Smart Board for Precision Farming Using Wireless Sensor Network

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***Abstract*— we live in a world which is rapidly moving toward smart systems to make every aspect of living easy and versatile. Smart farming systems are being adapted by farmers throughout the globe. This paper is going to venture through smart arable farming system for the farmers of Bangladesh with the concept of internet of things (IoT). The paper proposes a smart sensor system supported by actuators to automate farming and provide precision farming experience. The system helps person with inferior knowledge of technology to understand and maintain the system with a new device namely Smart Board. The board helps to monitor status of the farm and to send action command to farm machineries. This work also helps the practice of e-governance by setting a simple but effective data exchange between government and farmers. Farmers will get benefitted as the smart board will keep them up to date on governments agriculture related announcements. It is a systematic mixture of many technologies including a smart sensor network system.**

Keywords*— smart, precision farming, smart board, e-governance, Crop yield, pest control, irrigation, G2C, internet of things

I. Introduction

Precision farming known as precision agriculture is a concept where the farm is managed by observing, measuring and responding to inter and intra-inconstancy in corps. This is a more accurate and controlled method of growing crops. The process can be conveyed effectively and in an organized manner with a series of machineries, sensors and actuators connected with help of the concepts of internet of things (IoT).

Worldwide, concept of precision farming is being adapted by farmers precipitately. But the prospect for the mentioned progress is not concrete in Bangladesh. As Bangladesh is an agricultural country, here around 1, 51, 83,183 out of 2, 86, 95,763 families own farms [1]. A study done among 160 farmers in the northern region of Bangladesh shows that a high percentage of farmers use or are interested to use new cultivation systems, upgraded seeds and fertilizer. But only 3.1% are capable of using and understanding modern day technology in the field of farming [2]. To remedy the problem, this paper introduces a smart farming system comprising an interconnected wireless sensor network and an interactive user front for illiterate farmers in form of a Smart Board. The practice of e-governance can be enabled for the agricultural population of Bangladesh through the smart board.

The paper proposes a system to work with four major part. The first part is smart sensors, secondly the connection mechanism, then the actuators that act on the crops and finally the smart board to provide sensor and actuator management interface.

The internet of things can be seen as a system of connected computing devices, mechanical objects, digital equipment and living entities with the ability to transfer data within a network without the help of physical connection. The IoT based precision farm management consists of smart devices that use embedded processors, smart sensors. Smart sensors can communicate to collect, transmit and act on data they collect from their surrounding environment. Sensors are crucial and integral element in precision farming, as this is an increasingly prevalent environment in which most of the devices which are collecting crop status need to be outfitted with unique ids and be able to transmit data over a particular network. A smart sensor at minimum is made of a sensor, a microprocessor and any communication technology. The three-part construction of smart sensor enables it to gather more accurate and automated sets of data with minimum variability [3]. Actuators are a type of mechanical devices which control a mechanism or system by moving itself or controlling any other device's trigger point. The paper proposes precision farming system where several actuators execute farming processes on the basis of instruction from farmers through smart board or output signals of the sensors.

Electronic governance is the application of information and communication technology for government's promotional agendas. The goal is to reach to the mass in faster and efficient way. Among various operational models of e-governance, government to citizen (G2C) model focuses on the communication between government and citizens. Government tries to remove poverty, illiteracy and bring more transparency to governmental procedures through help of technology. The feature proposed for the smart board can in the long run help practice e-governance in agricultural sector of Bangladesh.

II. Related Work

The idea of precision farming exists from around 1994 and has gone though many advancements over the last decade. Advancements have been done like detection of borer insects in tomato plants with the help of video processing. Researchers have also included concepts of

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IoT and cloud computing to detect pests [4].New image processing techniques have been introduced using Support Vector Machine (SVM) classification. Saturation, hue and intensity of the crop image are utilized to fit for SVM classification and then presences of parasites are assessed [5]. Identification of pesticide is a research concern also. Researchers have found out ways to identify pests by trapping them in pheromone trap, which is basically a chemical applied sticky board or bucket to attract male insects [6]. Fine grained optimization can be used in crop images to identify pests [7]. Due to the mentioned research, further pest control action can be then done according to focus pest species.

A crucial component of farming is irrigation. For farming to be smart, automation irrigation process can be a key concern. K Srinivasa Rao and N Nagedra, two electrical electronic engineers came up with a project of automatic watering of plants using Arduino UNO. Need of watering is detected by measuring the level of moister in the soil using soil moister sensor [8]. Parwinder Singh Bains, Raman Kumar Jindal, Harpreet Kaur Channi developed a project similar to the mentioned above and upgraded it with ATmega32 microcontroller. Project at first schedules a daily routine to apply water accordingly. A tank stays put beforehand with water and the plant is watered automatically from the tank without any human interaction [9].Using IoT concepts, Indian researchers have tried to enable web based control of irrigation for farmers [10]. Methods have been ventured where the applied water is controlled according to pH levels minimizing water wastage [11].

While thinking of smart farming, yielding of crops is another thing to be concerned with. Esmael Hamuda, Brian Mc Ginley, Matin Glavin and Edward Jones developed crop detection using computer vision techniques. The first step is to take picture of the field and then configuring crop yield based on crops, weeds and soil ratio in the pictures. The mentioned three types of components are discriminated based on HSV (Hue, Saturation, Value) color space values [12]. Other researchers have also ventured the idea of using satellite time series data to identify harvestable rice crops. Through satellite spatial and temporal description of the crop gets extracted and analyzed to decide on harvestable crop amount. An extensive study was done in rice farms of Italy, India and Philippine. The variability of regions was to find out data for seasonal harvesting as mentioned areas are tropical. A rule based algorithm was developed called PhenoRice to extract temporal information of crops which can be further used to analyze satellite imageries for crop yield count [13].

The idea of smart board also has been around since last two decades for class room and meeting purposes. While the main functions of the smart board stays similar to a simple white board [14]. Another use of smart board has been surveyed with math students in math class. Teachers interacted with the smart board like a white board while teaching math. The study benefitted in increased proficiency of students in math [15]. Both studies show better understanding of subject matter while taught through smart board.

III. PROPOSED METHODOLOGY

Arable farming defines cultivation of crops, which includes growing, maintaining and yielding of crops. Modules mentioned below makes this system a precision farming system-

- Automated calculation of crop yield.
- Automatic watering of field.
- Timely reporting of dis order.
- Automatic pesticide application.

For a full complete smart farm, many more features need to be added. As this paper tries to minimize complexity for the farmers, some core features have been added only. Automated calculation of crop yielding needs a number of Temperature, Humidity and Crop moisture sensors installed. Counters are also needed to count the number of ripe crops. These equipment will function together and will transfer signals to one another.

Counter is the most important equipment to note the quantity of crops. It'll communicate with other sensors and increase the count. Anand Nayyar and Er. Vikram Puri designed an agriculture stick for live temperature and moisture monitoring using Arduino, cloud computing & solar technology. The stick has a predefined temperature range for counting crops. [16]. It can detect the increased IR ray of the crops, sense the temperature. The signal communicates with the counter and the counter increases the count. A moisture detector will produce a signal when an object containing moisture is located within the detection range. A counter will be in communication with the moisture detector. The moisture detector transmits the signal to the counter to increase the count. The counter is used to count number of items being processed by a moisture sensor [17].

Automatic watering of the field needs installation of pH sensor, Temperature sensor, Moisture sensor. The actuators for this particular feature are water pump, servo motor and power supply (5 volt). PH sensor calculates the nutrient index of the soil. Moisture sensor measures the dielectric constant of the soil. The higher dielectric constant indicates higher moisture. Water pump supplies water to the field and servo motor controls the movement of the pipe, it rotates the water pipe from 0 to 180 degrees for equal distribution of water throughout the field. Based on pH level value, moister and temperature the actuators will decide the movement of servo motor and amount of water to be supplied according to coverage area of crops. Ideal range for temperature sensor is 450-800 Ohm, for moisture sensor it is 300-700Ohm and Ideal pH range is 5.5-7.0 .If the values collected from the sensors are higher than the mentioned range, then servo motor will water the crops [11].

An ultrasonic pest detector smart sensor can be used for precision pest control module of this system. Pests emit ultrasound between 20 to 50 kHz bands. A transducer placed in sensor circuit recovers the sound pressure which is emitted by insects and output an electrical voltage of

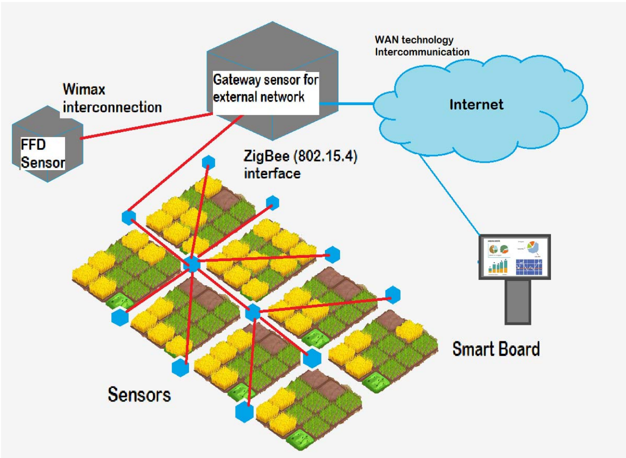

Figure 1 . Architecture for the sensors communication

small amplitude. Then the voltage is amplified through four amplification stages to acquire the output signal same as the inputted one [18]. If the output signal falls between the frequency bands mentioned before then the presence of pests will be assertive. The level of dis order will depend on which portion and how much of the field is infected. A scale of 1 to 10 will be introduced symbolizing this. By default if output from the pest detector is under level 4, it will prompt an alarm. Depending on which the farmer can trigger the pesticide distributor pump through the proposed smart board of this paper, an elaborated discussion will be done later on the smart board instructions.

Farmer can set an automatic trigger point between the scale values 1 to 10. Whenever the dis order level crosses the predefined point, pesticide distributors will automatically go off. For this, just like the water distribution model a servo motor can be used to spread pesticide to a wide area or the farmer can choose to provide pesticides on the field manually by hand.

A Wireless Sensor Network (WSN) can be implemented to systematically manage the sensors of different modules of this precision farming module. The sensors and actuators used will be equipped with 802.15.4 technical standard. The sensors then can transmit data through ad hoc architecture to a ZigBee Full Function Device (FFD).Here 802.15.4 gateway node allows the exchange of data. Through GSM the remote network distribution of the data (collected from the sensors) to the storage and processor unit can be done. For this particular project federator-network technology like WLAN and WWAN can be used. The ZigBee Technology can be used as a hotspot in 802.11 standard Nano Station range. To avail all these communication without internet, WiMAX technology of 802.16 standards can be used to set up inter connections [19] [20]. The smart board in this set up intercepts the resultant data and works as storage. The board will be able to process the data and send back command to the actuators. Currently the above-mentioned mechanism is planned to partake until any other better method can be implemented or any error occurs in the future testing of the system. Fig.1 illustrates the proposed architecture of smart sensor network for this remote farm monitoring module.

Smart Board is a new concept which this paper is introducing. It is designed for farmers with inferior technical knowledge. As it can be seen that this precision farming system has more than one system modules working for different part of farming, keeping track is hard most of the time. And for a farmer of poor technical knowledge, it is very difficult to even understand basic functionalities. The board shows farm status to farmers and takes action command from them so that the farmer doesn't have to interact with each sensor or actuator him-self.

Field where the system is installed will be divided in four sections – A, B, C & D. Each section will be quarter part of the total area of the land. It'll be noted from what section the sensors value is coming from to minimize over use of pesticide or unnecessary watering. If the values of section 'A' are lower than ideal, then only actuators covering portion 'A' of the farm will become active. Actuators and sensors will be installed in all four sections. Data of the sensor will be stored under the name of section it is installed in.

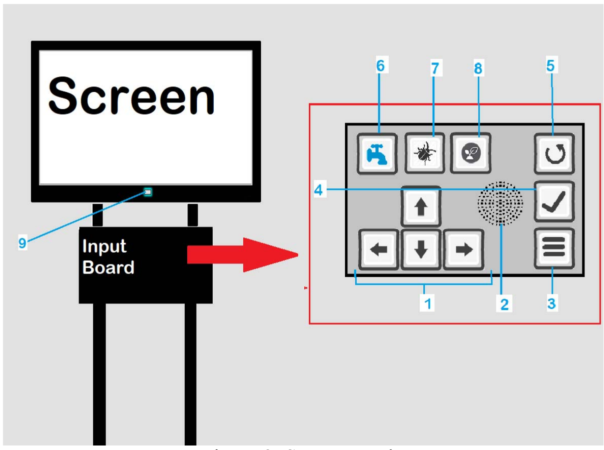

Figure 2. Smart Board

A 16-inch screen with just some simple instruction board below on a stand as shown in Fig. will have a metal body. Thin film transistor liquid crystal display (TFT LCD) is enough for the smart board. But if we think of the wide-angle view and screen color in sun, In Plane Switching (IPS) display can be used to. The input board will consist of 10 buttons and one speaker output. As shown in Fig.3, button set 1 is for navigating options in the screen. Button marked 3 is a menu button which opens options regarding any selected function. Button marked 4 selects any highlighted function. Button marked 5 is back button, pressing which goes to the previous state of the screen. Button 6 opens instruction set for irrigation. Button 7 opens up instruction set and functions for pest control on the screen and button marked 8 refreshes the crop yield counter shown in Fig.4. Component 2 is speaker for sound output, especially for alarm output. The button 9 in the Fig.2 is for turning the screen on and off. Even though the screen can be turned off, the functions of the smart board continues to run in background.

Like a simple mobile device, the smart board will have processor. It will have network feature of GSM and LTE. It will also support WLAN, Wi-MAX and will be java

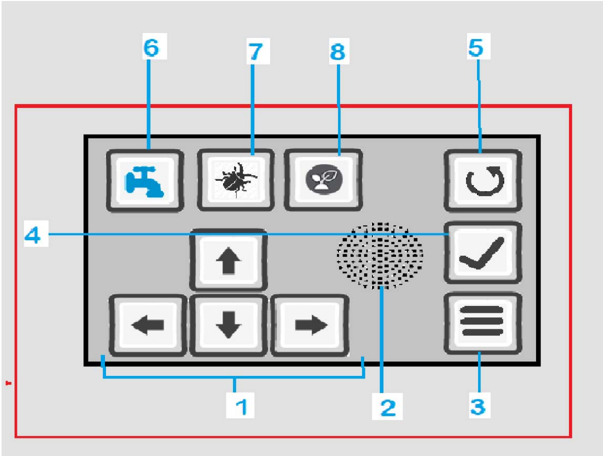

Figure 3. Input Board

enabled. At this time details about the operating system hasn't be finalized but simple functions of a wearable device is sufficient to support the interface.

The smart board makes it possible for the farmer to see the status of the farm in a summarized way. The user interface is simple as shown in Fig.4. Fig .1 shows main dashboard of the smart board screen. The bottom bar works as a warning portal for farmers, any news alert for any coming cyclone of flood will be shown in the bar. The news alerts can be a part of net portal where governmental services set warning for the agricultural population as well as suggestions for the current years expected yield. For example: if in the year of 2019 government estimates that an increase in potato production will be beneficial for the country, then that data is uploaded on the portal sending it to these smart board for the farmers to see. The bar helps setting the G2C governance process. In regular days the bar will show weather forecast. A bar chart in lower left corner just above the alert bar will show record of water sufficiency in soil, moisture level in soil, Dis-order level depending on number of pests present in the field, level showing the amount of infected area, level of crops ready for harvesting respectively on a scale of 1 to 10. For example: Level 10 in the 4th bar means portion A through D, all are infected with pests; Level 10 in 5th bar indicates that crops in all portions are harvestable. Also the name of the sections which needs harvesting or pest control chemical will blink letting the farmer know the exact location.

The level is decided by the average value of all sensors of a particular module. For example: In watering module, there are 3 type of sensor. If 5 pH sensors are allocated in section A, Average value off the result of all five sensor will be calculated. The average value will contribute to (100/3)33.33% of the decision making as there are three type of sensor. All three percentage will be added and the resultant percentage will be then reduced to 25% (As the calculation is done for only one section, Ex: Section A). In watering module, High values of all sensors will contribute lower percentage. Values from all 4 sections will be summed up and a level value will be decided from 0 to 10 using unitary method.

In case of pest control if the output signal falls between selected bands mentioned before, it'll increase the percentage value for a particular section.

For yielding module, the more count in the counter will contribute higher percentage for the section. Then deciding the level will follow the same unitary method for pest control and crop yielding module.

Part in the lower left corner over the alert bar shows level of pesticide on the container so that the farmer can refill when needed. The red rectangle shows dis-order status, green rectangle shown how many units of crop is ready and from which portion, blue notifies if the field needs watering.

Fig.5 shows menu screen which appears after selecting the red rectangle through input board, or pressing the button

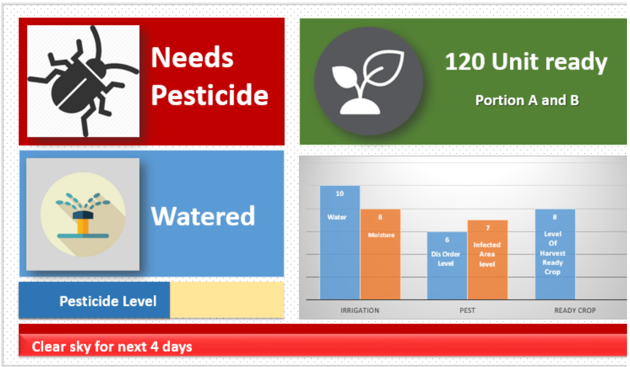

Figure 4. Dashboard

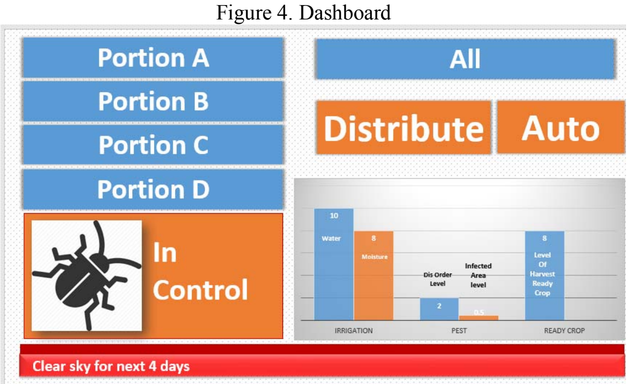

Figure 5. Pest Control menu

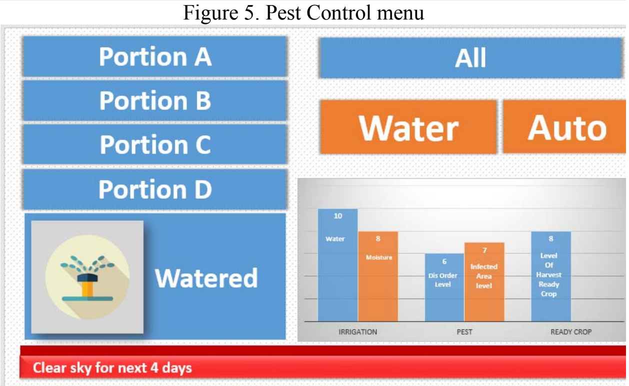

Figure 6. Watering Menu

marked 7 in Fig.3. Farmer can select portions he desires to distribute pesticides to and select 'Distribute' or can schedule auto distribution when the level of dis-order exceeds a chosen level through opening a menu selecting

'Auto'. The same goes for the watering menu in Fig.6, which can be triggered by selecting blue rectangle of Fig.4 or pressing the button marked 6 in Fig.3.

The trigger point for watering and applying pesticide can be selected through arrow buttons in the input board by selecting the 1st and 3rd bar respectively from the lower right bar chart. The farmers will then increase and decrease the level and hit the button number 4 shown in Fig.3.

It can be seen that the pest notification rectangle changes color according to the situation, Red indicated dire situation and orange symbolizes that the situation is in control. In a moderate situation it'll show if any portion is infected. In its extreme status (while red) the speaker output of Fig.3 will output alarm sound with one hour interval for 5 minutes until pesticides or water have been provided.

When in the menu of Figure 5 and 6, the option button of the input board will open menu options for refreshing the calculations in situations when the farmer has already applied pesticides through hand or any equipment is compromised, and watering is being done by hand.

As the paper is a collection of methods working together as a whole smart farming system and not yet has been implement the success rate of the project is going to be estimated in terms of economic data.

IV. Result

As mentioned in the previous section economic aspects have been ventured for the proposed system. The pricings of the sensor sets were fetched from current market situation. Here, the smart board being new equipment the price of it is hard to predict. A budget of 15,000Taka can be allotted to WSN network setup and the board.

Price estimation for the project has been stated below in an itemized table [21] [22]-

TABLE I. TOTAL COST ESTIMATION

Equipment	**Needed Quantity per acre**	**Price (Taka)**
PH Sensor	1	6,500
Temperature Sensor	6	3,000
Moisture Sensor	20	10,200
Ultrasonic Sensor	4	640
Servo motor	8	4,000
Total for sensors		24,340
Estimated Budget for smart board and network connection components		15,000
Total		39,340

V. Future Work

Future work of the project can be a more simplified wireless sensor network proposal minimizing the cost of the project. The proposed e-governance benefit from the project can also be maximized by integrating a customized statistical algorithm in the smart board system which will enable government in agricultural survey. The advancement of calculating methods will be possible with the help of an agricultural engineer .And finally experimental implementation which will allow a data analysis to conclude efficiency of the project.

VI. Conclusion

The project availed automation for every farming step and provided a complete automated smart farming system. Management of a smart farm is easier with a simple user interface and management system, all of which the smart board provides. Wireless sensor network establishes a systematic workflow of farming minimizing complexity. According to the results, the project is an affordable mid-range system which will benefit in farming. According to the authors knowledge the idea of smart board for precision farming hasn't been ventured before.

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