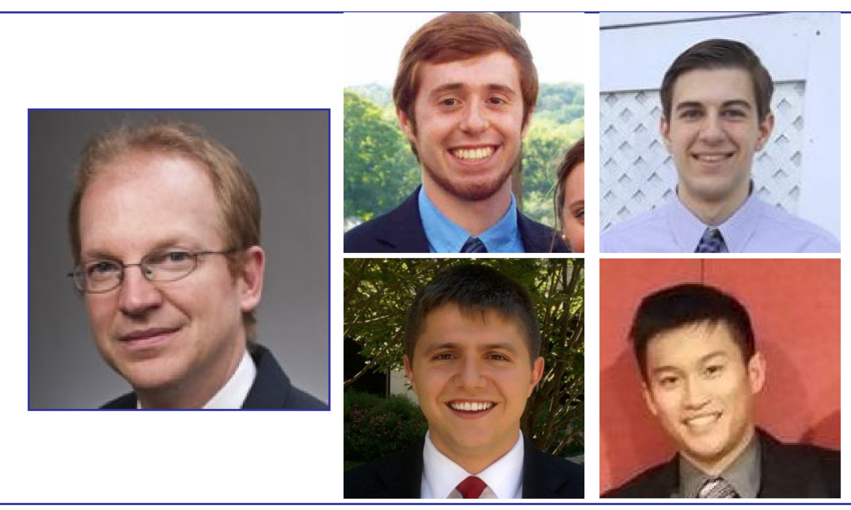
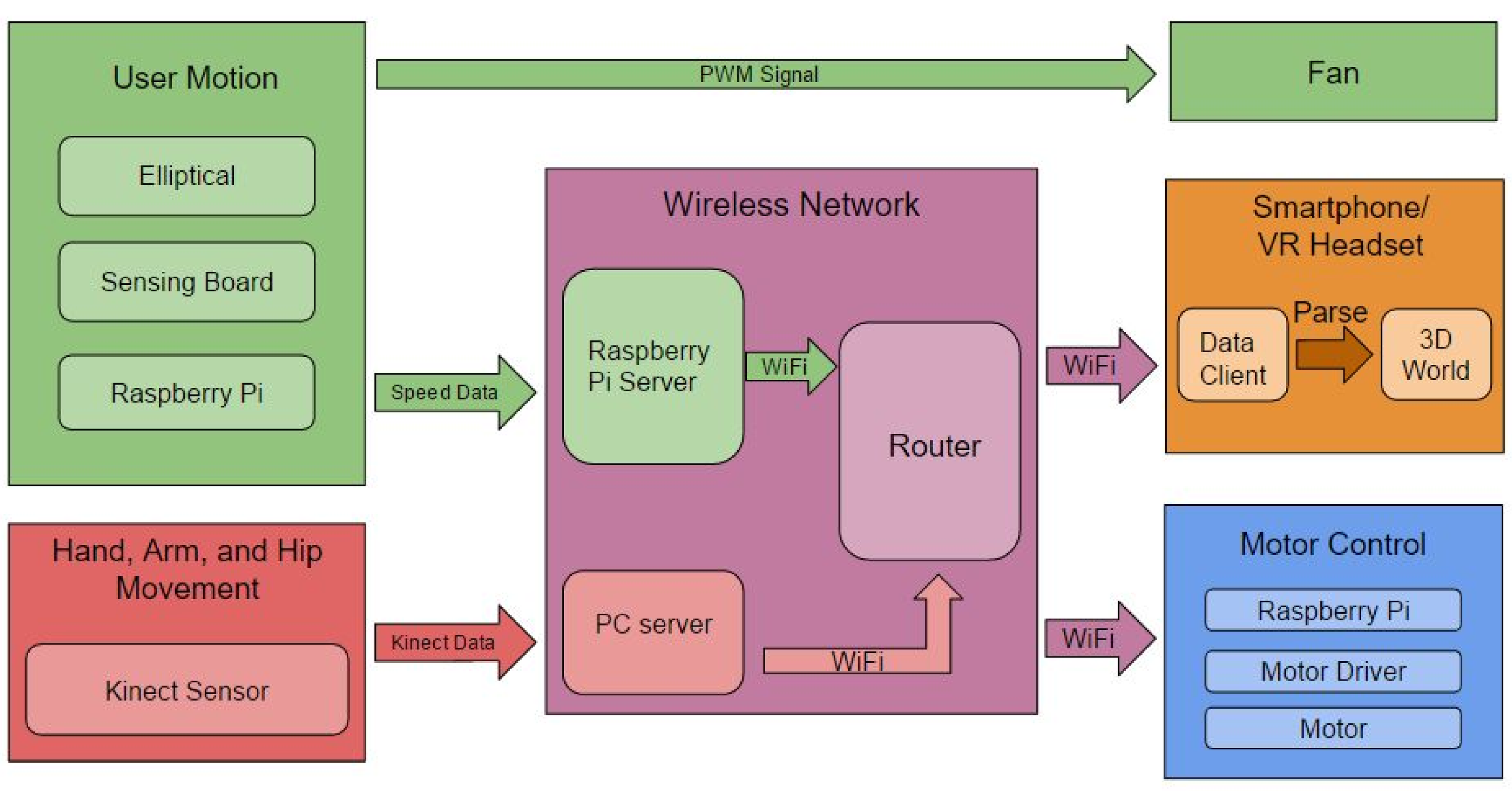


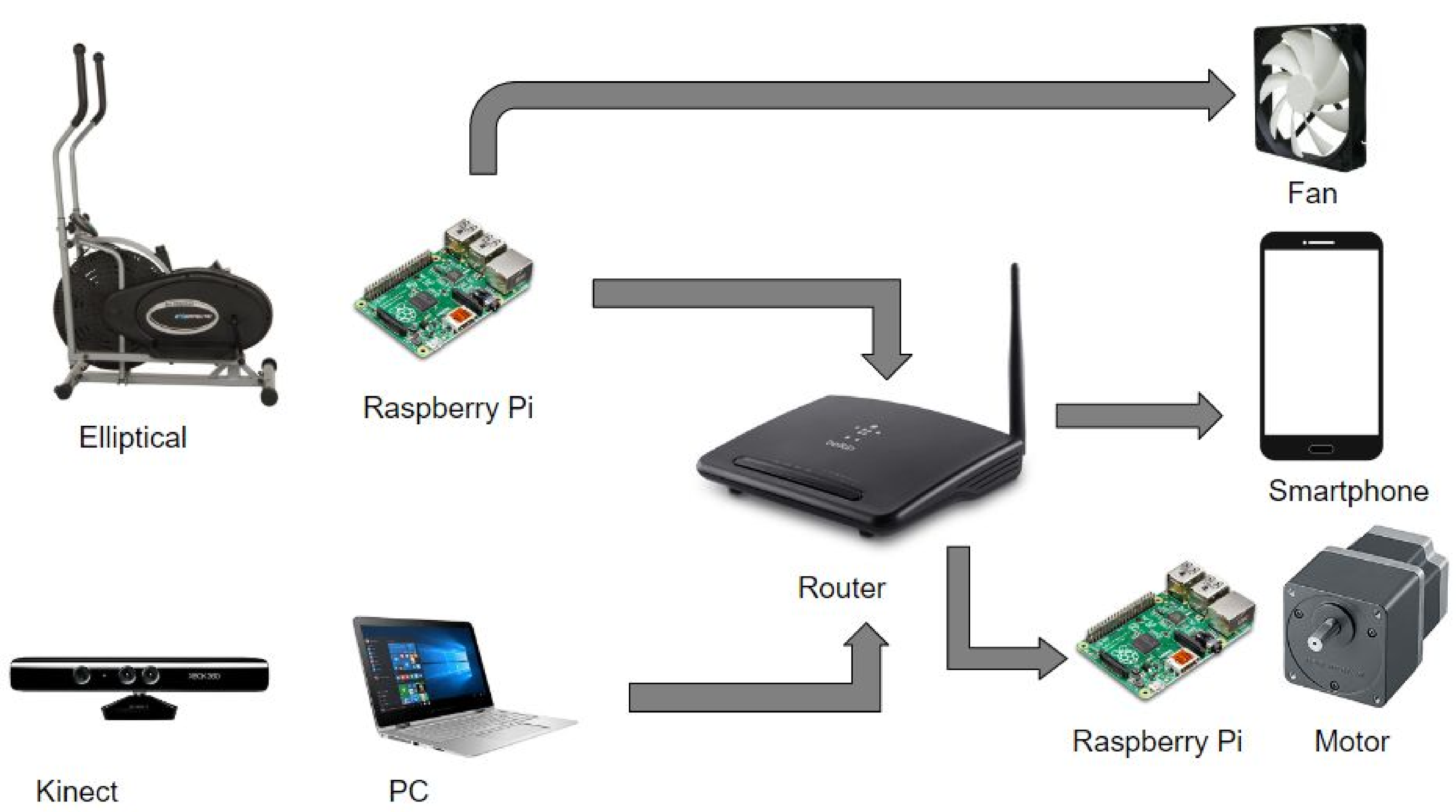
Abstract

Step is a virtual reality system that will change the way users interact with virtual worlds through enhanced immersion. Unlike most virtual reality systems, the user's movements will play a role in the virtual environment, as a user's walking, running, turning and other physical movements will correspond to movements in the virtual world. While making virtual reality more realistic, it will also improve user's health and provide a platform for entertainment or realistic training.

Block Diagram



System Overview



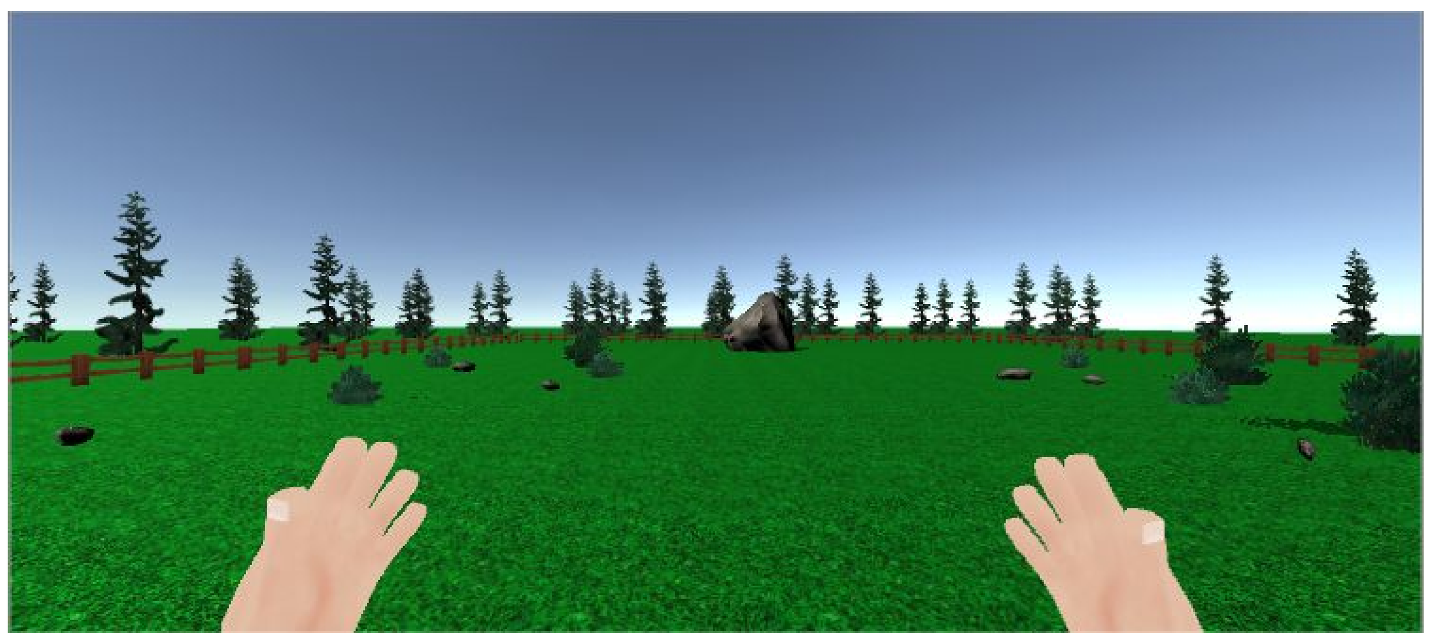
Specifications

Specification	Value
End-to-End Latency	< 200 milliseconds
Frame rate	60 frames per second
Speed Accuracy	±0.5 MPH
Depth Accuracy	< 1 inch st. deviation
Reset Button	Reset at any time

Results

End-to-end latency measured at ~163 milliseconds.
Frame rate measured at 50-60 frames per second.
Speed accuracy standard deviation at 0.152 mph.
Depth accuracy standard deviation at 0.85 inches.
Motor driven rotating platform to simulate turning.
Digitally controlled fan to simulate wind.

Real Environment



Virtual Environment

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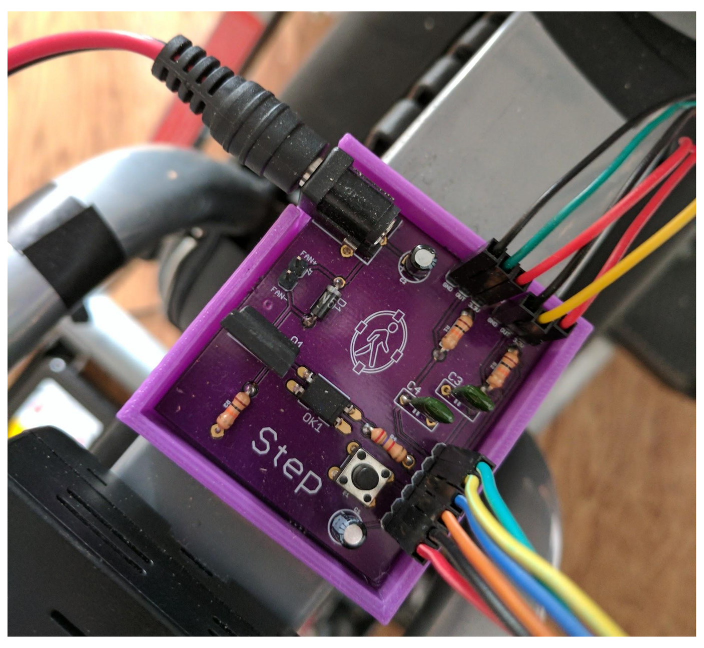
Speed Detection

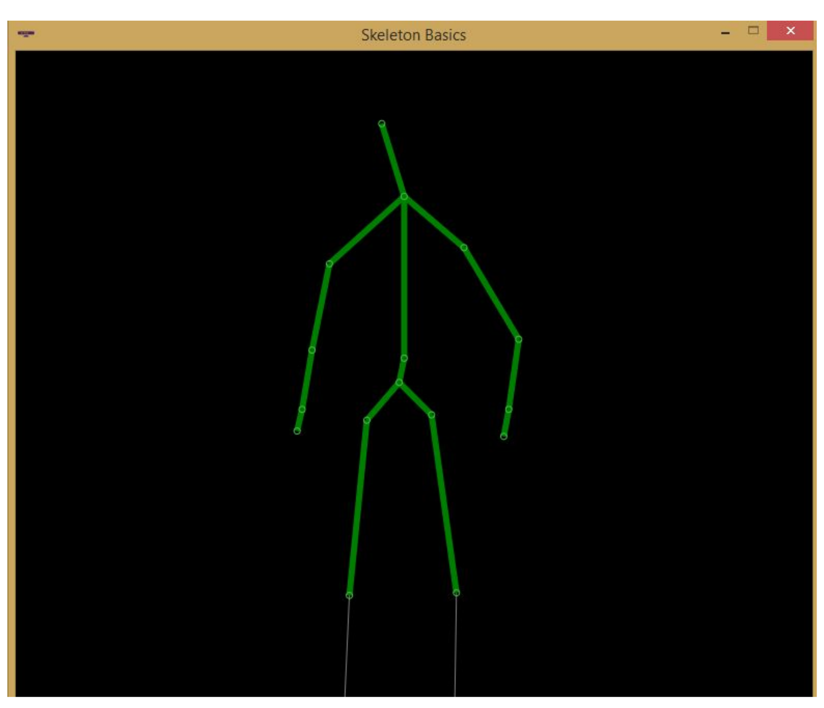
- User's movement speed and direction on elliptical calculated using two Hall effect sensors
- Speed and direction data sent to smartphone over WiFi to determine in-game movement
- Speed and direction data additionally used to set speed of fan
- PCB interfaces sensors with Raspberry Pi, controls fan, and implements reset button



PCB

Motion Detection

- Kinect tracks user by creating a skeleton that uses joint type-objects which have (X,Y,Z) coordinates to determine location of user's body
- Uses Visual Studio to process Kinect data and wirelessly sends data to smartphone over WiFi



Kinect Skeleton

Cost

Development

Part	Price
Elliptical	$100
Raspberry Pi kit	$100
Micro SD Card	$22
Kinect	$38
Wood	$65
Steel	$130
Casters	$21
Fan	$20
Banners	$80
Stepper Motor	$268
Motor Driver	$184
Power Supply	$31
Support Harness	$40
Paint and Stain	$30
PCB	$5
Total	$1134

Production

Part	Price
Elliptical	$50
Raspberry Pi kit	$70
Micro SD Card	$2
Kinect	$21
Wood	$25
Steel	$80
Casters	$7
Fan	$12
Banners	$60
Stepper Motor	$200
Motor Driver	$80
Power Supply	$15
Support Harness	$25
Paint and Stain	$10
PCB	$1
Total	$658

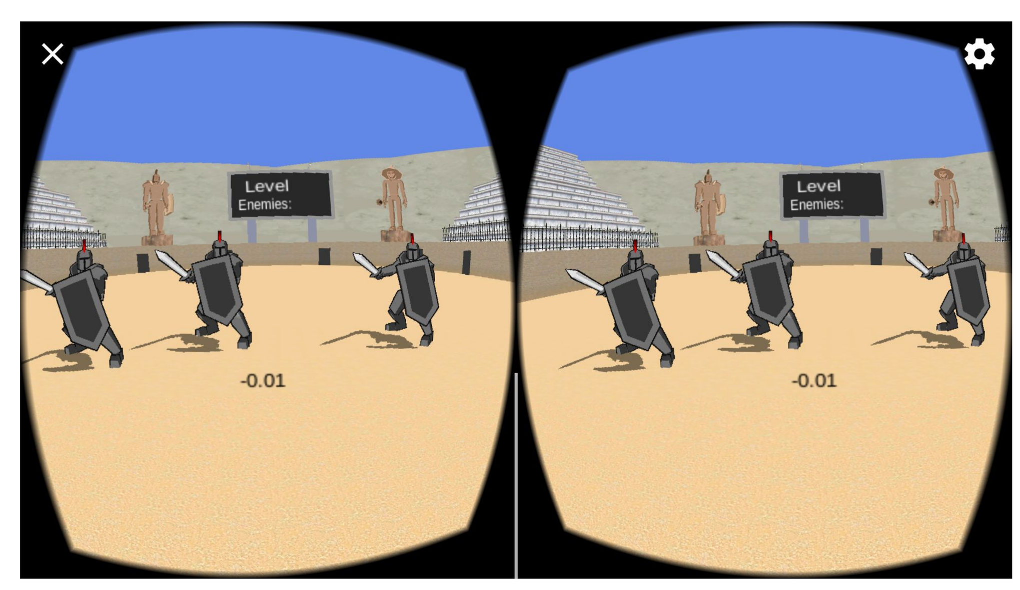
Motor Drive

- Raspberry Pi receives flags via WiFi from the PC and Kinect on which way to turn
- Raspberry Pi sends PWM signal to motor driver which then controls the motor rotation
- Platform rotates by friction drive between the platform and wheel; enhanced by friction tape

Motor with Wheel

Smartphone Application

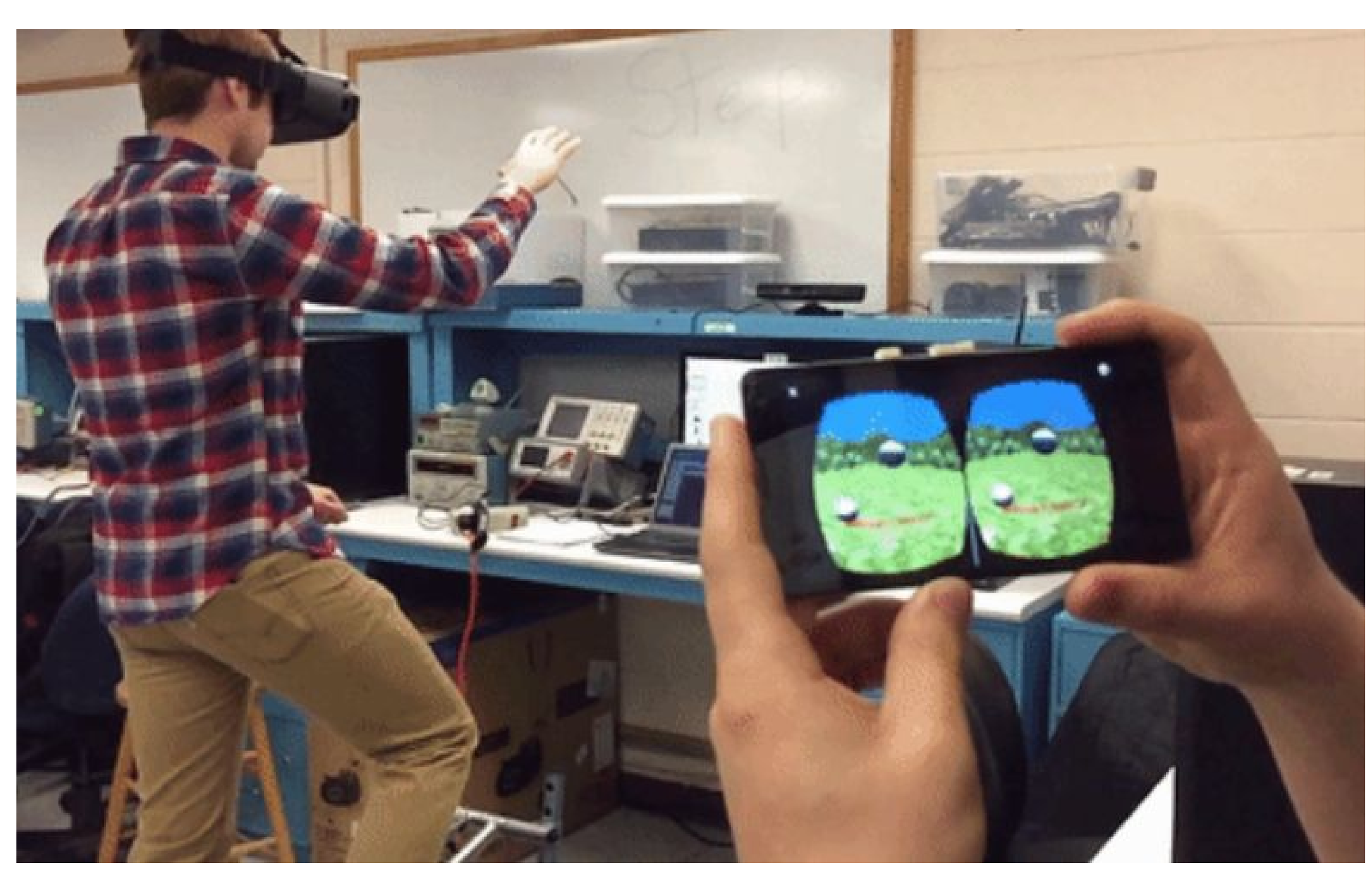
- App developed with the Unity 3D Game Engine and the Google Cardboard SDK
- Receives speed data from the Raspberry Pi of the elliptical and receives motion data from the PC of the Kinect camera, and translates this data into in-game movement and motions
- Compatible with both Android and iPhone



VR Game (Google Cardboard View)

Experiments

- Slow motion camera used to measure end-to-end latency from Kinect to smartphone, ~163 ms latency
- Kinect depth performance analyzed, <1" std. dev.
- Speed accuracy verified through comparison to elliptical built-in speedometer, 0.152 mph std. dev.



End-to-End Latency Experiment

Tape Measured	Calculated Kinect mean (n=100)	Standard Deviation (m)	Standard Deviation (in)	Performance <inch (=0.0254 m)	Performance <4cm
1.0 m	1.0021 m	0.0214	0.844	80%	93%
2.25 m	2.2452 m	0.0218	0.859	77%	96%

Depth Experiment Results