Motion Pro

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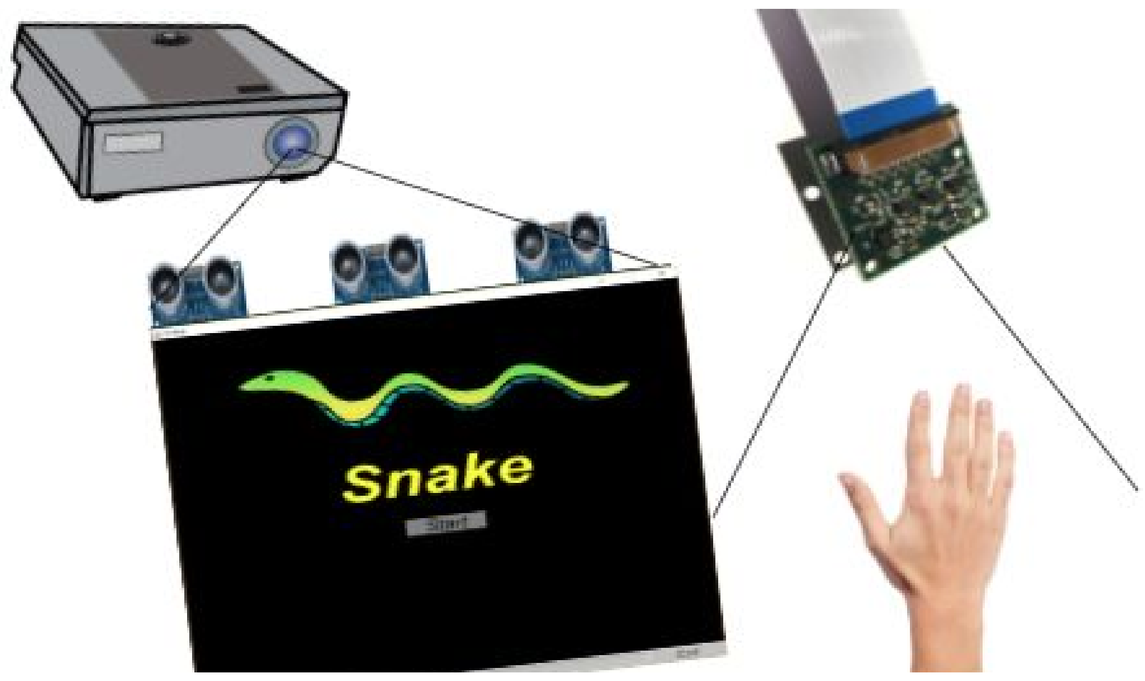
Abstract

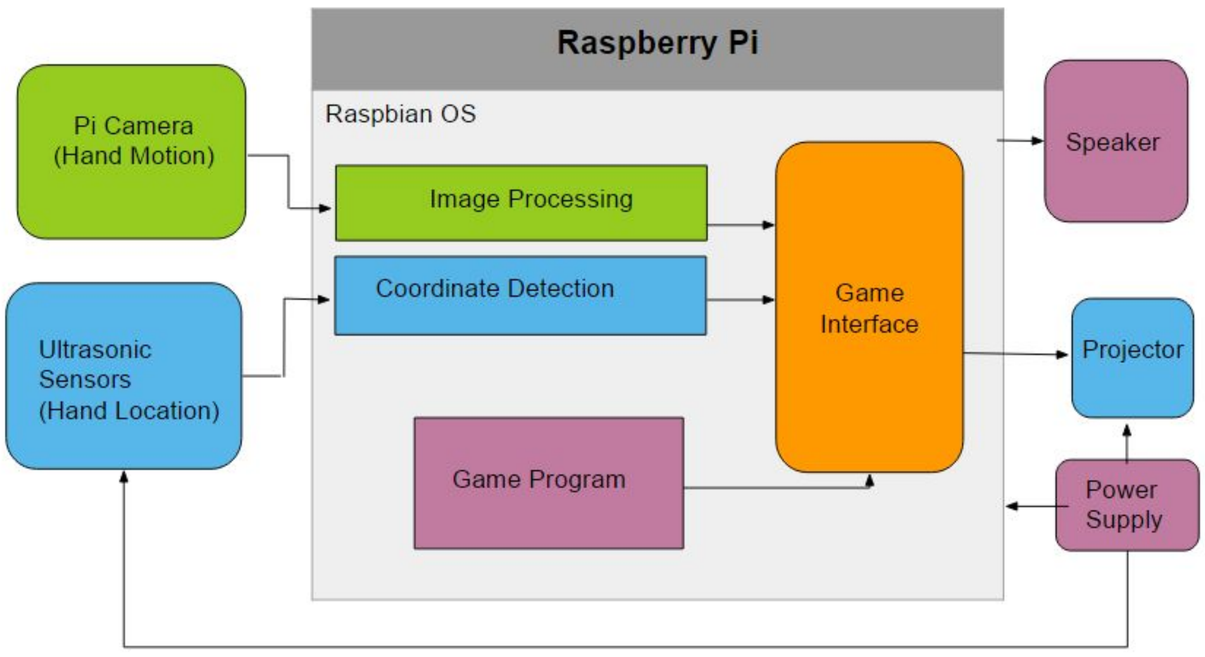
Our team is designing and building a system that projects an electronic game onto any flat surface. The user will be able to play the game while touching any surface without touching any sensors or buttons. We will be detecting the motion and location of the user's hand using a camera and ultrasonic sensors. To project the game, we will be using a microcontroller and a pico-projector to make the system as portable as possible. This is a step towards hologram gaming, which will allow for true player immersion.

System Overview



The design of the virtual gaming device requires portability and compactness. For this to be accomplished, we used a Pico-projector, ultrasonic sensors, a Raspberry Pi microcontroller and a Pi camera. The Pi camera and ultrasonic sensors provide input to the Raspberry Pi and after processing, send output via HDMI to the pico-projector which displays onto a flat surface. Design choices for hardware and software are based on the speed of processing required for real time gaming.

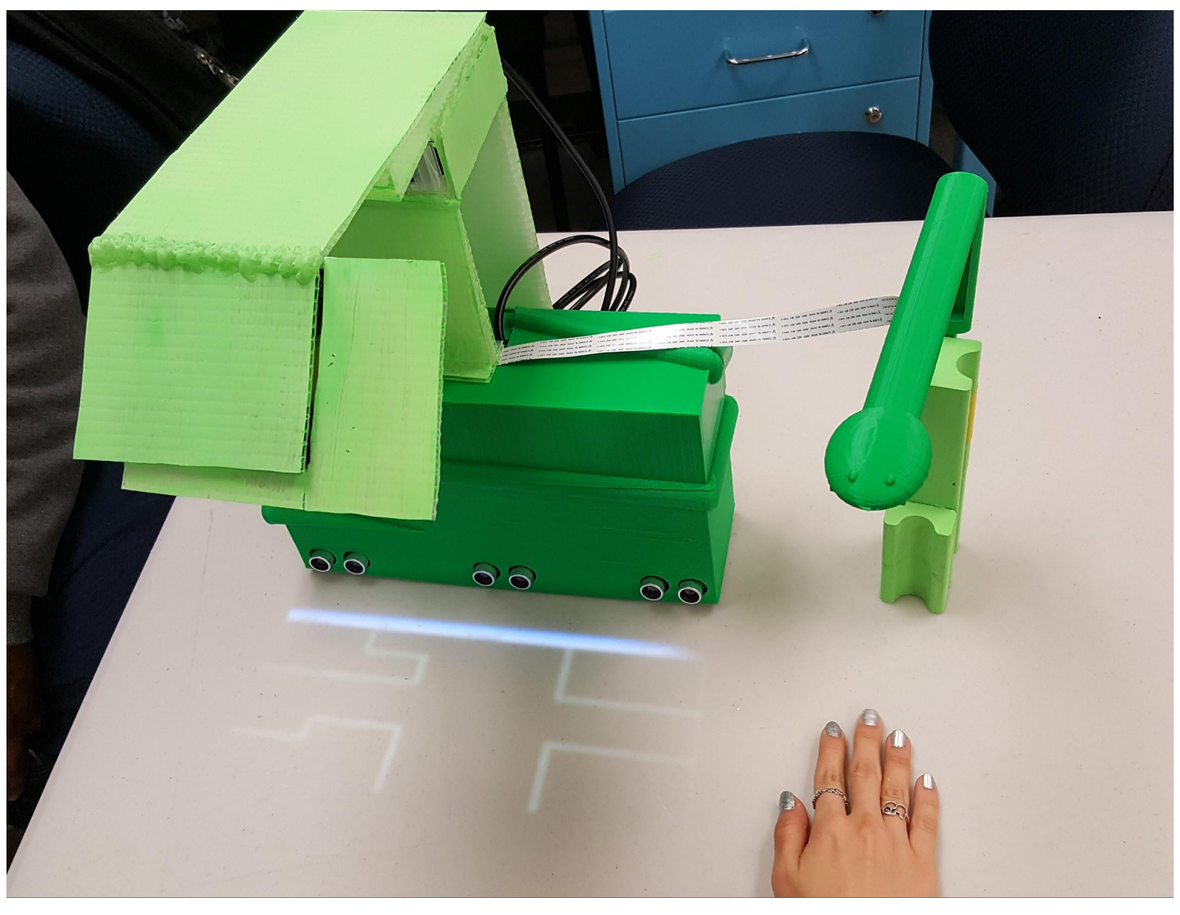
Block Diagram



Specifications

Specifications	Goal	Actual
Projection Size	21.5 by 28 cm	17 by 30 cm
Frame Rate	15 fps	62 fps
Total Latency	0.25 seconds	0.197 seconds
Battery Life	> 2 hours	6 hours
Weight	< 5 lbs	< 3.5 lbs

Results



Acknowledgement

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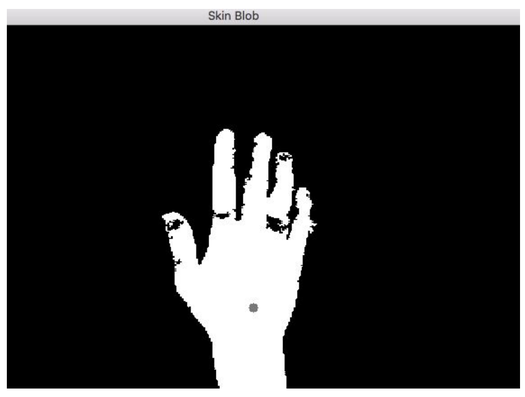
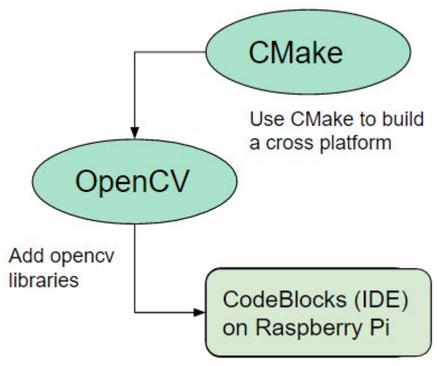
Motion Detection

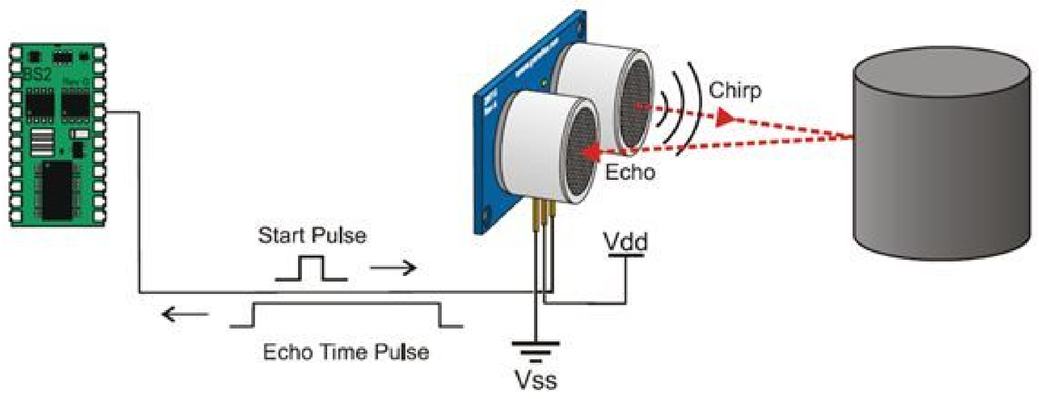
The Pi camera is used to detect the direction of a user's hand movement. This is performed by separating the hand from the background through OpenCV and C++ code. Next, the center of the hand is calculated. The derivative of the hand position between frames is used to calculate the direction.



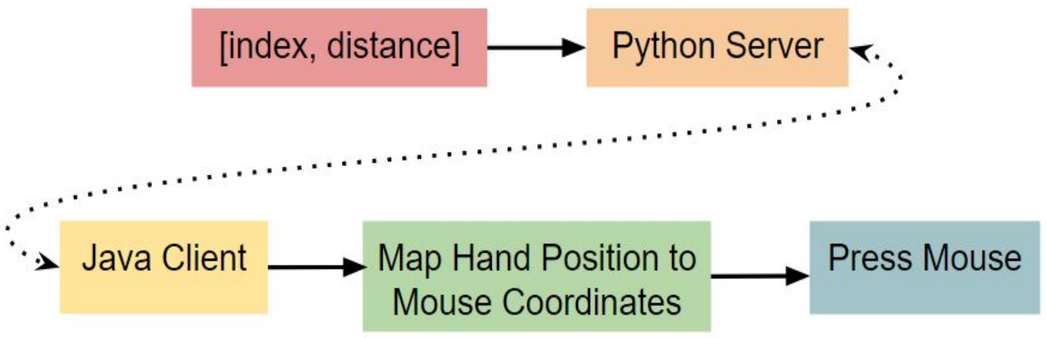


Button Detection

An array of ultrasonic sensors rapidly searches for obstacles using 40 kHz waves and Python code.

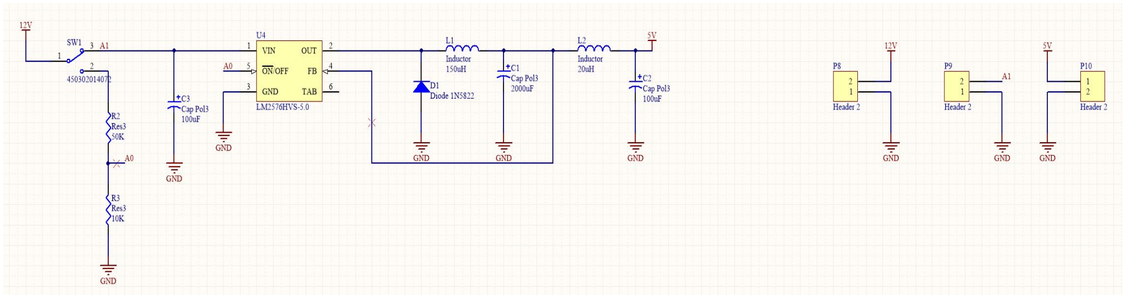


This data is then used to calculate which sensor the user's hand is closest to, and how far away it is. This information determines which button was pressed.

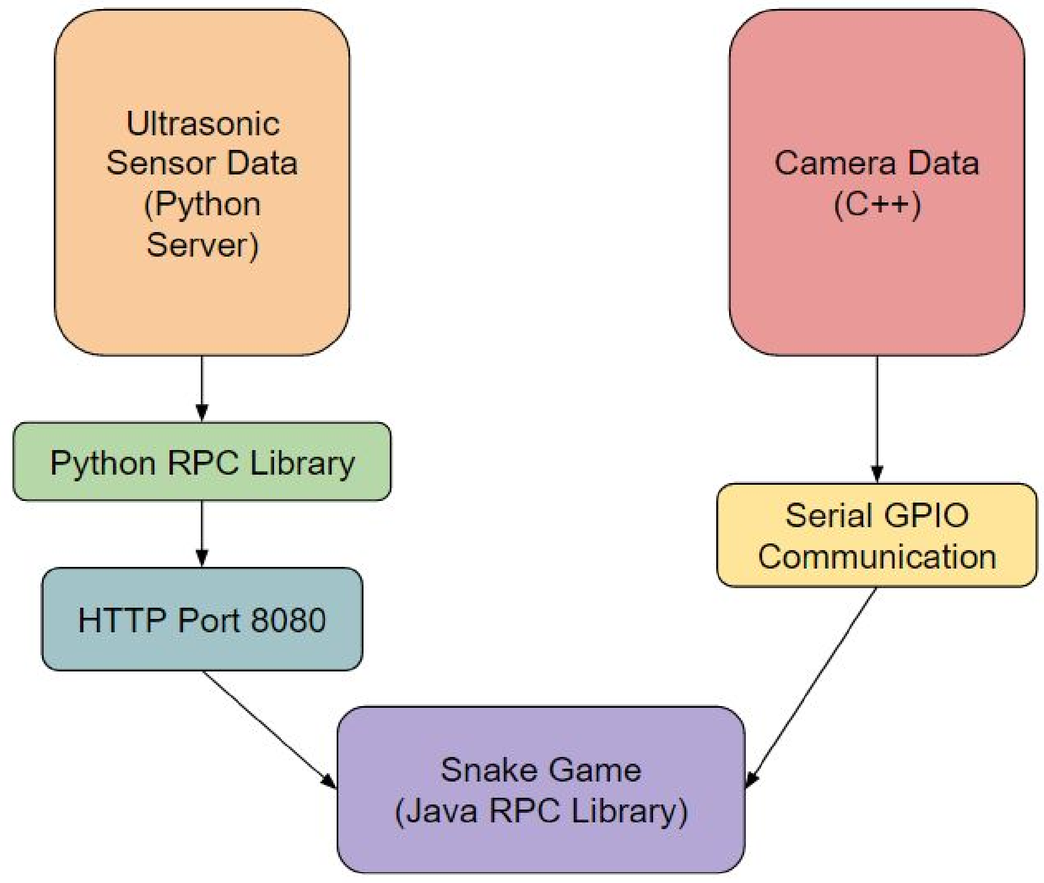


Power Supply

A rechargeable battery bank with 24000 mAh capacity is used as the source. The battery bank is required to power two Raspberry Pi (5V, 2.5A) and one projector (12V, 1.5A). The figure below shows the circuit which converts 12V input to 5V output with 3A maximum output current.

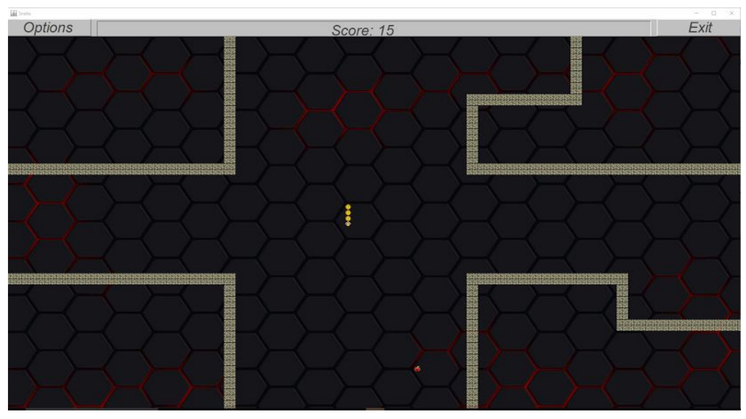


Interfaces



The combination of the subsystems into a finite state machine is essential for our concept to work. The data from the ultrasonic sensors and camera were combined using XML-RPC and serial GPIO communication respectively. Processing for the sensor data took approximately 10 ms, while the camera data took approximately 40 ms.

Snake Game



The game being projected is a classic snake game. A user can choose different modes and difficulties.

Cost

Development

Part	Price
2 Raspberry Pis	70.00
3 HC-SR04s	11.85
Camera	26.95
PCBs	33.00
PCB Components	23.75
Projector	Free
3D Printed Housing	120
Battery Pack	Free
Total	335.55

Production

Part	Price
2 Raspberry Pis	59.90
3 HC-SR04s	10.68
Camera	25.00
PCBs	5.26
PCB Components	10.56
Projector	150
3D Printed Housing	100
Battery Pack	25
Total	386.4