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Low Cost Iot Enable Weather Station for Precision Agriculture

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*Abstract—****Agrometeorology plays an important role in Precision Agriculture for resource management and effects both the quality and quantity of agriculture products. The existing solutions for monitoring weather parameters in agrometeorology are highly global and costly. These solutions are most of the time are inaccessible to the common man or farmers and require frequent physical visits to the field for obtaining information. But in agriculture monitoring highly localized weather condition is required because the weather conditions applicable farm land of one city may not be as such for a farmer of small rural. Weather conditions such as wind speed, wind direction, rainfall, solar radiation, atmospheric pressure, air particle level humidity and temperature measurement plays an important role in different fields like Agriculture, Science, Engineering and Technology. The proposed work provides an optimal solution for monitoring the weather conditions at extremely local level with low cost, compact Internet of Things (IoT) based system. In this paper the design of the system is presented with the use of NodeMCU for realizing the low-cost solution. This low-cost weather station is a product equipped with sensors to measure atmospheric conditions like temperature, humidity, wind speed, wind direction which has predominant effect in agriculture. With embedded IoT connectivity, the proposed weather station is capable to upload the information to IoT cloud ad can be used for further analysis.The user can access the information uploaded by the system anywhere from the world with the help on mobile app or web link on laptop/desktop. The "Low cost Compact IoT enabled Weather Station" does not have any display which make the proposed system more power efficient with overall current rating of about only 80mA to 90mA.***

Keywords—Precision Agriculture, Agrometeorology, IoT, Weather Station, NodeMCU, Humidity, Temperature

I. INTRODUCTION

With the IoT the form of the communication has been revolutionized. The generic form of communication is either human to human or human to machine but IoT has given rise to machine to machine (M2M) communication giving great future to internet [1]. The first application of IoT was developed in 1982 as modified coke machine enabling it to report about the drinks contained and their temperature.

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The machine was connected to internet for the purpose of reporting about drinks contained and its temperature. Thereafter in 1991, ubiquitous computing concept to IoT was given by Mark Weiser. In 1999, Bill Joy discussed about Device to Device communication and Kevin Ashton gave the term Internet of Things (IoT) in the same year [1].
IoT is interconnected network of everyday object which may also be considered as self-configuring wireless network of objects. It allows the everyday objects, embedded with electronics, to be sensed and controlled remotely through network. By connecting the numbers of objects to internet makes it dynamic global network with ability of self-configuration [2]. In [3] IoT has been viewed in three paradigms - internet oriented (middleware), things oriented (sensors), and semantic oriented(knowledge) [4]. The IoT covers the various aspect of extending the internet in to the physical world with the deployment of various distributed devices having embedded identification. IoT gives the concept of linking the digital entities with the physical on through suitable information and communication technology, thus giving a whole new area of applications.
The IoT in the near future will make it possible that everyday object will be equipped with microcontrollers; trans-receivers for communication and required protocol making them enable to communicate with each other and also with the users. This will make the internet more immersive and pervasive. The heterogeneous application fields of IoT such as applications areas like consumer electronics, health care, industrial automation, smart homes, public administration, mobile healthcare, smart grids, intelligent energy management make it a daunting challenge to identify a solution capable of satisfying he requirement of all possible applications. This sometimes leads to propagation of different or sometimes incompatible solution of practical implementation of IoT systems [5 papers to IJRE].
Precision Agriculture (PA) is the use of technology in agriculture so as to provide better solution to monitoring and controlling of agriculture parameters and thus improving overall production of agriculture products. *Agrometeorology* is the study and use of weather and climatic information for enhancing the agricultural productivity. Weather/climatic conditions such as wind speed, wind direction, air temperature and humidity in addition to soil temperature and moisture content are some of the critical parameters which affect the agricultural productivity and irrigation planning[12, 13].

II. RELATED WORK

As the issue is very grave, there has obviously been previous research work done on this specific field.This section presents the previous work in the domain as per table 1 and also carried out the cost comparison of some of the commercially available weather station in table 2.

Table 1: Previous Work done with Weather stations

S.No.	Papers	Processing Unit	Parameters monitored	Communication Technology	End user Monitoring
1.	P. Sushmitha et al. [2014] [6]	ARM 9	Humidity, Temperature, Gas	GSM	PC, Mobile
2.	Purnima et. al.[2012][7]	8052 Microcontroller	Humidity, Temperature, Gas-CO2, Moisture	GSM, Bluetooth	PC, Mobile
3.	NorakmarbintiArbain et. al. [2019] [8]	Arduino Uno, Node MCU	Pressure, Humidity, Temperature, Light, Soil Moisture	Wi-Fi	Mobile, Blynk app
4.	Rajinder Kumar M Math et.al.[2018] [9]	Node MCU	Rain, Humidity & Temperature, Pressure, Light	Wi-Fi	Thingspeak
5.	Hammad Aameret.al.[2018] [10]	Node MCU	Humidity &Temperature Gas GPS	Wi-fi	Google sheet
6.	YasasPanselu Jayasuriya et.al. [2018] [11]	Arduino Mega	RH CO_2 Temperature, Pressure, Light Wind speed Wind Direction Rain Gauge Soil Moisture	Wi-Fi	Splot

Table 2: Cost Comparison of various Weather stations

S.No.	Weather Station Product	Cost/Unit	Make	IoT Feature	Source
1	Automatic Weather Station, for Industrial: ATM1136	70,000	Advance Tec India Private Limited	No	https://www.indiamart.com/proddetail/automatic-weather-station-12477572848.html
2	V Tech Ultrasonic Weather Station for Agriculture: VT-UWS01	120000	V TECH	No	https://www.indiamart.com/proddetail/ultrasonic-weather-station-19054403862.html
3	Portable Weather Station: 110-WS-18	325000	Auro Electronics Private Limited	No	https://www.indiamart.com/proddetail/portable-weather-station-4539296991.html
4	Automatic Weather Station, Usage: Industrial: RK900-01	143000	Infinity Enterprise Private Limited	No	https://www.indiamart.com/proddetail/automatic-weather-station-18244123933.html
5	Automatic Weather Station, for Official	500000	Nevco Engineer Private Limited	No	https://www.indiamart.com/proddetail/automatic-weather-station-13513226588.html

The proposed system is very much cost effective having cost value ranging from 20k to 25k as compare to the existing systems as mentioned in table 2.

III. PROPOSED SYSTEMDESIGN

The system comprises of main processing board with IoT connectivity receives the sensor data from after being conditioned by signal conditioning interface. Then main processing applies the calibration equation and encoding to the received for converting the raw data into usable weather information of wind speed, wind direction, temperature and Humidity. The block diagram for the same is shown below in figure1:

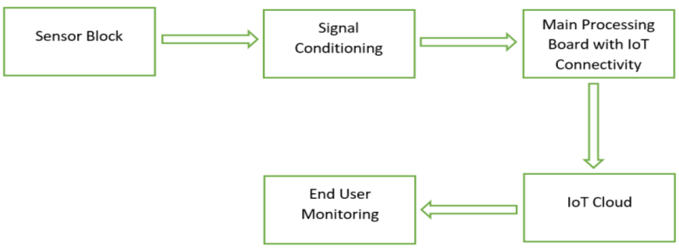

Figure 1: Representation of the System

A. NodeMCU

NodeMCU is an open source freeware hardware IoT platform.NodeMCU has flash upto 1Mb and is programmed in Embedded C with well-known Arduino IDE.There are almost 40 NodeMCUor similar modules supporting almost major IoT protocols like MQTT, HTTP, CoAP, etc.

Figure 2: Representative image of NodeMCU

B. Data Acquisition system

The data acquisition system consists of various sensors that are acquiring the data of various meteorological parameters. They include:

(i) Wind speed Sensor

Wind speed sensor measures the rate of wind flow as analog output signal proportional to wind speed. Wind speed sensor output voltage is read by the NodeMCU through 12 – bit ADC and the obtained voltage is converted to wind speed by applying the calibration equation as follows as per the specification of the sensor.

Wind Speed = (outvoltage - 0.061) / 1.6 * 32.4

As per the equation upto 0.061V i.e 61mV the sensor does not give any information about wind speed.

Figure 3: Representative image of Wind Speed Sensor

(ii) Wind direction Sensor

Wind direction sensor provides the analog signal which can be mapped to the wind direction by first converting the analog signal to digital with 12-bit ADC and then mapping the digital value to angular position of sensor vane. Form the angular position of sensor vane wind direction is obtained.

Figure 4: Representative image of Wind Direction Sensor

(iii) DHT11 sensor

DHT11 is digital sensor for the measurement of temperature and humidity and gives the temperature and humidity information in 40-bits binary data stream with 16-bits for temperature, 16-bits for humidity and 8-bits for checksum. Figure 4 gives the pin details for DHT11 and figure 5 gives the data format of DHT11.

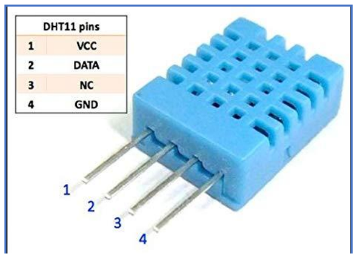

Figure 5: DHT 11 Sensor pin connection

RH-Integral	RH-Decimal	T-Integral	T-Decimal	Checksum
1st Byte				5th Byte

Figure 6: DHT 11 sensor data format

C. Thingspeak Server

Thing Speak is sixth most popular open source Internet of Things (IoT) platform[12] and is selected for the proposed system on the basis of

- Capability to display data graphically
- Integration with MPLAB for further data analysis
- Low infrastructure cost with no cost upto 8-channel usage
- Compatible with most of the open and freeware hardware like Arduino, NodeMCU, Raspberry Pi etc

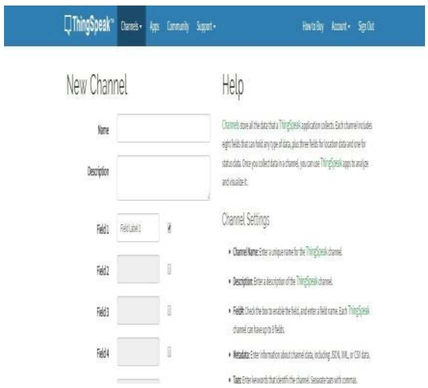

Figure 7: Thing Speak server

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed IoT based weather station confirms with the three-layer architecture for IoT namely perception layer, Network layer and Application layer as discussed in [8 synopsis].

- Perception layer: This is the sensor layer and is responsible for sensing the information from the environment. The sensorsalong with signal condition in proposed weather station interface forms the perception layer of the IoT architecture and communicates the physical parameters to the IoT network

- Network layer: This is the transmission layer and is responsible for receiving the information form the perception layer and determining the route for the data and information to IoT hub or cloud. The code with all details of Thigspeak IoT clout channel to route the information to correct channel in the proposed system implement the network layer of IoT architecture.
- Application layer: This layer is the topmost layer in IoT architecture. Application layer receives the data from network layer and provides the services and operations. The Thingspeak cloud with graphical representation of information is the application layer implementation in the proposed weather station.

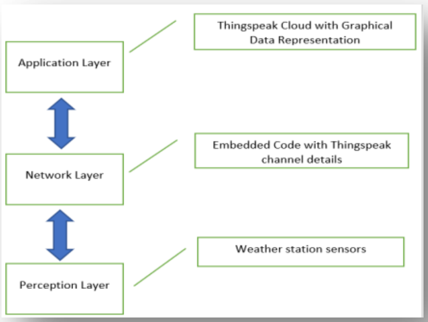

Figure 7: IoT Architecture of Proposed Weather Station

V. CONCLUSION AND FUTURE SCOPE

To conclude this work, we verify that weather monitoring is an important element in precision agriculture. The IoT technology has aided us to engineer a low-cost system to monitor weather conditions continuously.

To expand the work further the system can be implemented for soil agronomy measuring the important parameter of agriculture soil affecting the agriculture productivity. Agrometeorology combined with soil agronomy provides the valuable information for agriculture resources management like irrigation, fertilizers, pesticides etc and will aid to achieve the main goals of precision agriculture i.e. profitability, sustainability and protection to environment.

Introduction of machine learning to the proposed system will lead to the anticipation of the weather conditions in advance that can be very useful for agriculture sector, industrial sector or service sector. There is also the growing issue of Air Quality Index in our country especially during winters due to stubble burning. The general weather monitoring systems provides the data for a large area. However, with our proposed work and enhancing further its sensor technologies we can detect the air quality index for a smaller area beforehand.

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AUTHORS FROFILE

Dushyant Kumar Singh, is Assistant Professor and Head of Embedded Systems Domain in Lovely Professional University. He has completed his master from Punjab Engineering College, University of Technology, Chandigarh. He has Industrial experience of 2 years and more than 9 years of Teaching experience. He is engaged in Embedded Systems design and IoT systems design since last more than 5 years. He has developed many professional systems like IoT enabled weather monitoring system, IoT enabled water level monitoring and control of overhead tanks, IoT enabled LED matrix display board, IoT controlled lights, Image processing with Raspberry Pi. He is continuously involved in passing the technology to students and faculty though trainings, workshops and Faculty Development Programs (FDPs). He has conducted workshop on Embedded System at Hindu College of Engineering in 2017 on Embedded System and at SLIET, Longowal on IoT in 2018. He has also conducted two workshop FDPs on ARM, IoT with Raspberry Pi. His project "Wireless Router" is recognized and certified by BSF, Jalandhar and one another project "PICASSO 4.0", IoT based project, has been the winner of the International competition Delta Cup, China in 2017. Not only this, he has been recognized amongst top 100 innovators from North India by Confederation of Indian Industry (*CII*) in 2017. He is also involved in training of the students and has trained more than 250 students in Embedded Systems and IoT.

Himani Jerath is an Assistant Professor of Embedded System domain in LPU. She has completed her Masters of Engineering in ECE with Honors from University Institute of Engineering and Technology, Panjab University, Chandigarh. Her research area include biomedical signal processing with embedded system in which she has presented her work in Chandigarh Science Congress and International Conference on Advanced Informatics for Computing Research (ICAICR-2017). Her recent work includes EMG sensor controlled wheelchair, smart irrigation system and Microcontroller based Vehicle control and safety system.