



# Lights Out

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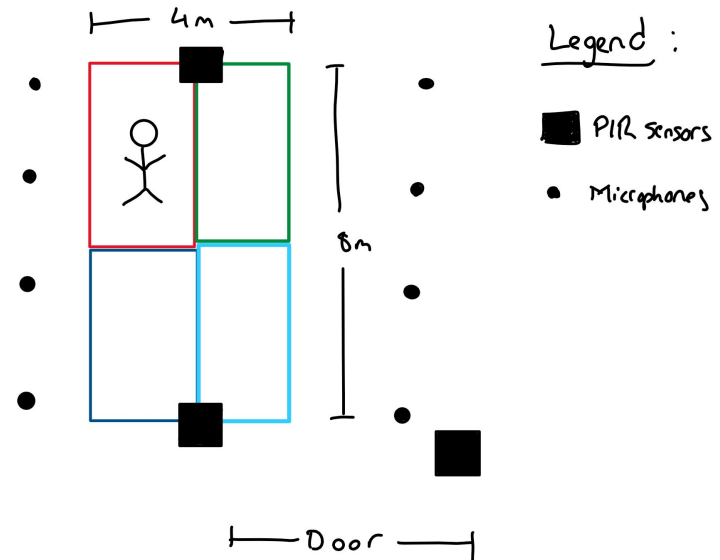
# Description

Lights Out improves light motion detectors in classrooms/labs/office spaces by combining audio localizing technology with motion detecting sensors to only turn on lights in specific occupied section(s).

Comes with a mobile application that allows for remote control access to LED lights.

Our goal is to solve these problems:

- Wasted energy caused by having all the lights on in room  
*Commercial buildings consume 2.5 kWh/square foot\**
- Lights shut off while still in room during a critical task  
*i.e. light motion detectors shut off when people are seated*





# Use Case and Areas



Our localization system can be used in a space such as our lab



Scalable to any open floor working space



We will use led light strips to mimic fluorescent light strips



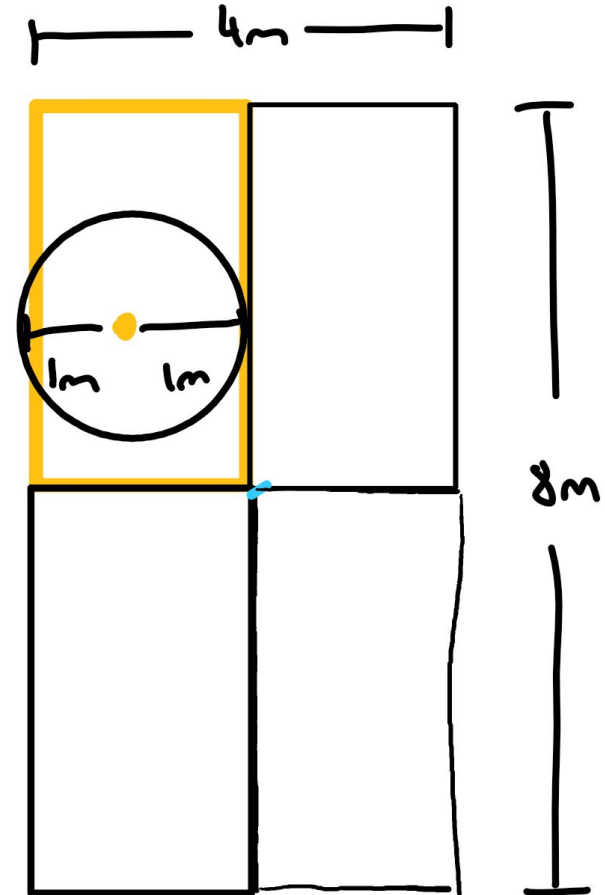
software



signals

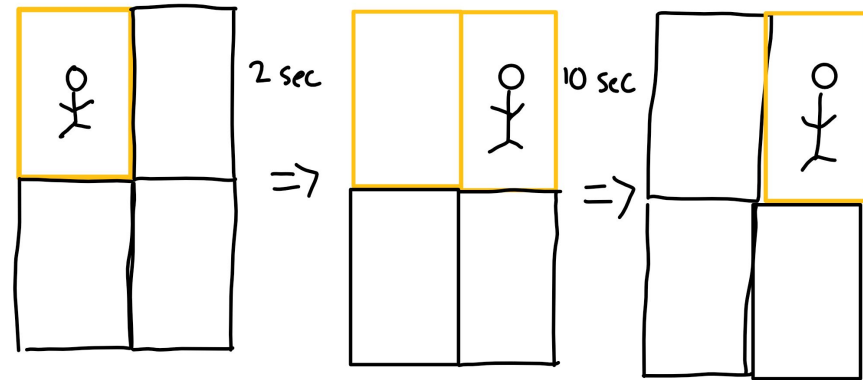
## Requirements: Location Accuracy

- Detect an individual within a 1 meter radius and turn on the LED strip lights around them
  - This precision allows us to assign to turn on lights in a portion of the 8m x 4m room divided into approximately 4m x 2m blocks
  - After measuring our test area, squares of 1 meter radius each
  - PIR sensors have maximum range of 6 meters, 120 degree field of view



# Requirements: Detection Latency

- Turn on the appropriate section of the grid within 2 seconds of an individual moving there. Grid will stay on for 10 seconds after individual leaves the space
  - 2 seconds window for time between individual moving to the block and lights turning on provides virtually inconspicuous delay
  - Individual will not notice the delay, does not interfere with user experience
  - 10 seconds provides brief enough window so as not to waste electricity, but also accounts for if the individual plans on returning to the space to prevent unnecessary flickering of lights





# Requirements: Audio Threshold and App Functionality

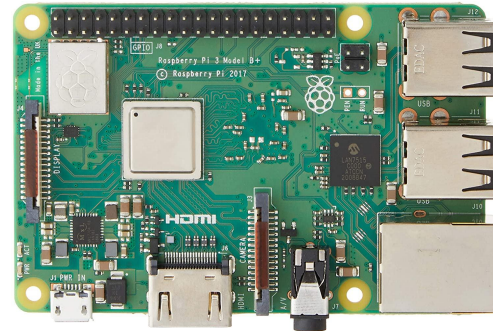
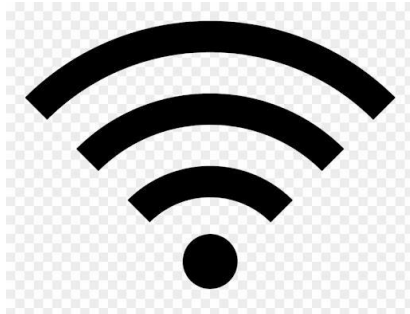
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- Corresponding light(s) should remain on when no motion is detected but volume is above 45 dB
  - 45 dB is the average dB level between a typical whisper and a normal conversation (CDC)
  - This threshold will be representative of situations where one would want the lights to turn on and also account for quieter scenarios
- Mobile App Functionalities
  - Press button to turn on and off LED lights
  - Be able to schedule lights to turn on and off at different times

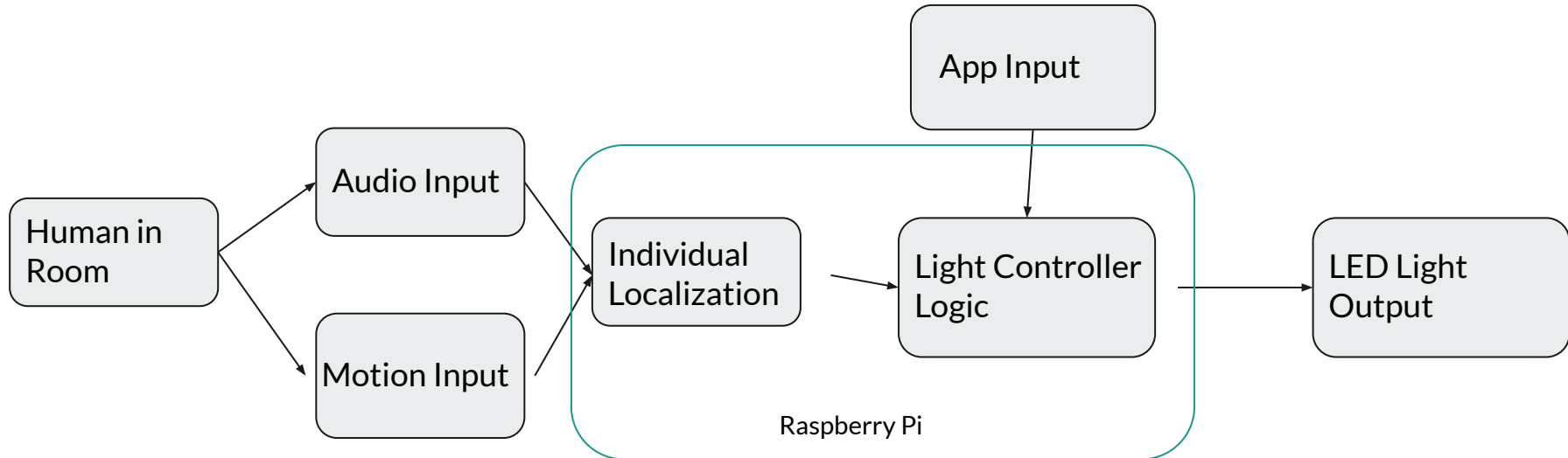


# Technical Challenge: Human Localization

- Combine values from two distinct sensor type outputs to obtain a localization confidence score
- Use confidence score to determine which section of lights should be turned on/off
- Time delay between user leaving/not making a sound and turning off the light
- No movement and no sound case
- Wifi enabled communication between sensors, app, and base
- Send collected signals to Raspberry Pi to perform computations



# Signals Flowchart/Diagram





# Solution Approach

**Microphone:** SPH0641LU4H-1 (\$2.14/unit) x 8

**PIR :** Adafruit PIR Motion Sensor (\$9.95/unit) x 3

-Compatible with Raspberry Pi, Arduino, Node MCU Mini

-6m range

**Led light strips:** LED light strips (\$11.99 / 2 strips) x 2

-1 strip  $\approx$  2m

-5V input

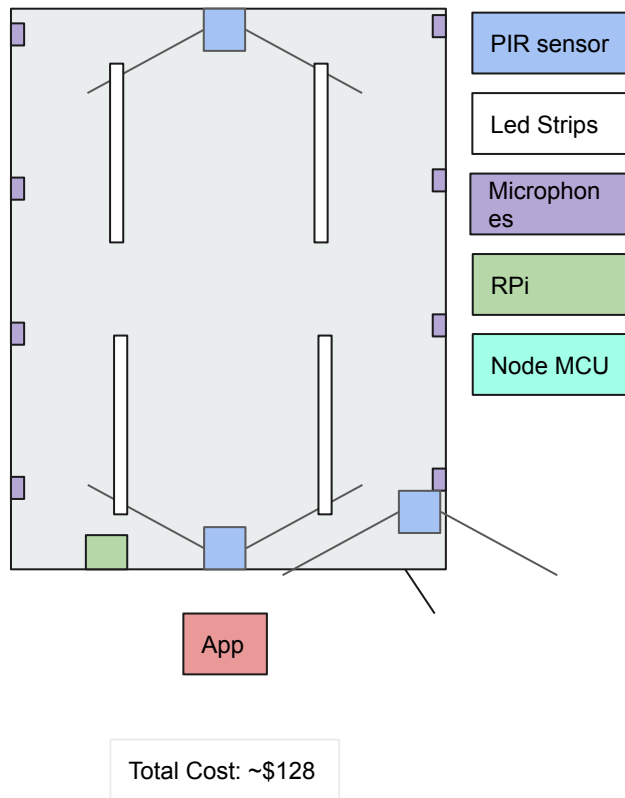
## Additional Hardware:

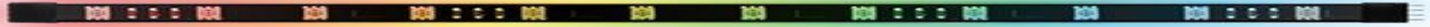
Node MCU Mini per sensor ( $\$16 / 6$  units) x 2 ,

Raspberry Pi base station ( $\$35$ ) x 1

**Localizing:** Beamforming, Weighting + Coupling sensors data

**App:** JavaScript/HTML/CSS





# Testing, Verification, and Metrics



Localization latency + communication latency	< 2 seconds
Detect location of individuals having a conversation (or significant noise)	< 1m radius
Detect individuals moving	< 1m radius
Detect individuals with low sound and low movement	70%
Functioning app	100%

# Tasks and Division of Labor

**Malavika**

Circuitry

Mobile App

**Diva-Oriane**

Audio Sensors

Combining Sensor  
Data

**Ryan**

PIR Sensors

Combining Sensor  
Data

User Behavioral  
Testing

Testing

