Transactions on Computer Systems and Networks

Amitava Choudhury ·
Arindam Biswas · T. P. Singh ·
Santanu Kumar Ghosh *Editors*

Smart Agriculture Automation Using Advanced Technologies

Data Analytics and Machine Learning, Cloud Architecture, Automation and IoT

Springer

Transactions on Computer Systems and Networks

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Preface

Agriculture automation is the primary concern and emerging subject for every country. The world population is increasing rapidly, and with the increase in population, the need for food rises briskly. Traditional methods used by farmers aren't sufficient to serve the increasing demand, so they have to hamper the soil by using harmful pesticides in an intensified manner. This affects the agricultural practice a lot, and in the end, the land remains barren with no fertility. This book talks about different automation practices like IoT, wireless communications, machine learning, artificial intelligence and deep learning. Some areas are causing problems in the agriculture field like crop diseases, lack of storage management, pesticide control, weed management, lack of irrigation and water management. All these problems can be solved by the techniques mentioned earlier.

Agriculture is the essential and most vital profession of our nation because it balances food necessity and the fundamental crude materials for a few enterprises and there is a consistent expansion sought after populace development. Various everyday issues are getting an incredible effect by the progressions in innovation. For a few years, individuals are running after the robotization with some degree of knowledge to supplant or limit humans from process cycles. Innovation in agriculture lessens reliance on individual human work and land. The invention permits operational concocting and speeds up decision-making on the farms. Ongoing headways in creation have an extraordinary effect on agriculture, and it has been set up that IoT is utilized in cultivating to improve the nature of farming. Advancement of Machine Learning (ML) and Internet of Things (IoT) has assembled consideration of specialists to apply these strategies in fields like farming. It causes ranchers to expand the profitability of their property so the overall demand for food can be satisfied. IoT is a high-level innovation for observing and controlling gadgets anyplace on the planet. It can interface devices with living things. IoT is making a critical imprint in numerous fields. These days, the versatile idea of IoT has changed and a conventional client can use it. IoT has created a few methodologies that make man's life simpler and comfortable. Aside from man's solaces, these strategies ought to be executed on necessities like food, which is accomplished from the farming fields. World Bank assessed that an overabundance is to be delivered before 2050 if the populace pattern is at the present rate. However, the current environment changes wouldn't sustenance such enormous yield creation. So sensors related to field, drones, progressed work vehicles and aquaculture cultivating may assist future ranchers with yielding more harvest at low costs. Like this, the need for exquisite cultivating is developing dramatically. The blend of Savvy Irrigation and the control to ML algorithms can find various disputes of agriculture. In ML adventure, the principle things need to be specific about the dataset and the algorithms. This book discusses the assistance of IoT and machine learning in farming, which can expand the productivity of yield production. Different climate parameters are taken into thought from which the best reasonable yield is grown predicted by a supervised learning algorithm, decision tree, along with classifier also discuss various ML applications in which rural ranches can be broadly utilized in regions like sickness recognition, crop discovery, irrigation system, soil conditions, also the Product quality and market analysis. By reading this book, readers can find the many noble aspects such as:

- *Machine Learning and IoT in Agriculture*
- *Precision farming and its application*
- *Precision farming in modern agriculture*
- *ML-based smart farming using LSTM*
- *Smart Weather Monitoring System using Sense Hat for improving the Quality of Crops*
- *IoT enabled smart farming: Challenges and Opportunities*
- *Fermat Point-Based Wireless Sensor Networks*
- *Application of IoT Enabled with 5G Network in Agricultural Sector*
- *An Economical Helping Hand for Farmers- Agricultural Drone*
- *Automatic Hibiscus Leaf Disease Detection and Classification Using Unsupervised Learning Techniques*
- *On Securing Smart Agriculture Systems: A Data Aggregation Security Perspective*
- *Urea Spreaders for improving the Crop Productivity in agriculture: Recent Developments*
- *Agricultural Informatics and Practices*

In summary, in this twenty-first century, there is a genuine need for agriculture upgradation. This book would provide a technical overview that leads to open a new dimension that may be useful to cover the solutions of the current growth of the agriculture process.

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Chapter 6
IoT Doordarshi: Smart Weather Monitoring System Using Sense Hat for Improving the Quality of Crops

Harshita Jain, Kirti Panwar Bhati, Nupoor Katre, and Prashant Meshram

Abstract The main aim of the proposed system is to build a system that will sense the environmental parameters in an area of interest for crop quality monitoring. System monitors the environmental parameters in real time and sends the data to a cloud that can be further used for analysis. This system describes a complete infrastructure for environmental monitoring and controlling. The proposed system makes use of low-cost Raspberry Pi and Sense Hat Sensor for monitoring the environment. As the title suggests Doordarshi, the one who is visionary and performs the task so to get the favorable result in future, likewise the proposed system monitors the environmental parameter to help us to take corrective actions for improving the crop quality in the future. The proposed system senses the weather parameters and monitors it in the real time and then email the information (using SMTP protocol) and phone notification (using Pushover IFTTT service) that can be further used for analysis. Cloud service, ThingSpeak, is used for storing and plotting the data. Weather detection system using IoT has been experimentally established to work satisfactorily by connecting the different modules of IoT into a single platform. The designed system not only monitors the real-time data for crop quality monitoring but also sends it into the mail and notification for further analysis. This will eventually help to determine the different environmental conditions and accordingly corrective measures can be taken for improving crop quality.

Keywords Crop Quality · IoT · Sense Hat · RPi · Doordarshi

6.1 Introduction

Doordarshi is a Hindi word the meaning of which "showing the ability to think about or plan the future with great imagination and intelligence" according to the Oxford Dictionary. Here title suggests Doordarshi which is a visionary IoT System for getting good quality crops by making use of low-cost tools and technologies. The

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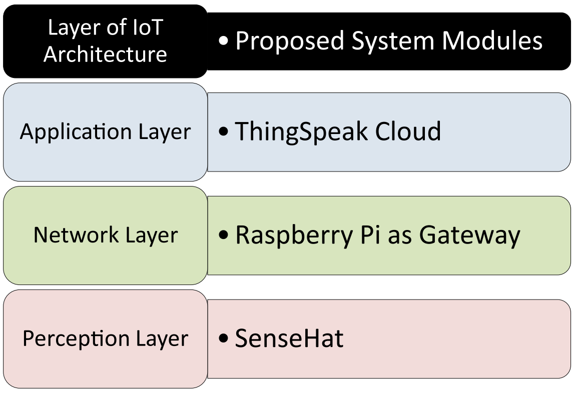


Fig. 6.1 Proposed system components for the implementation of three-layer IoT architecture

proposed system makes use of techniques where manual intervention is not required for crop environment monitoring.

IoT has found its place in each and every domain of human life. The application of IoT ranges from high-end technological domain to the area which deals with the stakeholders, which are not exposed to technologies at all. Agriculture is one of those fields that has end-users who are not very much exposed to the technology and carry out the process of agriculture the way it was before decades. India is a leading country in terms of agriculture output, it is the demand of the day for the introduction of technology in agriculture also.

The proposed system is making use of different hardware and software components for the implementation of IoT system, which performs the environment quality monitoring in a crop field and based on that, the operation can lead to quality crop productions. Figure 6.1 shows the proposed system components that are implemented at different layers or implementation of Thre-Layer IoT Architecture.

As suggested by Raj K. Goel et al., Smart Agriculture term is an umbrella that covers science, innovation and space technologies. They have talked about the various technologies, which have a positive impact on agriculture sector in developing nations (Goel et al. 2021).

Doshi et al. (2019) present an IoT solution for Smart Farming for enhancing the productivity in farming and have given the solution for remote monitoring of the field using IoT technologies.

Ratnaparkhi et al. (2020) present the importance of the sensor in Smart Agriculture. Sensors are the important parts of an IoT System, and selection of a suitable sensor plays a very important part in developing an IoT System.

Singh et al. (2021) present the scope of smart farming in India. Temperature has a great impact on crop quality. In this paper (Barlow et al. 2015), wheat crop is considered.

Hatfield and Prueger (2015) have discussed that Beyond a certain point, higher air temperatures adversely affect plant growth, pollination and reproductive processes so the maintenance of environment temperature is really required.

Temperature, humidity and other environmental parameters play an important role in crop yield, and monitoring the parameter helps to increase the crop quality and yield (Sawan 2018).

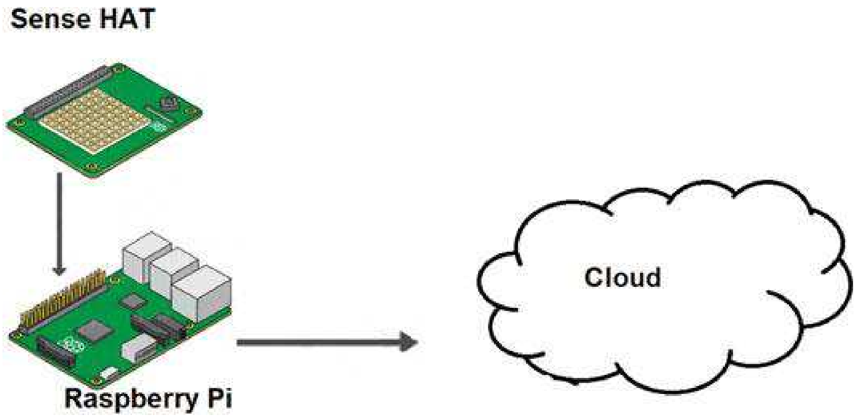


Fig. 6.2 System architecture

The proposed system makes use of Raspberry Pi as a gateway, which is interfaced with Sense Hat sensor, working as a sensor for monitoring the temperature, humidity and pressure of the environment. The data collected from the Sense Hat are logged on the Raspberry Pi and sent to the cloud for analysis. Here ThingSpeak cloud is used for analysis and visualization of data sent from the Raspberry Pi. Figure 6.2 shows the system architecture.

The parameters that are monitored for the environment are

- Temperature
- Humidity
- Pressure.

6.2 Methodology

Raspberry Pi used a Linux-based operating System Raspbian. After installing Raspbianon R-Pi, Sense HAT module has been interfaced with GPIO pin of R-Pi. LPS25H Pressure/Temperature sensors at $0 \times 5C$ address and HTS221 Humidity/Temperature sensor at $0 \times 5f$ address connected through i2c protocol. Installing the sense-hat package will allow the Python module to access Raspberry Pi Sense HAT.

"Sense-hat" is the official support library for Sense-HAT for providing access to onboard sensors and LED matrix. Using onboard sensors measure the value of environmental parameters such as temperature, humidity and pressure. These sensors are connected with I2C protocol on Sense HAT board and have access to GPIO pins of Raspberry Pi. Using Python coding and Sense-hat library value of environmental parameters has been displayed on terminal. Later, this parameter has been displayed on Sense HAT 8×8 on slide show format.

After monitoring of environment parameters in real time sends these data to Email and push notification as alert/inform messages about the environmental condition surround by field, necessary to detect for good crop quality. SMTP protocol is a standard protocol on a TCP/IP network that provides the ability to send and receive the email. It is an application layer protocol that provides intermediary network services between provider and Server. Using this SMTP protocol, real-time data have been sent as email notification. For push notification, Pushover Service has been used, it is a platform for sending and receiving push notification over phone. On server side an HTTP API is provided for message delivery to the device address.

Along with sending real-time data on Email and push notification, data have been stored on cloud services for further use. ThingSpeak cloud has been used for storing and plotting the data. There is a channel having two fields for receiving the data on cloud. On ThingSpeak MATLAB environment has been used for analysis and plotting the data on ThingSpeak. ThingSpeak also provides the MATLAB visualization for plotting data on 2D plot.

6.2.1 Components Used for Implementation of System

The components used for the implementation of the proposed system can be divided into hardware and software components as given in Fig. 6.3.

Raspberry Pi

The Raspberry Pi 3 Model B+ as shown in Fig. 6.4 is used for the implementation of system proposed here. Specifications of Raspberry Pi 3 B+ models are given below (https://www.raspberrypi.org/products/raspberry-pi-3-model-b-plus/).

- BCM2837B0 64 Bit ARM Processor running at 1.4 GHz
- 1 GB SDRAM
- Wireless LAN Support
- Bluetooth BLE Support
- 4 No. 2.0 USB
- Ethernet connectivity

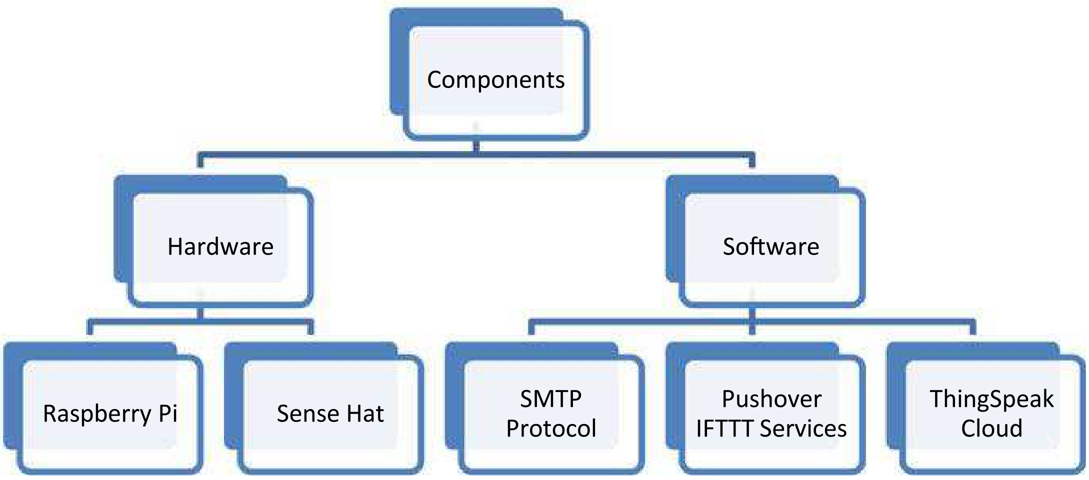


Fig. 6.3 Hardware and software components required for implementation

Fig. 6.4 Raspberry Pi 3 B+ model

- 40 Pin GPIO Header
- HDMI Connectivity
- CSI Camera Port
- DSI Display Port
- 4-pole stereo output and composite video port
- Micro SD Port.

SenseHat

Sense Hat as shown in Fig. 6.5 is used for sending the environmental parameter. Specifications are given below (https://www.raspberrypi.org/products/sense-hat/).

- The sense Hat is a board that can be mounted on Raspberry Pi.

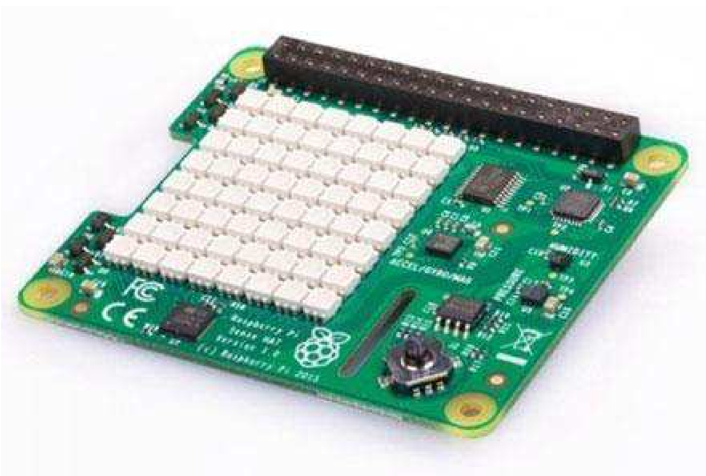


Fig. 6.5 Sense HAT

- An 8 × 8 LED Matrix, joystick and has following sensors
  - Gyroscope
  - Accelerometer
  - Magnetometer
  - Temperature
  - Barometric pressure
  - Humidity.

SMTP Client

SMTP Client is deployed on the Raspberry Pi for sending the email to the mobile phone. It is integrated with email client and having four components.

- Mail User Agent (MUA)
- Mail Submission Agent (MSA)
- Mail Transfer Agent (MTA)
- Mail Delivery Agent (MDA).

Pushover Service

To receive the notification of your device, pushover service is used. On the server side, push notifications are sent to the authorized user and client side those push notifications are received and shown to the user and also stored so can be seen even when a device is offline.

ThingSpeak Cloud

Data send by device visuals instantly to ThingSpeak, online analysis is done in ThingSpeak with MATLAB code. ThingSpeak uses REST API approach to communicate between IoT device and cloud. The key element of this platform is the channel, which stores and retrieves data generated from sensors via REST API.

Figure 6.6 shows the connectivity between the smart device and Cloud.

6.3 System Implementation

Sense HAT senses the parameters (temperature, humidity and pressure) and sends it to Raspberry Pi via GPIO pins.

R-pi processes the data and implements it on the terminal as shown in Fig. 6.7.

Displaying of parameters (temperature, humidity and pressure) on Sense HAT 8 × 8 matrix display done by Python coding on R-pi as shown in Fig. 6.8a–e.

Display of parameter is on 8 × 8 matrix on slide show moving text format.

After reading parameters and analyzing the data on Python editor whether suitable for crop environmental conditions, we'll send the required parameters to email through SMTP protocol as given in Fig. 6.9.

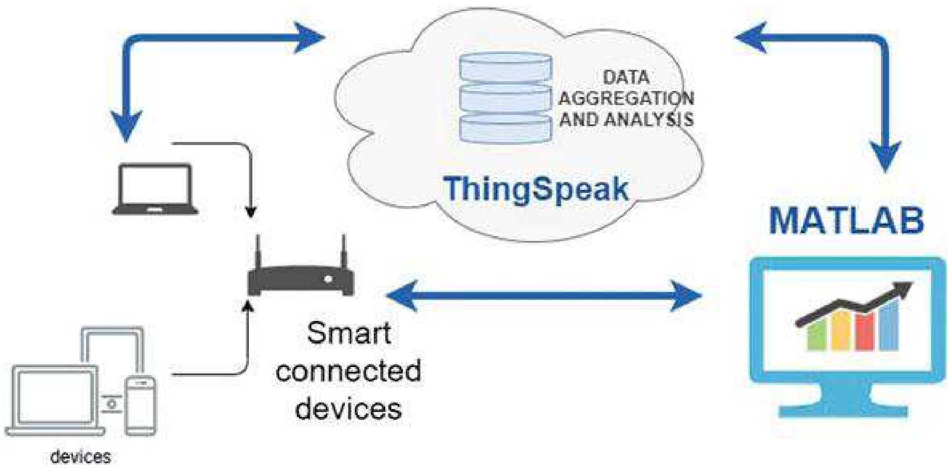


Fig. 6.6 Connectivity to ThingSpeak cloud

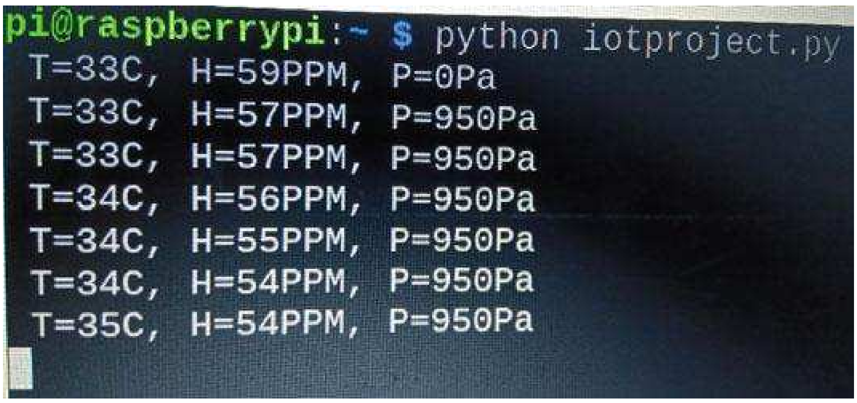


Fig. 6.7 Data display on RPi terminal

IFTTT service (if this then that) “Pushover” is used for push notification on phone as given in Fig. 6.10.

Push notification and email alert for showing real-time data and alert message. But we also need to store the parameters and analyze them for further analysis.

For this, ThinkSpeak Cloud is used. On ThinkSpeak cloud using MATLAB Coding analysis of parameters and 2D plotting has been done as given in Fig. 6.11**.**

Temperature and humdity plotting on a 2D plot after analysis is done, as shown in Fig. 6.12.

6.4 Conclusion

IoT Doordarshi has been experimentally established to work satisfactorily by connecting the different modules of IoT into a single platform. This system is able to sense the environmental parameters. These parameters can be sent to user mobile

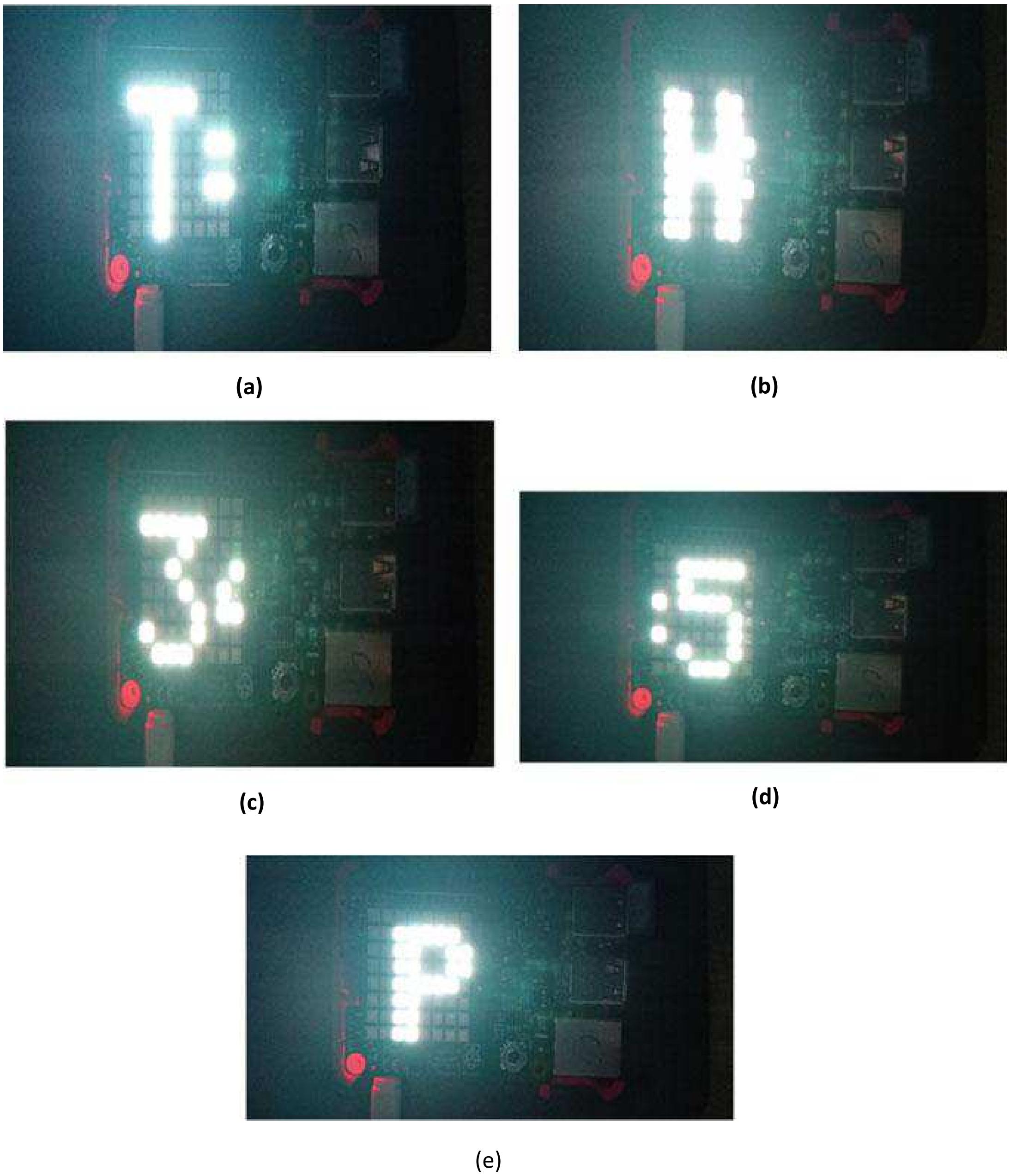
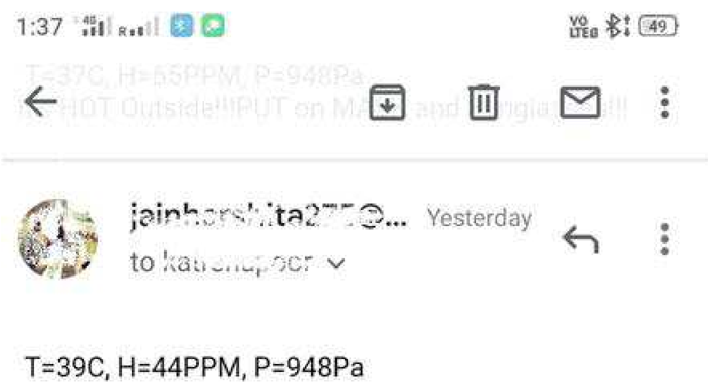


Fig. 6.8 Display of parameter is on 8 × 8 matrix on slide show moving text format

Fig. 6.9 Sending email through SMTP



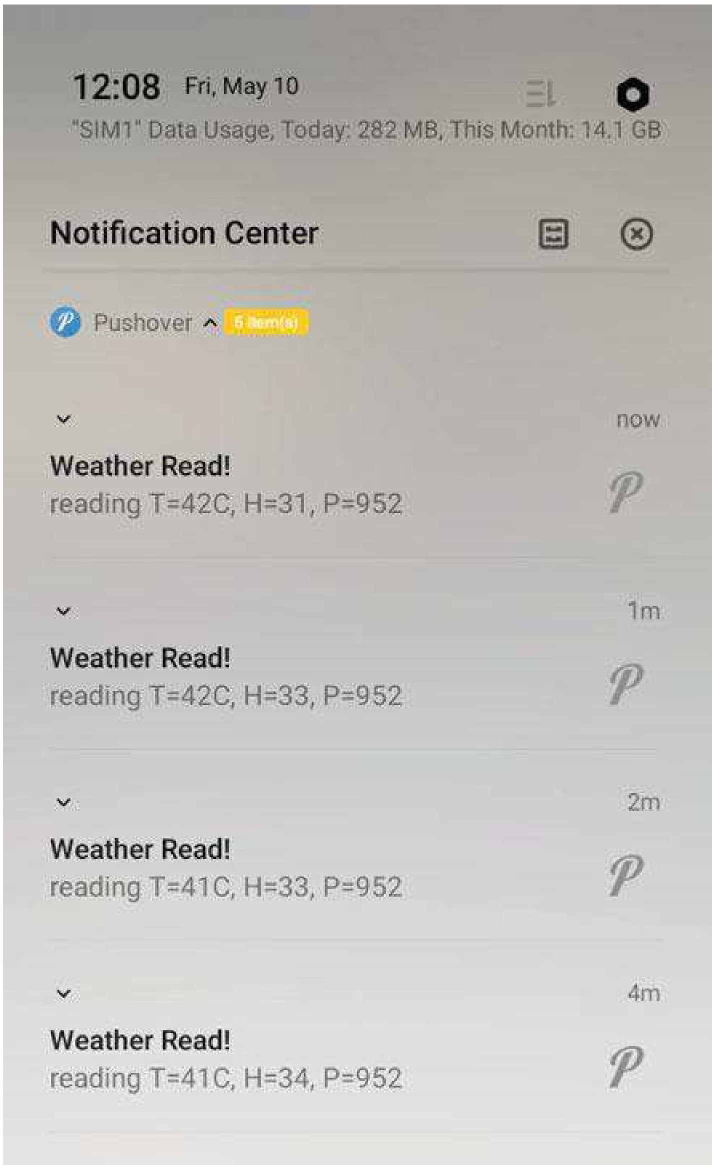


Fig. 6.10 Push Notification on Phone

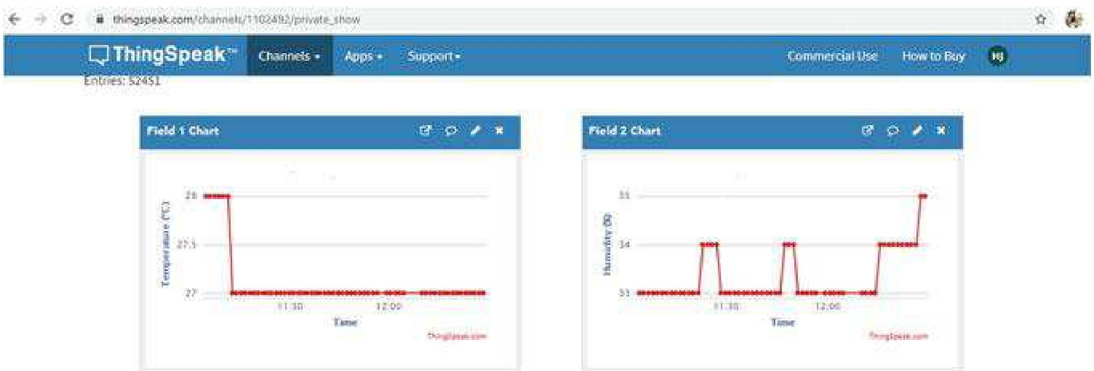


Fig. 6.11 Analysis of real-time temperature and humidity data

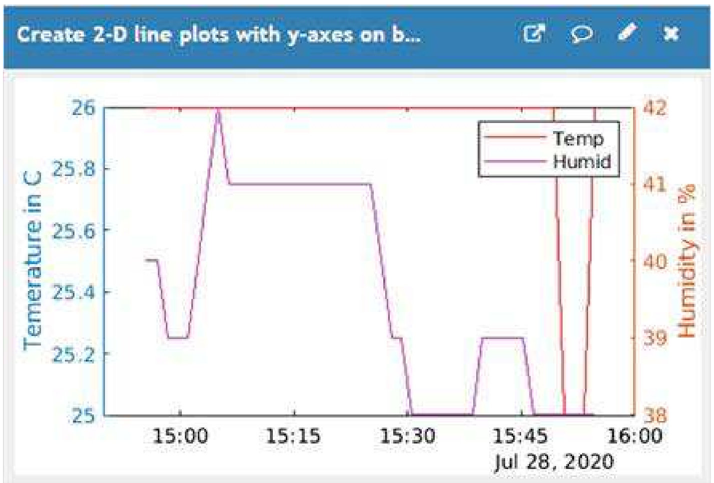


Fig. 6.12 2D plotting of real-time data

phone via push notification and email and can be further uploaded on the Cloud for analysis. After analyzing the real-time data on Cloud through predictive analysis a suitable action can be taken for improving the quality of crop.

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