Senior Design
ENG EC464

Occusense Second Deliverable Test Report

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From: Occusense ECE Senior Design Team
Team: Occusense: Team 11
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Subject: Second Deliverable Test Report

1.0 Project Objective

The overall objective of this project is to create a real-time, accurate and reliable sensor system that determines the occupancy of a room. With this information, air circulation in HVAC (Heating Ventilation & Air Circulation) systems can be adjusted according to the number of people in the room. This will not only save energy but provide useful feedback regarding current and past room usage.

2.0 Test Objective and Significance

2.1 The goal of this test is to verify that all of the subparts of the Occusense sensor system are able to interact with each other. In other words, we aim to validate the connectivity of the sensing system, web server, and web user application to each other. Basically, we will demonstrate that we are able to push data gathered by the MLX90621 thermal sensor to a Firebase Server where the real-time data will be stored and made viewable on our Firebase hosted web application.

2.2 The significance of this test is to show that we are able to successfully push data from the thermal sensing system to the Firebase web server where the data will be stored and finally pushed to the web application in real time. This is a vital step in the project design process because once we are able to validate that the connectivity of all of the parts we can focus on the robust machine learning algorithm used to accurately detect and identify people walking in and out of the room to keep a precise people count. We will also be able to build upon and improve the parts that are already in place.

3.0 Setup and Equipment

3.1 The test setup is displayed in Figure 1. This test utilizes an MLX90621 thermal sensor, Arduino Mega 2560, Raspberry Pi, PIR sensor and Firebase hosted database and web application.

3.1.1

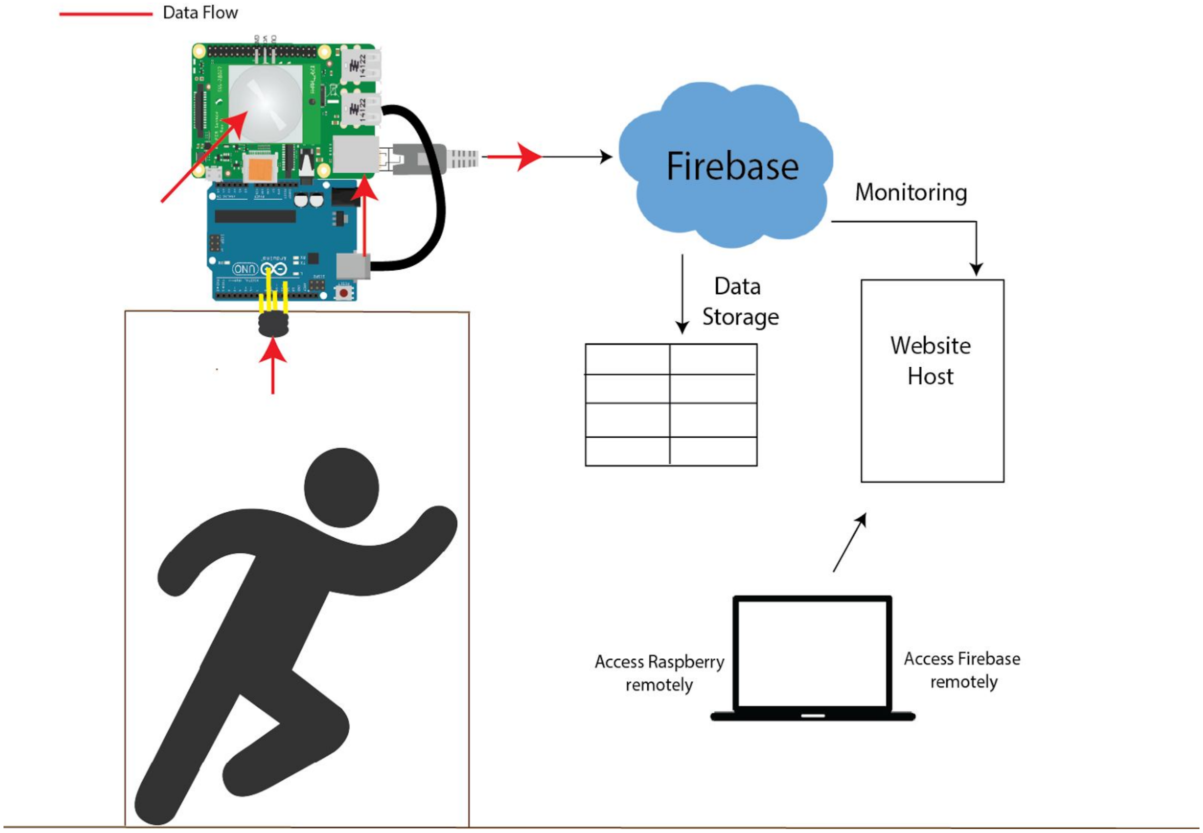


Figure 1: This diagram shows all the equipment setup and the red lines symbolize the flow of data of the integrated system. The input data comes from the thermal sensor and the PIR sensor which is then processed and displayed in the website host.

3.2 MLX90621 Thermal Sensor

The MLX90621 contains 64 IR pixels (as a 16x4 array) that detects objects moving in front of the sensor and a PTAT (Proportional to Absolute Temperature) sensor to measure the ambient temperature of the chip. The outputs of these sensors are stored in an internal RAM and can be accessed via I^2C. This process begins by reading the EEPROM calibration data that is used to prep the thermal sensor data points to be processed into ambient temperature (Ta) readings. The measurement data (PTAT and IR readings) stored in the internal ram of the sensor is used to calculate the Ta values of the thermopile array.

3.3 Arduino Mega 2560

The Arduino Mega 2560, connected to the thermal sensor and computer, is used to process the data signals from the sensor using I^2C and transmit the thermal data to the Raspberry Pi. The arduino is a microcontroller with 54 digital I/O pins, 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator and a USB connection.

3.4 Raspberry Pi

For this test, The Raspberry Pi's role is to house the Python server client program that initiates the thermal data transfer from the Raspberry Pi to the Firebase web server. We utilize the ability of the Raspberry Pi to connect to ethernet in order to act as the connection between the Arduino Mega that is actively processing the thermal data and the Firebase database that will store the real-time data. As we have it now, the Raspberry Pi is sending mock data to web server to prove that we have successfully connected the two pieces, but this is where we will eventually have our machine learning algorithm that will accurately detect the occupancy of the room.

3.5 PIR reset sensor

The Parallax wide angle PIR sensor has an 180º field of view and a 9m range, which makes it ideal to cover a big enough area around the door to accurately estimate when the room is empty. Its operation is simple, the output pin is high when it detects motion and low when it does not. Our reset system is based on the interval of time that the sensor does not sense any motion. If the sensor does not detect any motion in over three to four hours we can assume that the room is empty and send push a reset to the web server to update the count. This is very important since error can accumulate when the counting is based on a plus one, minus one basis.

3.6 Firebase Web Server

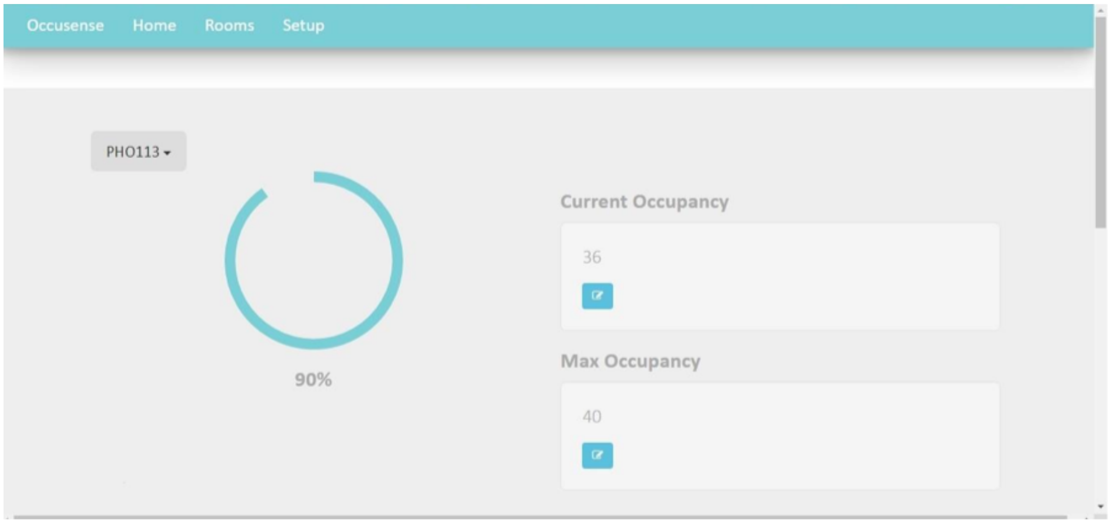
3.6.1 Real-time Database

The Firebase database is used to store the real-time and historical occupancy data for the specific room. So far the database stores three pieces of information per measurement: date, time, and value. The date and time of the measurement will be used to analyze the occupancy data historically. From this data we should be able to infer what days and times of days the room is most busy and adjust the power usage of our system accordingly. The value portion of the data is most directly used to update the real-time occupancy of the room. The value field will come in as a +1 or -1 and will keep a running total of the occupancy of the room for the client.

3.6.2 Web Application

The web application will house the web user interface for the Occusense sensing system.

Here, the client will be able to login and access the real-time and historical occupancy data of a specified room. This web application is housed on the Firebase web server and will draw the real-time and historical data directly from the real-time database also housed on the Firebase web server.



Current Occupancy

36

Max Occupancy

40

4.0 Measurements and Data

4.1 Thermal Array (grayscale)

The way we determine the count of people is based on the running average of the temperatures in the thermal array. If the average temperature in one frame is significantly bigger than the running average we can say that someone went through the door. We applied a dynamic threshold. Here are two snapshots of the thermal arrays when there is someone in the frame and when there is not.

Figure 2: Thermal array when there is no one in the frame.

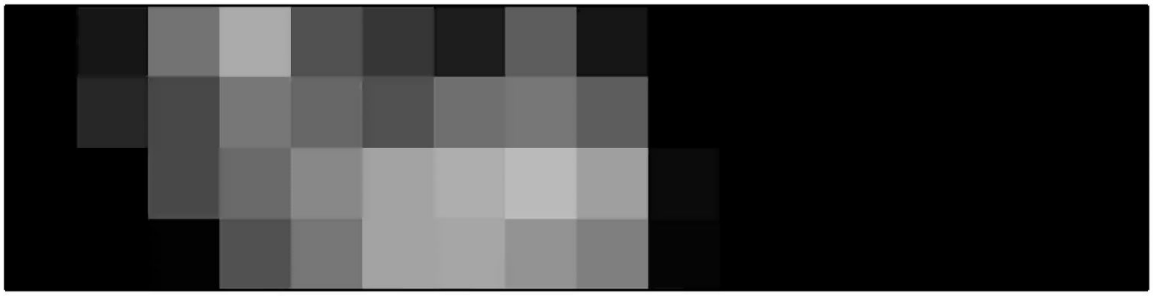


Figure 3: Person in the frame walking out of the room.

We have switched the color heatmap to grayscale to better identify how different the temperatures are relative to each other, since colors can be misleading. Clearly though, it is easy to identify when a person is there and we did successfully achieve that in real time during the testing. The next step is getting the direction of the people going in or out but we now have a good way to differentiate a background frame to a frame with a person in it.

4.2 Client Server Program

The client server program does not directly measure any data but only listens. When the algorithm detects a person it would send a plus one to the database of the server with a json dump. The web server and the database are then linked to each other so that the web graphical user interface updates in real time to show the current count.

5.0 Conclusions

5.1 We are able to demonstrate the we have a fully connected functional system. We are able to collect data using the MLX90621 thermal sensor and push the data to a Firebase web server where it is stored in a real-time database and update on a Firebase-hosted web application.

5.2 Future plans and Summary

Since we are able to demonstrate that all of the parts that make up the Occusense sensing system are connected and functional we can focus on the machine learning algorithm and more intricate parts of the project. We plan on spending the bulk of our remaining time working with our clients to come up with the most accurate machine learning algorithm possible to keep track of the occupancy of a given room in real time. This will involve collecting numerous data sets of possible cases of people walking in and out of a doorway. Once we have a sufficient amount of meaningful, usable data we can begin parsing through the robust algorithm that will drive our system. We also plan on making the casing for the Occusense sensor system using the resources found in the EPIC lab. Other aspects of the project that we plan on working on is interfacing a magnetic sensor that will monitor when the door is open or closed. Both of these features will go towards making our system as energy efficient as possible. In conclusion, now that we have the basic functionality of the system up and running we will now build and improve on the system to meet the final requirements of the project.