IoT Solutions for Smart Farming - A smart weather and wind speed monitoring system

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Abstract

This paper presents the-state-of-the-art on Internet of Things enabled plant growth monitoring, application of pesticides, prevention of insects, birds and animals into the agricultural fields, food storage, apiculture, animal husbandry, natural disaster alerts and energy harvesting using bio-waste. A smart weather monitoring system incorporating hall sensor, DHT11, UV sensor, CO sensor and IR sensors. The hall sensor detects magnetic field and provides frequency of magnetic field detected per second. IR sensor detects direction by sensing obstacles of the wind vane. Other sensors provide analog output according to weather parameters. The output data is processed by Arduino and the data is visualized on dashboard. Farmers can visualize the weather parameters of the field remotely on thingsboard dashboard. The data is also stored for graphical representations.

Keywords: *framing, smart weather, Data, Raspberry Pi, Arduino*

1.0 Introduction

Rapid growth of population and limited supply of resources drive toward smart technologies for optimum utilization of the resources, especially in farming. Smart farming encompasses advanced technologies for plant growth monitoring, application of pesticides, prevention of insects, birds and animals entering into agricultural fields, food storage, apiculture, animal husbandry, natural disaster alerts, energy harvesting using bio-waste, etc. Advanced technologies enable to assess the health state of farming, optimum production and utilization through automated decisions of interventions on the feeding of the soils, protection from insects, etc. With advances in Internet of Things (IoT), a number of sensors can be used to capture, process and analyses data in real-time employing different IoT platforms.

Agriculture has fostered advances in human civilizations over the ages. In developing countries like India where agriculture is mainly dependent on rainfall is still a gamble for farmers. Automatic sensing of the conditions on a farm enables to implement best possible practices in farms which can result in maximising the yield. Authors [1] used Temperature and humidity sensors and height measuring apparatus comprising of magnetic switches and a Neodymium magnet. Data pertaining to height of the plant, moisture content in the soil,

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ambient temperature and relative humidity collected from the sensors were compiled and transmitted to the farmer for suitable action which is also recorded. The ground data and the actions taken together help to improve the productivity. Zhang Xiao-dong et al. [2] developed a digital monitoring solution for grain warehouse based on microcontroller and Linux embedded OS. The experimental results showed that the IoT solution was capable of real time monitoring the warehouse environmental parameters namely the grain temperature, humidity, video image and other important sensor data's.

Priya et al. [3] developed a prototype model for continuous monitoring of potato crop in cold storage unit. The prototype evaluated the appropriate threshold range and updated the condition to the vender using GSM in the form of SMS. The developed model was tested for accuracy with respect to monitoring conditions of light intensity, humidity, temperature and detection of potatoes rotting in the initial stage. Ahmed et al. [4] proposed integrated management of production by an automatic monitoring system for biogas plants using Arduino. Automatic monitoring involves the supervision and planning functions that ensure continuous and efficient operation of the plant. The measure of gas production and consumption were tested by deploying an Arduino micro-controller. The program automatically warns the instructor on the amount of methane production by setting an alarm in case of an increase or deficit in produced quantity.

Suruchi Dedgaonkar et al. [5] studied the process monitoring parameters in two different groups for measuring the volume of biogas using microcontroller and GSM. The first group of parameters includes the early indicators of process imbalance and this indicator allows the biogas plant operator to react in time, before a process imbalance occurs. The second group of parameters are the one which characterize the process. Dasig Jr. and Mendez [6] presented the introductory apiculture space, challenges and evolving methods of the apiarists in beekeeping at lesser cost IoT. Authors deployed remote sensing technologies for gathering information and vigor monitoring to improve the beehive colonies productivity.

Anatolijs Zabasta et al. [7] developed IoT based modern autonomous beekeeping system. The IoT system aids to analyses correlation data with video, mass changes in-time with the interpretation of humidity, temperature, networking to local biological and geographic situations. IoT system permits a beekeeper to collect key information indicators and in agreement with this display beekeeper reacts in-time and provide the best preservation of the bee colony. By employing the autonomous beekeeping, the situations of the hives can be tracked remotely. Abhinav and Deshpande [8] described the method to protect farms from animals through ubiquitous intelligent security system wired network devices to farm along with traditional method. Operational amplifier circuits are utilized mainly for the detection of animal intrusion into the farm. S.R.Kurkute et. al. [9] designed the agriculture wonder drone system using GPS which automatically control areal drone consisting of a quad copter and spraying mechanism. Initially quad copter is assembled using necessary components such as flight-controlled board, GPS, BLDC motor, ESC controller and battery.

Review of literature [1-9] indicated that IoT is effectively used for smart farming with different automation technologies. Their efficiency of these systems depend on the robustness of the sensors and accuracy of the output signals. The main objective of this paper was to develop a smart weather and wind speed monitoring system. Using Internet of things, the weather parameters are monitored in real time, the data is stored in a remote cloud server. The stored data can be visualised in graphical forms.

2.0 Development of Smart weather and wind speed monitoring system

2.1 Methodology of developing monitoring system

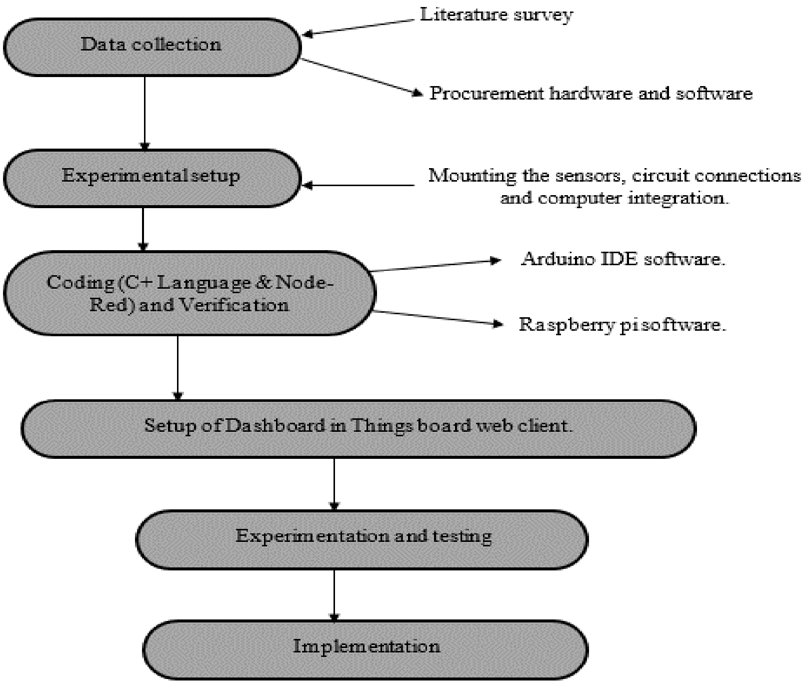
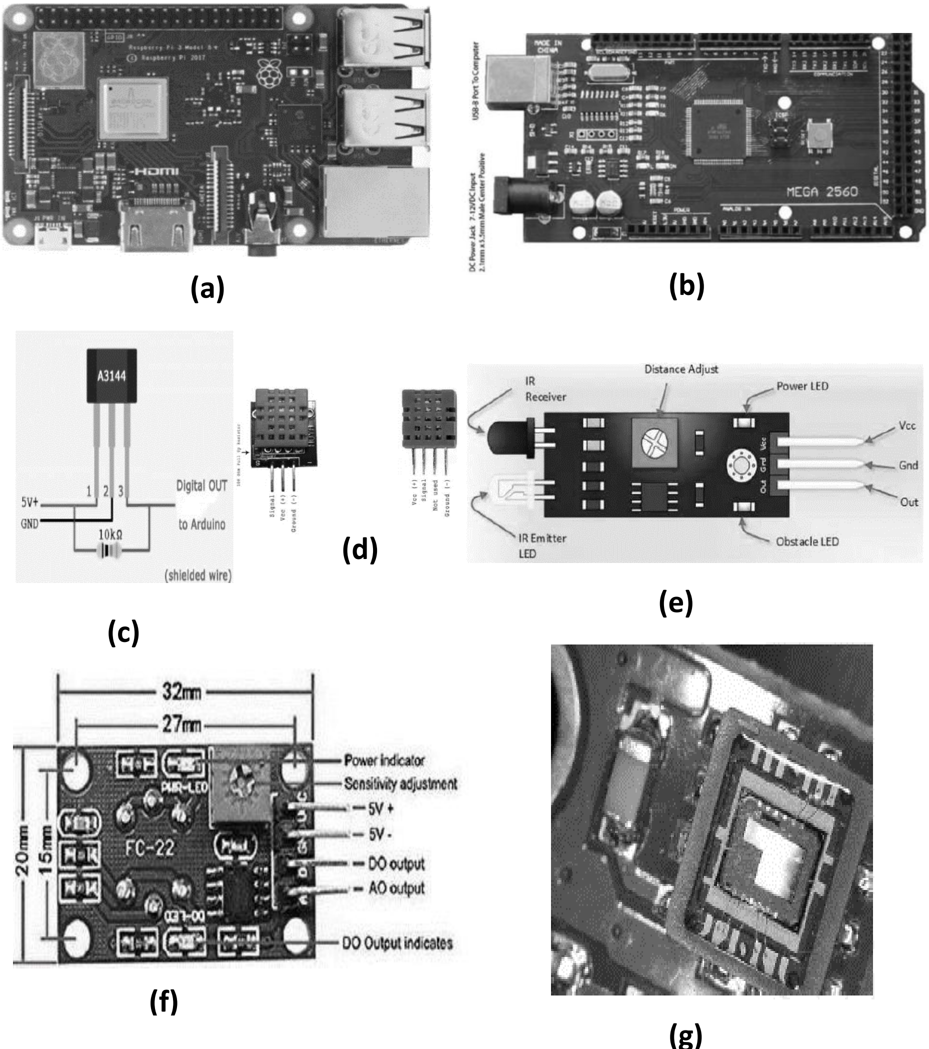


Fig. 1. Stages of developing smart weather and wind speed monitoring system

Different stages of developing smart weather and wind speed monitoring system are presented in Fig. 1. The stages include: data collection on existing weather monitoring systems by literature survey and simultaneous procurement of required hardware and software installation, building the experimental setup i.e., mounting the sensors, circuit connections and computer integration, coding in C+ in Arduino IDE software, verification of the program code by compilation and uploaded onto the Arduino Board, coding in Node-Red environment in Raspberry pi and set-up of Dashboard in Thingsboard web client. Experiments and testing were conducted to examine the required outputs and implementation.

2.2 Specifications of Smart weather and wind speed monitoring system

2.2.1 Hardware Specifications



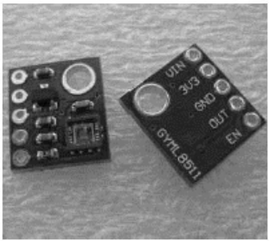


Fig. 2 (a) Raspberry Pi B+ Model with 64-bit quad core processor, (b) Arduino Mega 2560 pin-out configuration microcontroller board, (c) Hall Effect sensor, (d) DHT11 Temperature and Humidity sensor, (e) IR sensor Module with pin-out configuration, (f) CO sensor pin-out configuration and (g) UV sensor and sensor pin-out

Fig. 2(a) presents Raspberry Pi B+ model with 64-bit quad core processor at 1.4 GHz, dual-band 2.4 GHz. This model consists of dual-band wireless LAN with modular compliance certification, allowing designed board into end products of reduced wireless LAN compliance testing by improving both cost and time to market. Fig. 2(b) presents Arduino Mega 2560 microcontroller board built on the ATmega2560 with 54 digital in/output pins, 16 analog inputs, 4 UARTs hardware serial ports, a 16 MHz oscillator crystal, a power jack, an ICSP header, and a button to reset.

Fig. 2(c) shows an integrated Hall Effect non latching sensor A3144. This sensor is monolithic integrated circuits with tighter magnetic specifications, designed to operate continuously overextended temperatures to +150°C, and are more stable with both temperature and supply voltage changes. Fig. 2 (d) show DHT11 temperature and humidity sensor which a calibrated digital signal output. The sensor includes a resistive-type humidity measurement component and thermistor temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

Fig. 2(e) shows IR Sensor Module with pin-out configurations. The IR sensor module consists mainly of the IR Transmitter and Receiver, Op-Amp, Variable Resistor (Trimmer pot), output LED. Fig. 2(f) shows MQ-7 CO sensor pin-out configuration. The sensor detects CO gas at high and low temperature. Fig. 2(g) shows UV sensor pin-out configuration of ML8511. The ML8511 UV sensor is suitable for indoors or outdoors for acquiring UV intensity. Depending on the UV intensity photo-current is converted to voltage through ML8511 consists an internal amplifier. This distinctive feature offers an easy interface to external circuits such as analog-to-digital converter.

NSK 696ZZ Ball Bearings of miniature size with Dynamic load rating of 1,750 N, Static load rating of 670 N is used to provide rotational motion to the wind speed and wind direction vanes. Single start threaded bar and hexagonal nut of 6 mm diameter is used to support the bearings and mount the sensors. to create interrupts in Hall Effect sensor for measuring wind speed a neodymium permanent magnet is used, which is the most widely used type of rare-earth magnet.

2.2.2 Software Configuration

Arduino with integrated development environment (IDE) is a cross platform application for operating systems such as Windows, Linus, mac, written in the C programming language. The Arduino IDE services the program avrdude for converting the executable code to a text file in a hexadecimal encoding loaded into the Arduino board by a program loader in the board firmware as shown in Fig. 3(a). Code written in Arduino IDE though the interface called sketch.

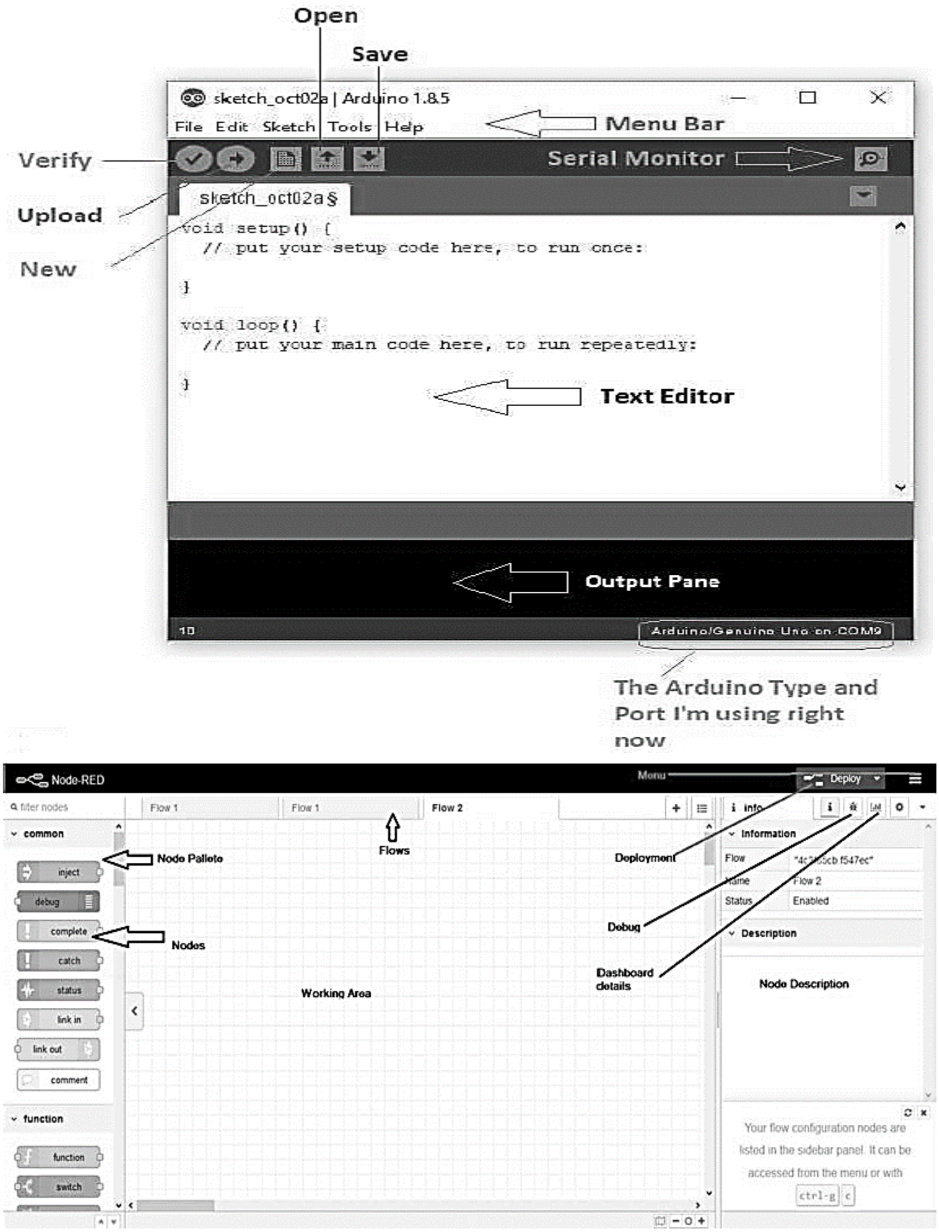


Fig. 3(a) Arduino IDE interface and (b) Node-RED interface

IoT applications is build using a powerful tool called node-RED with application on streamlining the wiring together of block of codes to carry-out complex tasks. Node-RED uses a visual-programming approach allowing the developers to link block codes, called as nodes. The connected nodes so called combination of processing nodes, input and output nodes are wired-together to make up a flows. Fig. 3(b) shows Node-RED interface.

ThingsBoard platform is an open source IoT aimed at data collection, processing, visualization, and device management. The board enables device connectivity via industry standard IoT protocols - MQTT, CoAP and HTTP and supports cloud as well as on premises deployments.

2.3 Development of working model and working procedure

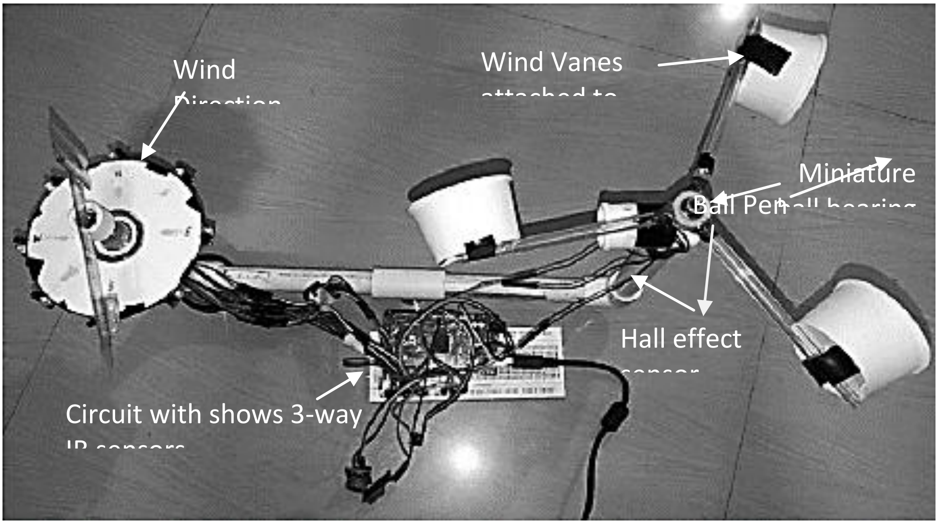


Fig. 4. Top view of prototype model of smart weather and wind speed monitoring system using IOT

Fig. 4 represents the top view of prototype model of smart weather and wind speed monitoring system using IOT. The model consists of miniature ball bearing fixed inside pipe of 15mm ID and 10 mm height, 3 ball pen ends are attached at angle 0-120-240º. Either ends of the pens are attached to the bearing and tea cups. A magnet is attached to one pen at a distance of 33 mm. Hall Effect Sensor mounted for measuring the magnetic interrupts.

IR Sensor Module are attached to a disc with 45 º between them. The disc is mounted on the threaded bar using washer and hexagonal nuts. At the top end of the threaded bar miniature ball bearing is supported. A scale is used as wind vane. An obstacle is attached to vane at a distance equal to the distance of IR Led from the centre. A 3-way circuit diagram of IR sensors connected to 0k ohm resistor between +5V and Data of Hall Sensor A3144 with USB type A/B cable to Arduino and Raspberry Pi.

Wind rotates the anemometer vanes, magnet attached to the vane comes near above the hall sensor. When the sensor detects magnetic field the output toggles to HIGH. The sampling time is 1 second i.e, the system counts number of time the sensor output state is HIGH in 1 second. The system stores number of counts per second. The wind vane moves in the direction of the wind, the obstacle attached to the vane reflects the light from IR LED to photo diode and the output state of that IR Sensor Module toggles to LOW. This output is detected by the Arduino and it gives the wind direction.

The windspeed is calculated by $windspeed = \frac{\pi DN*3600}{1000}$ kmph. where, D = diameter at which magnet is fixed (m), N = counts/second.

Fig. 5 shows the node-red flow for visualizing the data on node-red dashboard as well as thingsboard dashboard.

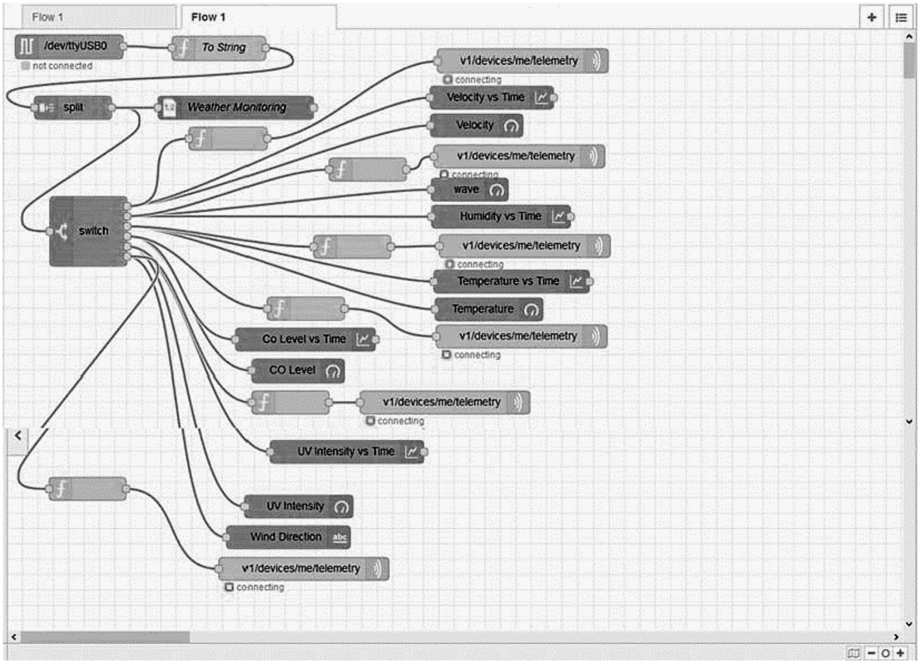
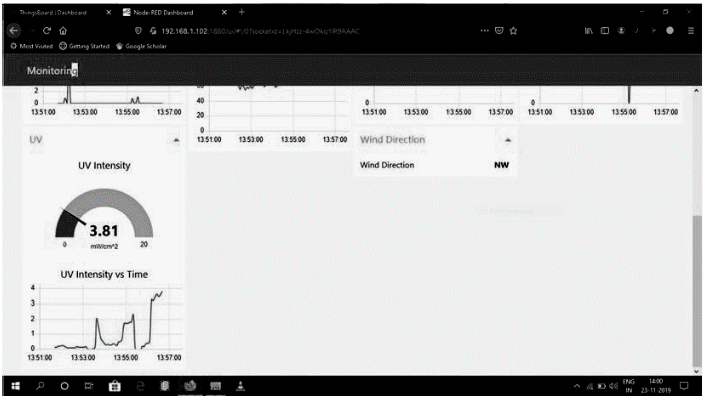


Fig. 5. Node-RED flow for data visualizing

3.0 Results and Discussion

The weather parameters were visualized on the local server without internet connection using node-RED dashboard. Fig. 6 presents visualization of weather parameters in real time on node-RED dashboard.



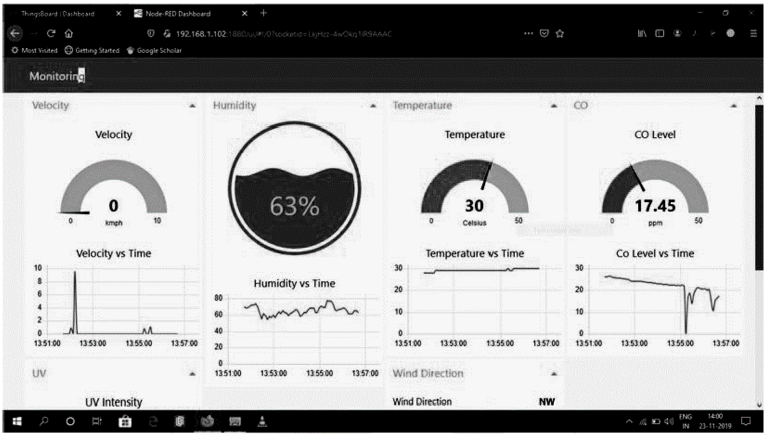
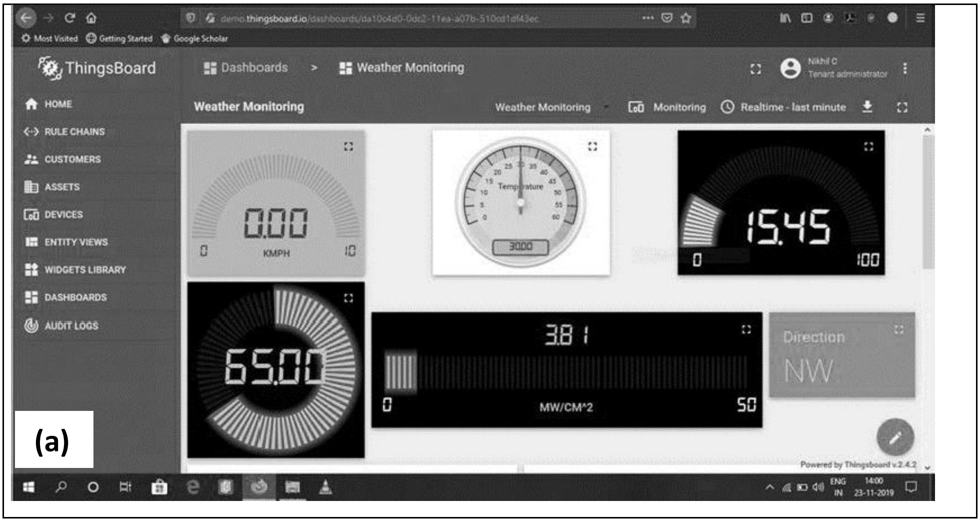


Fig. 6. Node-RED dashboard (a) showing velocity, humidity, temperature and CO level and (b) showing UV intensity and wind direction

When the raspberry Pi is connected to the internet the weather parameters are logged to the remote cloud server. The data is stored on the web server and can accessed anytime and anywhere using ThingsBoard. Fig. 7 (a) shows visualization of weather parameters and Fig 7(b) shows graphical representation of parameters in real time on ThingsBoard dashboard.



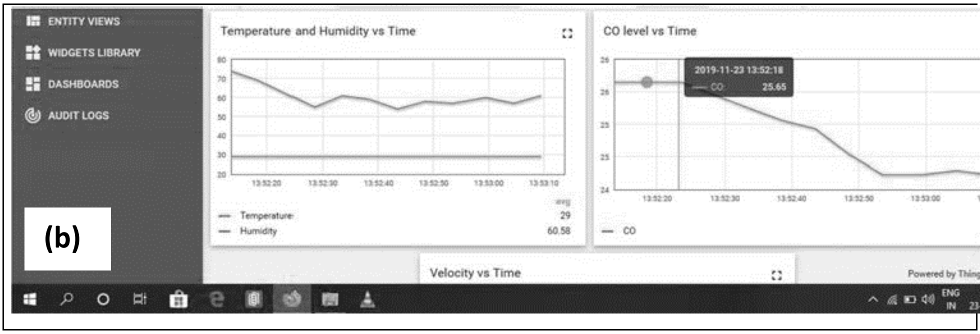


Fig.7. Thingsboard dashboard (a) weather parameters, (b) graphical representation

4.0 Conclusions

As Internet of Things application in farming continue to develop, farms will become more streamlined, connected, efficient and productive. The IoT brings a broad efficiency to the farming space by creating a worthy cycle which makes food crops more readily available to consumers, saves farmers' time and money, and reduces the environmental effect on farming by driving sustainability into the process. IoT based smart weather and wind speed monitoring system using Raspberry Pi and Arduino Mega 2560 was developed. The model demonstrates that cost effective sensors can be used to monitor weather parameters in agriculture field and in greenhouses. The use of node-RED on device connected to local server enables to visualize parameters without internet. The model also reveals how the data can be stored and visualized in real time at remote location using IoT. In future, the range of transmission can be increased by using transmitter and receiver module to visualise data at multiple locations using one station by configuring more number of receivers.

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