Neptune

Hang Do, Scott Powell, Frankie Viscusi
Faculty Advisor: Prof. Daniel Holcomb

Abstract

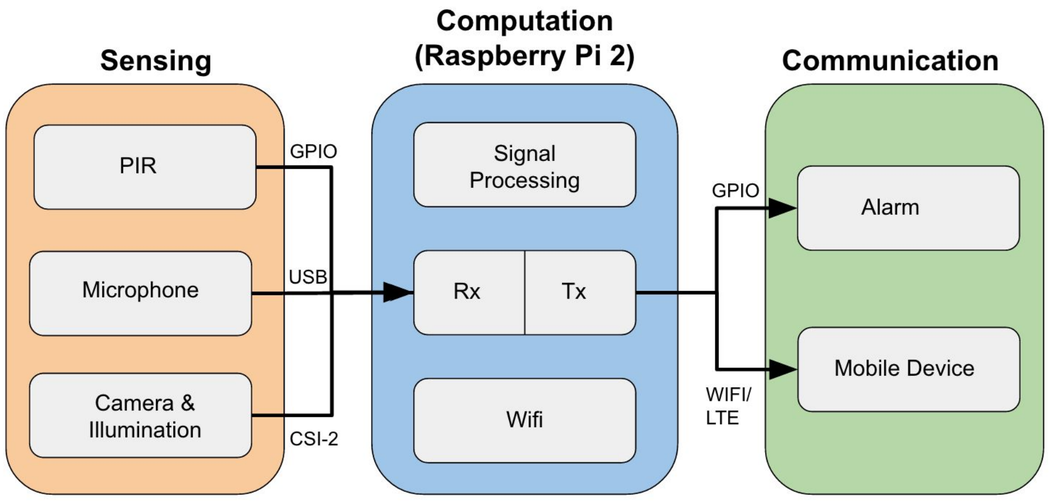
Unauthorized entry into residential swimming pools is a concerning issue which in many cases can lead to property damage, injury liabilities, or even death. The Neptune system will address this issue by constantly monitoring the pool environment for signs of intrusion. Utilizing Passive Infrared (PIR) sensors and audio analysis (microphone), Neptune will determine the current risk associated with the pool. The PIR sensor will constantly monitor for people and animals that cross its field of view. The microphone will be listening to all sounds, utilizing machine learning and signal processing algorithms to identify when a splash occurs. This twofold detection system will produce accurate results with a low probability of false alarms. When a person is deemed to be near the pool (PIR) and a splash occurs, poolside alarms will sound and the user will receive a Multimedia Messaging Service (MMS) notification with a warning message and a picture of the pool environment if the pool is determined to be at risk.

System Overview

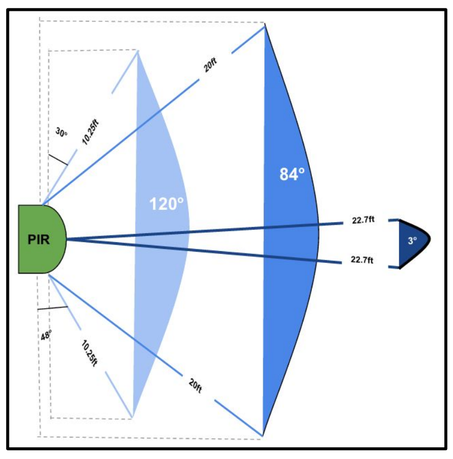
Drowning Prevention and Pool Security System

- Utilizes a PIR sensor to detect human movement in combination with audio analysis to detect splashes
- KNN Audio Classifier (Machine Learning)
- Alerts those nearby with audible alarm located poolside
- Contacts the person in charge via MMS picture message
- Floodlight to illuminate pool area for night-time disturbances

Block Diagram

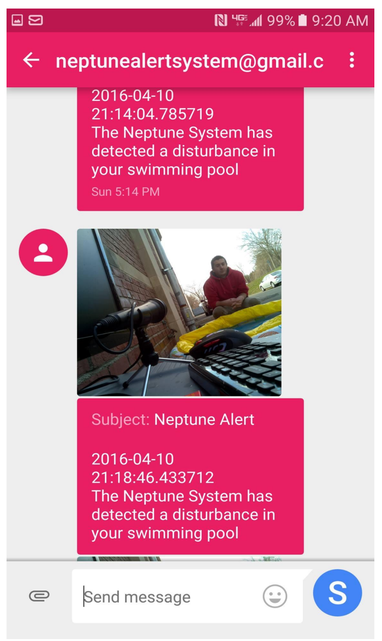


Results



In the diagram to the left are the results of our PIR sensing range tests. The sensor has a 10 ft range for 120° scope but the range improves to a max of 22 ft directly in front of the sensor. Many sensors used in unison could cover an entire pool deck.

Our final prototype of Neptune met all of our major specification goals and can be an effective as a pool security and drowning defense system. The system is capable of detecting people and/or splashes and sending messages within a minute of detection. Shown on the right, you will see a sample text message similar to the one a user would receive if a threat was detected in their swimming pool.



Specifications

Specification	Goal	Actual
PIR Sensing Range	10.25ft. 120° view	One PIR covers Inflatable children's pool (60 x 60 x 13 in)
Weight	< 7lbs	7lbs
Power consumption (DC)	< 50 W	36 W
Alarm Decibel Level	> 30 decibels	70 decibels
Weatherproof	Watertight	Sheltered
MMS Message Sent Time	< 1 minute	< 1 minute
Alarm/Floodlight Response Time	Immediately upon splash detection	Immediately upon splash detection

Acknowledgements

Big thanks to all of the professors and other students for all of their guidance and advice along the way. Specifically, we would like to thank our evaluators Professors Marinos Vouvakis and Mario Parente for providing stern, yet constructive criticism throughout the entire process. We would also like to thank Fran Caron for the work he does behind the scenes to support all of the SDP projects. Last but not least, we need to thank our advisor Professor Daniel Holcomb for constantly making himself available to support us and this project.

Power System

Requirements:

- Provides 12V-3A to supply the alarm system
- Provides 5V-2A to power the Raspberry Pi

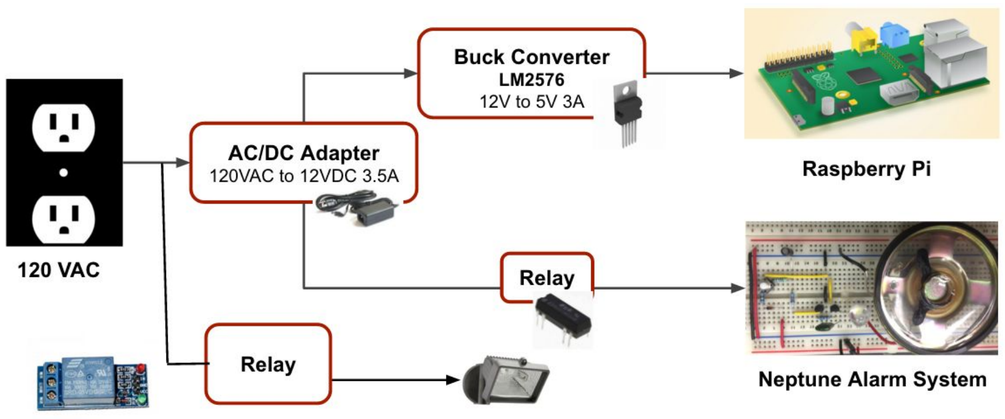
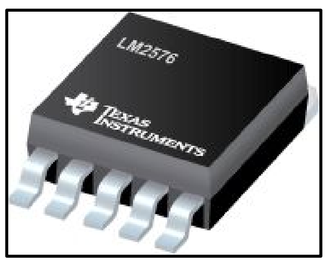


Fig. X: Power System Block Diagram

Due to the simplicity, low cost, high efficiency, and TTL shutdown capability, we chose LM2576 as our switching voltage regulator to step the AD/DC Adapter voltage (12V) down to 5V in order to supply the Raspberry Pi.



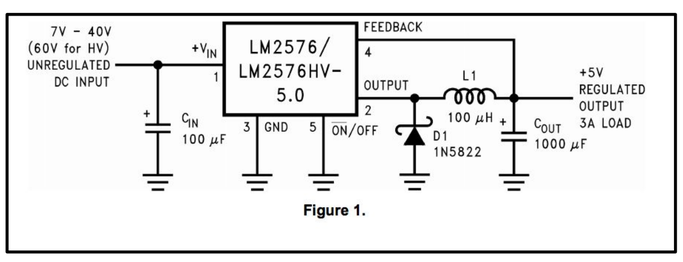


Fig. 1: LM2576 Schematic

Results:

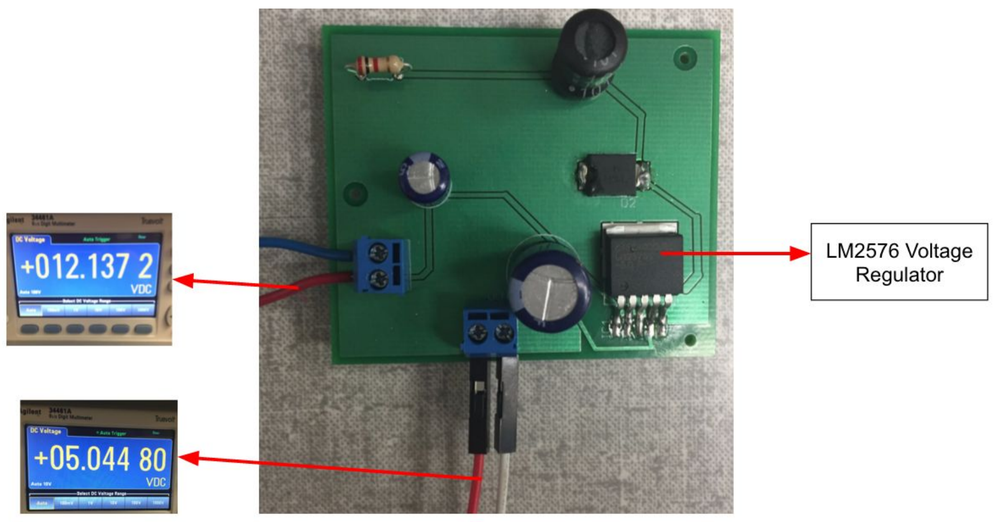


Fig. 2: Voltage Regulator PCB

Floodlight/Relay

- The floodlight shown in the below photo was mounted on the side of the birdhouse enclosure and points toward the pool.
- This wall mounted floodlight was purchased off the shelf at the Home Depot in Hadley, MA.
- The light was retrofitted with a relay and plug housing for use with a standard 120V outlet.
- A relay package was chosen that would allow the 3.3V from the Raspberry Pi GPIO pin 07 to switch on the floodlight when an intrusion was detected.
- This package included the Songle SRD-05VDC-SL-C relay, which can accommodate up to 10A, 250V AC.
- The relay coil requires 5V in order to operate correctly. This 5V is supplied by the Raspberry Pi.
- 150W halogen lamp provides adequate illumination for nighttime use.

Fig. 3: Lithonia Lighting OFLM 150Q 120 LP BZ M12

Audio Analysis

Utilizing the python library PyAudioAnalysis were able to easily incorporate machine learning in order to achieve an accurate splash detection system. After long hours recording hundreds of .WAV files of “splash” and “non-splash” sounds, we then separated them into separate folders and used them to train a KNN audio classifier using PyAudioAnalysis.

Our microphone will constantly record live audio into seven-second audio clips and be fed into the classifier we trained with experimental “splash” and “non-splash” data. The classifier then gives its decision on if the given audio segment is a splash or not based on the audio features extracted during the training process. At this point if the latest audio segment is determined to be a “splash” sound, the system will see if the PIR sensor has been triggered recently. If both methods of detection are in a positive state, the picture of the pool will be taken, the message will be sent to the user's phone, and a pool-side alarm will sound.

Alarm System

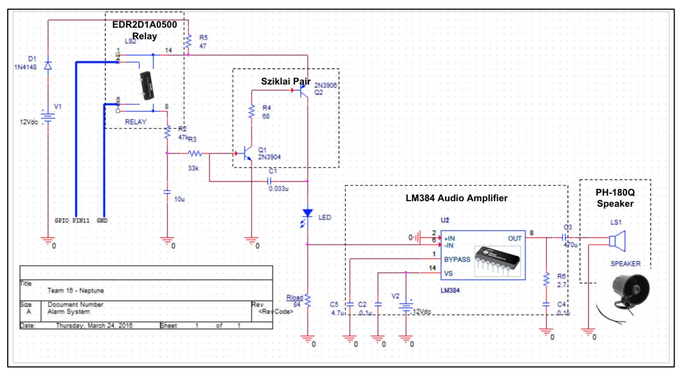


Fig. 4: Alarm System PSPICE Schematic

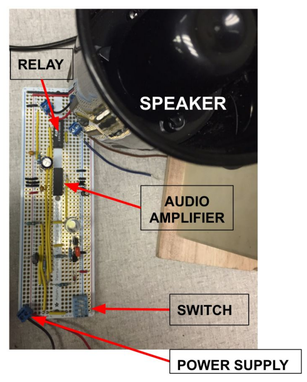


Fig. 5: Proto-board Alarm

- Our alarm system is supplied by 12V and could produce up to 70 dB.
- In order to integrate the alarm system into Neptune, we utilized EDR201A0500 Relay to serve as a switch, which will be triggered by the Raspberry Pi GPIO PIN11.
- To accomplish the goal of designing a high-decibel alarm, we chose LM384 Audio Amplifier to increase the power and successfully drive our 15W speaker horn.
- The Sziklai Pair is the cascaded combination of 2N3906 (PNP) and 2N3904 (NPN) transistors to provide a higher current gain of β^2 .

Cost

Development

Part	Cost
Speaker	$11.29
Audio Amplifier	$2.13
Voltage Regulator	$2.68
Floodlight Relay	$7.95
USB Microphone	$32.99
USB Wifi Adapter	$8.50
PIR Sensor	$9.95
Camera	$26.65
Raspberry Pi 2	$35.00
Floodlight	$12.97
12V 3A AC/DC Converter	$7.48
Birdhouse	$11.67
RPi 3D Printed Enclosure	$8.88
Voltage Regulator PCB	$78.15
Terminal Blocks	$2.95
Plastic Enclosure	$19.35
Total	$278.59

Production

Part	Cost per 1000
Speaker	$7,966.44
Audio Amplifier	$1,048.35
Voltage Regulator	$1,414.00
Floodlight Relay	$7,950.00
USB Microphone	$32,990.00
USB Wifi Adapter	$8,500.00
PIR Sensor	$8,960.00
Camera	$26,650.00
Raspberry Pi 2	$35,000.00
Floodlight	$12,970.00
12V 3A AC/DC Converter	$7,480.00
Birdhouse	$11,670.00
RPi 3D Printed Enclosure	$8,880.00
Voltage Regulator PCB	$13,025.00
Terminal Blocks	$2,360.00
Plastic Enclosure	$19,351.50
Subtotal	$206,215.29
Adjusted Unit Price	$206.22