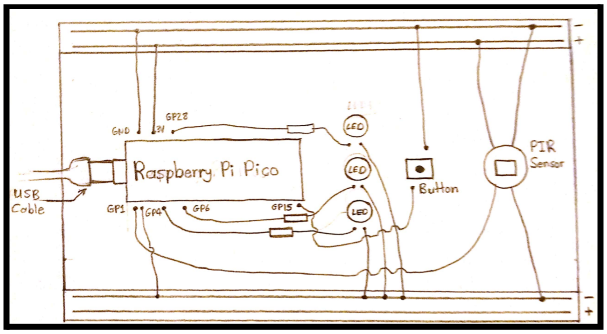
Widget 3 Challenge Activity

Introduction: In this activity, we assume that our hypothetical company is looking into sensing options to improve daily operations in the greenhouse. Our task is identifying a useful quantitative metric in a greenhouse and implementing a sensor-based approach to both monitor and respond to it in a useful way.

Description of Team's Final Design: The team's final design features the addition of a Passive Infrared (PIR) Sensor to sense motion; specifically, to detect whether a human has moved in or out of the sensor's range. Sketches of design, as well as a picture of the final product is shown below.



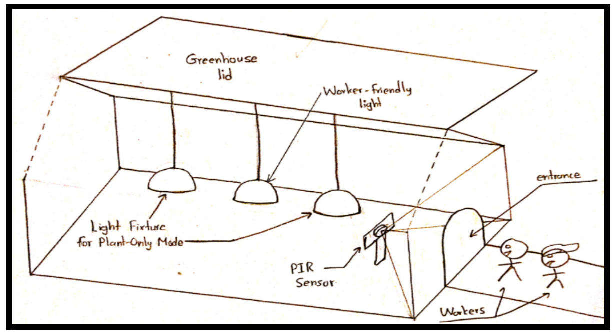


Figure 1a: Sketch of prototype and 1b: Sketch of one possible real-life implementation

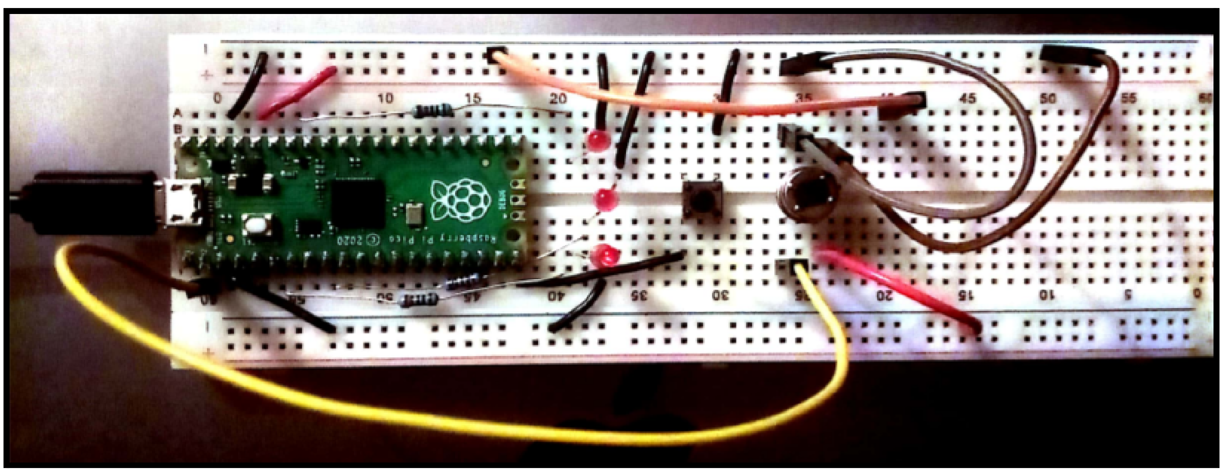


Figure 2: Final Product, featuring PIR sensor to turn on worker-friendly light when human is detected, and turn it off when human is not detected. Button only used to switch between off and plant-only mode.

How we arrived at final design:

The first step in our design process was identifying a key quantitative metric of interest to us. To do this, we first brainstormed all metrics we could think of. This included distance, heat/temperature, humidity, vibration, fluid property sensors, motion, and smoke/gas, to list the most common ones amongst group members.

We then decided on a requirements model for our design. Based on team values developed by working on the course project and identified when writing the design proposal, we selected design for usability, simplicity, ease of implementation and cost as the most important design considerations. After comparing all sensible alternatives, we converged on the PIR motion sensor to detect humans and turn on the worker-friendly light automatically when humans are detected.

Our design is usable and effective. A PIR sensor allows one to sense motion, and is almost always used to detect whether a human has moved in or out of the sensor's range [1]. This is because PIR sensors detect heat changes in its range; because humans are warm bodies, the PIR is triggered by infrared waves radiated from them. This implies that instead of workers having to manually turn off lights, their presence is automatically detected and controls the turning on/off of the worker-friendly light. This is effective as it reduces human labour associated with our original design. Furthermore, the design is simple. The only change to the circuitry from Widget 1 Challenge Activity is wiring the PIR sensor; this meant our prototype was easy to debug. The only change to the code is adding logic so that instead of transitioning to worker-friendly mode from plant mode on button press, it does so if we are currently in plant mode and PIR sensor outputs 1. This is easy as the PIR sensor naturally outputs digital pulse high (3V, output = 1) when triggered (motion detected) and digital low (output = 0) when idle (no motion detected) [2]. The updated state diagram from Widget 1 is shown in Figure 3 below.

Note that implementation in real-life is also simple; from Figure 1b, we show that attaching a PIR sensor to a board is one alternative. This has been implemented in Japan, with good results [3].

Continuing, a PIR sensor is cost-effective. In fact, the "DIYmall 5 Pack HC-SR501 Pir Motion IR Sensor Body Module Infrared for Arduino" [4] from Amazon costs $16.49. This means about $3 for one module, which is a reasonable price for a sensor because it is around the same as ultrasonic or other sensors initially brainstormed.

After converging, we verified that our design did not go against any of the UN Sustainable Development Goals (UNSDGs). In fact, we were aligned with UNSDGs highlighting the need for reducing resource consumption (since solution is simple and easy to implement), responsible consumption & energy efficiency (only turning on light when sensor detects it is needed), and sustainable cities.

Finally, we distributed work. Since this was simple to implement, not all team members were involved.

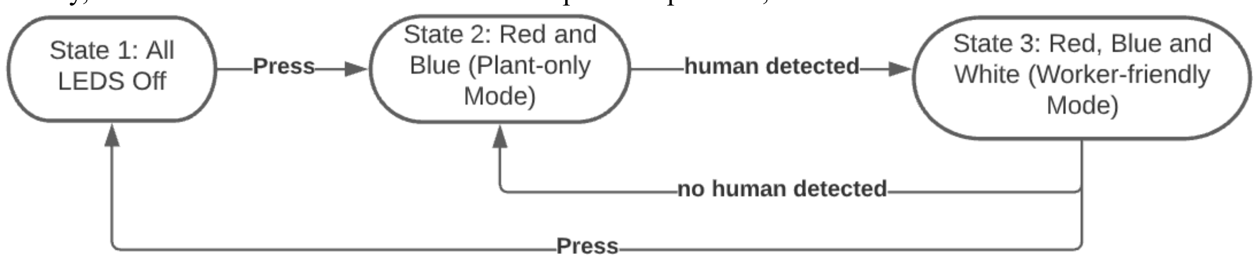


Figure 3: State diagram of system. Box represents state, arrows are conditions for state change

My contributions to the process and the design: I was involved in the brainstorming and convergence processes explained above. I made initial sketches of our design (Fig 1) which helped guide prototyping. I was further responsible for the code, I used my program from widget 1 and updated it for this design. I also verified design by checking wiring to match I/O pins in code, and tested the system when complete to make sure it was both displaying proper sequence and printing proper sensor value when (i) sensor was exposed to human motion stimuli and (ii) when the stimulus was taken away from range of sensor.

Reflection: I was able to obtain valuable experience wiring and coding a PIR sensor using Raspberry Pi Pico. For the high-fidelity prototype in our course project, I am responsible for getting our ultrasonic sensor (used to measure distance between trash can lid and garbage) working with Arduino. Thus, this activity will be useful as PIR and ultrasonic sensors are similar in both circuitry and code, and it is very easy to switch from Raspberry Pi to Arduino. Generally, working on a system with multiple components (sensor, button) and reacting to some form of input in real time will be useful for our high-fidelity prototype. On a finer scale, I learnt the pinout of the PIR sensor, and how it works (i.e. detecting differential changes between two slots sensitive to IR radiation).

What helped my learning was selecting a sensor that I could find lots of online resources about. The fact that we worked on the system as a team also sped up the process of debugging, as well as the divergence + convergence processes. Areas of growth related to this activity include exploring other (sensor, metric) pairs, especially making use of analog signals, including how you would display this information to an app (related to course project). Overall, I think our idea is an effective way to save energy, by only turning on lights when needed. Our solution can be implemented in different contexts, for example libraries, where light is only needed when people are a certain distance from a table or the light source. In grade 12, I wired an ultrasonic sensor as a class exercise; this activity helped build off that experience by introducing a new sensor and presenting a real-world context where such a system would be useful

References:

[1] L. Ada, “Pir motion sensor,” *Adafruit Learning System*. [Online]. Available: https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor. [Accessed: 06-Dec-2021].

[2] L. Ada, “Pir motion sensor,” *Adafruit Learning System*. [Online]. Available: https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor. [Accessed: 06-Dec-2021].

[3] L. C. from Daliworks, “Thing+ IOT smart greenhouse project in Japan - A practical overview featuring temperature &...,” *Medium*, 16-Jul-2018. [Online]. Available: https://medium.com/@leland.creswell_70268/thing-iot-smart-greenhouse-project-in-japan-a-practical-overview-featuring-temperature-92fcdfcc4726. [Accessed: 06-Dec-2021].

[4] “DIYmall 5 pack HC-SR501 pir motion IR sensor body module infrared for Arduino,” *Amazon.ca: Tools & Home Improvement*. [Online]. Available: https://www.amazon.ca/DIYmall-HC-SR501-Motion-Infrared-Arduino/dp/B012ZZ4LPM. [Accessed: 06-Dec-2021].