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Smart Agricultural Management using IoT Based Automation Sensors

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Abstract*: All humans mainly rely on cultivation for food. Agriculture acts as a backbone for many countries' economy. Deprived of agriculture there could be no towns, universities, industries or workplaces. As humans we have to improvise our cultivation to increase the gained profit and also to handle all the food demands due to the increase in world population. Basically we need to have a basic understanding about our environment and its altering conditions to improvise our farm production techniques. Manual collection of these agricultural data will not be qualitative since there won't be any data collection of earlier techniques used by our ancestors. Such information is required to avoid invalid conclusions before being utilized in our current agricultural methodologies. IoT in agricultural field plays a vital role in providing improvements in cultivation techniques, disease diagnosis, providing fertility rates, water stress level, field monitoring, detecting soil erosion, smart data handling, analysis of crop yield, automation to water spreading, better product's quality, risk management, effective data handling etc. We can utilize IoT wireless networks for the collection of all the information necessary for agriculture. We can receive spatial data from IoT cameras and many more new technologies utilized to improvise the irrigation methodology. The decision making will be improved with more security and optimized outcome will be gained. In our proposed method, a smart agricultural methodology based on IoT platform is proposed. The collection of various data related to fertilization, soil, environment, irrigation etc. are done to perform data correlation and data filtering. Crop forecasting and prediction can be done to perform perfect farming by agricultural assessment. Our proposed model can be integrated to any IoT sensors; cameras etc. in a virtual manner and it supports cloud data storage as well. A stable connectivity is also possible between the IoT devices. Here we have provided a detailed survey of all the research works we have referenced, our proposed model along with the architecture, hardware (Microcontrollers, Zigbee Module, Moisture sensor etc.) and software (Debugging, Simulator, Dip Trace, Monitoring etc.) used, result evaluation is also done for temperature, humidity value, channel status etc. All the results are graphically represented and our brief conclusion is given.

Keywords: Smart Agriculture, Internet of Things, Automation Sensors, Irrigation, Warehouse.

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I. INTRODUCTION

Since agriculture is considered to be the major source for food grains, various raw materials etc. and also for human species it acts as the life basis [24], [25]. For the economic growth of any country it plays a substantial role in it. Many employment opportunities are created for the people. It is very much necessary for an agricultural sector to grow further is mainly because it paves the way for a country's economy to grow more. But still many farmers utilize the traditional methodologies for cultivation thereby resulting in low manufacture of fruits, vegetables, major crops etc. In the areas where automation is employed, humans are substituted with machineries and hence the production is drastically improved. Implementing such modernized technologies into agricultural field will improvise the crop yield. Many referenced papers explains about the usage of wireless networking environment including data collection from various sensors and with the help of wireless protocol the data will be sent to main server. This will help in monitoring the system since the collected data contains information about environmental factors. We have to provide an effective solution to yield more crops instead of just monitoring. Factors like insects; pets etc. are also the main reason for affecting the crop yield. But we can keep them under control by means of pesticides and insecticides spray. There are other factors like wild animals attack and birds during the crop growing process. When the crops are at harvesting phase there are possibilities for thefts to happen as well. When the harvesting is completed farmers also face difficulty in storing it in proper place. For avoiding all these problems it is very much essential for integrated system development thereby improvising the crop production during cultivation, pre and post harvesting phases. In our paper, we have suggested an integrated system for monitoring and controlling the field operation in a more flexible way. Our main aim is to provide automated smart agricultural system utilizing IoT technologies. Our best features include remote controlled robot with smart GPS for performing spraying tasks, moisture sensing tasks, weeding tasks, scaring birds and animal tasks, etc.

and smart irrigation system for real time data handling and smart management of warehouse including maintenance of temperature, maintenance of humidity, detecting thefts in the warehouse etc. We also provide a complete control over all these operations with the assistance of smart remote controlled device with internet connected computers including Wi-Fi modules,

micro-controlled actuators etc. Since the world is going forward with trending technologies, it is very much essential to develop ourselves up-to-date in agricultural field as well. Various research works have been undergone related to agriculture and many of the projects portray the usage of wireless networking environment for the collection of deployed sensor data at numerous nodes and transferring it to corresponding wireless protocol. Though countless integrated systems have been developed [21], [22] so far to improvise the agriculture field and yet it is not been given directly to farmers. Our proposed integrated system is been given to the farmers. The major profit in agriculture will always depend on the final outcome of the harvest. We have clearly undergone survey regarding the technology gap between the cultivation phase and the final outcome and we have provided a complete solution for the same as well.

II. LITERATURE SURVEY

We have made several research works regarding our idea and have mentioned all about the papers and their research works in detail below. In [1], in order to handle water scarcity in underground, tanks, rivers etc. and for the proper utilization of water, They have developed an algorithm along with moisture and temperature threshold values for controlling the quantity of water by programming with micro-controller based gateway. With the aid of photovoltaic panels system is powered on. Cellular internet interface based duplex communication is established thereby allowing inspection of data and scheduling of irrigation that will be programmed with the aid of a web page. In [2], they have mentioned about the possibility of usage of greenhouse parameter’s control and monitoring in precision agriculture which is made possible by wireless sensor networking environment and this is considered to be the major technological development. In [3], they have researched about various criteria in agricultural field and they have found that crop yield is very much decreasing every day. In order to reduce the extra added man power for the increased production, the technology usage plays a vital role in it.

To increase the yield of agriculture many research works are attempted with the aid of helpful technologies mainly for the betterment of farmers. In [4], they have suggested a system with irrigation control and remote sensing with the aid of distributed wireless sensor networking environment for altering rate of irrigation, sensing the field at real time basis, irrigation system control to increase the production with less usage of water. They have given a brief explanation about all these systems along with suitable software. The entire system is developed with the aid of five sensor stations which is in field. The data will be collected and transferred to base station using GPS in which required actions will be taken to control the irrigation based on the available database. Their proposed system provides solution with less cost involvement and also with remote controlled precision irrigation.

In [5], here they have presented a wireless sensor network which is hierarchical to measure soil related factors like humidity, temperature etc. In their proposed scheme sensor nodes are placed underground for collecting all the necessary soil measurements. Such nodes will possess radios to transfer those measurement values to the nodes present above the ground level. Such nodes are named as relay nodes which will transfer the data to a workstation via a base node. The system also utilizes a communication protocol to provide low duty cycle and provides a long life time applications. In [6], they have made IoT utilization along with picture handling for identifying the places where the minerals and sufficient enough thereby influencing the yield growth. In [7], they discuss about the advanced and fast improvisation for agrarian transformation in the modern world and also aid horticulture by providing excellent solutions and explanations to the identified issues with ranchers. In [8], they have suggested a method to picture and keep track of rural items in the network of inventory.

In [9], their suggested idea surrounds around engineering with equipment, design arrangement and to program the process control for the correctness of water system framework. In [10], here they have suggested an approach for directing water in the fields present in the rural areas. In [11], they are suggesting an idea that provides a greenhouse condition for all the plants by allowing the users to monitor from the remote location about the agriculture environment. To provide development to country’s stature precision agriculture will support it. In [12], they suggest a smart controlled smart irrigation method with intellectual decision making ability in the collected field data. It also includes temperature and humidity maintenance in warehouse through ZigBee modules, actuators, raspberry pi etc. In [13], they propose a method that combines the cons of developing technologies like IoT and web services for constructing an effective methodology for handling vast data.

It helps in the rapid growth of agricultural transformation in the modern world and to aid farmers to resolve the field issues effectively. In [14], they mainly focus on the physical factors measurement such as soil, moisture, nutrient, pH value etc. With the help of the smart irrigation process (water along with compost and green manure is splashed in the field area) smart farming system is developed and their model is explained in detail. In [15], they are suggesting a system that will increase the farm efficiency by giving water at the right amount. Their main aim is to design a cost efficient wireless sensor technique in the networking environment to grasp the moisture and temperature factor from various farm places for taking the required decision whether to proceed the irrigation or to stop it.

In [16], they have proposed an algorithm containing temperature and moisture threshold values that is supported with microcontroller gateway for controlling the quantity of water. With the aid of photovoltaic panels and communication duplex the system is powered.

The entire system is tested in sage crop field and resulted in more water saving as well. It is supported in limited geologically isolated areas. In [17], with the help of Zigbee protocols, environmental conditions are closely monitored. For saving water partial zone root drying process is implemented. CAN, WSN, Zigbee etc. technologies are utilized for more crop yield. In [18], they have designed a monitoring system based on IoT technology for analyzing the environment of the crop and for improvising the decision making in analyzing the statistics of crop harvest.

In [19], they utilize two image based database for training the affected images. Then they are categorized based on color, morphology etc. They demonstrate efficient algorithm for spreading disease and for counting mango. With the help of MATLAB neural networks practical implementation is done. In [20], here they have discussed all the problems related to farm made up of various greenhouses. They have used Zigbee and controller area network protocols for creating a smart distributed system. ZSDS allows us to access the network resources that are in connection.

III. PROPOSED SYSTEM

In our current system, we have used various sensors and devices and with the help of wireless communication system [**23**] all these devices are connected via one central server. Internet connectivity is required for a server to transfer and receive the user messages. In fig.1, we have two operative modes such as auto mode and mode by manual operation. Own decision making will happen and controlling all the installed devices will happen in auto mode phase and with the help of PC commands or android application user can able to control the system operations as well. We have utilized a mobile robot which is completely based on GPS and it is remotely controlled with the help of computer programming for autonomous navigation within the boundary field with GPS module given coordinates.

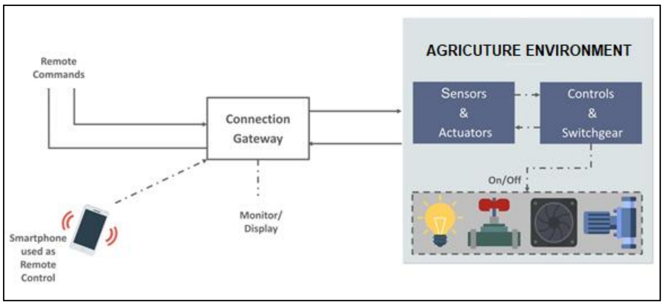

Fig. 1. Proposed System model

There are different devices and sensors are available in the robot which is controlled remotely and the devices are obstacle sensor, siren, camera, sprayer and cutter. With the help of these we can perform vigilance handling task, animal and bird scaring task, spraying task and weeding task. With the help of motion detection system, any new motions in the room will be detected by making the security mode 'ÓN' and when the motion is detected an alert signal will be sent to the user with raspberry pi and thereby helping in theft detection. Support to smart irrigation operation with various features like smart controlling of water pump with the help of real time data of the field which means an automatic operation is inbuilt in water pump that will turn on or off based on the moisture content of the soil along with remote handling of mobile or computer in manual mode. There will be continuous monitoring of the moisture content in the soil. There will be much response from all of the above systems to make the system grow to next level. The upcoming phase will discuss about the software and hardware requirements for our system that will support flexibility and stability is discussed below.

A. Hardware utilized

Microcontrollers and Processor–We have utilized AVR eight bit microcontroller which is of low power consumption containing eight kilobytes self-programming flash memory with in-system, eight channels, ADC with ten bits, programmable serial USART and programmable 23 I/O lines. One of the most popular micro-controller is 16F877A. It is convenient for the users and supports easy handling. With the help of flash memory, program can be easily erased. It has various applications which is been utilized in various big industries. It is been utilized in security systems, remote sensing applications and automation industries. EEPROM utilized for storing data permanently such as transmitting codes, frequency receiving etc. ARM7 processor is used which will interface each part in relation with development pack. There are totally 64 pins in it. Every stick is related with precise unit segment to perform precise capacity.

B. ZigBee Module and Camera

It is mainly utilized for attaining communication in wireless mode among node 1 and node 2. Zigbee's range is about fifty meters and it can be amplified with the help of high power modules or by network modules. Its operative frequency is 2.4 GHz. The consumption of power is very low and when compared to other modules of wireless mode (Bluetooth, Wi-Fi etc.) it is cheaper [21]. Establishing local area wireless networks [22] can happen. In order to see the real time plant's status camera is utilized.

C. Temperature Sensor

The IC temperature sensor we used is LM35. The Celsius temperature or the centigrade will be directly proportional to the outcome voltage. There is no need for trimming or external calibration for providing correct range of the temperature. It is of less cost sensor. IT contains less outcome impedance and linear outcome. -550tok+150˚C will be the functioning temperature range. When the temperature is increased the outcome voltage of the sensor will also increase in a linear fashion and voltage value is transferred to microcontroller which is then multiplied with the help of conversion factor for giving the actual temperature value.

D. Moisture sensor

It is used for measuring soil water content. The electrical resistance property of the soil is been utilized. A calibration is done between measured electrical resistance along with soil moisture and the result might vary based on the environment factors like temperature, type of the soil or its electrical conductivity. In order to switch on or off the water pump the moisture in the field is sensed and transferred to microcontroller.

DHT11 is considered to be the humidity sensor with less cost digitized temperature. The outcome value of it will be digitized so there is no need for conversion algorithm at microcontroller (ADC) and output can be given directly to data instead of it. In order to measure humidity a capacitive sensor is used. A little drawback of this sensor is we can get a new data for every two seconds only.

E. Obstacle Sensor

It is said to be an ultra-sonic sensor type operating on the sound wave principle and its property of reflection. There are two phases involved here named ultrasonic receiver and ultrasonic transmitter. The receiver will receive 40 KHz sound wave and the transmitter will transmit 40 KHz sound wave. During its reception, microcontroller will receive the electrical signal and sound speed is known already. The obstacle distance will be calculated in between the time taken for receiving back the transmitted sound wave. It is utilized for detecting the obstacles if mobile robot is used and for detecting ware house motions to prevent thefts. The robot will be enabled by ultrasonic sensor for detecting and avoiding obstacles and for measuring the distance from the obstacle point. Its operation range is from ten centimetres to thirty centimetres. In order to find PA, TrA, OI and OE four equations are developed and it is mentioned below.

Equation 1:

$$PA\ ratio = \left(\frac{TrA\ contracted}{TrA + OE + OI\ contracted} - \frac{TrA\ rest}{TrA + OE + OI\ rest}\right) \times 100$$

Equation 2:

$$PAM\ ratio = \left(\frac{TrA\ contracted}{TrA + OI\ contracted} - \frac{TrA\ rest}{TrA + OI\ rest}\right) \times 100$$

Equation 3:

$$TrA\ ratio = \left(\frac{TrA\ contracted}{TrA\ rest}\right) \times 100$$

Equation 4:

$$OE/OI\ ratio = \left(\frac{OE + OI\ contracted}{OE + OI\ rest}\right) \times 100$$

F. RaspberryPi

It contains very less pocket sized computer to perform small computing and operations related to network. It is a significant IoT element. It provides internet access and hence there will be a possibility for automated system connectivity along with remote location. This hardware is also available in various versions. In our model Pi 2 and B model is used containing quad-core ARM and Cortex-A53 CPU with 900 MHz along with one GB. It contains forty pins, complete HDMI port, and USB ports with four quantity, Ethernet port, and audio jack with 3.55 mm capacity, CSI, DSI and a slot for SD card.

G. Debugging Software

Its main purpose is for writing, building, compiling and embedded C program debugging are required to burn into microcontroller for performing the necessary operations. In Fig.2, we can see the simulation between hardware and software and to compare the performance. The software will provide a file with extension .hex and that will be easily burnt to microcontroller.

H. Proteus8k Simulator

It is one among the effective software available for simulation including numerous microcontroller circuit designs. It is considered to be the widely used simulator because all the electronic components and microcontrollers are available anytime. It is utilized for testing the programs and electronic embedded designs before the testing of hardware. Microcontroller simulation programming is done in Proteus. Such simulation will avoid the hazard of hardware damaging because of wrong design.

I. DipTrace

It is considered to be EDA software or CAD software to create diagrams in schematic fashion and along printed circuit boards. Multi-lingual interface and tutorials will be provided by the developers which are presently available in twenty two languages including English as well. It contains four modules such as PCB layout editing with already built shapes based auto router, capture schematic editor, 3D Export and preview, Component editing and pattern editing. Fig.3 displays all the controlled modules which is under maintenance by software.

J. Calculation Software

A Hex downloader application named SinaProg contains AVR Dude along with Fuse bit calculator. It is mainly used for downloading programs and also for setting fuse bits of all AVR microcontrollers.

K. Raspbian Operating System

It is an open source and also a free OS. It is based on Debian and raspberry pi as well in an optimized way. In order to operate raspberry pi set of programs and utilities are provided. It contains 35,000 pre-compiled software packages which are perfectly bundled for hustle free installing. Good community developers are running the forums to given solutions to various problems. But it is under development stage still in order to improvise its performance and stability of Debian package.

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O. Livestock Monitoring

Wireless IoT applications can be utilized by very large owners of the farm for location, cattle health and well-being based data collection. This aids them to identify sick animals and to separate them from the herd. Thus disease spreading can be prevented without the involvement of labors. Cattle can also be located with the aid of ranchers using IoT depending sensors.

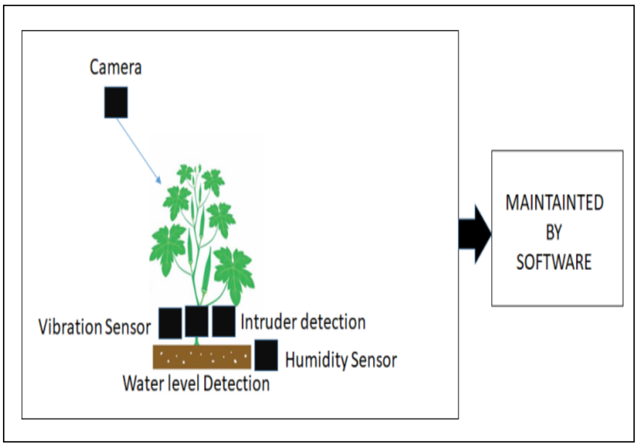

Fig. 2. Modules connected with software

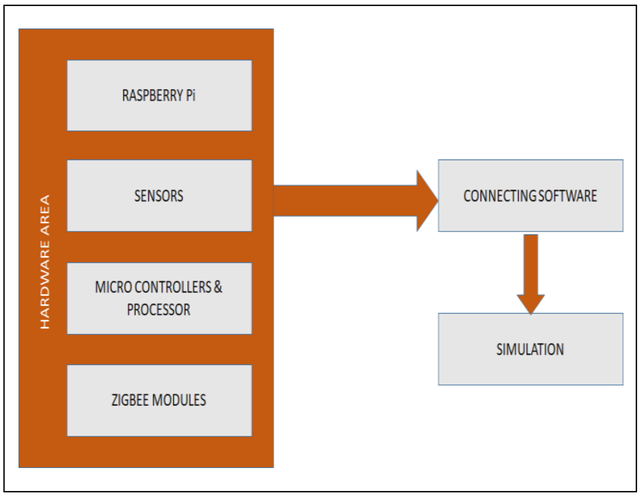

Fig. 3. Hardware controlled by Software

IV. RESULT EVALUATION

We have experimentally verified our proposed system with the aid of ThingSpeak software for result simulation and also a comparison is made with the existing system as well. In Fig. 4, the humidity and temperature value is recorded from the device in connection with the environment. For checking the level of water, it is sampled with normal water. When there is a decrease in the water level, the motor will be switched ON with automated sensor. Hardware interface happens with all sensors on board. Buzzer, ADC converter, microcontroller, relay, GSM module are all the sensor interfaced hardware components. SIM card is utilized for owner and recorded values communication which is inserted in the board.

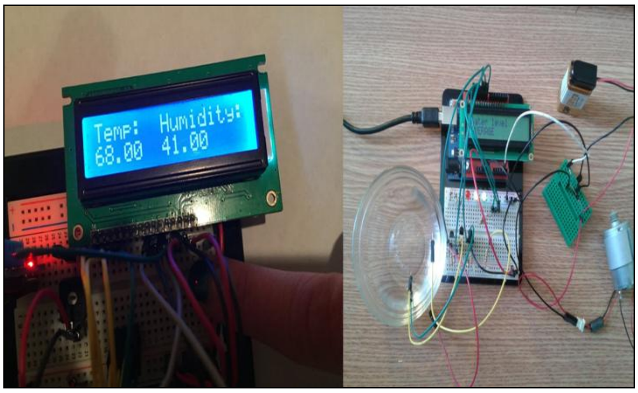

Fig.4: Temperature and Humidity Value

In Fig.5, chart generation is represented from ThingSpeak software to identify the current stage's system's performance and status. From this method it will be very helpful for checking the device connections. The charts represented are Field 1 chart, pressure histogram chart, T-H YY plot chart and T-H correlation chart. All the measurement values are represented clearly here.

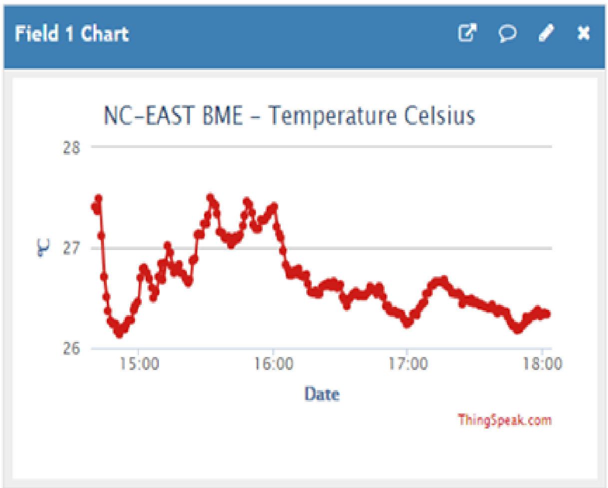

Fig. 5(a). Field 1 Chart (Temperature Celsius)

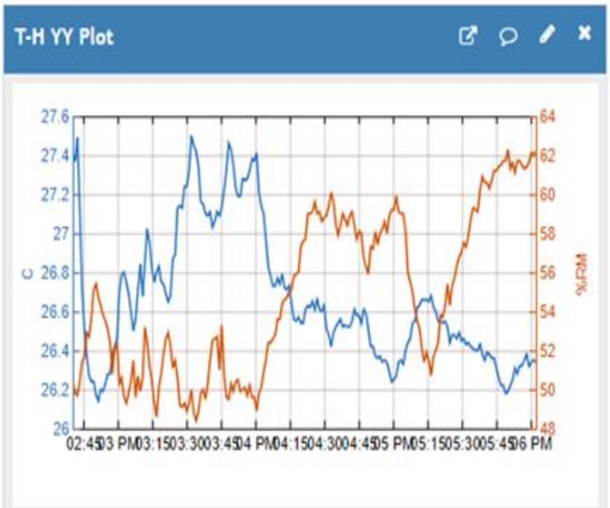

Fig. 5(b). T-H YY Plot

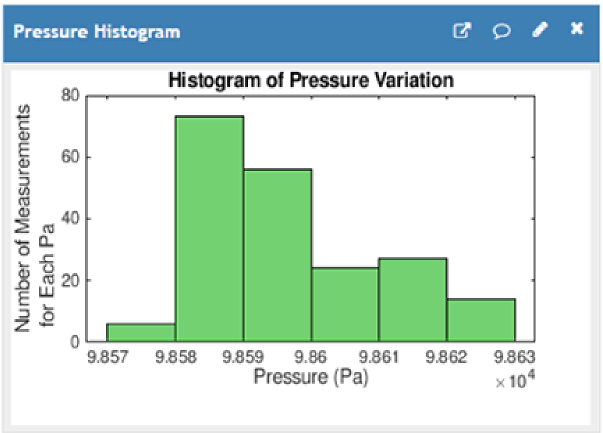

Fig. 5(c). Histogram of Pressure Variation

In Fig.6, graphical representation for ideal humidity, distance from ideal humidity, variation between actual and ideal humidity and Channel status updates are represented. The charts are named as Field 2 chart, Field 1 chart, Actual vs Ideal Humidity chart and Channel status updates chart. The main parameter used for comparison and plotting is date.

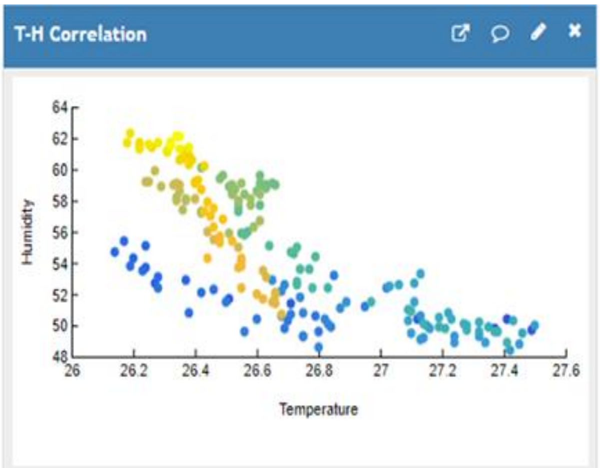

Fig. 5(d). Histogram of Pressure Variation

Fig. 6(a). Field 2 chart (Ideal Humidity)

Fig. 6(b). Field 1 Chart (Distance from Ideal Humidity)

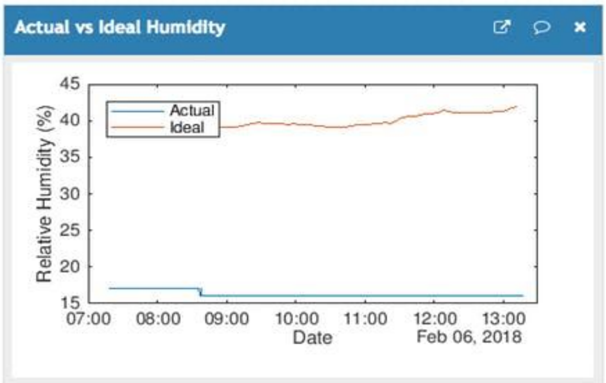

Fig. 6(c). Actual Vs Ideal humidity

Fig. 6(d). Channel Status Updates

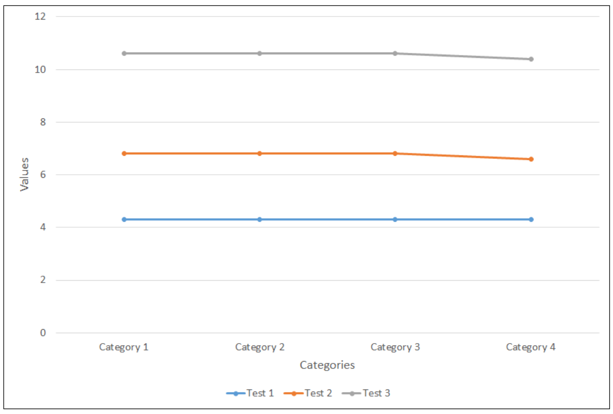

Fig.7. Stable Connection

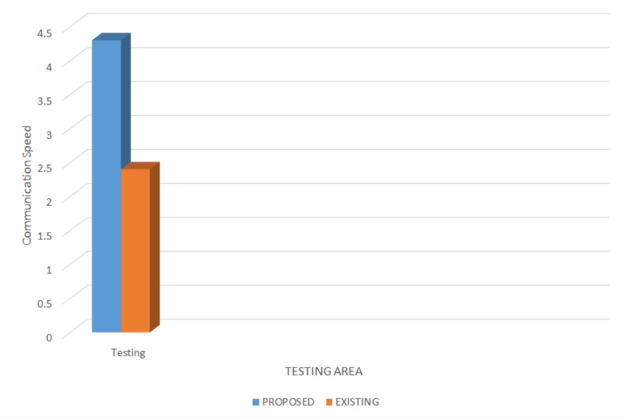

Fig. 8. Communication Speed

In Fig. 7, stable connectivity in all connections are verified by individual method and combination method. Both the methods are giving the values properly. At last communication between hardware and software is achieved and it provided the correct value in combinational communication. In Fig. 8, the communication speed of the testing is compared with proposed system (represented in blue color) and existing system (represented in orange color). The values are plotted from ‘0’ to ‘4.5’ and the maximum communication speed achieved only in the proposed system.

V. CONCLUSION

In irrigation process, to predict and measure the necessary values our suggested model is collaborated with different sensors including humidity, temperature etc. Our model supports smart irrigation and warehouse management. Monitoring all the stocks becomes our system’s major responsibility. In future, our system can be enhanced to support larger acres of land. The system is very much integrated with soil quality and crop growth. Interfacing of all the required sensors and microcontrollers are successfully done and wireless network paves the way for it. To increase the accuracy temperature and various sensors works together. Our system is cost effective, very much faster and more reliable. We also experimentally verified it using ThingSpeak software and the results prove that we have a complete solution for all the irrigation problems. Thus the overall production is improvised with advanced technology.

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