Smart Farming System Using Sensors for Agricultural Task Automation

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***Abstract*— Agriculture is the broadest economic sector and plays an important role in the overall economic development of a nation. Technological advancements in the arena of agriculture will ascertain to increase the competence of certain farming activities. In this paper, we have proposed a novel methodology for smart farming by linking a smart sensing system and smart irrigator system through wireless communication technology. Our system focuses on the measurement of physical parameters such as soil moisture content, nutrient content, and pH of the soil that plays a vital role in farming activities. Based on the essential physical and chemical parameters of the soil measured, the required quantity of green manure, compost, and water is splashed on the crops using a smart irrigator, which is mounted on a movable overhead crane system. The detailed modeling and control strategies of a smart irrigator and smart farming system are demonstrated in this paper.**

Keywords*— Compost, Green Manure, Smart Irrigator System, Smart Sensing System.

I. INTRODUCTION

Agriculture is the backbone of Indian economy. In India, around 70% of the population earns its livelihood from agriculture. The recent betterment in information and communication technologies has allowed farmers to acquire a vast amount of site-specific data for the fields. The main activities involved are data collection, processing, and variable rate of application of inputs. We can reduce a lot of manual work in the field of agriculture using automation.

The major problem faced in many agricultural areas is that lack of mechanization in agricultural activities. In India agricultural activities is carried out by manual labor, using conventional tools such as plough, sickle etc. Our Smart Farming System reduces the manual work and automates the agricultural activities. The ground water is polluted due to the usage of synthetic fertilizers and pesticides. In Smart farming, they are replaced by organic fertilizers (e.g. compost, animal manure, green manure) and by using it the soil structure is enhanced.

II. RELATED WORKS

We started to explore the recent trends in implementation of ICT in smart farming techniques. In the meantime, we did a brief literary survey on the published works of eminent scholars in this field.

In [1], a novel approach for Digital Agriculture was proposed describing Relationships between Precision Agriculture, Digital Earth, Information Agriculture, Virtual Agriculture, and Digital Agriculture. The requirement to put forward the concept of Digital Agriculture, was discussed.

In [2], sensor data collection and irrigation control was put forward on vegetable crop using smartphone and wireless sensor networks for smart farming. The environmental data can be collected and the irrigation system can be controlled using smartphone.

In [3], a novel cloud-computing-based smart farming system was proposed for early detection of borer insects in tomatoes. This problem is solved using Cloud computing and IOT.

In [4], a real-time monitoring of GPS-tracking was suggested for multifunctional vehicle path control and data acquisition based on Zig-Bee multi-hop mesh network. It summarizes portion that is related to path planning for a multifunctional vehicle. The vehicle-tracking system uses the global positioning system (GPS) and Zig-Bee wireless network based on to make the system communicate.

In [5], Web of Things case study for agriculture was put forward, which focuses on an experimental smart farm that uses a range of environmental sensors and livestock-monitoring technologies. A system that specifies the alert was tested in a farming area and the results were analyzed. The linked cube was used which allows longer-term analysis and data sharing to a larger scale.

From the above literary survey, we have found a novel approach using a smart sensing system that keeps track of the external environmental factors and does communication with the smart irrigator system to perform necessary tasks that are required for farming. In this system, we have furnished a resolution for the problems faced by the farmers. The main problems faced by them are electricity shortage, manual labor work, lack of mechanization, knowledge deficit about farming, and not knowing about the adequate usage of macro mineral contents (N, P, and K). Our system does the job of sensing and also habituates to the surroundings.

III. PROPOSED MODEL

The main idea of our system is to automate the activities of farming by using the principles of mechanics, communication, and electronics. We accomplish our goal by using mechanical machineries, sensors, and electronic components. We have used two modules, namely a smart farm sensing system and movable smart Irrigator that moves on mechanical bridge slider arrangement.

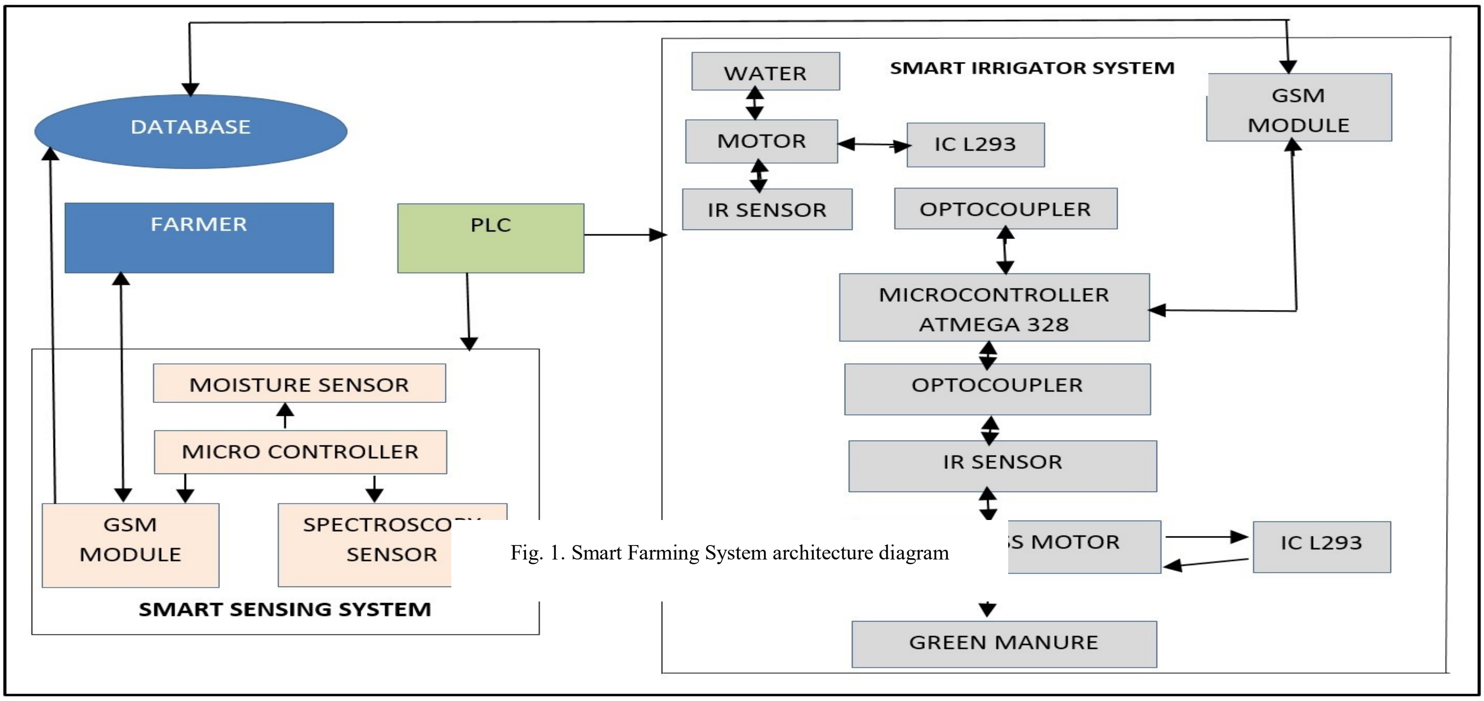

Fig. 1. Smart Farming System architecture diagram

Both the systems consist of microcontrollers, sensors, and the GSM module to communicate with each other and with the external environment. The smart farm sensing system senses the moisture content with the aid of the soil Moisture sensor. The spectroscopy sensor consists of a multispectral light source consisting of LEDs of different wavelength. The LED and laser diode intensity is adjusted by pulse width modulation using a microcontroller. The light absorbance for each light source is measured by the sensitive photodiode, which measures light intensity in infrared and visible ranges. Parameters such as chlorophyll content, stress, and moisture content are found by shining 650 nm, 940 nm, 605 nm, and 1330 nm light, respectively. The measured leaf chlorophyll content is used to evaluate the nitrogen and potassium nutrient present in the crop.

The architecture of our proposed system is shown in Fig. 1. The measured data from the smart farm sensing system are sent to the smart irrigator via the GSM module. The farmer can have control over the system by having a wireless communication with gsm module through his mobile phone. Smart irrigator is mounted on an overhead crane system and it consists of two main sensors that are connected to different pins of the microcontroller. It receives the signal from the smart farm sensing system via the GSM module. The recorded readings are then transferred to a central database server from which all the crop-growth details are analyzed and transferred to the irrigator system. In the meantime, sensors trigger the optocouplers that are connected to green manure, seeds, compost, and water container. After the triggering action, the necessary components are splashed on the field.

A. *Crane System*

The smart irrigator is moved throughout the field with the help of this overhead crane system. An overhead crane consists of parallel runways with a traveling bridge spanning the gap. The smart irrigator travels along the bridge. Fig. 2 shows the layout diagram of a two-cell overhead crane system. The DC motors of the overhead crane system are operated with the help of the solar panels of 150 W power. These solar panels are mounted on the ends of the poles.

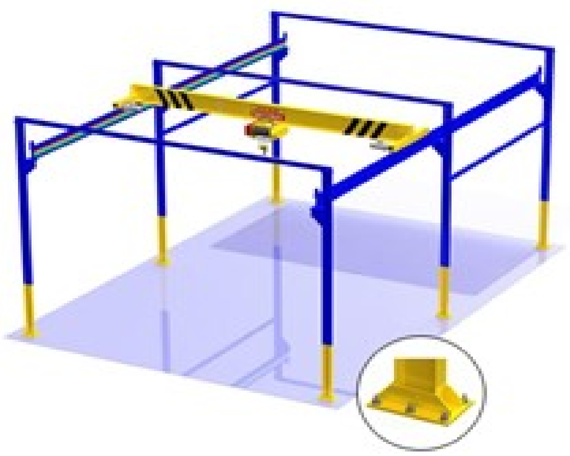

Fig. 2. Two – cell Overhead crane system

B. Infrared Sensor

The emitter is an IR LED (light emitting diode) and the detector is an IR photodiode, which is sensitive to IR light of the same wavelength as that emitted by the IR LED (see Fig. 3, circuit diagram of IC L293). When IR light falls on the photodiode, its resistance and correspondingly its output voltage change in proportion to the magnitude of the IR light received. This is the underlying principle of working of the IR sensor. The smart irrigator system involves three motors that are being attached with the optocouplers. These motors are made to rotate with a constant speed and are attached with a mechanical component called impeller. In this particular system, the IR sensor acts as a feedback component for the motor driving circuit. The key objective of the feedback is to maintain and regulate the speed of a motor.

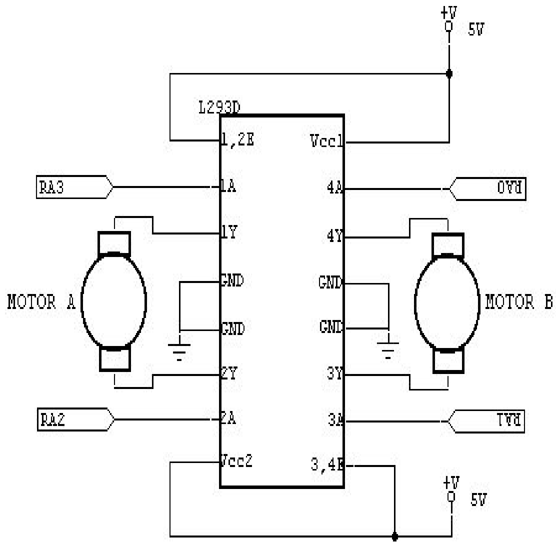

Fig 3: IC L293 for motor control

C. Optocoupler

An opto-isolator contains a light source, which is mostly a LED that converts electrical signal into light, a closed optical channel and a photo sensor, which detects incoming light and either generates electric energy directly or modulates electric current flowing from an external power supply. The sensor can be a photo resistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR), or a triac (see Fig. 4, optocoupler IC pin configuration). In the smart irrigator system, the optocoupler acts as a sensor (see Fig. 5 for optocouplers basic working). Whenever the signal is received at the GSM module, the microcontroller switches the optocoupler IC SFH6916. IC SFH6916 in turn activates only one motor that is connected, either the green manure part or water part or the seeds part. According to the requirement of the signal, the particular component will get activated and the component's corresponding actions will be initiated.

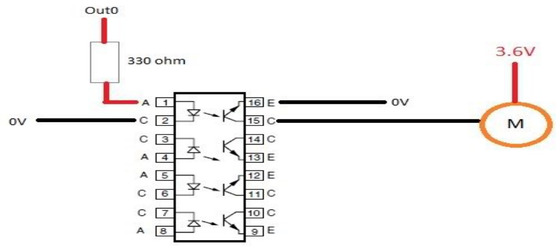

Fig. 4. Optocoupler IC

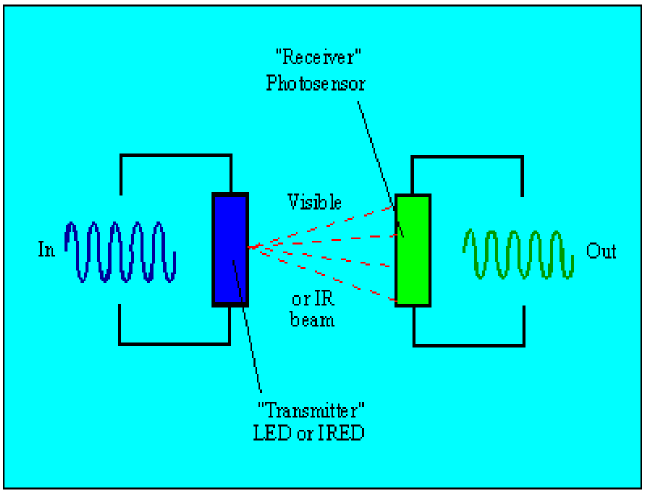

Fig. 5. Optocoupler basic working model

D. Smart Irrigator

After a proper communication link has been established between the two systems through the GSM module, the motor present in the overhead crane is started. This motor helps in horizontal and vertical movements of the Smart Irrigator across the field. Based on the activation of a particular sensor mentioned above, a specific part of the system components like green manure, composts, seeds, and water container gets activated to accomplish a specific task. These tasks are controlled by the master microcontroller ATMEGA – 328. This microcontroller works on a voltage range of 3.3–5 V. There is a rechargeable lithium polymer cell present in the system for powering up the electronic components. When the amount of green manure, composts, seeds, and water get reduced, there is a provision for auto filling by means of simple pipeline system. These pipelines are connected with the storage tank that consists of necessary commodities in an inclined position. These pipelines have valves that can be opened and closed with the help of PLC (programmable logic circuits) with the aid of sensors. Whenever there is a need to fill the necessary commodities, the motor reverses the movement of the load that is connected to the overhead crane system. In this way, the smart irrigator system eliminates the difficulties faced in manual farming.

IV. EXPERIMENTAL ANALYSIS

After analyzing the problems faced by farmers discussed in the related works section, we started making a smart farming model, which could overcome all the above problems faced in farming. To overcome the electricity shortage, solar panels were fit in this system. The problem of manual labor was solved by wheel-mechanized crane system. To overcome the knowledge deficit problem of not knowing the exact soil moisture contents, its macro mineral contents (N, P, K), compost, green manure required (see Figs 6 and 7, corn nitrogen requirement and yield response of cereals under different moisture conditions). We analyzed the crops and created a database server through which the farmer could get all the details of the best efficient crops to be grown in a particular season based on their soil environmental condition. We implemented this for the growth of corn and the model sensed the accurate amount of green manure and compost required for this crop (see Tables 1 and 2, Manure content details of different crops). It splashed the green manure and compost in the soil as per the requirement of the crop. Based on our proposed model, with all the necessary components, we have implemented it on the field. We had obtained good results on the implementation of this model. This Model was efficient and it served its purpose.

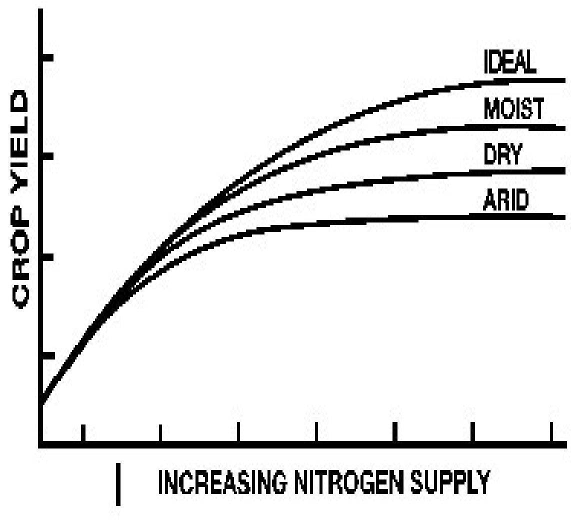

Fig. 7. Yield response of cereals to nitrogen supply under different moisture conditions

TABLE I. MANURE CONTENT DETAILS OF DIFFERENT CROPS

Name of Fruit or Vegetable	**Water Content (g)**	**Nitrogen (lb/ac)**	**Phosphorous (mg)**	**Potassium (mg)**
Soybean	8.54	193	704	1797
Apple	85.25	150	11	107
Rice	11.35	120	115	115
Corn	75	112	80	270
Cucumber	95	130	24	147

TABLE II. GREEN MANURE REQUIREMENTS FOR RICE

Organic manures	**Nitrogen Content**		**Quantity added to substitute 100% recommended N for rice (75 kg h/a)**	
Year	2007	2008	2007	2008
Farmyard manure	0.60	0.50	12500	15000
Farmyard manure compost	1.41	1.32	5319	5682
Vermicompost	1.91	1.74	3937	4310
Composed poultry manure	2.27	2.23	3304	3363
Enriched poultry manure	3.20	3.22	3344	2329
Neem Cake	4.20	3.8	1.786	1974

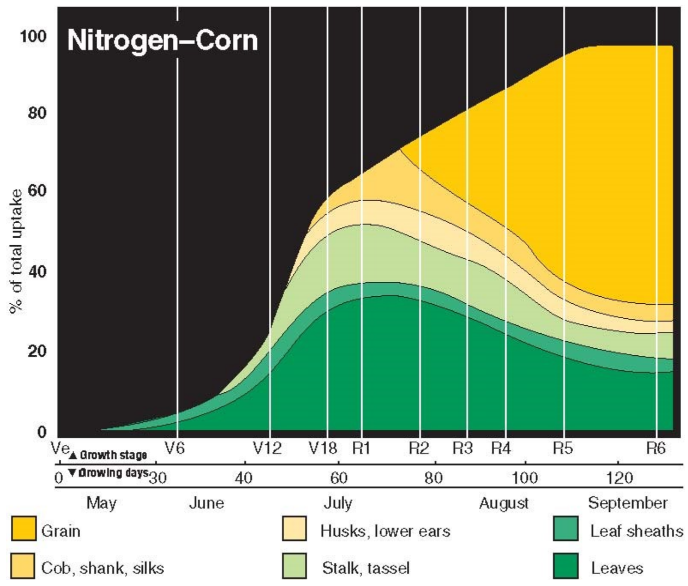

Fig. 6. Nitrogen content required for crop

V. CONCLUSION

In India 70% of its population earns it livelihood from agriculture. The inordinate majority contributes only 18% of the GDP. The key reason for this deprived performance is lack of agricultural task automation. Our Smart sensing system provides precise results and the Smart irrigator system manages to spray the necessary nutrients according to the requirements of the crops. Based on the moisture content results of the soil, adequate amount of water was sprinkled by the irrigator system. We are developing a user friendly smart farming system which will liberate agricultural productive force greatly, change the mode of production, and realize a qualitative leap in agricultural activity.

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