Directions

The following is a template for you to write your research paper with. For every section there are questions that you should address in your answer and a word count. **Please treat these word counts as a minimum.** But you may go over the word count if you please – but do not go under it. To check a word count in Google Docs, highlight the portion and press Ctrl + Shift + C, or ⌘ + Shift + C for Mac users.

Certain sections are marked with a star symbol (★), which means you are required to cite multiple sources in your response. Sections with no ★ do not require an external source but you are welcome to cite one if you think it is appropriate.

Note that you are writing a proper research paper here, so keep your word choice professional, proper, and formal. Don't use contractions in your writing. Using "we" is appropriate for this type of paper, but don't use "I" or "you."

When citing texts, you *must* follow academic plagiarism rules. Do *not* directly copy-paste from another source without quoting or paraphrasing. Failure to do so will cause significant trouble for you. See the next page for a more thorough explanation of how to properly do it.

For reference, you may look at previous research papers to get a feel on how to write it (please note that these papers do not have the exact same format as the one that you are writing; it is roughly similar).

- Paper 1 - Volunteer Management
- Paper 2 - COVID Tracking
- Paper 3 - Blood Sugar Tracking
- Paper 4 - Marine Pollution (Same format as this template!)

If you're not terribly fond of writing or it's not a strong point for you, then your instructor should be able to provide writing assistance and guide you on how to write your ideas down. Do note however that you are expected to write a significant portion of this paper by yourself.

Citations and Sourcing

Citations in academic research papers are different from how you would normally do it in a typical research paper. Unlike your typical paper where you must include the author(s), date published, and specific page, all that is required for a citation is the index of the work cited at the end of the sentence in square brackets. That means it's easier to cite, but you still must follow proper citation guidelines. Try not to copy-paste sections from other works. If you do, put it in quotation marks. And for the record – yes, copy-pasting even 3 words without quotation counts as plagiarism.

Finding Works

Generally stick to Google Scholar for your sources. Don't use works outside of GS, unless you're using a government website (for example, the CDC). When it comes to your works cited, cite in APA format. If you're using Google Scholar to locate your sources, almost all papers found on GS should have an APA style citation for you.

Paraphrasing

Paraphrasing is summarizing or rewording an author's point. It doesn't require quotation marks but still requires citation since you are directly referencing their ideas. Consider changing the whole sentence structure, re-contextualizing ideas, or substituting words with synonyms.

It could be argued that video game players compete so aggressively for mostly self-satisfactory purposes. In one study, players reportedly gained more motivation and satisfaction when they found that they were doing well and did not require as much assistance [2]. In that sense anti-social behavior in video games may not be necessarily linked to violent content.

Quotes

For academic papers, you should actually not quote very much, but you still can if you please. When quoting, only quote a portion that best represents a singular idea or point. Of course, remember to enclose it in quotation marks. If your quote is at the end of the sentence, put your bracket citation after the ending quote, but before the period.

It could be argued that video game players compete so aggressively for mostly self-satisfactory purposes. At least one study has shown that "enjoyment, value, and desire for future play were robustly associated with the experience of autonomy and competence in gameplay" [2]. In that sense anti-social behavior in video games may not be necessarily linked to violent content.

Preliminaries

Title

A [SMART ADJECTIVE] system/program to [PURPOSE] using [TECHNOLOGIES]

For example: *An Intelligent Mobile Application to Assist in Video Editing and Human Motion Tracking using Machine Learning and Object Detection*

A Motion Timer Detection Lamp Aiding in a Reduction in Energy Cost

Keywords

Energy Consumption
PIR sensor
Motion Detection
Adafruit ESP32-S2

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Section 1 – Introduction (500 words)

1.1 – Introduction to Problem (250 words) ★

What problem are you trying to solve? What's the background/history of your problem? Why is your problem important? Who does your problem affect in the long run? Provide some statistical examples.

The rapid advancement of technology, coupled with urgent environmental crises like climate change [1], global warming [2], and greenhouse gasses [5], highlights the critical need for innovative energy-saving solutions. One adverse effect is light pollution which is a now widely accepted terminology for the consequences of artificial light on nature and humans [9]. Light pollution impacts the wildlife, health, visibility, and even our own health [8]. Households around the globe must reduce their individual and collective fossil energy consumption to help mitigate the present and future effects of climate change [7]. Lighting systems account for a significant portion of energy use in commercial, industrial, and residential settings [3]. Traditional lighting systems often suffer from inefficiencies, leading to wasted energy and higher costs [4]. As a result, studies suggest that existing lighting systems may consume anywhere from 20 to 45% of total energy usage [6]. The clear solution is easier than one might expect, turning the light off when not in use. Lighting alone has shown that it can account for 15% of the typical electricity bill and this doesn't take account for all of the other electrical devices in a household such as a tv, air conditioning, computers, chargers, and appliances which all factor in [10]. However, forgetfulness, inconvenience, and situations where individuals are away from the lightswitch make this a more complex problem than it may initially appear. Even unplugging devices doesn't necessarily work because even when not in use electrical devices are still using power. All together in an era and future encompassed with technological advancements there is a clear need for user-friendly, controlled automation that will allow great improvements in energy efficiency.

1.2 – Method Proposal (250 words)

Propose your method of solving this problem. First, explain what your solution is in one sentence. Then, discuss how your solution solves your problem. Why do you think it is an effective solution, and why would it be a better solution than other methods that you've discussed?

To combat excessive energy consumption from inactive electronics, traditional solutions often fall short. Manually turning off devices can be inconvenient, while sleep modes still consume some power. We propose an alternative which offers a control system that will ensure that energy will be saved, through a PIR motion detection controlled light system. Manually controlled lights often remain lit in unoccupied spaces, leading to wasted energy and increased electricity bills. This inefficiency is particularly prevalent in areas with frequent movement, such as hallways, basements, or storage areas. Additionally, traditional lighting systems lack the ability to capture and transmit valuable environmental data. Our data will take into account environmental data as well as offering needed sources. This is impactful because it allows us to be able to actively use our device and help save energy when not in

use. The solution is better than the proposed one since customers can take advantage of the quick switch between on and off from the active state. To ensure that the data will be accurate, countless testing will go into the detector so that efficiency of the controls are best optimized. The application that users of this system could take advantage of is a user-friendly web application that is connected to the lighting system. Users will be able to see temperature information and detect air quality with the use of this system. Specifically, users will also be able to detect the air quality by detecting levels of Volatile Organic Compounds (VOC). This is impactful since VOCs are emitted in the form of gasses or liquids that can lead to short and long term health effects [11]. Even away from home or the office the lights will be able to adjust to the ideal setting based off of motion and can easily switch the setting without even standing up. Overall, this motion-detection solution effectively addresses the issue of wasted energy from idle electronics while promoting energy savings, ease of use, and environmental benefits.

Section 2 – Challenges (300 words)

2.1 - Challenge A (100 words)

Think of a major component of your program. Imagine the sorts of problems that you had to consider when implementing this component. What could potentially cause problems that you need to address? Provide a short explanation as to how you could resolve them. Do not go into detail about how you solved it in your project! Word it as if you would be discussing how you would go about solving these objections (instead of “I used,” say “I could use”).

One of the challenges is the small amount of power that I’m using with the Adafruit ESP32-S3 Reverse TFT Feather. So this can lead to delay with turning the light on and off, compared to when we actually want the switch to switch states.This can lead to issues where the light is flickering on and off super fast or issues where the response time is far too late. We can use a more powerful controller and power source to toggle the on and off state of the light. Ultimately, the effectiveness will be predicated on a timer being set for the data to be correctly processed.

2.2 – Challenge B (100 words)

Follow the same directions as 2.1 but with a different component in mind.

One of our biggest concerns is the communication between all of the devices and the potential for delays or unexpected results. This can become a major issue with the code if one device is sending the wrong signals out and could jeopardize the rest of the results. This could especially be an issue with the on/off buttons from the HTML website working with the code. Now that one device has the wrong information that could leak into the other devices and cause unexpected results. We could use pins to make sure that each device can exchange data and seamlessly work together to do actions. In addition, error detection and debugging is vital to the success of a project with multiple device communication.

2.3 – Challenge C (100 words)

Follow the same directions as 2.1 but with a different component in mind.

Factoring in the strength and distance of the PIR motion sensor is a huge point of contention that must be taken into account. It becomes of serious importance to do numerous tests with the sensor to know its strengths and weaknesses for valid results. The sensor is essential in this project as it controls whether or not the lamp will be saving or using energy. There will be important signals that the sensor needs to send to the Adafruit ESP-32. To conduct experiments the most important device is the PIR motion sensor. The sensitivity of the motion detector will notice any changes in motion along with the potential issues of false positive

detections. Controlling the test environment becomes extremely essential in combination with a clear detection zone for the sensor. Inconclusive and inaccurate data can not be accepted since this application strives to achieve efficiency along with practicality for the utmost findings.

If you’re confused, refer to the next page for a quick guide on how to write this out.

Section 2 Writing Guide

Consider a mobile application with an AI that can detect specific objects. 3 components would be:

- UX (user interface and experience)
- AI Model
- Data Storage and Tracking

Let's consider problems that would come up with the second component:

- Where are you going to get data from? —> collecting data takes a lot of time
- How robust does this AI need to be? —> the AI can't be too big or too small
- What if the AI is not accurate? —> the AI can't be inconsistent

How would we solve these problems?

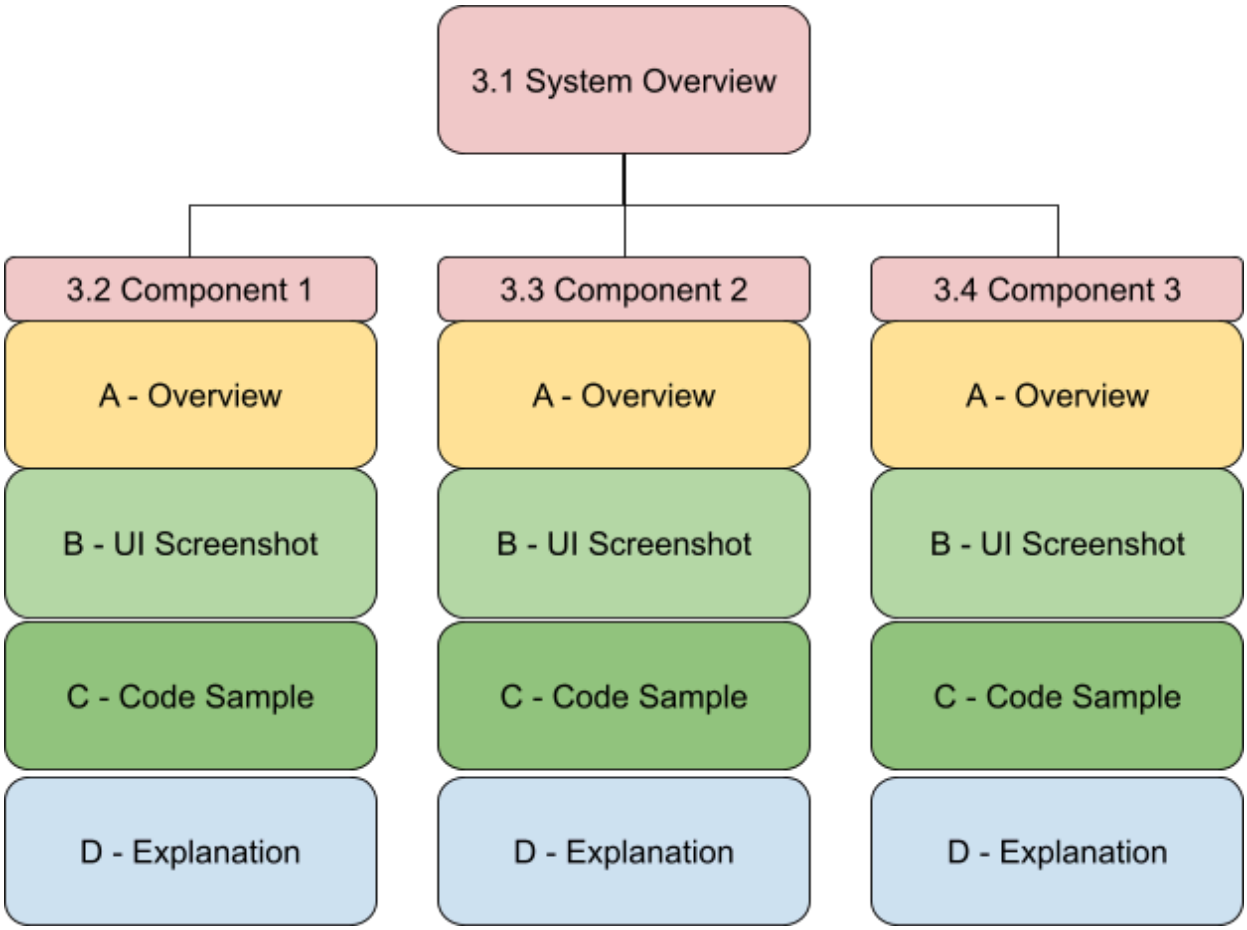
- We will get data using a data scraper.
- Our AI will at minimum focus on identifying basic foods like bread and rice.
- To ensure the AI is accurate, we will train it with at least 500 images and perform quantitative assessments.

At this point, you will only have to write it out. The following exceeds the 100 word minimum (132).

The performance of this application is heavily impacted by the artificial intelligence model that we are using. We must first consider where we are going to find adequate data, as AI models need hundreds of images to train. To expedite this process, we will use an image scraper on Flickr. The AI must also be comprehensive, but it cannot be so large that development would take too long, but not so small that it serves no utility. We will establish that at minimum our AI must be able to identify basic foods such as bread and rice. Our AI must also be accurate at identifying these objects to provide utility to users and so they are not frustrated. To account for this, we will train at least 500 images per object and perform quantitative assessments for adjustment.

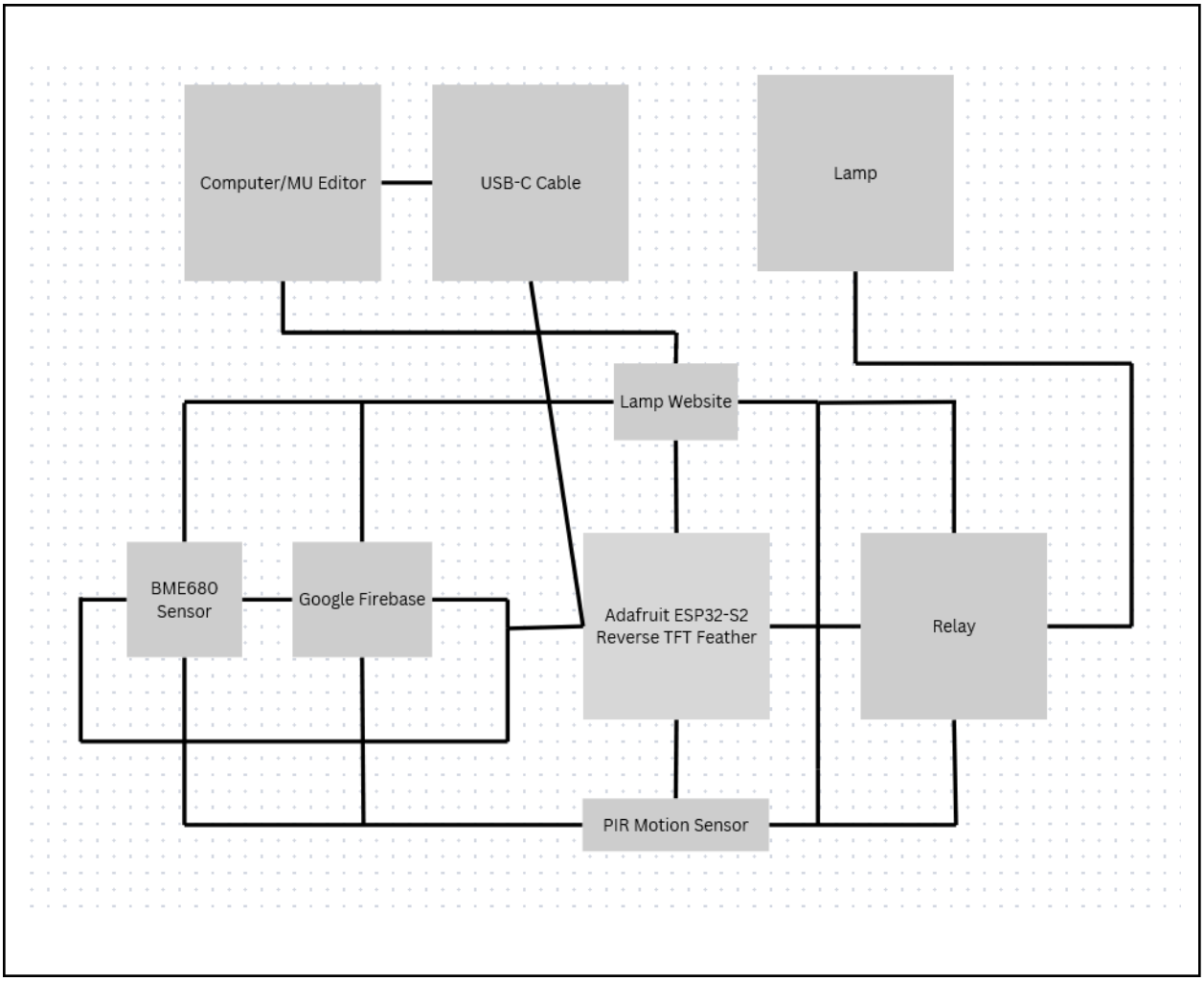
Section 3 – Method Analysis (850 words)

Your Section 3 should be based on this structure below:



3.1A – Diagram

Provide a flowchart of your program. You should probably already have one made for you. If not, construct a diagram with your application screens. If the one made for you isn't indicative of the final product, modify it to be so.



3.1B – System Overview (250)

Explain the main structure of your program. What are 3 major components that your program links together? Discuss the “flow” of your program – how does your program work from start to finish? What did you use to make this program?

This project proposes an intelligent lighting and environmental monitoring system that utilizes an Adafruit ESP32-S2 board to automate a lamp, triggered by motion detection. The system also incorporates environmental sensors to capture data on temperature, gas, humidity, and pressure. To make this program we used CircuitPython in MU Editor to write out the code to instruct the controller on what it should be doing. We also made a web application in Replit that will display the sensor information as well as two buttons that can also control the state of the lamp even from a distance while on the same network. The main structure of the program is a two-way communication that consists of multiple devices. The Adafruit ESP is connected to the relay, the HTTP server, PIR motion sensor, and the BME680 temperature sensor. The PIR Motion Sensor sends critical information that tells the lamp to turn or off to BME sensor,

relay, Google Firebase, and back to the Adafruit ESP. It is important to note that the PIR motion sensor is different from a traditional motion sensor, as it detects infrared changes in heat signals that can be more accurate than and lead to less false detections. The temperature sensor sends its data information to Google Firebase to record the history in an organized way and the website to display to the user. The website can also send information to the Adafruit to turn on and off the lamp as well. The IoT relay receives information from both the Adafruit and the motion sensor to tell the lamp what state it should be in. The three main components are AC/DC Control Relay, Adafruit ESP32-S2 Reverse TFT Feather and motion sensor, and HTTP server application. The motion sensor and controller tell the program whether or not the lamp device should be turned on or off if someone is near the motion detector. Then, it tells the relay device to toggle on or off which then sends the signal to the lamp to turn the lamp on and off.

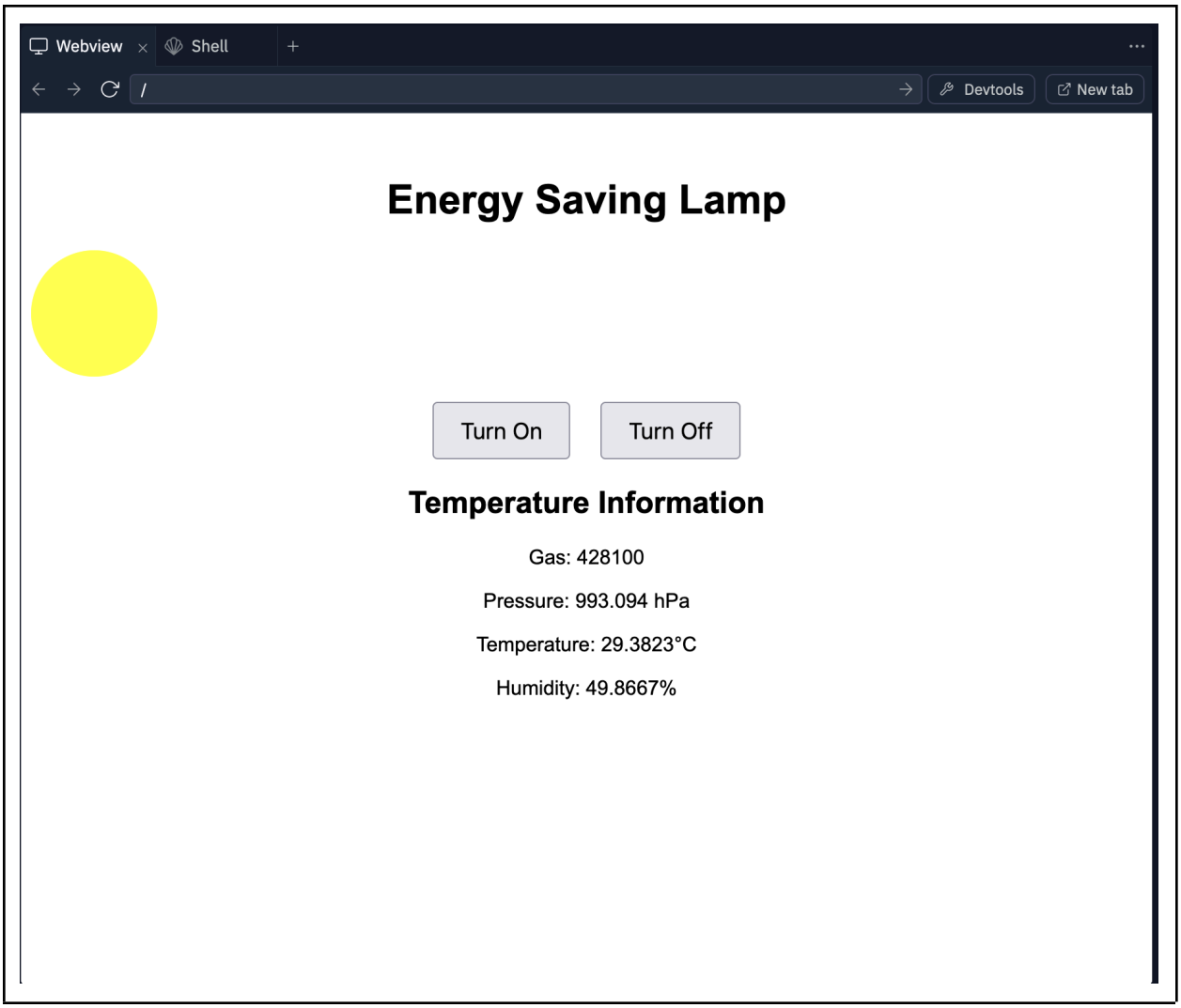
3.2A – Component Analysis A (50 words)

Take one of the components that you established in 3.1. Discuss what the component's purpose is. What services did you use to implement this system? Does your component rely on a special concept (eg. NLP, Neural Networks, Authentication)? If so, briefly explain what the concept is.

The first component is the lamp and more specifically how it is able to function using its connections to the Adafruit Reverse TFT, IoT relay, motion sensor, and BME temperature sensor. The main services being used are Google Firebase to store the temperature information from the sensor and CircuitPython to run the code.

3.2B – UI Screenshot

Show a screenshot of your program that best displays your program. If necessary, you can add an additional screenshot if you feel it best communicates what your component does.



3.2C – Code Sample

Find a screenshot of your code that best represents the component. It does not need to necessarily include the entire component's code. It's best if you can find a method that best encapsulates your component, but fine if not.

```
    if pir_value:
        if not motion_detected:
            print('Motion detected!')
            relay.value = False  # Turn on the relay
            if relay.value == False:
                print("The lamp is turning on")
            motion_detected = True

            motion_label.text = "Motion Detected!"  # Update display label

            print("\nTemperature: %0.1f C" % temperature)
            print("Gas: %d ohm" % gas)
            print("Humidity: %0.1f %%" % humidity)
            print("Pressure: %0.3f hPa" % pressure)

            data = {
                'temperature': temperature,
                'gas': gas,
                'humidity': humidity,
                'pressure': pressure
            }

            requests.post(firebase_path, json=data)

            # Update display
            temp_text.text = "Temperature: %0.1f C" % temperature
            gas_text.text = "Gas: %d ohm" % gas
            humidity_text.text = "Humidity: %0.1f %%" % humidity
            pressure_text.text = "Pressure: %0.3f hPa" % pressure

            # Set a timer for quick checks (adjust the sleep interval as needed)
            motion_timer = time.monotonic() + 2  # Check every 2 seconds

    elif motion_detected and motion_timer is not None and time.monotonic() > motion_timer:
        # Motion has stopped, perform actions for motion end
        print('Motion ended!')
        relay.value = True  # Turn off the relay
        if relay.value == True:
            print("The light is turning off ")
        motion_detected = False
```

3.2D – Code Explanation (150 words)

To put it simply, what's going on in that screenshot? When does this code run in your program? What does each method represent? What variables are being made? Walk through each method that you showed step by step. If it's communicating with a backend server, what's the server doing?

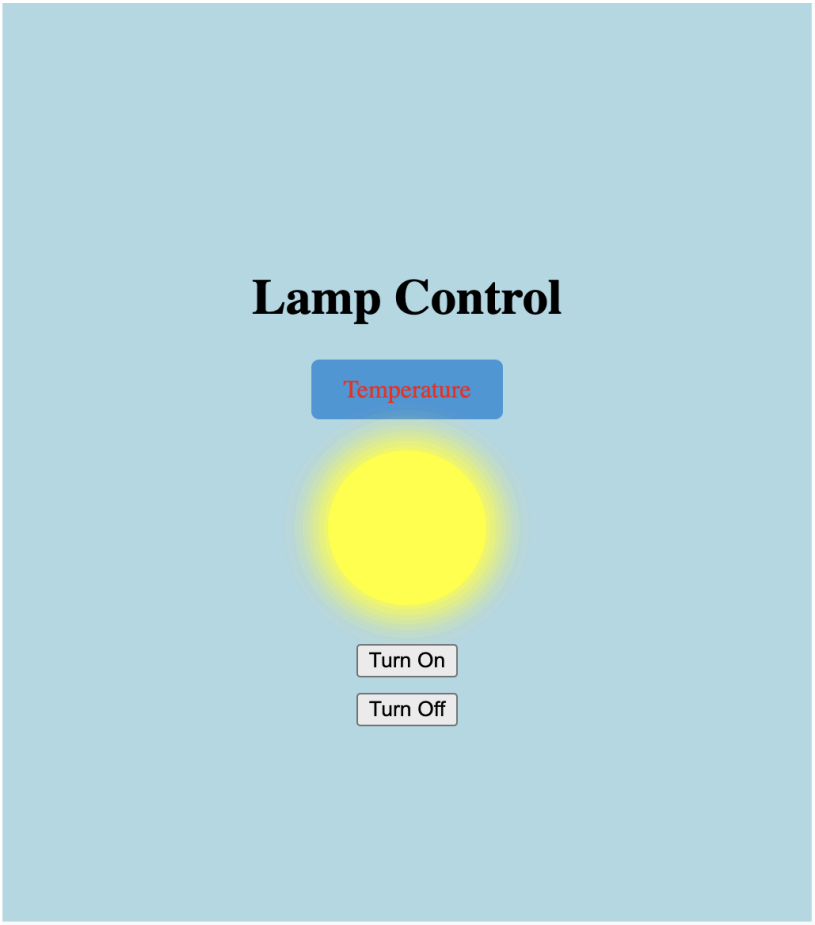
This is the main code for the program that allows the PIR motion sensor to be able to detect any movement. The pir_value is the variable that holds the condition (True or False) of whether or not the sensor is detecting any movement. The code first checks if pir_value is True, then ensures that the motion is only detected once and not continuously. The relay is then turned on, and temperature information will be stored in Google Firebase to keep track of the data. Also, the screen display shows the BME information such as temperature, gas, humidity, and pressure. The motion_timer adds a timer for 2 seconds to see if motion is happening. The other condition is for when there is no motion being detected and waits for a timer to switch the state of the lamp from on to off. When there is no motion detected, pir_value is False which means that the motion has ended and the relay should turn off.

3.3A – 3.3C – Component B (200 words)

Repeat the same steps as Steps 3.2A – 3.2C on a different component.

The second component of the program is the application that the user can view and control the control system. From the webpage, there are two buttons to control the relay of the lamp that turns it off or on. This component relies on communication through network ip from the Adafruit and the web server, which allows the Adafruit to receive and send information also allowing for the server to do the same.

Ui screenshot:



Code sample:

```
  const app = initializeApp(firebaseConfig);
  const analytics = getAnalytics(app);

  // Get a reference to the database service
  const database = getDatabase();

  // Function to send data to Firebase
  function sendData(state) {
    console.log("Button clicked. State:", state);
    set(ref(database, '/relay_state'), state);

    // Update the light based on the state
    const light = document.getElementById("light");
    if (state) {
      light.classList.add("on"); // Turn on the light
      alert("Relay turned on!");
    } else {
      light.classList.remove("on"); // Turn off the light
      alert("Relay turned off!");
    }
  }

  // Bind event handlers to buttons
  document.getElementById("turnOnButton").addEventListener("click", function() {
    sendData(true);
  });

  document.getElementById("turnOffButton").addEventListener("click", function() {
    sendData(false);
  });
</script>
```

3.3D – Code Explanation (150 words)

Code explanation: The handle_connection function provides an HTTP server that helps control the lamp and obtain sensor information through a local connection. The client_socket argument in the function represents the connection between the server and the client. The function splits the request into lines and extracts the method, path, and protocol from the first line of the request. When the method is set to post and the path is “\lamp”. The content_length, request_body, and action parse an HTTP request to extract the content length, retrieve the request body, and extract a specific parameter value from the body. There are two types of actions (“on” or “off”). If the state is “on”, the code will turn the relay.value from to false if the button clicked on the website and likewise if the state is “off” then the relay.value is true. Doing this ensures that the user is able to control the lamp status from the buttons remotely as long as the Adafruit and the computer are on the same server. Changing the method to “GET” allows for the retrieval of sensor information from the BME680 sensor (gas, temperature, pressure, and humidity). The response variable sends an

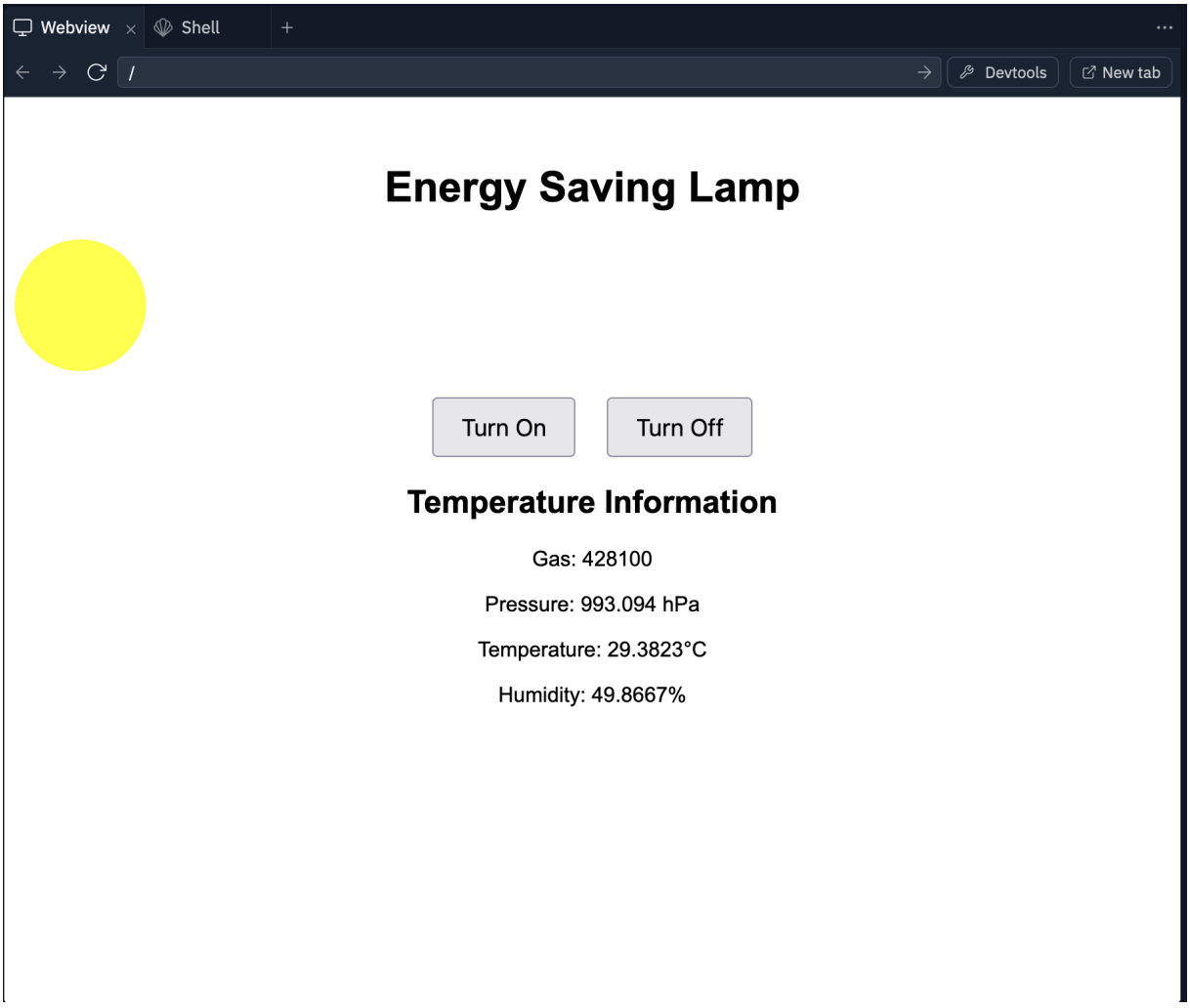
HTTP response in the form of a json of the sensor data and sends back to the client an OK status code. This function is constantly being called in the main() function which means that the website is constantly updating, controlling, and monitoring the status of the lamp and the environment.

3.4A – 3.4C – Component C (200 words)

Repeat the same steps as Steps 3.2A – 3.2C on a different component.

The third component is the website itself, which displays information from the temperature sensor and can also transmit HTTP requests to turn the lamp on and off. This website was made using HTML in Replit for a simple application to work along with the project.

UI Screenshot:



```
<script>
  function fetchTemperature() {
    fetch('http://<your-device-ip>/temperature')
      .then(response => response.json())
      .then(data => {
        document.getElementById('temperature').textContent = data.temperature + ' C';
        document.getElementById('gas').textContent = data.gas + ' ohm';
        document.getElementById('pressure').textContent = data.pressure + ' hPa';
        document.getElementById('humidity').textContent = data.humidity + ' %';
      });
  }

  function toggleLamp(action) {
    fetch('http://<your-device-ip>/lamp', {
      method: 'POST',
      headers: {
        'Content-Type': 'application/x-www-form-urlencoded',
      },
      body: 'action=' + action
    });

    // Change lamp color based on action
    if (action === 'on') {
      document.getElementById('lamp').style.backgroundColor = 'yellow';
    } else {
      document.getElementById('lamp').style.backgroundColor = 'gray';
    }
  }
```

3.3D – Code Explanation (150 words)

The fetchTemperature function is accountable for obtaining temperature information from my Adafruit ESP32-S2 Reverse TFT Feather that is connected in tandem through a network ip. Then it will process the response asynchronously using promises and once the response is received the sensor information being passed over will be stored into HTML with the fetched temperature data from the BME680 sensor. The toggleLamp function will toggle the status of the lamp that is connected. First the action parameter holds the specification of whether or not the lamp should be on or off. Also using the fetch API, a POST request will be made telling the Adafruit to then pass on the information to the relay to control the lamp. Next the action can be either “on or off” that will show the lamp on the website either lighting up if the turn on button is clicked or the lamp becoming gray if the turn off button is clicked. These functions are essential in order for the sensor data to be passed into the website and also manually controlling the lamp state with the buttons.

If you’re confused, refer to the next page for a quick guide on how to write this out.

Section 3 Writing Guide

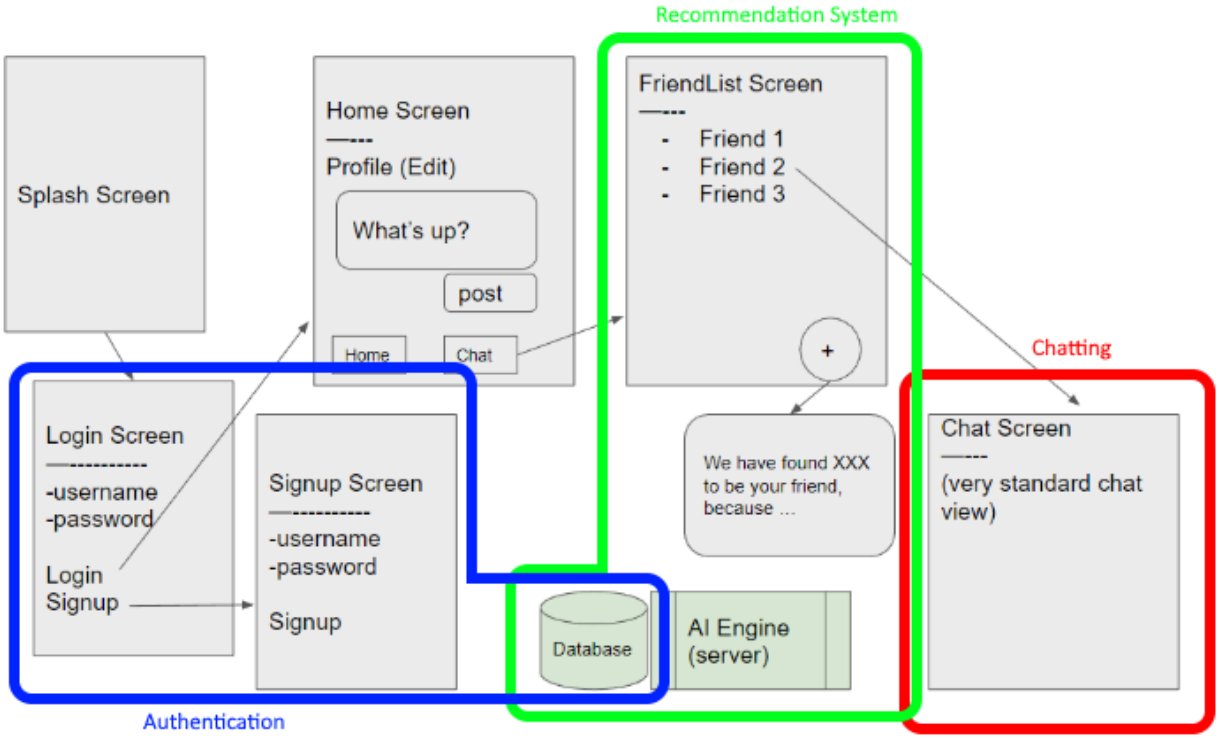
Suppose we are writing for a social networking application that will let users find and send messages to one another. Let's say that we've established that our main components are the chatting system, the authentication backend, and a recommendation system that uses AI.

3.1 - System Overview

Main Structure:

- Three parts: an authentication service, a recommendation system, and a chatting system
- Information is all uploaded and stored to Firebase database

Here's our flow chart. Let's circle the 3 major components that we can identify. For 3.1A, you would put the flow chart without these circles.



Flow is as simple as following the arrows.

- Get splash screen
- Login Screen
- Signup Screen if needed
- Both go to the dashboard
    - you can make posts from the dashboard
    - displays profile information
- Friend Screen
    - shows all your friends that you can talk to
    - if you don't have any, then ask for a recommendation

    - AI server will respond back with a potential new friend
- Chat Screen
    - chat with someone
    - similar to SMS or WhatsApp

What did you use to make this program?

- Flutter
- Firebase
- Repl.it

The following exceeds the 250 minimum word limit (273 words)

The program is split into three large components: an authentication service, a recommendation system, and a chatting system. All the information sent through the app is stored within a database to later be processed by a sentiment analysis AI. To construct this program, we used Flutter for the codebase, Firebase for authentication and database services, and Repl.it to host our sentiment analysis AI model. We decided to use Firebase primarily because of its ease of use but also because we can allow certain portions of our database to be accessible through HTTP requests. We decided to host our sentiment analysis AI on a repl.it server running flask because it is simple to set up and make API requests to. Our program is designed to be a simple application that users can download free on app stores. When opened, it will display a splash screen to the user and prompt them to log in. If the user doesn't have an account, they may sign up. Logging in and signing up both use the authentication service offered by Google's Firebase, which allows us to manage a database efficiently. When they log in they are shown the dashboard, and can make posts that are uploaded to Firebase, or they can visit a Friends List screen. If they do not have friends in the system, they can prompt the app for a friend. The app will send an HTTP request to a server hosting a sentimentality AI that will determine the best match for a user. There is also a chat screen for users to communicate through that operates similarly to SMS or WhatsApp messaging.

3.2A – Recommendation System

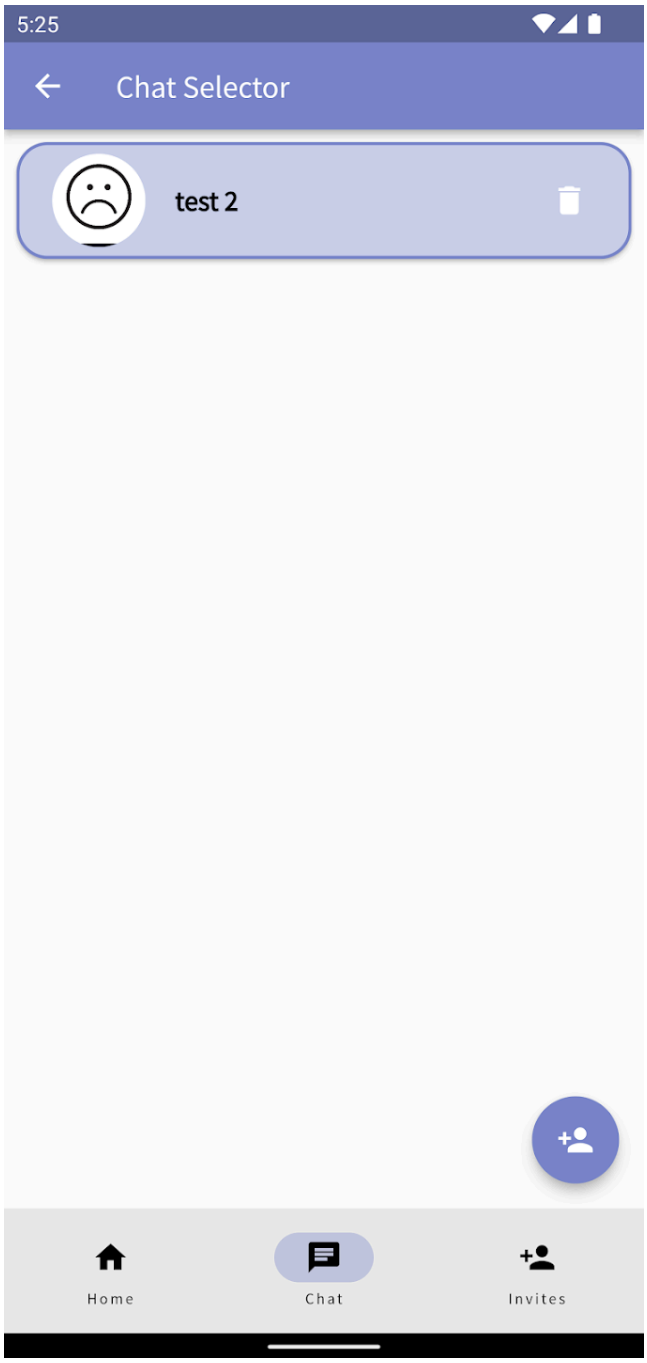
Let’s try writing about the third component.

- What is its purpose?
    - the “social” component of the app, allows users to connect with one another
- What services did you use?
    - Repl.it server
- Explain special concepts
    - Natural Language Processing
        - a way of computing language as data
        - ability for machines to recognize human emotions and suggestions through written words only
- Connect to program
    - To be used in conjunction with friend request system to find new users to chat with, and is required in order to instigate a conversation

The following exceeds the 50 word count minimum (76 words)

A key part to the app's functionality is our recommendation system. This system is integral to the app's core design because it is the primary way for users to find new users to send friend requests to. This recommendation system relies on a simple repl.it backend server, that hosts an NLP model. NLP, or Natural Language Processing, is a way to compute written language as data and recognize human emotions and suggestions from that data.

3.2B – UI Screenshot



3.2C – Screenshot

We need to find a screenshot that best represents the component and best illustrates how the component is used within the program's codebase. The method that we decided to show here, *sentimentFriendSelector,* includes the code where we make a request to a server, and shows how we process the information that we get back.

```
Future<dynamic> sentimentFriendSelector() async {
  String url = "https://userpostsentimentanalysis.marisabelchang.repl.co/" + getUID();
  String pickedUID;
  String pickedName = "";
  String pickedDescription = "";

  //Get a UID from the server
  var response = await http.get(Uri.parse(url));
  print(response.body.toString());
  var listData = jsonDecode(response.body.toString());

  pickedUID = listData[0].toString();
  if (pickedUID == getUID())
    {
      pickedUID = listData[1].toString();
    }
  print("RESULT: " + listData.toString());

  //Get the username and description
  await FirebaseDatabase.instance.ref().child("userProfile").child(pickedUID).once()
      .then((event) {
    print("Successfully grabbed profile for user " + pickedUID);
    var profile = event.snapshot.value as Map;

    pickedName = profile["Username"];
    pickedDescription = profile["Description"];

    print(pickedName);
    print(pickedDescription);
  }).catchError((onError) {
    print("Could not grab user profile for user " + pickedUID);
  });

  return [pickedUID, pickedName, pickedDescription];
}
```

3.2D – Code Explanation

- When does it run in the program?
    - On a friend recommendation page, when the user presses a recommend friend button
- What does the method represent?
    - sentimentFriendsSelector will make an HTTP request to the server hosting the NLP AI, and then display to the user the profile information of the user that the server sent back
- What variables are being made?
    - url – the URL of the HTTP request. To request the server for a recommendation for a specific user, we attach their unique identification at the end of the URL.
    - pickedUID – the user identification of the user that the server sends back. Used to lookup the user's profile information
- What does the server do
    - AI model will go through all user's posts and perform sentiment analysis on each post that they've made
    - It computes the average sentiment per post for that user
    - It does the same for every other user
    - It returns the UID of the user whose average is closest to our user
- Step by step process
    - 1. Generate a URL with the user's UID.
    - 2. Make an HTTP request with that URL. Wait until response
    - 3. With UID, look up Firebase Database and get corresponding user profile info
    - 4. Return an array with the UID, name, and description
    - 5. Data is shown as a pop up and user can either add them as a friend or ask for new recommendation

The following exceeds the 150 word count minimum (287 words)

The method *sentimentFriendSelector* best represents this component. It is called in the program on a recommended friend page when the user presses a button. When called, it will make a request to a separate server hosting an NLP model, and it will then display to the user the profile information of a recommended friend. There are two important variables. "url" is the URL

of the HTTP request. To request the server for a recommendation for a specific user, we attach their unique identification at the end of the URL. “pickedUID” is the user identification of the user that the server sends back. It is used to lookup the user’s profile information. When the method runs, it first makes an HTTP request with the URL. The method waits until the data is sent back. Serverside, the AI model will go through all user’s posts and perform sentiment analysis on each post that they’ve made. It computes the average sentiment per post for that user, with lower scores representing more negative posts and higher scores representing more happy posts. It does the same for every other user and returns the UID of the user whose average is closest to our user. Once the server sends a UID back, we search our Firebase Database in the userProfile section and use that UID to access the profile information of the recommended user. Once all the data is compiled, we wrap it up in an array and return it. In the program, this data is then shown to the user via a pop up and the user is given a choice to either request a new recommendation, or accept it, and send a friend request.

Section 4 – Experiments (560 words, 280 per experiment)

4.1A – Experiment A (30 words)

Provide a possible blind spot in your program that you want to test out (for example, an AI's accuracy). Why is it important that this part of your program works well?

One potential blank spot in our program is checking the motion sensors range of detection. We will test the light if it can turn on or off if the movements are far away and also close to check the accuracy. This is important to test out to see if it is working properly because the lamp should be properly displayed based on the needs of the user; ie: when in range the lamp should be off, then when not in use (user is away) then the lamp should be turned on.

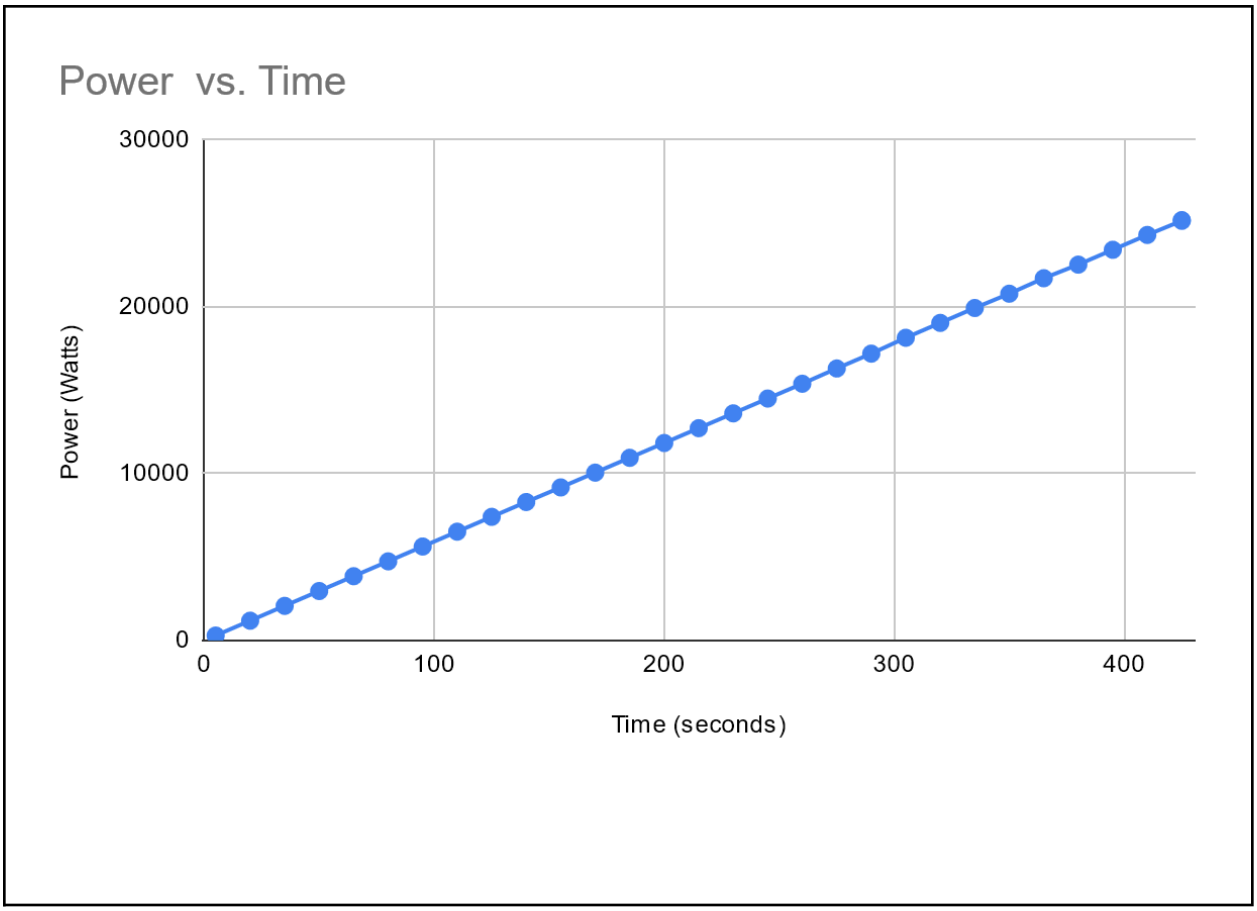
4.1B – Design (100 words)

Explain how you will set up the experiment to test it. Why is the experiment set up that way? State where you're sourcing control data from, if at all.

Measuring the lamp energy when someone is moving by the lamp but we are controlling the light on and off using our html application by hitting the on and off button. The experiment is set up to compare the difference in energy between light constantly on for five minutes versus the user controlling the light. The control data is measuring the light constantly being left on. We will be using the formula Power = Energy * T, we will also use a watt meter to measure the power of the lamp and the time will be five minutes. Next, we will be comparing the average energy between the two experiments to see which is more efficient. Also we will be comparing the difference in the change of temperature from these two experiments (light on versus light controlled).

4.1C – Data and Visualization

Provide the data from your experiment, as a graph.



4.1D – Analysis (150 words)

Analyze the data. What's the mean and median? What's the lowest value? What's the highest value? What data surprised you or did not meet your expectations? More importantly, why do you think that it turned out that way? What has the biggest effect on your results?

The lowest value from the data is using 0 W of energy when no motion is being detected when the light is off, and the highest value of the data was around 59.5W of energy due to the heat being exerted from the lamp. The biggest impact of these results is the sensitivity of the motion detector which can either leave the light on or turn it off. The data was able to reach the expectations due to the timer implemented with the motion sensor, although experienced some delay issues where the motion sensor should detect movement but a two or three second delay would sometimes persist. From the BME680 sensor the gas readings also gave out a value of , which means low VOC that correlates with healthy air quality in the room. In addition, clearly from the results and the data that the user controlled status helped reduce the temperature by 0.39 Celsius in only four minutes.

4.2A – 4.2D – Experiment 2 (280 words)

Repeat the steps for 4.1 on another potential blind spot.

4.2A – Experiment A (30 words)

Provide a possible blind spot in your program that you want to test out (for example, an AI's accuracy). Why is it important that this part of your program works well?

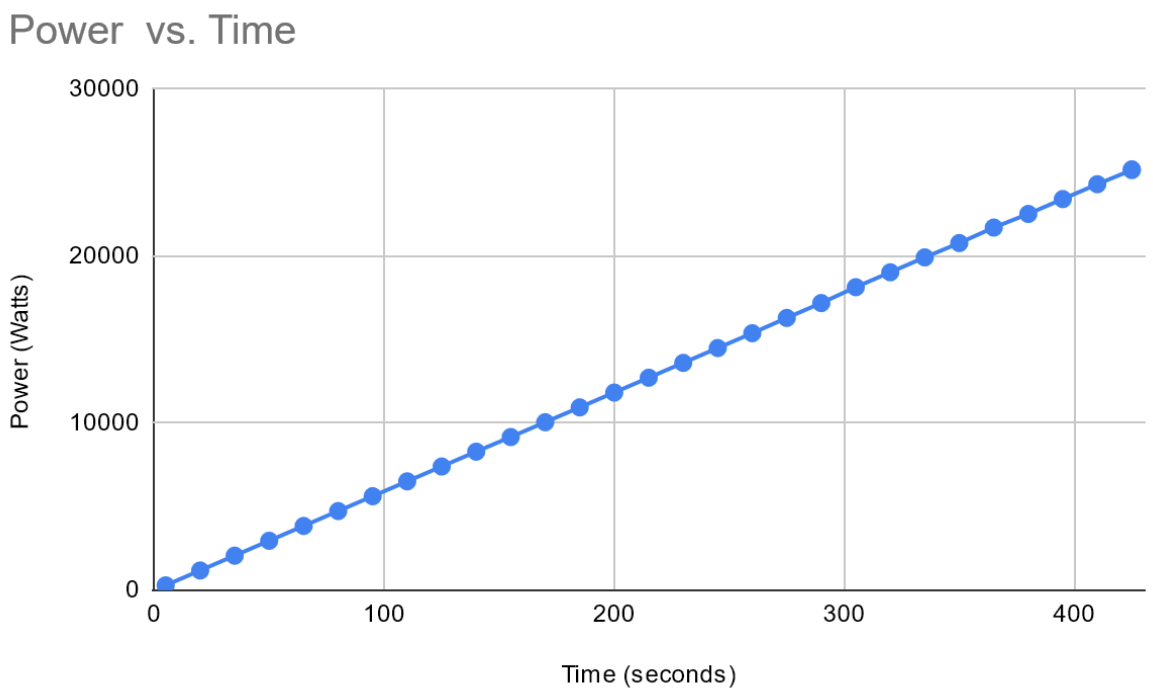
The other blind spot that will be tested is checking and changing how frequently the motion sensor can turn the relay for the lamp on and off. This is important because of the interaction with the website buttons which need to be able to communicate with each other to get instant results rather than being delayed.

4.2B – Design (100 words)

Explain how you will set up the experiment to test it. Why is the experiment set up that way? State where you're sourcing control data from, if at all.

This control experiment will have a similar control setting to the previous experiment with a timer of 12 seconds and the motion detector being close to the source of movement. This will lead to accurate testing and a control setting that ensures that the timer and the sensor work together in harmony to send sensor information to Google Firebase to store the data. Now we will be testing out the range of the motion sensor and the effect of long range detection vs short range detection in terms of temperature. It will be very important that there is no other movement around other than the movement from a distance that is being checked, this is because the PIR motion detector is very sensitive to any changes in motion. This research is being performed like this in order to mimic a person walking into a room or out of a room where the light should be able to adjust accordingly to the situation based off of the relay.

4.2C – Data and Visualization



4.2D – Analysis (150 words)

Analyze the data. What's the mean and median? What's the lowest value? What's the highest value? What data surprised you or did not meet your expectations? More importantly, why do you think that it turned out that way? What has the biggest effect on your results?

The lowest value from the experiment was a power of 0W, this is the expected value as this is the condition where the lamp is turned off from the website turn off button. The highest value from the dataset. The biggest impact of the results would be the timer that has been implemented to ensure that the relay can't be repeatedly clicked to help hold more validity and accuracy towards the results that were obtained.

The data that surprised me was that when compared to the control test case, it seemed that the temperature data was very similar in terms of Celsius. In this case the lamp turning on or off did not have much impact on affecting the overall temperature that the BME sensor was able to detect. This is due to the fact that the lamp would stay at a constant wattage and hence the same temperature so this would allow for the relatively constant temperatures that are being shown. Overall the results show that there is really not too much of a difference in

the temperature readings from the constant state of the lamp in comparison to the user controlled.

Section 5 – Methodology Comparison (300 words)

5.1 – Methodology A (100 words) ★

Find a scholarly source that tries to tackle the same problem that you're solving. Provide an explanation on how the solution works. How effective is this solution? What are its limitations? What are some things that it ignores? What does your project do that improves on what they tried?

Researchers Wagiman and Abdullah sought to implement an intelligent lighting control system used in office buildings for additional energy saving [12]. They found an increased savings in energy of 34%, by using an artificial neural network called ANN and controllers that have the capability of dimming light fixtures within office buildings [12]. ANN are computer programs that accumulate information from data patterns and recognition and are best used in non-linear relationships [13] . The limitations of the study showed that during the morning the energy consumption was significantly higher than any other time during the day, where brighter light is needed [12]. Our project attempts to improve on this to allow ease of use regardless of whether the user is situated in the room or not. Also, the project still allows for dimming the light in comparison to this where the lights will turn off if no motion is being detected.

5.2 – Methodology B (100 words) ★

Repeat the same steps as 5.1.

Engineers Jinsung Byun, Insung Hong, Byoungjoo Lee, and Sehyun Park opted to experiment on intelligent household lighting with the use of LED lighting [14]. Using multiple sensors along with wireless communication, the LED being controlled was able to maximize the energy efficiency by adjusting the minimum light intensity that would be necessary, coinciding with a 21.9% decrease of energy in a household [14]. One limitation that arises is that the system suggested doesn't automatically adjust the lighting rather waits for a countdown timer, this can lead to inconveniences for the household. Our method tackles the automatic control system by turning off or on the light whenever there is some movement being detected.

5.2 – Methodology C (100 words) ★

Repeat the same steps as 5.1.

Find a scholarly source that tries to tackle the same problem that you're solving. Provide an explanation on how the solution works. How effective is this solution? What are its limitations? What are some things that it ignores? What does your project do that improves on what they tried?

The problem that researcher Wang Fei is trying to solve is that they want to make a solar LED street lamp to save energy using microcontrollers [14]. China is rapidly urbanizing and estimates that street lamps will cover nearly 100% of all roads and 97% of street lamps will be illuminated [14]. The down side of this project is that the batteries constantly need to be checked and maintained as over time the battery will degrade with use. Another limitation is the time of day where during the night the solar LED is less effective compared during the day. The main difference is that our project uses a motion detector and a temperature sensor.

5.2 – Methodology C (100 words) ★

Repeat the same steps as 5.1.

Find a scholarly source that tries to tackle the same problem that you're solving. Provide an explanation on how the solution works. How effective is this solution? What are its limitations? What are some things that it ignores? What does your project do that improves on what they tried?

They are trying to solve the light problem. Roisin and Bodart look to find which control system is the most efficient of IDDS (individual daylight dimming system), occupancy control system and a combination of both of the systems [15]. The experiment was conducted by an automatic light control switch and measuring the total voltage by connecting the wattmeter to the ballast. The solution is effective because the testing simulation was done in three separate locations across the world. The limitation is that the user will not always turn off the light even if 500lx are not reached which would save even more energy at the expense of eyestrain and comfort [15]. Our project improves on the researcher's method by physical testing of energy usage rather than practical testing in an imaginary room.

Section 6 – Conclusions (200 words)

6.1 – Limitations and Improvements (150 words)

What are some limitations to your project? What do you think needs to be fixed? How would you implement these if you had more time with your project?

One of the limitations include a time delay from the code that takes time to process some of the information. Also accounting for the numerous communications between the devices it seems that a lower motion timer encounters issues with efficiency. More testing needs to go into finding the perfect timer that allows for the correct relay state for the lamp while also being able to take in information from multiple sources at the same time. With more time some implementations that we would make is using a more powerful relay device to control the status of all electronic devices. While testing multiple electronic devices some of them wouldn't be able to turn on resulting from too much power being needed from the IoT relay. Another limiting factor was the length of the cables which made the setup for the electronics inflexible and the connections are short. To properly fix inaccuracy issues it seems that an AI model would be an extremely useful feature to help the sensor determine what is and is not movement that requires any changes to the lamp. The effectiveness of the project could be improved through optimization of the testing environment, addition of testing modules, and more reliable components.

6.2 – Concluding Remarks (50 words)

Provide some concluding remarks.

In order to make the lamp more effective, a stronger motion detector could be used to tell whether someone is in the room. Also, object detection using AI to train what movement looks like, this way the lamp isn't constantly turning on or off when idle for a brief moment. Another observation is that in a future project a lighting dimmer/timer might be better than completely turning on or off to save more energy. Through this implementation this allows the user further customization and control of how much light they want in their room. This is a more practical application of energy saving devices.

Section 7 – Summaries (200 words)

Papers tend to include subsections with recaps or previews of other sections in the paper. For your convenience, we've compiled these subsections at the end so that you can more easily recap your findings. This section may be tedious, but you will still have to fill these out. Don't copy-paste anything from your previous sections here.

7.1 – Experiment Recap (150 words)

Essentially, recap Section 4 in 150 words. What were you trying to test with each experiment? How did you set up each experiment? What were the most significant findings for each experiment? Briefly recap the reasonings for why your results came out the way they did.

The first experiment we were testing the delay time that it would take for the lamp to turn on and off between the intervals of the motion sensor detecting and stopping motion.

The second experiment we tested the distance and the accuracy of whether or not the lamp would switch its state with movement. From the data results we could easily see that the

7.2 – Methodology Comparison (150 words, 50 per method)

Recap the 3 methodologies that you went over in Section 5. What does each try to accomplish? What are the shortcomings of the 3 solutions? What did your project do to try and improve on these works?

Resurcher's Byun, Hong, Lee, Park try to decrease the usage of energy in a household with controlled lighting. They found a 21.9% decrease in energy consumption. A shortcoming is a countdown timer that doesn't automatically adjust the lighting. Scholars Roisin and Bodart work to find which of the three control lighting systems is the most efficient. The shortcoming is that they use a simulation rather than physical testing and our project used real data by using an energy meter to measure the power of the lamp. Researcher Wang Fei looks to see the use of solar LED street lamps to save energy in China. The shortcoming is the time of day and the battery state that needs to be maintained. Our project improves on this one as ours are controlled by a motion sensor. This project allows for the user to have more control in the state of the lamp through the website buttons as well as changing the timer for the motion sensor to update based on activity status that the sensor is able to detect.

7.3 - Abstract (150 words)

An abstract for paper writing is a summary of the entire paper, including the introduction, methodology, experiments, and results. In your case, you're basically summarizing the entire paper from Sections 1 to 6, but in 150 words.

Discuss briefly the background to your problem that you're trying to solve. Then, provide a proposal on how you intend to solve this problem. Summarize the key technologies and components of your program. What challenges were there and how did you fix them? Discuss

how you applied your application to various scenarios during experimentation. Present the most important results that you found. Why is your idea ultimately something that people should use?

In recent years, environmental and technological concerns have rapidly approached, emphasizing the importance of energy consumption. The paper details the design and implementation of an motion detection based lamp system, capable of switching a lamp on and off based on predefined conditions, leading to significant energy savings. The project includes two way communication between devices, a user-friendly control interface, and an accurate way to save energy. Users can control their system through the application and specify the requirements to their likening. This application can help ease of life along with a reduced energy consumption. Careful testing has been done along with control cases to compare the findings and shows the amount of precision that must be used for intelligent control systems. The results show that automated lights or electronics can be extremely useful along with the ability to remotely control your devices with the application. This application is suitable for consumption and offers a great opportunity for those invested to save energy with minimal effort.

Section 8 - References (15-20 References)

If you've done a considerable amount of research prior to or while writing this paper, then you should already have the links for your sources. Cite in APA for this paper. If you already have the citations ready at this point, great! If not, assuming you consulted Google Scholar for your sources, each source page should have some area where you can copy an APA citation of it and paste it here. If you didn't consult Google Scholar (i.e. you have an article from a government resource or you're using a news article), then you can consult this website to help you generate them quickly. If you don't have your sources down at this point or haven't conducted research, then consult this video as an example on how to quickly allocate your sources. For each reference, place its number in brackets (for example, [2]). Note that the number that you place for each source doesn't reflect when you cite it in the paper. Please remember to go back to where you placed your inline citations to reflect its corresponding source number.

[1] Popp, D., Newell, R. G., & Jaffe, A. B. (2010). Energy, the environment, and technological change. *Handbook of the Economics of Innovation*, *2*, 873-937.
[2] B. K. Bose, "Global Warming: Energy, Environmental Pollution, and the Impact of Power Electronics," in *IEEE Industrial Electronics Magazine*, vol. 4, no. 1, pp. 6-17, March 2010, doi: 10.1109/MIE.2010.935860. keywords: {Global warming;Pollution;Power electronics;Energy consumption;Fossil fuels;Environmental factors;Sea level;Hurricanes;Tornadoes;Floods;Climate change},

[3] *Energy efficiency: Buildings and industry*. Energy.gov. (n.d.). https://www.energy.gov/eere/energy-efficiency-buildings-and-industry

[4] Dudin, M. N., Frolova, E. E., Protopopova, O. V., Mamedov, O., & Odintsov, S. V. (2019). Study of innovative technologies in the energy industry: nontraditional and renewable energy sources. *Entrepreneurship and Sustainability Issues*, *6*(4), 1704.

[5] Sarwary, M. H., & Pavlov, D. (2019, September). Energy efficiency and Economic aspects of Lighting. In 2019 Second Balkan Junior conference on Lighting (Balkan Light Junior) (pp. 1-5). IEEE.

[6] Dubois M-C, Blomsterberg A, "Energy saving potential and strategies for electric lighting in future North
European, low energy office buildings: A literature review", Energy Build, 2011; 43: 2572–82.

[7] Zhao, C., & Niu, S. (2012, March 8). Effects of household energy consumption on the environment and its influence factors in rural and urban areas. Energy Procedia. https://www.sciencedirect.com/science/article/pii/S1876610211044353?ref=pdf_download&fr=RR-2&rr=85c0535a9fc369c2

[8] Hollan, J. (2009). What is light pollution, and how do we quantify it. In Workshop paper at Darksky 2007 conference (pp. 1-12).

[9] Hölker, F., Moss, T., Griefahn, B., Kloas, W., Voigt, C. C., Henckel, D., ... & Tockner, K. (2010). The dark side of light: a transdisciplinary research agenda for light pollution policy. Ecology and Society, 15(4).

[10] Longcore, T., & Rich, C. (2004). Ecological light pollution. Frontiers in Ecology and the Environment, 2(4), 191-198.

[11] Wang, H., Nie, L., Li, J., Wang, Y., Wang, G., Wang, J., & Hao, Z. (2013). Characterization and assessment of volatile organic compounds (VOCs) emissions from typical industries. *Chinese Science Bulletin*, *58*, 724-730.

[12] Saving using intelligent lighting control system: https://www.researchgate.net/profile/Khairul-Wagiman/publication/325286877_Intelligent_Lighting_Control_System_for_Energy_Savings_in_Office_Building/links/5b518cefaca27217ffa68eb4/Intelligent-Lighting-Control-System-for-Energy-Savings-in-Office-Building.pdf

[13] Agatonovic-Kustrin, S., & Beresford, R. (2000). Basic concepts of artificial neural network (ANN) modeling and its application in pharmaceutical research. Journal of pharmaceutical and biomedical analysis, 22(5), 717-727.

[14] Byun, J., Hong, I., Lee, B., & Park, S. (2013). Intelligent household LED lighting system considering energy efficiency and user satisfaction. IEEE Transactions on Consumer Electronics, 59(1), 70-76.

[15] Roisin, B., Bodart, M., Deneyer, A., & D'herdt, P. (2008). Lighting energy savings in offices using different control systems and their real consumption. *Energy and buildings*, *40*(4), 514-523.
