Project Title

(Try to choose a catchy title. Max 20 words).

Be Alert with Smart Human Detection Technology!

Student/Team Information

Team Name: *Team # on Canvas:*	*Innovators* *Group 3*
Team member 1 *(Nakano, Yuta; SDSU ynakano7285@sdsu.edu):*	*Nakano, Yuta– ynakano7285@sdsu.edu* 
Team member 2 *(Mehdiyan, Aatusa; amehdiyan6298@sdsu.edu):*	*Mehdiyan, Aatusa – amehdiyan6298@sdsu.edu* 

ABSTRACT (15 points)

(Summarize your project (motivation, goals, system design and results). Max 300 words).

Our motivation for the project was to improve security and safety in various settings by developing a functional system that could detect the presence of intruders. We also wanted to challenge ourselves with this project as we did not have any prior knowledge of using a microcontroller and other hardwares. It was important for us to accomplish this task. Further, we aimed to develop a cost-effective, easy-to-install, and efficient intruder detection system using an ESP32 microcontroller board, a PIR motion sensor, and a microphone. The system is capable of detecting both motion and sound and sends the data to the ThingSpeak, a cloud-based platform for data analytics and visualization, via Wi-Fi for remote monitoring. ThingSpeak then sends an email notification including the time and date of the intrusion to alert the user. The results of the project demonstrated the effectiveness of the system in detecting intrusions with good accuracy and providing real-time alerts to users. Overall, this project showcased the potential of combining hardware and software components to develop innovative solutions to real-world problems.

INTRODUCTION (15 pts)

Motivation/Background (3 pts)

(Describe the problem you want to solve and why it is important. Max 300 words).

Security is an essential component of existence and a basic human need. Individuals and the community as a whole must feel safe and secure in order to thrive. Our goal is to create a trustworthy, cost-effective home security system that can identify intruders and notify homeowners in real-time. When an intrusion is detected, our system will use sensors to detect movement and sound and will send an alert. Creating an efficient home security system is crucial not only for personal safety but also for peace of mind. Homeowners can rest easy knowing that their homes are secure, and they will be immediately alerted in case of any breach. Therefore, ensuring the safety and well-being of individuals and communities.

Project Goals (6 pts)

(Describe the project general goals. Max 200 words).

The overall objective of the project is to develop and put into use a wireless Internet of Things system that can detect motion and sound and notify the user when both occur. The device can be installed in a room to serve as an intruder detection system and alert users to any unusual activities. The system is created to be inexpensive and simple to set up, making it available to a variety of users. By using a simple LED to indicate when sound and motion have been detected, users can easily understand when the system has been triggered. Additionally, by sending the data to a cloud service, the system allows users to remotely monitor noise levels and motion detection, enabling them to control and manage noise levels in their environment more effectively.

Assumptions (3 pts)

(Describe the assumptions (if any) you are making to solve the problem. Max 180 words).

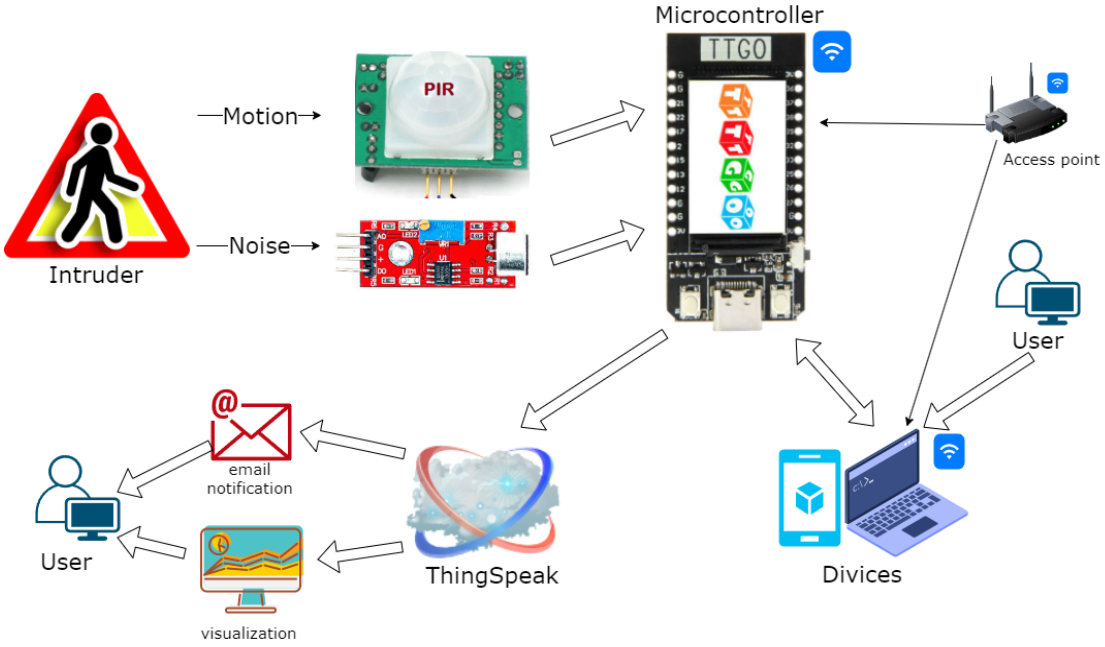
To solve the problem of intruder detection, we are making the following assumptions. The system is being installed in a closed and secure environment where only authorized people are allowed. The intruder will produce sound and motion, which can be detected by the system's sensors and the sound produced by the intruder is above the ambient noise level, which can be determined by calibrating the microphone. The user has access to the internet and can receive the alerts in a timely manner. These assumptions form the basis of our approach to solving the problem of intruder detection.

SYSTEM ARCHITECTURE (20 pts)

(Describe the final architecture you have implemented listing sensors, communication protocols (Wi-Fi, BLE, ...), cloud services and user interfaces. Include a block diagram of the system. Max 300 words).

The architecture implemented is a wireless IoT system that detects sound and motion, and sends the data to ThingSpeak cloud service using Wi-Fi protocol for storage and analysis. The system consists of a ESP32 microcontroller, a microphone, a motion sensor, an LED, and a Wi-Fi module, which are connected to each other as shown in the block diagram below. The microphone is connected to one of the ESP32's analog inputs, while the motion sensor is connected to one of its digital inputs. The ESP32's digital output is used to control the LED. The ESP32 is also equipped with a Wi-Fi module that connects to a local Wi-Fi network. When the system starts, it connects to the Wi-Fi network using the Wi-Fi module. The ESP32 then calibrates the microphone by measuring the maximum value of its output during a calibration period. The calibrated value is used to set a threshold for sound detection. The ESP32 then starts a loop that runs for 60 seconds, during which it checks the microphone and motion sensor outputs. The microphone output is compared to the threshold value, and if it exceeds the threshold, the ESP32 turns on the LED and counts the number of detections. At the end of the loop, the ESP32 sends the number of detections and the maximum sound level to ThingSpeak cloud service using the Wi-Fi protocol. Additionally, the system sends an email notification as soon as the HTTP request has been completed. ThingSpeak stores and analyzes the data, and allows users to visualize it. .

Example block diagram:



FINAL LIST OF HARDWARE COMPONENTS (5 pts)

(Write the final list and quantity of the components you have included in your system)

Component/part	Quantity
ESP32	*1*
Jumper Wires	*10*
PIR Motion Sensor	*1*
KY-037 4pin Voice Sound Detection Sensor	*1*
LED	*1*
Resistor (10K ohm)	*1*

Micro USB cable	*1*
Breadboard	*1*
Laptop	*1*

PROJECT IMPLEMENTATION (30 PTS)

Tasks/Milestones Completed (15 pts)

(Describe the main tasks that you have completed in this project. Max 250 words).

Task Completed	**Team Member**
In our group project, I focused on completing the code for the ESP32 microcontroller board. I connected the board to a WiFi network, calibrated the microphone, and detected motion using the motion sensor. I also read the microphone's output and sent the data to ThingSpeak for monitoring and further processing. Throughout the process, I examined various pins and parameters used in the code, such as the pins for the motion sensor, LED, and microphone, and adjusted the sensitivity of the microphone and calibration time. I ensured the code's functionality by connecting an ESP32 board to a motion sensor and a microphone and monitoring the data sent to ThingSpeak. Additionally, I provided suggestions for improving the code's performance, such as adding error handling.	Yuta
As part of our group project, I worked on tasks involving ThingSpeak and MATLAB. I also helped Yuta troubleshoot other tasks like connecting thingSpeak. Further, One task was to create a 2-D line plot with y-axes on both left and right sides using MATLAB's "plotyy" function. This plot helped visualize the two different types of data collected from the ESP32 board. I also compared motion and noise data from three different days, retrieved from ThingSpeak, and used MATLAB's built-in plotting functions to create a side-by-side graph displaying the data. Another task was to create a noise vs motion scatter plot, which involved retrieving both the noise and motion data from ThingSpeak and using MATLAB's "scatter" function to plot the data points. Through these tasks, I gained insight into the powerful data collection and analysis capabilities of ThingSpeak and MATLAB.	Aatusa

Challenges/Roadblocks (5 pts)

(Describe the challenges that you have faced and how you solved them if that is the case. Max 300 words).

During the development of the project, we encountered a number of challenges that we had to overcome. One of the main challenges was connecting to ThingSpeak, as we did not have prior experience with it. We had to spend a lot of time learning how to properly connect to the cloud, and how to implement HTTP requests to post collected data to the ThingSpeak cloud. We found that the documentation provided by ThingSpeak was very helpful in understanding the API and how to use it. Additionally, we applied error handling in the code to ensure that the program could handle any errors that may occur while sending data to the ThingSpeak cloud.
Another challenge that we faced was calibrating the microphone. We represented the calibration as a percentage, but was not sure if this was the best way to do it. We found that some experts suggest using a decibel meter to calibrate the microphone. However, we found that this was not practical for our project, as we wanted to keep it simple and easy to use. We decided to use a percentage-based calibration method, and implemented a calibration function that reads the maximum value of the microphone output over a specified calibration time. We also included a feature that allows the user to adjust the calibration time, in case they need to make any adjustments.
Overall, we could overcome these challenges. We found that it was important to read the documentation and seek out information from reliable sources in order to find the best solutions. Additionally, we found that implementing error handling in the code was essential to ensuring that the program could handle any errors that may occur while sending data to the ThingSpeak cloud.

Tasks Not Completed (5 pts)

(Describe the tasks that you originally planned to complete but were not completed. If all tasks were completed, state so. Max 250 words).

Task	**Reason**
Adding buzzer as an alert	All the tasks that we had initially planned were completed successfully. However, one of the tasks that we had initially planned was to add a buzzer as an alert to the system. The idea was to have the buzzer sound an alarm whenever the noise level exceeded a certain threshold. However, we decided against this because the system was already using a microphone to detect the noise level, and adding a buzzer would have added unnecessary complexity to the system. We also considered the fact that adding a buzzer would have required an additional component and wiring, which would have made the system more difficult to assemble and troubleshoot. Additionally, we felt that using the LED to indicate noise levels was sufficient for our purposes. Overall, we were satisfied with the final design of the system, and we felt that it met our objectives effectively. While we did not include a buzzer as originally planned, we were able to implement all the other features and functionality that we had set out to achieve.

WEAK POINTS / FUTURE WORK (15 pts)

(Mention at least two points of your project that have room for improvement. These points can be additions to the existing project setup (components) or improvement of the current implementation. Max 200 words).

The limitations of the current system provide opportunities for further development and improvement. One of the primary limitations is the minimum interval of 5 seconds for the PIR sensor. This duration results in the system freezing for that time, which could be an issue in critical situations where a fast response time is required. The responsiveness of the system could be improved by exploring better PIR sensors that allow for a shorter interval and faster response times. This could involve researching and testing various PIR sensors to identify the best fit for the system's requirements. Another weakness of the current system is the limited accuracy of the microphone. The accuracy issues could be attributed to scaling issues, where the microphone's output is not accurately scaled to the 0-100 scale. Refining the scaling technique could improve the accuracy of audio input and enhance the overall performance of the system. One approach could be to calibrate the microphone in a more precise manner and optimize the scaling technique to obtain better results.
Overall, by addressing the limitations of the current system and identifying opportunities for improvement, we demonstrate a proactive approach to enhancing the system's performance. Continuous improvement is essential to ensure that the system can be used effectively in real-world scenarios and improve the security and safety of individuals and their property.

SOURCE CODE (25 pts)

Please include a link to the source code of your project. A link to a repository (like GitHub) is preferred.

https://github.com/no4paragon/CS549Iot-finalProject