Yara Hanafi
Research Paper
Faculty Mentor: Jorge Ortiz
Lab Members Project : Shantanu Laghate, Murtadha Aldeer

SmartBox

Abstract

This project builds a hardware prototype referred to as the smartbox that will enable data collection, storage, visualisation, and user input for labels. The project consists of a hardware and software aspect. The device will be placed in buildings and act as a sensor to measure data from the surroundings. Many boxes would be placed around the building and record data simultaneously. The data is sent directly to a database and uses the SmartDash web application to analyse the data by the user selecting parts of the data and custom label the specific piece of data. The classification process will be the foundation used to implement active learning methodologies to build a smart device. With the implementation of the smartbox project it will be able to detect and analyse stimulus without the user interface. Global energy consumption in buildings is estimated to be 35-40% of total energy generation and this is expected to rise further [1]. So it's significantly important to find ways to save energy in buildings. In a large scale implementation the smartbox can be used in buildings to address energy efficiency issues [2]. The device will be able to detect it's environment and alter the heater and fan to lower energy consumption and keep the individuals present in the environment comfortable.

Introduction

There are two aspects to be built in the implementation of the smartbox. The software part that'll be responsible for managing the analysis and record of data and the hardware part that'll measure and send data to the software program. The first aspect to look at is the sensors in the box to be used in the data collection process. These sensors will merely record data and send it to the database for

storage. These sensors should also be privacy sensitive as the box would be placed in rooms. So sensors that are small in size and can give information like the camera or microphone was used. For data storage a NoSQL database was used to allow for a fast storing process as it's less time consuming and suitable for large amounts of data. The second aspect is the data visualization and user custom labels. The SmartDash is used to accomplish the task.It's a web based platform that provides an easy interface for the user to stream the data and start the classification of data process through labeling the pieces of incoming data from the sensors with their appropriate action. The incoming data will provide a large amount of synchronized data at each moment in time. All these sensors work to detect changes in stimulus with time and feed the information to the SmartDash. With the user manually interpreting the data these labels can be used as the bases of implementing an active learning algorithm to achieve a smart device that can interpret and analyse data on it's own. The first step to implement the SmartBox project.

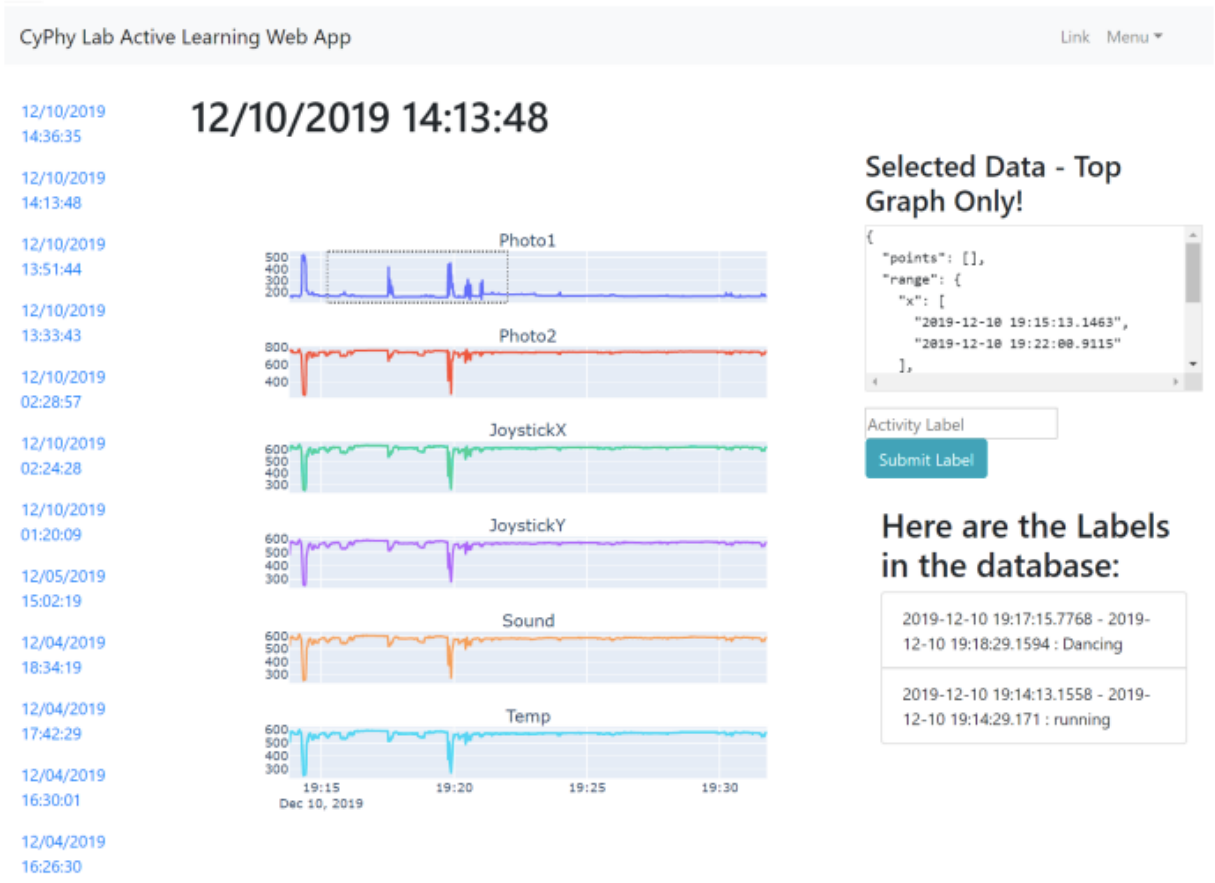
Methods

The first step was building the SmartBox hardware. The Box acted as a sense-and-send microcontroller board, that collects data from the sensors and send it to the database. One of the sensors used was a passive Infrared sensor that uses infrared to measure data related to the detection of movement. Another sensor used was a magnetometer that is used to detect changes in magnetic fields in the surrounding areas. Also a 6-Axis Gyroscope Accelerometer sensor, Color and Illumination sensor, Audio sensor, Temperature/Barometer/Humidity sensor, GeoPhone sensor that detects levels of vibration and a WiFi Transciever so that the smartBoxes can send WiFi signals. The Box is still at its initial phase so the implementation of a working box was prioritised over box size and compatibility. All sensors are sampled at a 1-second interval and every 10 seconds a node of data is compiled and uploaded to the database. The SmartDash was implemented that allow the

user to select which time frame of data present they wish to label. The labels are then stored in a database with the timing of when the data was being detected and will be later used in active learning implementation. The SmartDash was built using Dash, Plotly, and Python that allowed easy programming.

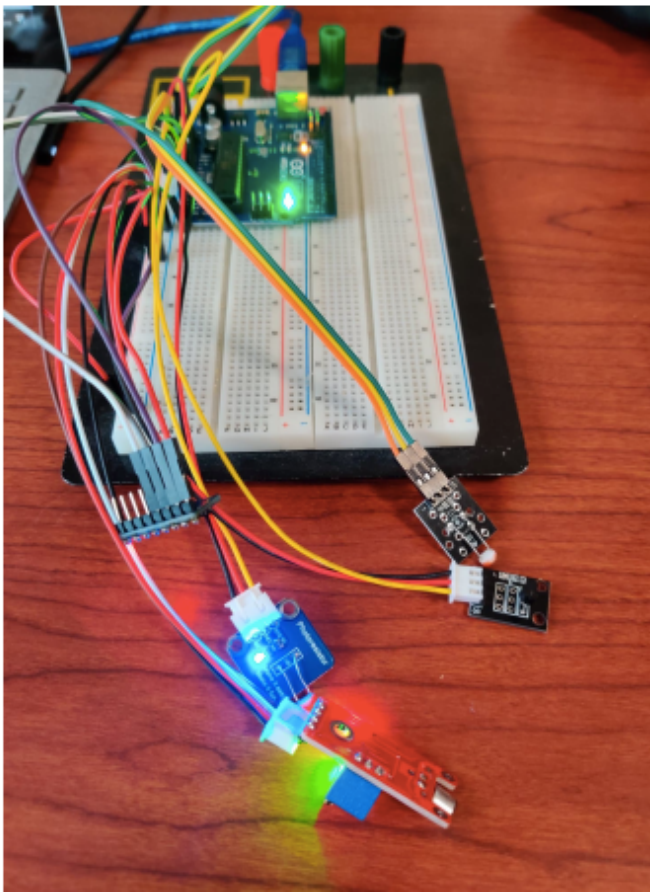
Results

Results was both achieved in the hardware and software aspect with the implementation of the SmartBox. The SmartDash Web platform was the software implemented that analysed the data and distributed the data based on it's label made by the user.



On the left are all the timings for the data collected that can be viewed. If data is selected then it is retrieved from the database and plotted. The gray box on the first plot is an example of the easy markup feature, and the details of the selection are shown in the right 'Selected Data' box. The user

is then able to type a label and submit it to the database. On the bottom right, a list of all the existing labels is displayed. [3]



The SmartBox Hardware was built that consisted of a board with sensors attached to it. The prototype includes a configuration feature that allows the user to specify what sensors are plugged into the SmartBox. The sensors work with the Arduino microcontroller, connected to a Raspberry Pi for wifi and database access. In the future, the hardware will be miniaturize to allow it to plug directly into a wall outlet. The prototype worked effectively but was too inconvenient to be used as many boxes placed around the building. They needed to be a smaller version so they can be placed everywhere without causing inconvenience. [4]

Discussion

Questions to be asked as the building and testing of the SmartBox is implemented is how to achieve maximum efficiency with this system while using the least resources. In order to implement

the SmartBox in a larger scale around the building we need to develop a prototype of an hardware that is east to manufacture and a software that is effective in comprehending large amounts of data. The testing and trail of building the SmartBox will show us the most effective prototype that can be used in a wider skill.

Future Directions

In the future work the SmartBox data collection should be tested by placing the box in a faculty office and collecting data to be used for the active learning algorithm. By testing the box with real data we can effectively evaluate if the box is functioning properly to fulfil it's purpose. The second step is to develop a more efficient SmartDash to process more data. With a stronger and easy to use software the process of data labelling will be faster and more convenient. The third step is to work on implementing an active learning software using classified data from different experiments. As with the successful implantation of the active learning loop we can further start developing the smart boxes and placing them around the building to implement a system that controls energy usage levels.

References

[1] Energy outlook 2010. Energy Information Administration. [Online]

[2] Shantanu Laghate, "SmartBox: A Full Stack Framework for Data Collection and Active Learning", Page 6, Feb 2020

[3] Shantanu Laghate, "SmartBox: A Full Stack Framework for Data Collection and Active Learning", Page 4, Feb 2020

[4] Shantanu Laghate, "SmartBox: A Full Stack Framework for Data Collection and Active Learning", Page 2, Feb 2020