Lights Out

Design Review

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Application Area

- In motion detection lights market, many systems are limited to few sensors.
- Often turn on more lights than required in a large room.
  - Wasted energy caused by having all the lights on in room
    Commercial buildings consume 2.5 kWh/square foot *
- Often fail to stay on while a person is still in the room.
  i.e. light motion detectors shut off when people are seated

*Commercial Building Energy Consumption Survey (CBECS)

Requirements

Current Motion Detection Systems	Lights Out	Motivation
Turn on within 2 seconds of motion in room	Turn on lights within **2 seconds** of person entering room	Maintain latency of current system
Turn on all lights in room when motion is detected	Detect an individual within a 1 meter radius and turn on the lights around them	Reduce energy consumption by proportion of unoccupied space in room (50% of room is occupied = 50% energy consumption)
Turn off after approx. 20 minutes with no motion	Keep lights on when no motion is detected with >50% accuracy	User is interrupted from task to turn back on lights

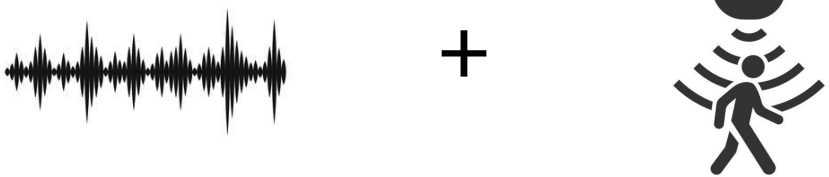
Solution Approach

Lights Out improves light motion detectors in classrooms/labs/office spaces by combining:

- audio localization technology (detect individuals when there is no motion)
- motion detecting sensors (adding to existing technology)
- position tracking
- Lack of cameras, LiDar, and infrared sensors makes the product relatively inexpensive and maintains user privacy

Goal: Turn on lights in specific **occupied** section(s).

- Save energy
- Improve user experience (lights remain on with no motion detected)



Hardware Solution Approach

Sensing:

Microphone (SPH0641LU4H-1)

PIR: (Adafruit Motion Sensor)

2m radius, 120° FOV

Communication:

Node MCU Mini (Wifi communication)

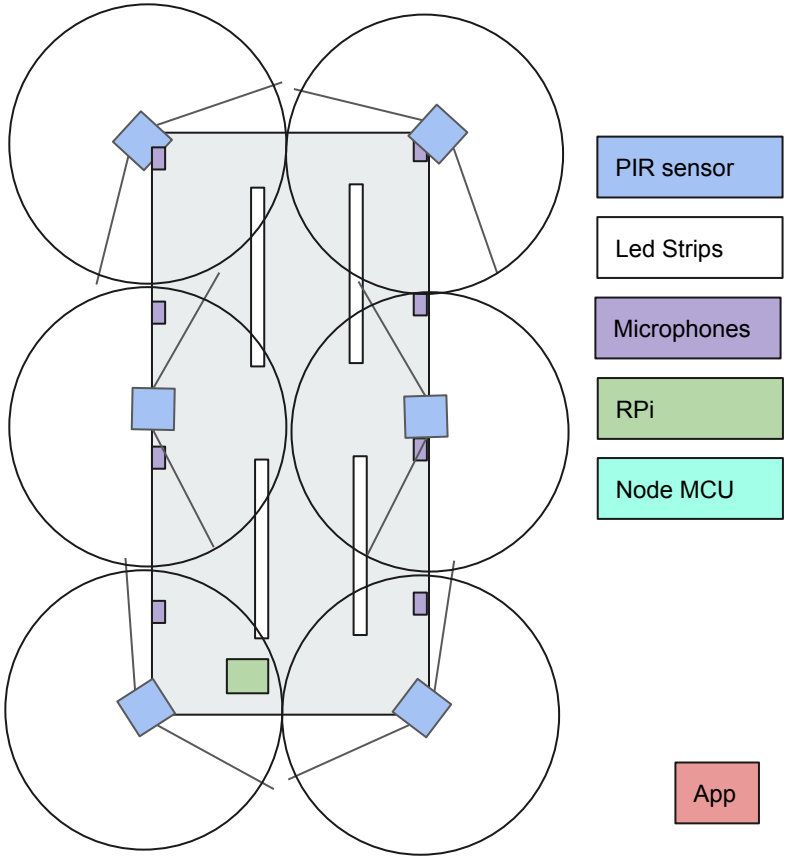
Computation/Localization:

Raspberry Pi

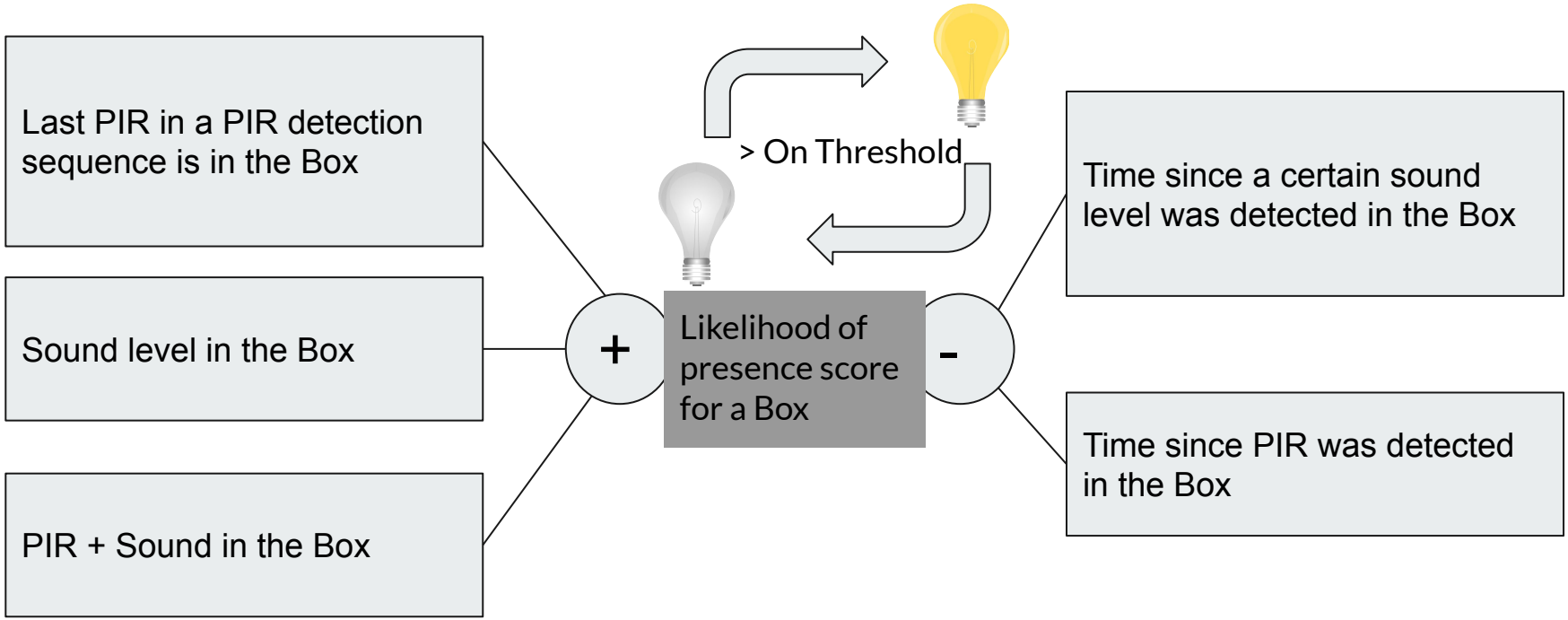
Led light strips: LED light strips ($11.99 / 2 strips) x 2

Localizing: Weighting + Coupling sensors data

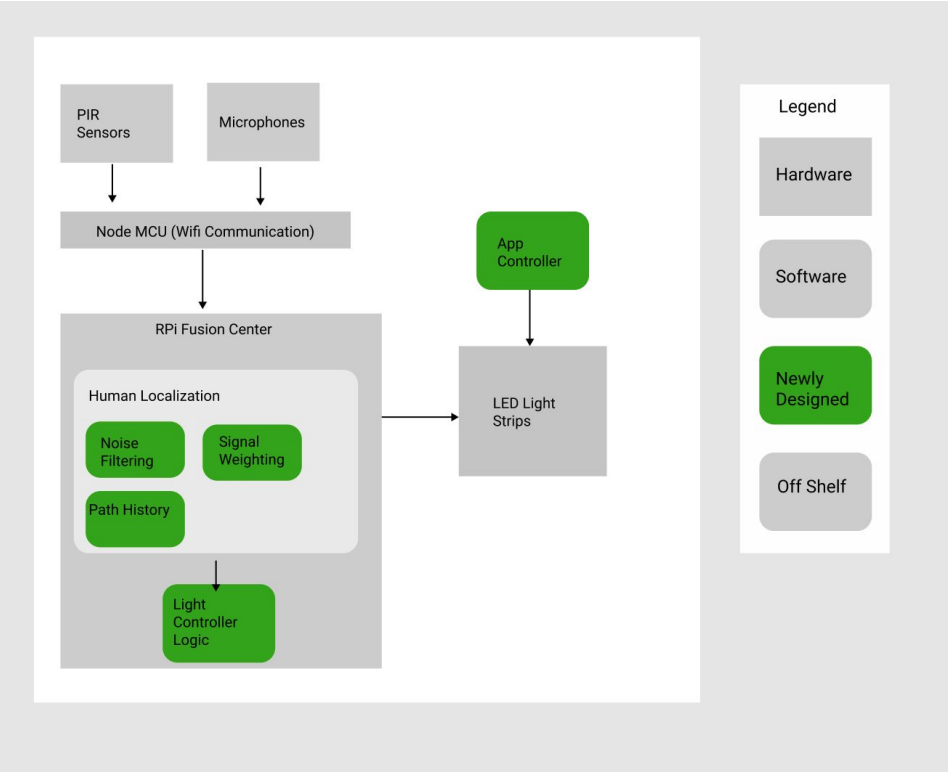
App: JavaScript/HTML/CSS



Software Solution Approach



Implementation and System Specification



Testing, Verification, and Metrics

Requirement	Testing	Metric
Localization latency + communication latency	Person enters zone of detection; lights turn on within 2 seconds	< 2 seconds
Detect location of individuals having a conversation (or significant noise)	Individuals are still and talking at conversation level	< 1m radius
Detect individuals moving	Individuals are not speaking while walking across the room	< 1m radius
Detect individuals with low sound and low movement	Individual enters room then does not move or make a sound	> 50%
Functioning app	Manual and unit testing	100%

Risk Factors and Mitigation

Risk	Mitigation
Cannot determine number of people in room	Generalize to groups of sensing from PIR and microphones
Cannot distinguish between audio input from two or more microphones	More heavily weigh PIR and path history
Cannot determine if individuals are in the room if not moving or making noise	Increase microphone sensitivity Adjust threshold and rely on last location of detection

Tasks and Division of Labor

Malavika	Diva-Oriane		Ryan
Circuitry	Audio Sensors	User Behavioral Testing	PIR Sensors
Mobile App	Combining Sensor Data		Combining Sensor Data
Testing			

Schedule

Ryan | Diva | Malavika | Everyone | Ryan+Diva