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Fuzzy Logic Based Farm Automation Using Arduino and LabVIEW with X-Bee Based Control System

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Abstract— ***In spite of the vast advancement in technology, the exposure of a primary sector like agriculture to technology is quite limited in India. With an exponential decrease in the labor availability for agriculture, a second green revolution is the order of the day. The objective of this paper is to reduce the pressure on manual labor. The system has been tested and the results have been obtained. This is done with the help of Arduino, LabVIEW and Zigbee Technology. Essential parameters of the field are sensed to have a continuous unmanned supervision.***

Index Terms— ***Arduino, RST-03, Fuzzy Logic, LabVIEW, ATMEGA 328, Zigbee technology, Farm automation.***

I. INTRODUCTION

The fundamental element for sustainment of life is food and it becomes inevitable for us to make sure that the production keeps pace with the growing population. So in order to efficiently produce the crops we introduce automation in the field of agriculture through this idea [1]. The basic parameters which are essential for production are Light, Mineral rich water, ambient temperature and humidity in addition with appropriate moisture content in soil.

The level of moisture present in the soil is a critical parameter in determining the overall growth and yield of the plant. When the soil moisture content is very low the phenomenon of agriculture drought occurs and in turn affects the reliable plant growth. On the other hand when the soil moisture content goes out of the range the plant's roots decompose because of the lack of oxygen. This is because when water percolates through the soil the oxygen gets expelled leading to the above mentioned phenomenon. Now coming to the second factor which impedes the growth of plant is the temperature and humidity. The relative humidity is the amount of water vapor in the air compared to that of the amount of water vapor that the air could hold. For optimum growth of crops the relative humidity should be high which would control the rate of transpiration.

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The next important parameter that affects is the light [2]. When the intensity of the light is too high there is a danger that the heat produced can increase the rate of transpiration and resulting in the crops to wilt. The equation (1) depicts the process of photosynthesis.

$$6CO_2 + 6H_2O + LIGHT \rightarrow C_6H_{12}O_6 + 6O_2 \quad (1)$$

There are some miscellaneous parameters which are crop specific like the water level. The water level sensor is used in the case of crops like rice which requires substantial amount of standing water. We found on our study that all plants need light but extremity of light either too much or scarce will definitely affect the growth of plant.

II.RELATED WORK

As a part of the literature survey, we visited a village on the outskirts of Chennai, Oragadam Postal Village. Based on the interview with a farmer, we came to know that there were a lot of problems confronted by the farmers. The important problem which they felt was the shortage or unavailability of laborers. We inquired them about the other problems and the understood the sophistication present in the farming. Hence the laborers who were employed had to do more work than normal to overcome the deficit of labors. Also there were lot of problems which was faced by them which were consumption of more time and also the cost of human labor. Thus we decided to design an automation system which reduces the human labor in the field of farming. Thus this paper helps the farmer as in case of the Oragadam Postal Village to reduce the pressure on the manual labors.

The idea that this automation can be done effectively is drawn from Fred. E. Sistler [3]. In this paper the use of the intelligent machines in the field of agriculture is done. Miranda [4] determined the irrigation amount based on the soil measurements. In this reference, the various physical parameters to be considered were taken into account. The application of X-Bee technology in the field of greenhouse management automation was done by Zhou Yiming [5] where the X-Bee module was used in the management. The idea of acquiring the values from the sensors and transmitting it through the X-Bee transmitter was implemented in the paper The idea of using precision agriculture was done by Richard W. Wall [6].Here in the paper the methods of improving the yield of the crop was discussed which are equipped with the sensors. Ali Mohammad [7] discussed about the automation of home where he incorporated the technology of connecting the data to the server.

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The idea of uploading the acquired data from the sensors was also implemented in the above mentioned reference.

The Zigbee is a high level protocol that uses small, low power radio based on the IEEE802.15.4-2003 open standard for wireless personal area networks (WPAN's) [8].Here we adopt the concept of remote sensing. The process involves the data acquisition of above mentioned parameters, prioritizing them and thus regulating them with the help of fuzzy logic. Based on the output of the fuzzy logic controller the critical factors are controlled. The values are entirely monitored with the help of LabVIEW. The system is completely autonomous and hindrance of distance is eradicated.

III. SYSTEM

The Fig 1 shows the block diagram of the entire system. It consists of sensors, the simulation software LabVIEW and the process has been facilitated by Arduino. All the components interact with each other to comprise the entire integrated farm automation system. There are 5 inputs which are obtained from the corresponding sensors. The data that has been received from the sensor is processed and based on the input the decision is taken and the corresponding output is triggered. The above mentioned process is facilitated by LabVIEW and Fuzzy logic. The entire system is completely autonomous.

A .SENSORS

A device that detects or measures a physical property and records, indicates, or otherwise responds to it. Here the above mentioned physical parameters are sensed by sensors. These sensors are parameter specific. The sensor that we incorporate to measure the moisture is BRICK SENSOR SEN92355P [9]. The use of this sensors aids us by giving us single sensor DHT the accurate data. The temperature and humidity both can be easily detected by high accuracy and stability and thus reliable in nature [10].

Coming to the detection of light here we use Light dependent resistors. They are nothing but resistors whose value changes based on the intensity of the light. They are used here to detect the basic light intensity changes. Finally the water level is detected by Float sensor which gets short when desired water level is attained.

B.LABVIEW

The LabVIEW is graphical user interface software developed by National Instruments. The paper which primarily targets the farmer who is a layman will have scarce knowledge about the computer.

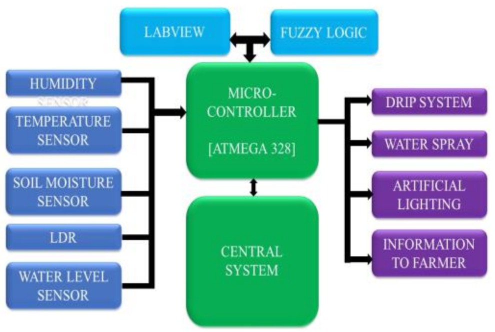

Fig 1: Block diagram of the entire system incorporated in the Farm automation

Providing comprehensive tools that you need to build any measurement or control application in dramatically less time, LabVIEW is the ideal development environment for innovation, discovery, and accelerated results. So, if we can develop a graphical user interface which could aid him to interact with the system that could give the optimum utilization of his farmland. In order to develop the GUI we use the LabVIEW as a hub which governs the entire system. Also the paper which uses fuzzy logic as a controller .The fuzzy logic platform has been provided by the LabVIEW. The X-Bee technology can be used directly by the computer and this could be sent to LabVIEW to process the data.

C. ARDUINO AND ATMEGA 328 MICROCONTROLLER

Arduino is the software which is used to interface the LabVIEW and the environment. The Arduino is used here because it provides a simple programming environment which is user friendly and it has enough flexibility to accommodate the future scopes [11]. The device operates between 1.8-5.5 volts.

IV. STRUCTURE OF PROPOSED WORK

Here in our project we categorize our entire system into three different levels. The highest level known as the MONITOR LEVEL, the intermediate level known as the CONTROL LEVEL, and the lowest level is known as the FIELD LEVEL. The Fig 2 shows the implementation of the three levels which are connected to the peripherals. The field level is placed within the farm. The system consists of several field levels but only one control and monitor level. The control level can be placed anywhere according to the user's necessity which is within the vicinity of the farm. The monitor level can be placed in any remote locality. All the three levels of the system communicate using the Zigbee protocol [12].

A.FIELD LEVEL

This is the primary level of the system to which all the sensors are connected. The main function of sensors is to acquire all the data and send it for processing to the control level. A large farm is segregated into multiple small sub-plots and a field level is placed in each sub-plot.

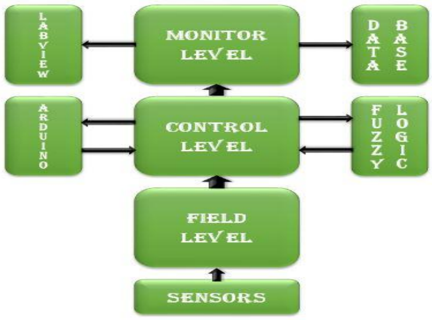

Fig 2: Illustration of three levels of the system with its peripherals connected to each level.

The Fig 3 shows the multiple field levels which can be connected according to the area of the farmland. Each of these sub-plots has multiple sensors connected. These sensors acquire all the physical parameters namely; temperature, light intensity, humidity, moisture level and water level and store it.

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Fig 3: Illustration of the interaction between the control level and field level and the master level (FL-Field Level CL-Control level ML-Monitor Level).

The sensors are connected to the ATMEGA 328 IC. The data is acquired with the help of microcontroller. All the individual data acquired are sent to the X-Bee by the microcontroller with the help of serial communication [13]. The X-Bee at the Field Level transmits this data to the X-Bee Module at the Control Level. Alternatively, the sensors can also be directly connected to the X-Bee module. The data acquisition from all the Field Levels are done at equal intervals of about one minute.

The Field Level also has the output unit, which comprises of the Drip System and the Spray System which helps in regulating the temperature, humidity and soil moisture. The controlling is done with the help of the Control Level. The regulating process is done by controlling the time duration of flow of the water through the drip and the spray system. There are output units separately for each sub-plot. Hence, just like the sensors these output units also cater individually to the needs of the various sub-plots.

B.CONTROL LEVEL

This is the secondary level of the farm automation system. The Control Level is located in a central area as it will make the data acquisition process easier. That is, for multiple Field Levels, there is one Control Level. The Fig 3 shows the interaction of the control level with the multiple field level to which the sensors are connected and the input is transferred to the control level. The main function of this system is acquiring the data from the Field Level and to process it with microcontroller by applying the Fuzzy Logic Algorithm. The data is first obtained by the receiver X-Bee module and it is sent to the ATMEGA 328. Since, the regulation of the parameters is a complex process, as the microcontroller can work with only digital logic levels, fuzzy logic algorithm is incorporated.

The data obtained is grouped into various categories depending upon its value. These categories are known as membership functions. This is done individually for the three parameters moisture, humidity and temperature. And the input parameters have three membership functions each. The output has five membership functions.

The fuzzy table above shows the various categories of the input and output parameters .The term L, M, H in the input corresponds to LOW, MEDIUM, and HIGH respectively.

The term VS, S, M, L, VL corresponds to very short, short, medium, long and very long respectively. Similarly MI, LE, INT, MO, and MAX correspond to Minimum, less, intermediate, more, and maximum. All the rules are combined by AND function. The figures below show the membership function of the various input and output parameters [14]. The membership label shows the variation of the influence of the various input parameters on the output parameters placed in a remote location so that the system is completely autonomous. The values are obtained from the control level to the monitor level. The main purpose of the monitor level is that it allows the system to perform extensive functions. The monitor level has been connected to the computer where the values have been received by the X-bee connected as a receiver. The LabVIEW software installed in the computer facilitates the display of accurate and accelerated results to the farmer.

This also helps in the easy analysis and tracking of data. This software also assists the farmer who can connect his computer to see the entire system parameters that has been regulated. The Fig 4 shows the implementation of fuzzy system implementation using LabVIEW so as to process the input parameters that are processed using fuzzy logic controlled implemented in the control level.

TABLE I
FUZZY RULES

Temp	Humidity	Moisture	Spray duration	Rate of flow
L	L	L	ME	INT
L	L	M	ME	LE
L	L	H	S	MI
L	M	L	S	INT
L	M	M	S	LE
L	M	H	VS	MI
L	H	L	VS	INT
L	H	M	VS	LE
L	H	H	VS	MI
M	L	L	L	MO
M	L	M	L	INT
M	L	H	ME	LE
M	M	L	ME	MO
M	M	M	S	LE
M	M	H	S	MI
M	H	L	VS	INT
M	H	M	VS	LE
M	H	H	VS	MI
H	L	L	VL	MAX
H	L	M	VL	MO
H	L	H	VL	INT
H	M	L	L	MAX
H	M	M	L	MO
H	M	H	L	INT
H	H	L	ME	INT
H	H	M	ME	INT
H	H	H	S	LE

The above table shows the fuzzy logic rules which has been tested and the result has been obtained by processing it in the LabView.

The Fig 5 shows the output parameters that will be triggered based upon the computations of the input data received which is in turn processed by the fuzzy logic controller in the control level. The farm land which is quite big in size and an agricultural research department can utilize the data by uploading and storing the data in the server and also can use it for future use.

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The various field parameters can be used as an archive that can be used for future processing in the case of studies or research. Upon the removal of the monitor level the entire system will be autonomous in nature and still the control level will control the entire process.

V. LABORATORY SETUP AND EXPERIMENTAL RESULTS

The entire experimental setup and the test system have been illustrated in the Fig. 6. The field level consists of the moisture, humidity, temperature, light intensity level sensors connected to it. The various input parameters are obtained from the sensors which are then transmitted by the ATMEGA 328 microcontroller.

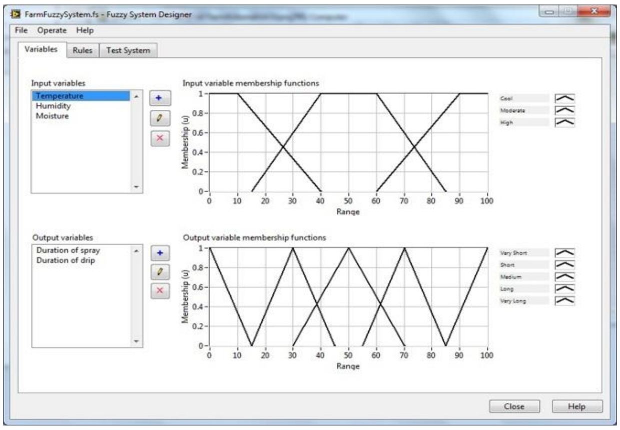

Fig 4: Fuzzy system of the LabVIEW of the input parameters which are implemented with the fuzzy logic for controlling the input parameter temperature

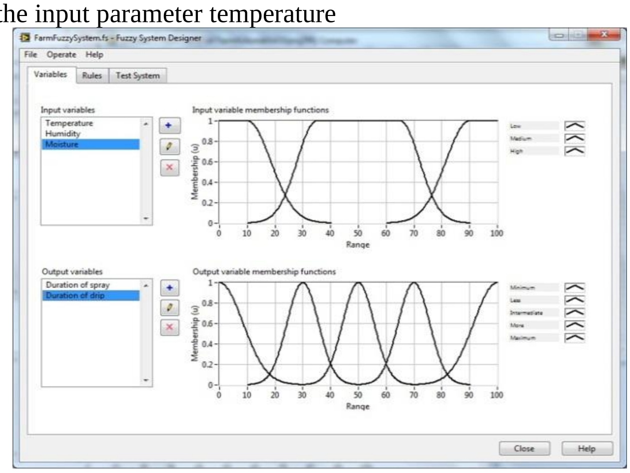

Fig 5: Fuzzy system of the LabVIEW of the output parameters which are implemented with the fuzzy logic for controlling the output parameter Duration of spray based on the input received.

The input parameters are sensed for every 1 minute of time interval and the corresponding values are transmitted to the control level. The field level even consists of the output parameters which are activated by the command of the microcontroller. The field level microcontroller transmits the data to the control level. In the test system the input parameters are programmed and calibrated in the scale of 0-100 such that the input parameters are transformed into the scale of 0-100 for the computation of output.

The fuzzy logic which has been defined in the control level is used to process the entire input parameters and in turn correspondingly generate an output

Fig 6: Experimental setup that consists of Field level, Control level and the Monitor level

In the scale of 0 to100. Here the output of duration of drip and duration of spray is set by the microcontroller and sent to the field level again which in turn switches on the relay for the particular duration. The output of the drip system and the spray system has been obtained from the Table 1 which is in turn calibrated in the level of 0-100. The motor which connected to the duration of spray and duration of drip system is run for milliseconds and the milliseconds which are generated by the fuzzy level output. The main advantage of the system is that with the implementation of the fuzzy level system the optimal use of the water is obtained and therefore the efficient use of the resources is ensured.

The Fig 6 shows the monitor level of the entire system. As said earlier the entire system is autonomous. Here the front panel of the LabVIEW is shown in the figure which provides a graphical user interface of the entire system. The input and output parameters are received from the control level from the microcontroller using the x-bee transmission. The various output and input parameters status are displayed on the screen.

The monitor level consists of the microcontroller which is interfaced with the LabVIEW to display the input and output. The front panel displays the Moisture, Humidity, Temperature and the light intensity level calibrated in the scale of 0-100 in the system. The display also shows the graph which has been plotted between the time and the Moisture, Humidity, Temperature, light intensity level.

The front panel display is that it allows the farmer's convenience in accessing the data from the field level without having his physical presence. The display of the system also indicates the duration of the spray as well as the duration of the drip system. The front panel allows the layman to understand the process that's been happening in the system. Fig 7. shows the front panel that has been designed using LabView.

Here the duration of drip and duration of the spray system is shown as milliseconds and milliseconds respectively and the status of the water level has been displayed accordingly. Since the system can be designed for individual crops, there is also an option for choosing a particular crop is specific. The graphs show the variation of the parameters with respect to the time which can be used for various research purposes.

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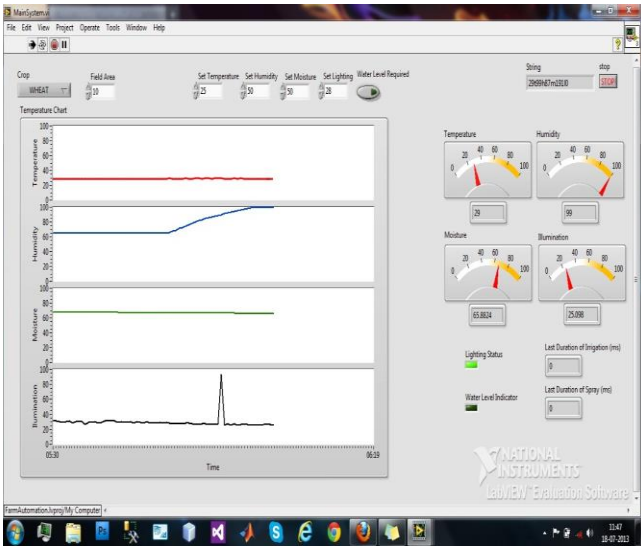
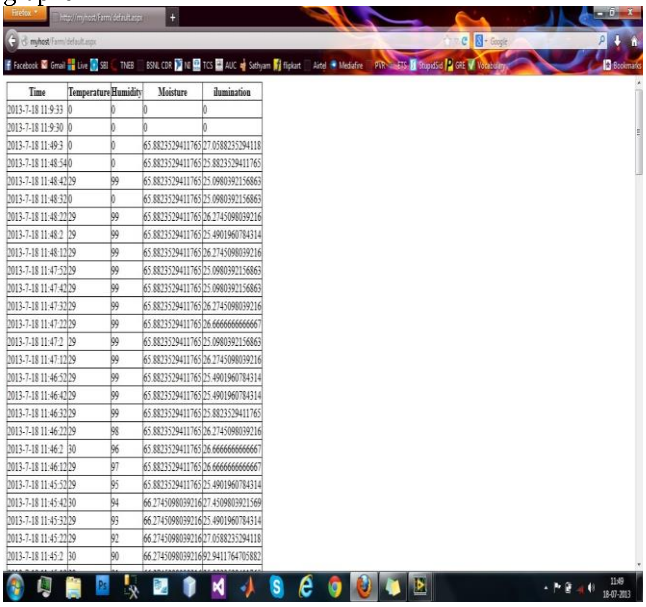


Fig 7. LabVIEW Front panel displaying indicators and graphs



Time	Temperature	Humidity	Moisture	ilumination
2013-7-18 11:9:33	0	0	0	0
2013-7-18 11:9:30	0	0	0	0
2013-7-18 11:49:3	0	0	65.8823529411765	27.0588235294118
2013-7-18 11:48:54	0	0	65.8823529411765	25.8823529411765
2013-7-18 11:48:42	29	99	65.8823529411765	25.0980392156863
2013-7-18 11:48:32	0	0	65.8823529411765	25.0980392156863
2013-7-18 11:48:22	29	99	65.8823529411765	26.2745098039216
2013-7-18 11:48:2	29	99	65.8823529411765	25.4901960784314
2013-7-18 11:48:12	29	99	65.8823529411765	26.2745098039216
2013-7-18 11:47:52	29	99	65.8823529411765	25.0980392156863
2013-7-18 11:47:42	29	99	65.8823529411765	25.0980392156863
2013-7-18 11:47:32	29	99	65.8823529411765	26.2745098039216
2013-7-18 11:47:22	29	99	65.8823529411765	26.6666666666667
2013-7-18 11:47:2	29	99	65.8823529411765	25.0980392156863
2013-7-18 11:47:12	29	99	65.8823529411765	26.2745098039216
2013-7-18 11:46:52	29	99	65.8823529411765	25.4901960784314
2013-7-18 11:46:42	29	99	65.8823529411765	25.4901960784314
2013-7-18 11:46:32	29	99	65.8823529411765	25.8823529411765
2013-7-18 11:46:22	29	98	65.8823529411765	26.2745098039216
2013-7-18 11:46:2	30	96	65.8823529411765	26.6666666666667
2013-7-18 11:46:12	29	97	65.8823529411765	26.6666666666667
2013-7-18 11:45:52	29	95	65.8823529411765	25.4901960784314
2013-7-18 11:45:42	30	94	66.2745098039216	27.4509803921569
2013-7-18 11:45:32	29	93	66.2745098039216	25.4901960784314
2013-7-18 11:45:22	29	92	66.2745098039216	27.0588235294118
2013-7-18 11:45:2	30	90	66.2745098039216	92.9411764705882

Fig 8.Webpage displaying the data uploaded in the server

The system has been equipped with the provision of uploading the data in the server. Uploading of the data is done with the help of LabVIEW to the database. A SQL command is then created. This command enables the uploading of data in the server which can be easily accessed by any ordinary web browser.

The Fig.8 shows the data that has been uploaded in the server and the server can keep track of the data. The main purpose of uploading of the data has been done in order to maintain a log of the data.

This feature is really useful in the case where it can be implemented in the agricultural research institutions and the research can be done on the basis of large volume of data available in the server which has been obtained automatically which reduces the human intervention and the accuracy of the data is obtained.

VI. CONCLUSION

With the advancement of technology it becomes inevitable for us to make sure that all the sectors of the modern society develop equally. The Farm Automation System is an appropriate system which helps in making sure that the most fundamental sector of the society gets benefitted. Furthermore, it has wide scope for improvement, which in turn eases the agricultural procedure for the farmers and ultimately helps in improving crop productivity. Here in this paper an entire automation system has been developed. A complete control system has been developed which is used to reduce the manual labor by automating the entire system with the help of low cost sensors. Initially the field level and the control level and the monitor level has been explained which has been used to process the input and output parameters and also using the LabVIEW the extension of the system has been done by updating the system data in the server. The data in the server can be used in the future for research purpose.

The entire system has been tested on the small level and the effectiveness of the system has been demonstrated. However the future direction is to employ the entire system in the large farms in order to verify the effectiveness of the entire system

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