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IOT based Smart Food Grain Storage Monitoring System for Silos using Google Apps Script

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Abstract

This work is carried out to develop a system to maintain silos in a safe and hygienic environment to store food grains by monitoring them at regular intervals. We keep track of the parameters in the silo such as temperature, humidity, and carbon-di-oxide level concentrations. Values recorded at regular intervals of time help us analyze and visualize the data and observe the effects of these parameters on the food grains stored, while providing protection against pests, rodents and other organisms that can affect the yield. It has also been observed that while the grains are stored in such silos, due to the natural processes we have a lot of carbon-di-oxide concentration in the silos which has caused many fatal deaths of farmers. This issue has been mitigated in this work by implementing an emergency procedure which will be activated to open the grain bin and release the toxic gases from the silo. Through this work, we believe we can innovate in the grain storage space and solve the problems faced by the farmers.

Keywords: IOT; Food; Grains; ESP32; Google Apps Script; Cloud

Introduction

Safe food storage has always been a major issue in our country. The changing climatic conditions of India have been posing a great challenge to our farmers who are heavily dependent on seasonal changes in weather. Global warming and rapidly increasing pollution have had a great impact on crop yield for years now. Bad weather conditions often damage the yields beyond repair. The food crops cultivation contributes to the major percentage in the overall agricultural production in India. This is because of the fact that in order to satisfy the demands of the ever-growing population with food to sustain the growth aspects of its country in a steady state [1]. Smart data analysis of warehousing system has been worked upon by RFID analysis [2]. Intelligent supervision of Food has been researched in [3]. Cultivation and Grain storage plays a vital role and they are given importance and highly invested in budget declarations which was declared by the governments [4]. Julius et.al. has worked upon the technology for storing the food grains after post harvesting in [5]. Sensor based warehouse monitoring has been studied in [6, 7]. Mona Haji has studied the major role of technology in the food storage monitoring system [8]. The role of multispectral imaging in Seed Phenotyping has been studied in [9]. Management of food grain storage system has been worked upon by Shalini in [10]. In India, majority of the population are dependent on agriculture, it becomes very essential to harvest and store the food grains and the produce should finally reach each and every citizen without any damage to the grains and the people who are involved throughout the process. However, there are plenty of problems which causes the damage to the produce in the fields or during storage and transportation which has unfortunately resulted in 25 to 30 percent wastage because of the following reasons: lack of cold storages, inadequate support, improper transportation, procurement issues and underdeveloped marketing channels. A system was developed for automatic monitoring of food grains in warehouses in [11]. Wastage of Food grain affects the economic growth of the country to larger extent. Apart from that, there is a huge wastage of water, man power and electricity used for the cultivation, storage and processing of food grains. With the advancement in Internet of things (IoT), these problems can be resolved. The role of technology in monitoring and predicting quality of grains using artificial intelligence has been researched in [12]. The internet of things has brought in several advancements in all the fields to develop automation in day to day tasks and brought new perceptive in solving the problems by combining internet and physical universes. The advantages of IOT and data analytics in the field of Agriculture has been extensively studied in [13] and the role of IOT and the anticipated challenges in sustainable agriculture has been researched in [14]. Also, the farming conditions in the field can also be monitored with the advancement in Internet of Things [15]. The application of Internet of Things in the field of agriculture has been elaborately reviewed in [16]. The role of various sensors in IOT which can be used in the applications of agriculture field is reviewed in detail [17]. Internet of Things technology mainly employs sensors, sensor networks and communication modules which are equipped into mobile devices with the advancement in communication technologies such as Wi-Fi. With the help of the above-mentioned technologies, an IOT based storage monitoring system is developed for implementation in SILOs to monitor the various parameters such as temperature, humidity, weight and carbon-di-oxide levels. These parameters are monitored continuously and when these parameters exceed the threshold limits, farmers will be intimated though SMS and email alerts. The methodology of implementation is described in section II and the results are discussed in section III.

Methodology of implementation

Figure 1 shows the block diagram of the proposed food grain storage monitoring system. The sensors are interfaced with the ESP-WROOM32 for sensing the temperature, humidity, weight and carbon-di-oxide levels and the module is connected to the internet using the WiFi module to send HTTPS (Hyper Text Transport Protocol Secure) requests to the Google Apps Scripts. Different sensors such as MQ135 Gas Sensor, Force sensor and DHT-11 sensors are used to sense the CO2, weighing the seeds and measuring the humidity and temperature respectively. These parameters which are sensed by the sensors are given as input to ESPWROOM32 where the parameters are verified. The system can be broken down into three parts: input elements, functional elements and output elements. The inputs are the sensors that collect different parameters of the Silo. The MQ-135 gas sensor reads the concentration of carbon dioxide in the silos in PPM (Parts per Million). The force sensor measures the weight of the grains and the DHT-11 gives us the temperature and the relative humidity of the food grains present in the silo. These sensors are interfaced with the ESPWROOM32 to process the data. The microcontroller is programmed in a way that, if any value of the measured parameters exceeds their threshold values, the buzzer is activated and an alert is sent to the user/famer regarding the current status of the silo in the form of an email. If no action is taken by the farmer and the parameters reached the maximum threshold, then an emergency procedure is executed, which triggers the buzzer to go off and by using the servo motor, the grain bin lid will be open to let out the bring the silo back to nominal conditions. The parameters are recorded to understand the silo status for a interval of time where the ESPWROOM32 contacts the Cloud Application hosted on Google via web POST request, the values from the POST request are parsed by the application and stored on Google Sheets, the ALERT_PARAM parameter of the POST request gives us the clear real-time indication of the silo status, depending on this value an e-email alert is sent to the user/farmer.

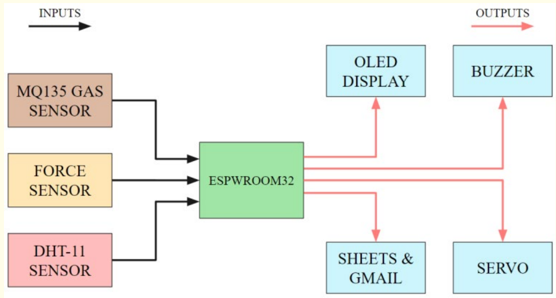


Figure 1: Block diagram of the storage monitoring system.

All the sensors are interfaced with the ESP32 module, some thresholds are set within the system as minimum threshold and maximum threshold. When any of the parameters i.e. carbon-di-oxide, humidity and temperature reach their minimum threshold, the buzzer interfaced is activated to alert the user/farmer, alongside a HTTPS (Hyper Text Transport Protocol Secure) request with the recorded values as query parameters in the request which is processed by the Google Apps Scripts application that is hosted on the GCP (Google Cloud Platform). The circuit diagram for the proposed system is shown in figure 2.

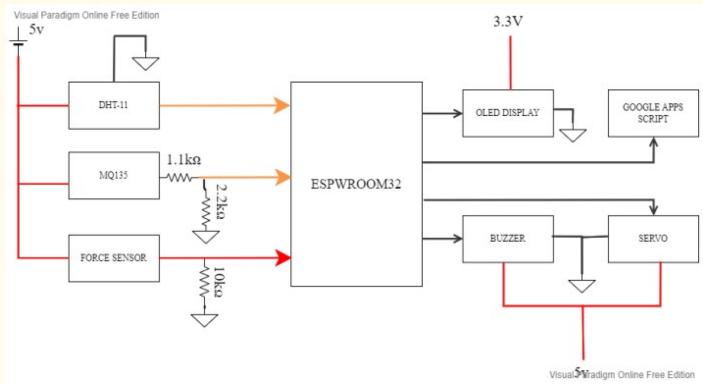


Figure 2: Circuit diagram of the proposed storage monitoring system.

Figure 3 shows the flow chart representing the methodology adopted for developing the grain monitoring system. Initially the parameters are collected from all the sensors and compared with the threshold limits which are known to the system. If the data collected from the sensors exceeds the threshold limits, then emergency procedure is triggered and the email alert is sent to the customer. using sensors. The CO2 concentration of the silo is monitored in PPM, using an MQ135 sensor which monitors it as a priority in our readings. The MQ135 sensor works on a resistive element whose resistance changes with respect to the changes in concentration, according to the concentration of the gases which is reflected as an output voltage. This output voltage is in the range of 0-5V which is reduced to 3.3 volts using a voltage divider circuit, as the ESP32 cannot handle more than 3.3 volts as the input voltage. The temperature and the humidity values from the DHT-11 sensor are read which has a sampling rate of 1 second. The temperature values read from the sensor are in Celsius and the humidity values are in terms of Relative Humidity. A round force sensor is used that gives the total force applied on the sensor. These values are then stored in variables of their specific data type to be stored in the database made using Google Sheets.

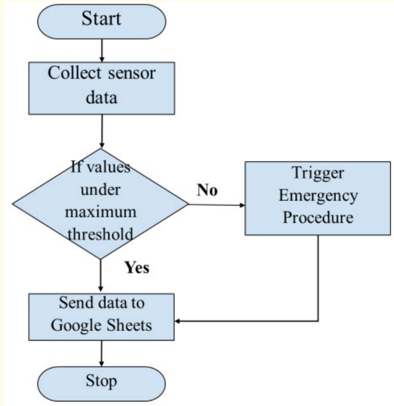


Figure 3: Flowchart representing the methodology adopted for the grain monitoring system.

Figure 4 shows the flow chart representing the methodology for sending the data to the google sheets where the data will be verified for the presence of abnormal values. If the sensed parameters lie outside the threshold limit, warning message will be sent to the user and if it lies within the threshold limit, status message will be triggered and sent to the user. The parameters are monitored in the silo like Temperature, Humidity, CO2 concentration and weight of the grains. Google Sheets is used as our database as it is very user friendly, cloud based and has a very generous free tier for our use case. We integrate the ESP32 using Google Apps Script that helps us read values that are sent from the ESP32 using a web POST request. The app reads the values from the parameters sent in the POST request to the app script instance.

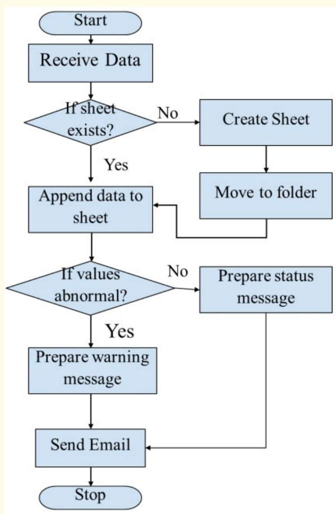


Figure 4: Flowchart representing the flow of information using google scripts.

These apps are run on Google's custom Javascript runtime V8 chrome engines, that have almost 0ms cold start and can be accessed from anywhere in the world. This POST request is processed by the google servers and sent to the application where the data of the parameters is parsed and stored as a new row in the excel sheet/ google sheet. The data is analysed in the code to find out any abnormalities in the values and then processed accordingly. If any abnormality is suspected or identified in the values, an Email using G-mail is sent to the user/farmer which has all the values in the email in a user-friendly format. And also when the abnormality occurs, for better understanding about the problem, if the user/farmer is unable to take any action and any of the values reaches the maximum threshold limit, an emergency procedure initialised automatically on the ESP32 to protect the produce from further damage.

Results and Discussions

Figure 5(a) shows the connection of all the electronic components in the storage monitoring system. In general, the data is displayed on the OLED display as shown in figure 5(b).

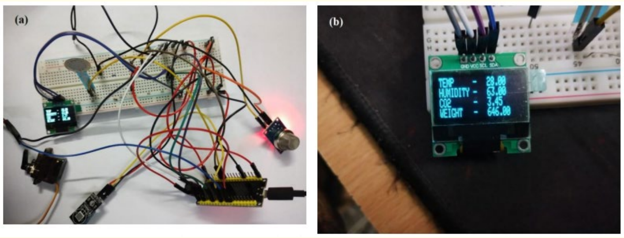


Figure 5: (a) Connection of Components in the storage monitoring system. (b) Display of Output values in the food grain monitoring system.

After the ESP32 has been turned on for some time, our data is being aggregated in the google sheets as shown in figure 6(a). The data is inserted into the sheet that corresponds to the google sheet file of that month and the subsheet of the google sheet (figure 6b). If the google sheets file of the month doesn't exist, a google sheet file is created and moved into the master folder (Figure 6a).

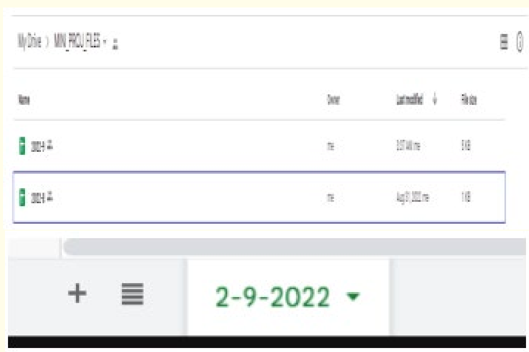
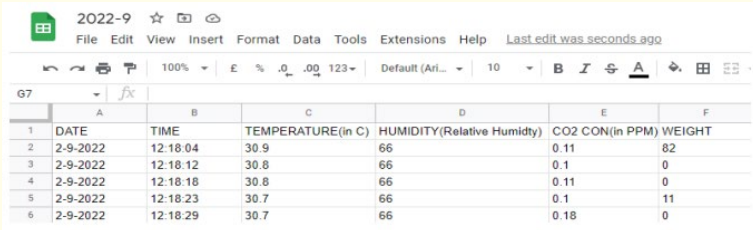


Figure 6: (a) Google Sheet files in folder; (b) Google Subsheets in a Googlesheet.

Similarly, if a subsheet doesn't exist in the google sheet file, it is created and the data is appended, after which we can analyse the data using sheet's inbuilt tools such as graphs and other visual components as depicted in figure 7.



DATE	TIME	TEMPERATURE(in C)	HUMIDITY(Relative Humidty)	CO2 CON(in PPM)	WEIGHT
2-9-2022	12:18:04	30.9	66	0.11	82
2-9-2022	12:18:12	30.8	66	0.1	0
2-9-2022	12:18:18	30.8	66	0.11	0
2-9-2022	12:18:23	30.7	66	0.1	11
2-9-2022	12:18:29	30.7	66	0.18	0

Figure 7: Google Apps Script Results.

When the parameters in the silo are within limits, status normal (Figure 8), over threshold, warning status (Figure 9), over maximum status and critical status (Figure 10).

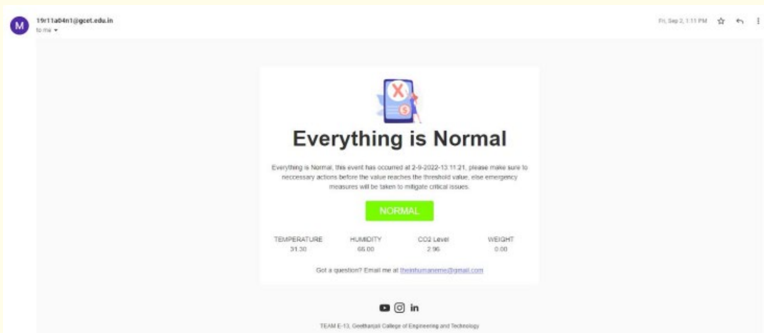


Figure 8: Normal Status Email.

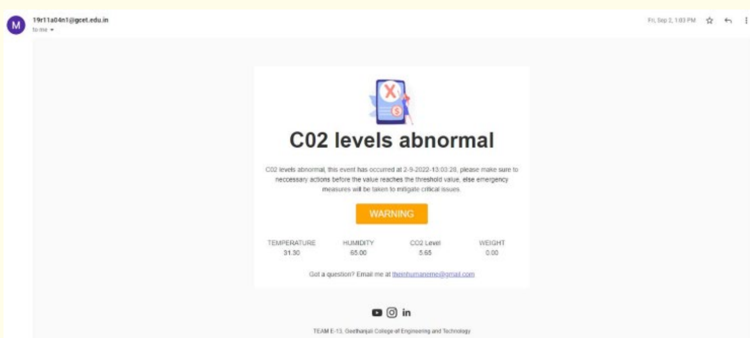


Figure 9: Warning Status Email.

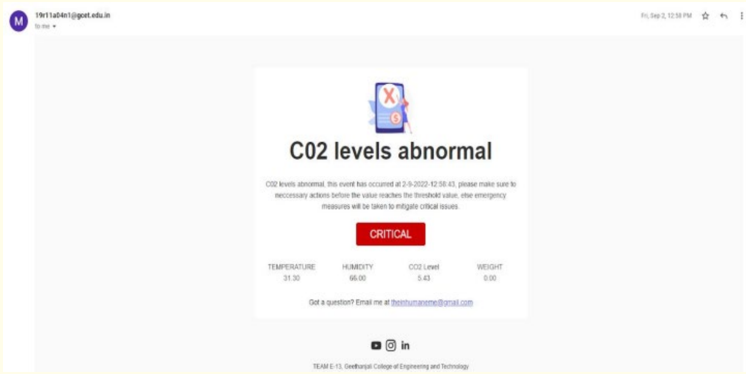


Figure 10: Critical Status Email.

Conclusion

In this work, a new methodology is employed to monitor the food grains in silos on various parameters such as temperature, relative humidity, Carbon-di-oxide concentration levels and weight of the grain in the silo. By using Google Cloud Platform a Data ingest system is also developed to aggregate the data from the silo control station and notify the farmer/user about the status of the silo when any parameter is above threshold limits via an email through gmail. All the possible ways are explored to alert the user/farmer about the abnormalities in the silo, the data ingested is stored on the cloud platform which is reliable which enables us to store and visualise the data to better understand how the grain reacts to the changes of the parameters that are being monitored. The purpose of this work is to ensure that the grain and the farmer are safe at all times and an emergency procedure that is activated automatically when any of the parameters exceeds the maximum threshold value. This work will be highly beneficial for farmers who cannot spend large sums of money on expensive storage systems to store their harvest.

Future Scope

This work has immense future scope as we can deploy multiple such monitoring systems in multiple silos at the same time. In such mass deployment situations the data ingress point is the same but the control hub needs to be installed in multiple silos. Using WiFi as a means of internet connectivity will get expensive in such deployments, so the data can be transmitted to another machine that acts as a Data Ingress station / Hub, and the control system is a spoke of such a hub. These devices could be connected by a low power, low energy communication such as LoRa technology which can transmit and receive data over large distances, helping us deploy such monitoring systems even in the most remote places of the country at minimal cost. This helps the government analyse and help create better solutions for farmers to store produce and support them by providing subsidies if anything goes wrong. This helps us collect data about various grains in a variety of storage conditions which will aid us in understanding the climatic conditions and the grain better, helping us create a more comprehensive solution in the time to come. As we use Google Cloud Platform in the future, multiple instances can be deployed on the edge and make the system completely automated and human error free.

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