Design Practicum (IC 210P)

Grain-eSense

Group : 8

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Abstract

To monitor the quality and quantity of food grains we have developed a prototype Grain-eSense that can be very useful in reducing the spoilage of food grains. At first we used the standard neural network with ADAM optimizer of batch size 4. Grain-eSense checks the amount of spoilage of grains by monitoring the gas emission level, humidity level, and temperature of wheat and grains. A screen notice that displays information on the grain's condition and freshness also provides the information about the degree of decomposition. The model used turned out to have a good accuracy rate. This prototype could have a greater future scope as in the near future we might face scarcity of food and there might be a greater need to prevent food from spoilage.

Introduction

Studies are being conducted to find new solutions to lessen food waste, which has become a matter of concern in recent years. It has been labeled as a significant issue for the long-term viability of the food supply, demand, and production chains. Meals have always been in great demand since they are the primary source of nutrition for all living things.

By measuring and monitoring the condition of the food and exchanging data with and from consumers, the Internet of Things (IoT), may be used to improve FSC management.

All types of food have a threshold value for heat, humidity, moisture, temperature, and oxygen content. When the threshold value is exceeded, food spoilage begins. Thus our prototype Grain-eSense helps in providing the complete dataset of the quality of the food and it also specifies the quantity of food. This could be of greater use to prevent the food from getting spoiled.

Statistics about wheat grain wastage

The Food Corporation of India (FCI) is a government body which runs the storage units that forms the backbone of India's extremely critical food security programme. According to the press release by the Ministry of consumer affairs, food and public distribution 0.02 lakh tonnes of grains are wasted in FCI godowns alone which doesn't include the damage caused in godowns other than FCI. The significant loss of food grains purchased by the government at a minimum support price (MSP) that are either rat-infested, sodden by rain, or some other type of loss.

Year	Quantity of damaged food (in lakh tonnes)
2017-18	0.027
2018-19	0.05
2019-20	0.02

Posted on 20 SEP 2020 by PIB Delhi, data about food wastage in FCI storage godowns.

According to data released by the Ministry of consumer affairs over 1550 tonnes of food grains were wasted during covid-19 induced lockdown period in April and May in Food corporation of India (FCI) storage godown. 26 tonnes of food were damaged in may and over 1453 tonnes were damaged in June. In 2019-20, the government purchased 75.17 million tonnes of foodgrains, out of which only 1930 tonnes were wasted, which is 0.002% of the total procurement. Similarly, the wastage for 2017-18 and 2018-19 was 0.003% and 0.006% respectively.

Beyond claims and challenges, India wastes a large amount of farm produce. The government cites low wastage at FCI godowns to counter charges but the challenge is deeper and wider than just FCI godowns. ICAR conducted surveys and presented their data in the parliament. The study calculated the economical value of harvest and post-harvest losses of major farm produce and the annual estimated losses were about Rs 92651 crores. The United Nations Food and Agriculture Organization (FAO) estimates that more than 40 per cent of food produced is wasted in India, and its costs could be as high as US$14 billion (111,780 crores) every year.

Implementation Details

Our work was majorly divided into two parts:

- ➢ Electronic devices Configuration or Circuit Designing
- ➢ Software part (Machine learning & App development)

Circuit Design Implementation -

In this work we have to develop two circuits, one for quantitative analysis and another for qualitative analysis.

1. **Circuit Design for qualitative analysis:**

   Circuit Composed of :

   A. BME 688 sensors
   B. Adafruit Huzzah32 feather board with ESP32 MCU
   C. Bosch Application board or shuttle board
   D. Micro SD card for data storage
   E. Coin cell battery (CR1220)

Details of the elements:-

- *BME 688 sensor :*

BME 688 is the sensor with high-linearity and high-accuracy pressure, humidity and temperature sensors. It is housed in a robust yet compact 3.0 × 3.0 × 0.9 mm^3 package. The gas sensor can detect Volatile Organic Compounds (VOCs), volatile sulfur compounds (VSCs) and other gasses such as carbon monoxide and hydrogen in part per billion (ppb) range.

- *Adafruit Huzzah32 feather board :*

ESP32 is capable of functioning reliably in industrial environments, with an operating temperature ranging from – 40°C to +125°C. Engineered for mobile devices, wearable electronics and IoT applications, ESP32 achieves ultra-low power consumption with a combination of several types of proprietary software. ESP32 also includes state-of-the-art features, such as fine-grained clock gating, various power modes and dynamic power scaling. ESP32 is highly-integrated with in-built antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules.ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI / SDIO or I2C / UART interfaces.

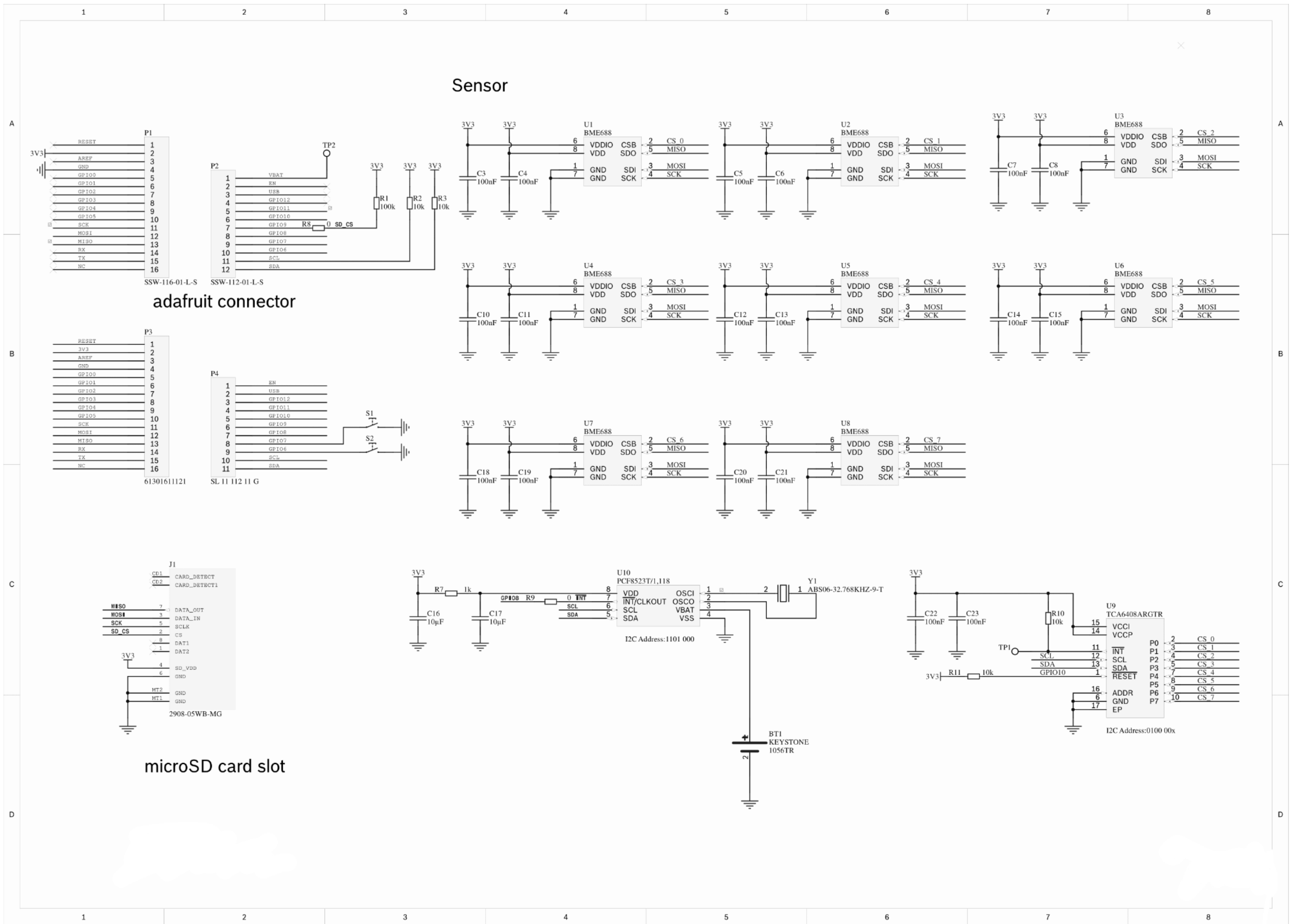

Figure : whole assembly of sensor for the qualitative analysis

There are a total 8 sensors in the circuit. By featuring eight sensors, the board allows us to test and gather data with more than one configuration at the same time. This significantly increases statistics and reduces development time as well.

***Note -** We have used open source software for the configuration of sensor and Huzzah feather board provided by Bosch.

Github link to sensor API - https://github.com/BoschSensortec/BME68x-Sensor-API
More details regarding sensor can be found at - Link

- **Steps to configure the whole system:**

1. Download the open source software from **Configuration Software**
2. Copy *.bmeconfig file on microSD card

3. Place the microSD card and CR1220 coin cell into the Application board and stack it on the Adafruit board.
4. Download & install USB driver from - **Link**
5. Connect the board to PC via micro-USB data cable.
6. Run "flash.bat" on PC by choosing the right COM port.

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2. **Circuit design for quantitative analysis:** The circuit design for this part is quite simple. In this our main work was to get a Grid of 3.0 × 3.0 × 3.0 dimension so that we can get the whole volume of quantity and division of this number with the volume of a single packet we will get the quantity.
   Circuit Composed of :
   A. HC-SR04
   B. Arduino Uno R3
   C. Breadboard (As usual :D)

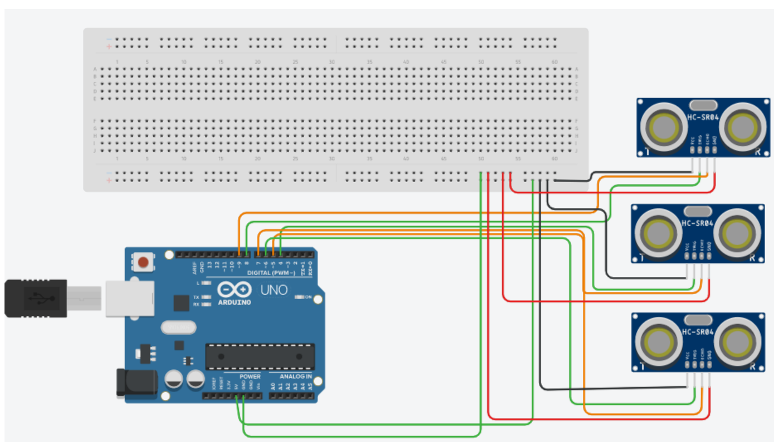


Figure : Circuit diagram for determining the quantity

***Note :** We are making the assumption that labor starts filling the godown from corners with the sags of wheat. Also, as it is a simple and quick approach there will be some approximation so the error ± 1-2.

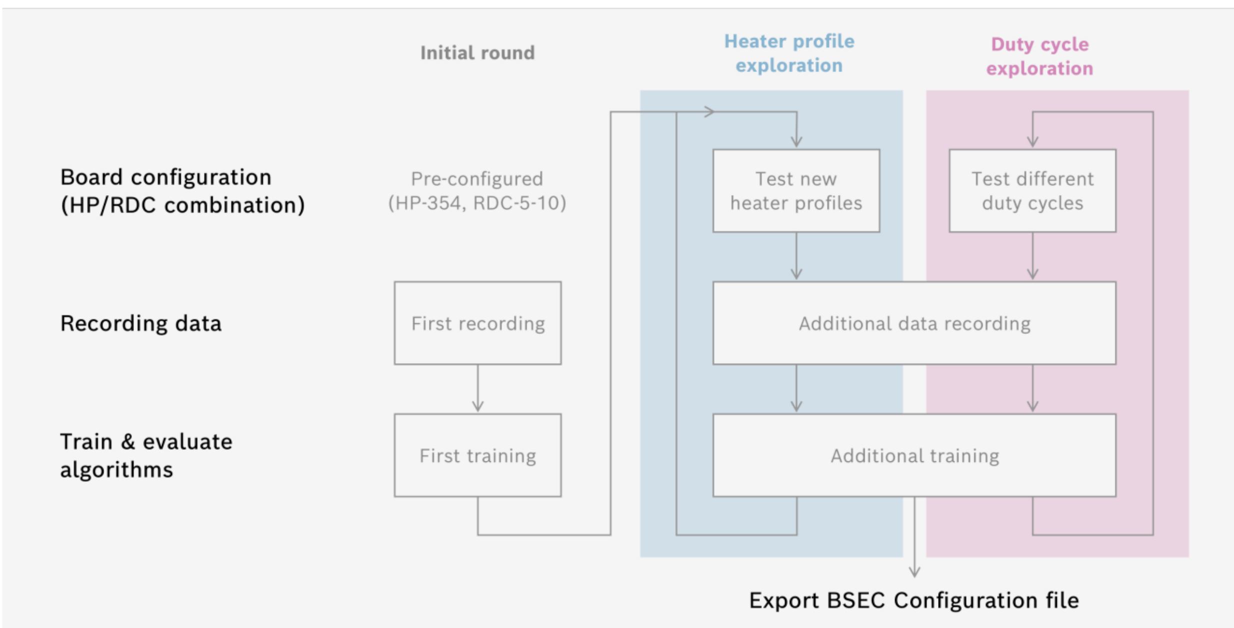
Machine Learning -

For the machine learning part, The BME AI-Studio (***Open source***) brings together our BME Board x8 (equipped with BME 688 sensor) and BSEC software. With the application, we can

collect gas measurements, train machine learning algorithms and export a final algorithm to be used with the BSEC Software.
Our board is configured at default configuration (HP-354/ RDC-5-10) where HP stands for heater profile and RDC stands for Duty cycle.

We can choose, which Data Channel of each specimen should be part of training:

- ➢ Gas Data Channel (10 data points)
- ➢ Humidity Data hannel (1 data point)
- ➢ Temperature Data Channel (1 data point)
- ➢ Barometric Pressure Data Channel (1 data point)



**For our work we have used Gas Data Channel & Humidity Channel only.*

For our training purposes we have used **ADAM optimizer** , batch size 4 or 16 depending on the output confusion matrix or accuracy & F1 score.

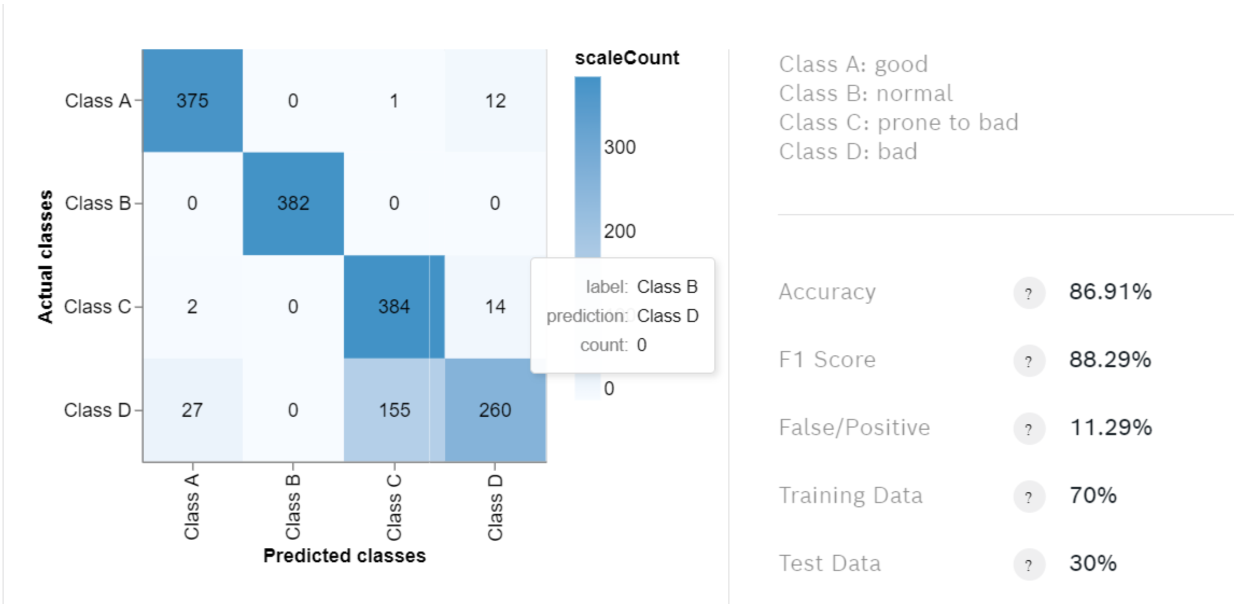


Figure : Results for 4 Class classification

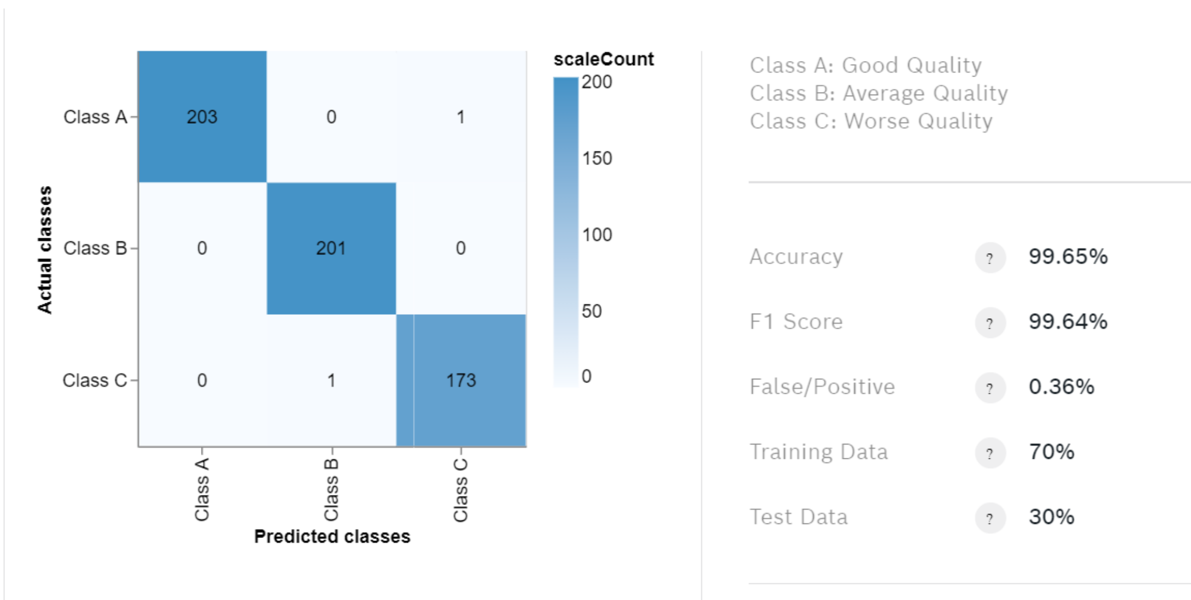


Figure : Results for 3 Class classification

Duty Cycles ? 2 Duty Cycles selected **Show Duty Cycle Profiles**

Duty Cycle	Scanning cycles	Sleeping cycles
RDC-1-0 Continuous	1	0
RDC-5-10	5	10

Figure : Duty Cycles

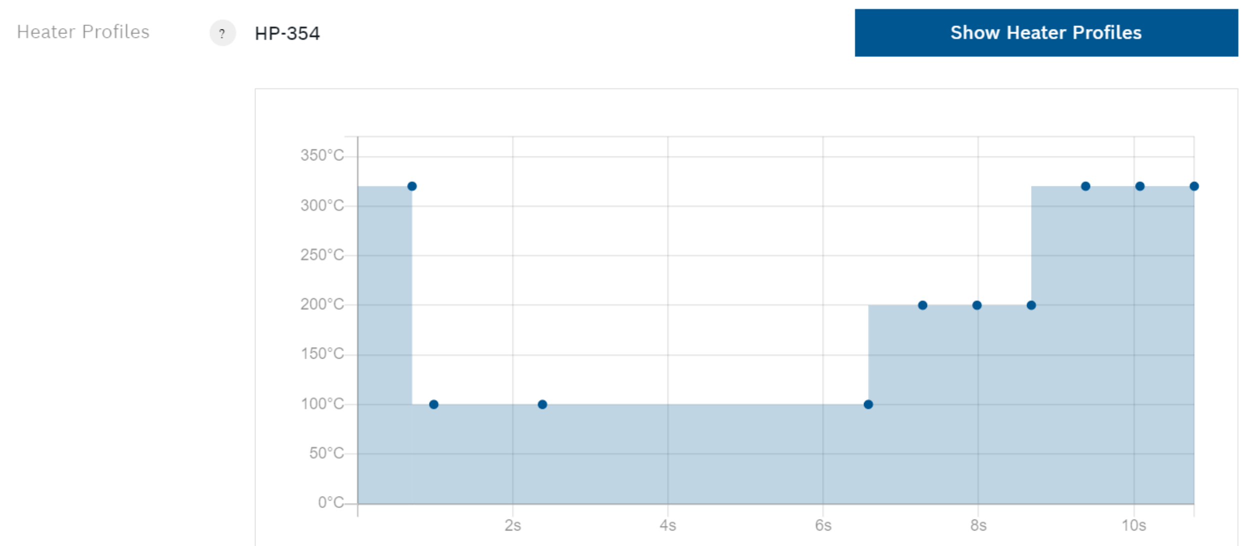


Figure : Heater Profiles

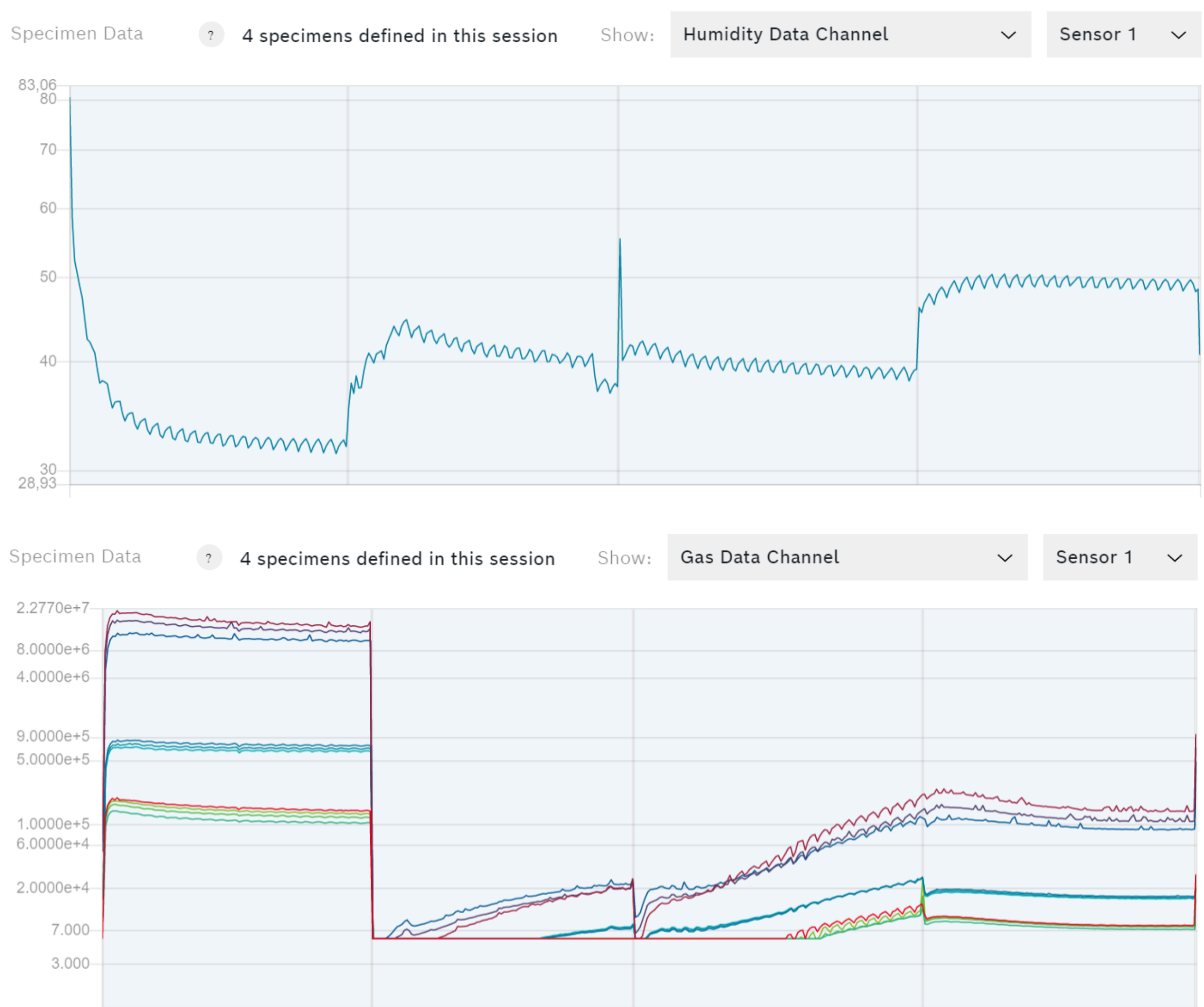


Figure : Representation of data for 4 classes of classification

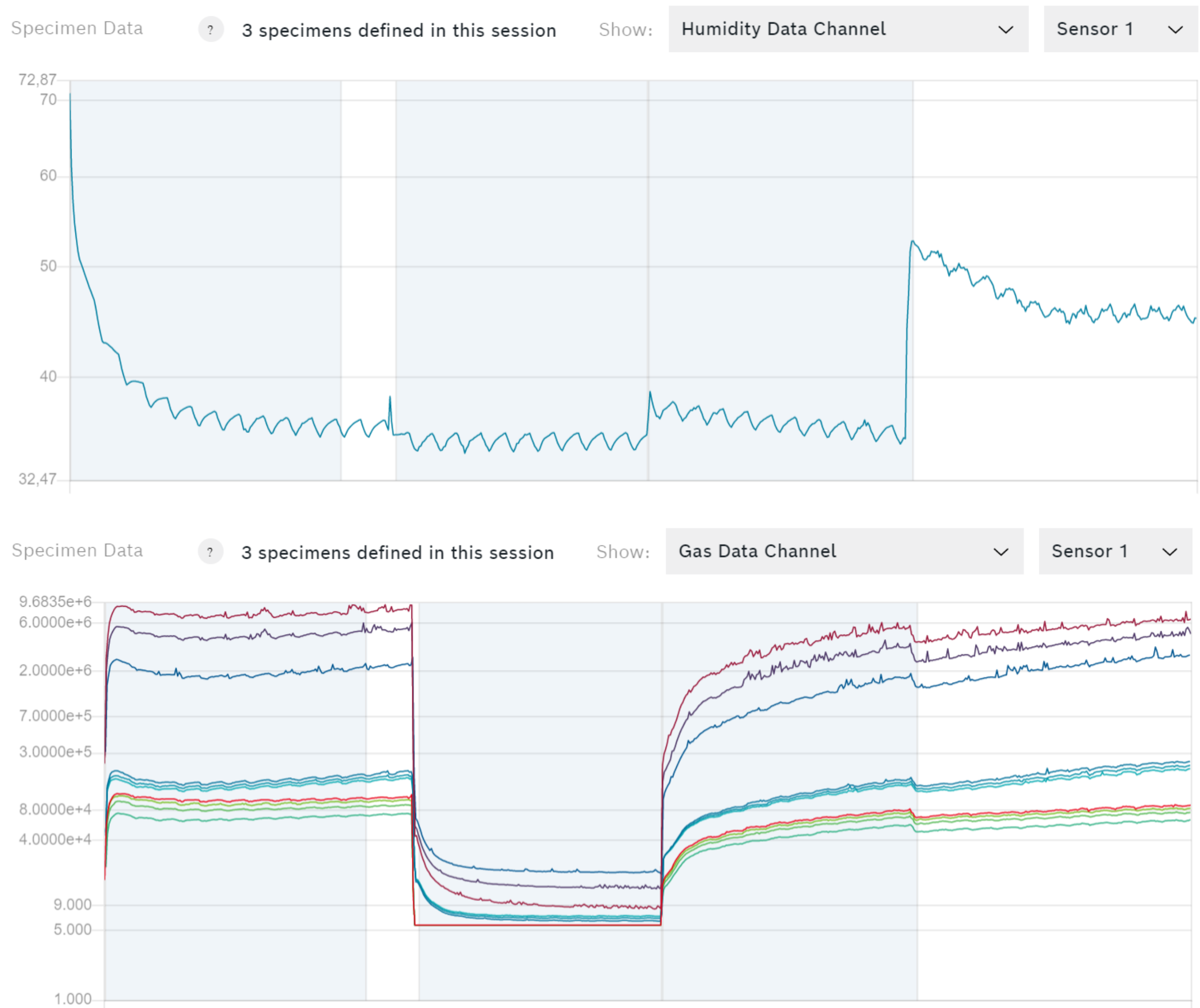


Figure : Representation of data for 3 classes of classification

3.2 Mobile & Web Application :

The mobile application (SensorReading) has been made using flutter and android studio, the main purpose of this application is to display the sensor reading in real time. The app is developed in android studio using flutter.
It uses the Bluetooth module to receive the data with a negligible latency of around 8 ms. The home screen displays the four parameters of the air in the sample i.e humidity, gas resistance, etc. Majority of the languages used to code the app are Kotlin and java. The frontend was made in kotlin. Layout was divided into three different sections,

a) Graphs
b) Background
c) Data

Protobuf compiler of google was used to make serialized objects for use in kotlin. It serializes and retrieves the data received from the bluetooth module in the event loop. The xml files display the databytes in the form of graphs, x-axis represents the time, y represents the particular parameter that is being set by the user.

Dependencies of the application included the internet permissions, storage permissions, bluetooth for the real time transfer, gps and location permissions to detect the HUZZAH32 feather board in the vicinity of the mobile device.

Four different label classes can be set to segregate among different types of gas quality in the vicinity of the sensors. To summarize the basic structure of the app -

1) Kotlin and java programming languages used
2) Protobuf compiler to make objects
3) Layout made in xml format
4) Dependencies - internet, storage permissions, bluetooth permission, gps, location permissions,

For testing we have developed the Mobile application which will connect to sensors through Bluetooth (perk of using HUZZAH32 feather board). In the application there is a visual representation of the data also it will give the information about in which class it falls.

In short, It will act as a real time monitoring system.

For determining the quantity, the user will give up the dimension of each bag and the application will return the number of bags or sacks present in the godown.

For the Web Application we have used HTML, CSS and Py-Script. The main purpose of this web application is to display the number of bags or sacks present in the godown. Py-Script is the simple extension which helps the user to run the python script on the web page thus causing it to enhance the Web-User interface. Using this we can also plot the graphs using matplot-lib and numpy, pandas as well. The web Application allows users to take inputs from the user in the form of Height, Breadth and Length of the box. Also, it allows the user to give the dimensions of a single sack i.e., Height, Breadth and Length of the sack. Thus, printing or giving the output, that is, the number of sacks when we will divide the Volume of the Box with the Volume of a single sack.

Also, the various languages that were used in the building of the web application other than HTML, CSS, and Py-Script are Jquery and JavaScript.

Results & Discussion

❖ ***Features and Advantages***:

We aimed for a effective and efficient prototype and some of the feature of our system are as follows:

1. Most common problem is the availability of data (Air quality index, Humidity level, barometric pressure, temperature) inside the granary as with place to place it can vary a lot. *We have designed a device through which we can collect the data ourselves and train a machine learning model on it.*
2. We do not need two or more different platforms for collecting data and training, mounting machine learning algorithms. *In this design it is possible to collect data and train (mount too) machine learning models on the same device.*
3. It is very compact and robust so it can be easily used in multiple configurations at same time. This significantly increases statistics and reduces development time as well.
4. You can develop your own test case easily as BME-AI studio (open source) is easy to use. We can also develop algorithms for fruit or vegetable storage houses.

❖ ***Future Aspect*** **:**

We can develop a fully automated headless version of software that enables automatic collection, labeling and partitioning of sensor data as well as automatic training of machine learning algorithms. All of this can be controlled through a newly developed API. By using Cloud Server it is possible to dynamically collect data from all sensors in the field, to retrain and continuously improve the algorithm.

❖ ***Anomalies faced*** **:**

We faced a problem in testing our algorithm due to changing environmental conditions. Environmental conditions vary a lot and this alters the data collected for testing. we were unable to create an environment (due to limited quantity of samples) that will be there in granaries which leads to wrong results at a time. Granaries are generally packed where such problems do not arrive. However, we choose to present in the flask with cork so while testing sensors only detect the gas only from the wheat grain not from the outside environment.

Conclusion

It is a prototype for our concept. We have tried to make it compact and robust. This system is going to be highly used in the future when the high-tech revolution begins. In the near future being a contender in this race we can take our society to a better level. This product presents the initial design and testing of a Food grains quality and quantity. By this prototype design, the implication of the result of the trial can be used on a larger scale with some considerations.
We can monitor Govt's godown filled with the wheat grain and get real time checks on the quality and quantity & Govt. will be able to take the appropriate step to stop it from spoiling. Which will lead to the less wastage or bare minimum wastage of wheat grains and contribute to growth and economy of the country.

Thanks for Reading .....