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An Efficient Method to Incorporate Precision Farming in Indian Agriculture Using Robotics and Internet of Things

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ABSTRACT

Farming is a primary sector in India. In spite of the Green Revolution and usage of modern farming methods, farmers are not able to reap sufficient returns. The need of the hour is to maximize the productivity, and ensure that the farmers reap maximum benefit. In a country like India, where farming practices are largely dependent on monsoon, efficient and economic methods should be made available. This can be achieved using Precision Farming. The soil texture and properties vary from one location to another across the country. They also vary, within a farm of considerable size. There is a requirement to map and monitor the various properties of the soil like mineral content, moisture levels, water bed present underground etc. The farmer can make a better choice, after knowing these details. It is a tough task to monitor different parameters manually. It will be easier if there is an automatic mechanism to do the same. We are concentrating on one single aspect that is moisture levels. The solution that we have come up with is a farming probe attached to a robot which moves around the field (crops arranged in matrix format) and uploads moisture values to the cloud. These values can be accessed via a smart phone. These moisture values can be mapped onto the field map so as to conditionally operate the irrigation system. In this paper, an automatic machine for mapping moisture levels across the field, has been proposed, using the principle of Internet of Things, for promoting the reduction of water usage in Indian agricultural practices.

KEYWORDS: Precision farming, cloud computing, robotics, internet of things, Indian agriculture.

1. INTRODUCTION

We can generally classify robot sensing into two modalities: remote contactless sensing (e.g. lasers, cameras, and ultrasound) and direct touch (e.g. haptics). Researchers have long speculated about a third sensing modality where “smart objects” or “smart environments” with embedded computation and sensing can directly measure and report salient information back to a robot. In more recent times, this general concept has garnered the moniker “Internet of Things” [1]. The idea of robotic agriculture (agricultural environments serviced by smart machines) is not a new one. Many engineers have developed driverless tractors in the past but they have not been successful as they did not have the ability to embrace the complexity of the real world. Most of them assumed an industrial style of farming where everything was known before hand and the machines could work entirely in predefined ways – much like a production line. The approach is now to develop smarter machines that are intelligent enough to work in an unmodified or semi natural environment. These machines do not have to be intelligent in the way we see people as intelligent but must exhibit sensible behavior in recognized contexts. In this way they should have enough intelligence embedded within them to behave sensibly for long periods of time, unattended, in a semi-natural environment, whilst carrying out a useful task. One way of understanding the complexity has been to identify what people do in certain situations and decompose the actions into machine control. This is called behavioral robotics and a draft method for applying this approach to agriculture is given in Blackmore [2]. Precision Farming is defined as an information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource [3].

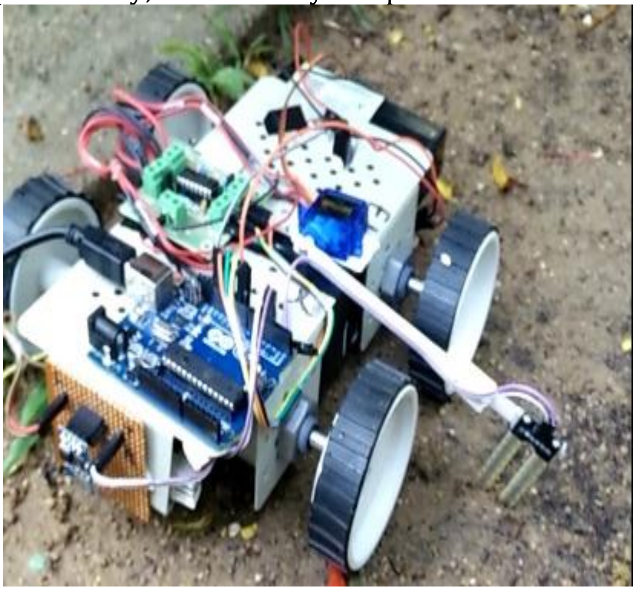

Fig1: Moisture sensing robot

In this paper, we have made an effort to develop an autonomous farming robot that can move in the field, which can be used to map moisture levels. A probe attached to the robot which moves around the field (where crops are arranged in matrix format) measures the moisture levels at each plant and uploads moisture values to the cloud. These values can be accessed via a smart phone. To survey whole farm we require many sensors, and we should carry the kit on our own. We simply are providing a better way to do it. In the future, the same robot can be used to spray fertilizers and pesticides. It removes the necessity of doing the job manually, so the farmer will not be exposed to harmful toxins. These moisture values can be mapped onto the field map so as to conditionally operate the drip irrigation. We are promoting precision farming, and are making an effort to make it suitable to the Indian farming conditions.

2. RELATED WORK

2.1. RAMSES IN USA

Across the U.S. and throughout the world, water conservation is a high stakes issue. In California alone, agricultural losses due to the record-breaking drought — including hay, wheat, corn, olives, rice, and even livestock — have inflicted a $2.7 billion toll on that state's economy. So when Jonathan VanBriesen '15 and Griffin van de Venne '15 were looking for a real-world problem to tackle for Research Science and discovered these troubling statistics, they knew they had found their year-long project. Combining physics, computer science, and no small measure of creativity, VanBriesen and van de Venne set out to invent an easier, cheaper way for farmers to monitor the moisture content of soil on their farms. The duo researched, designed, 3D printed, and programmed RAMSES, an autonomous rover designed to travel around a farm taking soil moisture readings at pre programmed intervals. The moisture measurements, taken by built-in probes, are then stored on a secure digital (SD) card. Once the rover – equipped with infrared sensors to aid in obstacle detection as it travels through rows of crops – surveys the designated area, all data is run through an algorithm that generates a heat map with different shades of red representing soil moisture content across the farm. The farmer can then adjust where and when to water, so as to obtain the best possible crop yield while increasing irrigation efficiency. The partners worked seamlessly together, with VanBriesen focused mainly on 3D modelling and printing the chassis and wheels, and van de Venne handling most of the coding and electronics [4].

2.2. ROBOSPHERE IN MADRID

Though it may look like a simple hamster ball, a new spherical robot may assist farmers monitor soil moisture levels and temperature, according to a redOrbit.com article which was developed by a team from the Technical University of Madrid. The ROBOSPHERE wirelessly reports information from its sensors back to farmers, letting them know when their crops need attention. The ROBOSPHERE moves by shifting its centre of gravity, similar to how a hamster rolls in its ball. This unique method of locomotion gives the ROBOSPHERE an edge over wheeled or tracked robots, which can struggle on uneven or cluttered surfaces. The scientists who designed the ROBOSPHERE are developing a second prototype with enhanced mechanics and the capability to utilize additional sensors.

2.2. AGRIAPP IN INDIA

Dealing with the modern challenges of agriculture proves to be difficult for many Indian farmers as they lack technical knowledge. Limited access to information (frequently caused by low literacy rates) directly translates into low-efficiency, low-productivity crops, trapping many farmers in a vicious cycle of poverty. Agriculture accounts for up to 18 percent of India's GDP and employs more than half of the country's workers. Yet agricultural communities are among the most deprived communities in the nation. Poor living conditions have been blamed for the suicides of 3,000 Indian farmers over the last three years, according to the latest figures from India's Ministry of Agriculture. Dr. Vijayaragavan Vishwanathan, the son of a South Indian farmer who has beaten all the odds to become a CERN (European Organization for Nuclear Research) scientist says that many Indian farmers still primarily pass information from generation to generation verbally, as they have for centuries. But modern factors—from evolving agricultural technology to the pressing concerns of climate change and subsequently ever-more unpredictable monsoons and irrigation levels—mean that traditional knowledge is no longer enough to prevent crops from failing. In India, groundwater availability is volatile or insufficient in many states. So, systematic, easily accessible information about crops is more vital than ever. Despite these obstacles, as well as asymmetries among India's urban and rural populations, India lays claim to a surprisingly high rate of mobile phone penetration. There are nearly a billion mobile phones in India today—and it has been predicted that all 1.4 billion residents will have a mobile phone by 2020. A recent report from the United Nations revealed that more Indians have access to mobile phones than toilets. Dr. Vishwanathan's "AgriApp," SmartAgri, can be used with any mobile phone, with or without WiFi, to tackle India's water shortage. Farmers connect their phones to a handheld device that Vishwanathan developed; when placed under the soil, the device measures and evaluates factors like moisture content, pH levels, and minerals. This information is then sent to the farmer's mobile phone using the cloud. The information is colour coded to indicate the results—green for good and red for bad—so any farmer, no matter the level of literacy, can make more targeted decisions about his or her crops. Vishwanathan represents a trend that is taking India's booming tech world by storm. The nation's biggest cities are now home to dozens of social enterprises that take advantage of the omnipresence of mobile phones to tackle issues experienced by farmers and other illiterate individuals. If we want to tackle literacy issues for farmers in India for the long-term and close the dent in India's literacy, we should target the young generation who will be the farmers of the future. And because future farmers can watch their role models take advantage of current technologies to better their circumstances, a more literate future is even likelier. Everything will accelerate in 20 years [4].

3. PRECISION FARMING ROBOT

Farming is a primary sector in India which has developed over time, yet, it is not on par with the other countries. In spite of the Green Revolution and usage of modern farming methods, farmers are not able to reap sufficient returns. The need of the hour is to maximize the productivity, and ensure that the farmers reap maximum benefit. In a country like India, where farming practices are largely dependent on monsoon, irrigation is a matter of concern for the farmers. It is necessary to shift to methods that ensure that sufficient amounts of water are provided at the right time in an efficient manner. The first step to attain that is to have a mechanism to monitor the moisture levels across the field.

3.1 SURVEY TO UNDERSTAND THE PROBLEMS IN IMPLEMENTING PRECISION FARMING ROBOT

We surveyed farmers having varying amounts of land and domain experts. The inputs obtained are given in the Table 1.

TABLE 1 -SURVEY RESULTS

NAME	DESIGNATION	REMARKS
Yadaiah	Farmer (4acr)	I 'am currently using HYVs and I'm happy with this yield.
Bhaskar	Farmer(5acr)	I cannot afford a robot. I'd rather use cheap labor available.
Dr. S. A. Hussain	Principal Scientist, PJTSAU	You have to convince the farmers that keeping track of these values can help in increasing their yields. The robot should be affordable.
Mr. V. Brijesh	John Deere	The idea is good, and will be helpful in increasing the yield. Try and map other values also.
Mr. Krishna Reddy	Landlord (100acr)	Keeping a track of these values for such a large area is not possible.
Mr. Komaraiah	Farmer(10acr)	I am not sure about how useful it will be to track the moisture levels. My father got sick due to continuous exposure to chemicals. If you can find a way to efficiently spray the chemicals, then we'll see.
Mr. Damodar	Farmer(10acr)	I will use it if it will be useful in cutting down my costs.
Mr. Subramaniam	Professor: Agronomy	It will be useful if one such robot is bought collectively for 4-5 farms. The farmers will need a lot of convincing, to go for one such robot.
Mrs. Sri Lakshmi	Professor: Agronomy	Not only monitoring the moisture levels, also add a mechanism to spray the insecticide and should be robust.

From the above survey we have understood that the devices should be user friendly and should have low maintenance. It should be affordable. The major challenge is to convince the farmers about the importance and advantages of the device. Alternate energy sources should be considered.

3.2 ARCHITECTURE OF PRECISION FARMING ROBOT

The device comprises of an arduino microcontroller, servo motor, moisture sensor, motor driver, ESP module which is connected to the cloud platform Thingspeak, an android application. This application can be used by the farmer to view the moisture levels at each and every plant, in a graphical format.

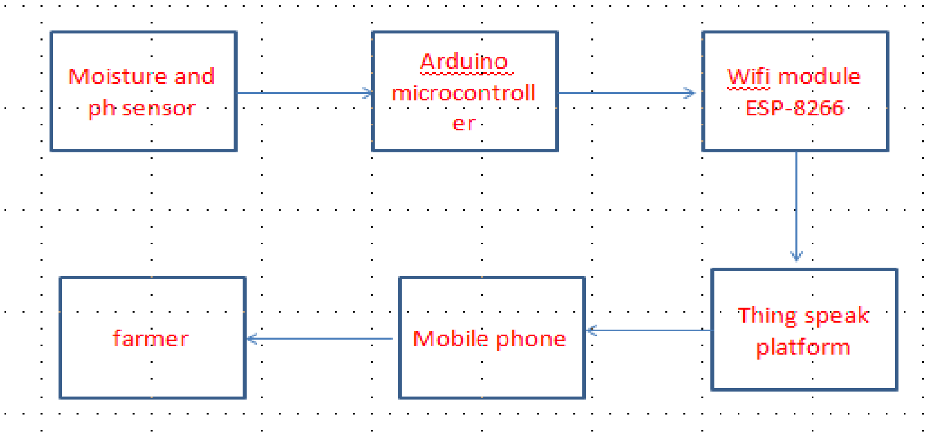

Fig. 2: Technology architecture of the device

Here, the moisture sensor is connected to the arduino board, placed on the chassis of the robot. It is attached to a servo motor that facilitates in changing the angle. This moisture sensor measures the moisture level at each plant and sends the information to the arduino board. A Wi-Fi module (ESP8266) provides internet connectivity to the robot. This module reads the data from the arduino board and uploads the data onto the cloud platform. In our project, we used the Thingspeak cloud platform. This platform provides mechanism to store and view the data read by sensors. A companion application called Thingsview is used in the mobile phone, by the farmer to view the data in the form of a graph.

3.3 PROPOSED ALGORITHM

1. START
2. Turn ON the device.
3. Connect the device to Wi-Fi.
4. While (device is ON) {
5. Move forward (distance);
6. Check moisture();
7. Upload data();
8. Move forward(distance);}
9. If(field=covered)
10. STOP;
11. Else if (battery low)
12. STOP;
13. STOP

First, the device is switched ON. It is then connected to the Wi-Fi. Now, the motor driver, controlled by the arduino facilitates in the movement of the robot. The robot moves for a certain duration after which it halts and the sensor takes the readings. These values are taken by the arduino. The ESP module uploads the reading to the cloud. The robot continues its movement around the field. It stops once the field is covered, or if the battery drains out.

4. KEY FEATURES

- **Compact-** The device is designed to be small in size. This increases its maneuverability. It is not bulky like other machines and is easy to maintain.
- **Automatic collection and display of data**- The device collects the data on its own by moving around the field.

- **No manual operation required**- The farmer has to put on the device, and it will start performing its tasks. In the end, he can view the collected data. The farmer need not stay with the device as it moves around the field.
- **Eco friendly, as it runs on electrical power**- The device comprises of rechargeable batteries that makes it eco friendly, as most of the machines used in farming run on fossil fuels.
- **Economic-** Farmers cannot afford costly products. We could develop the prototype within Rs.4000/-. It can be further developed and can be made available to the farmers for around Rs.6000/-

5. RESULTS AND DISCUSSION

We worked on the prototype and were able to develop a robot that could move around and measure the moisture levels, at regular intervals and upload the data onto a cloud platform. A companion application was used to view the data graphically. The first figure (Fig.3) shows the robot in motion. It moves along in a straight line, along the furrows dug in the field.

Fig.3: Robot during the movement

Here, in the second image (Fig.4), the probe attached has penetrated into the soil, and is taking the readings at that location. This data is read by the arduino board, from where the ESP module reads and uploads the data into the cloud.

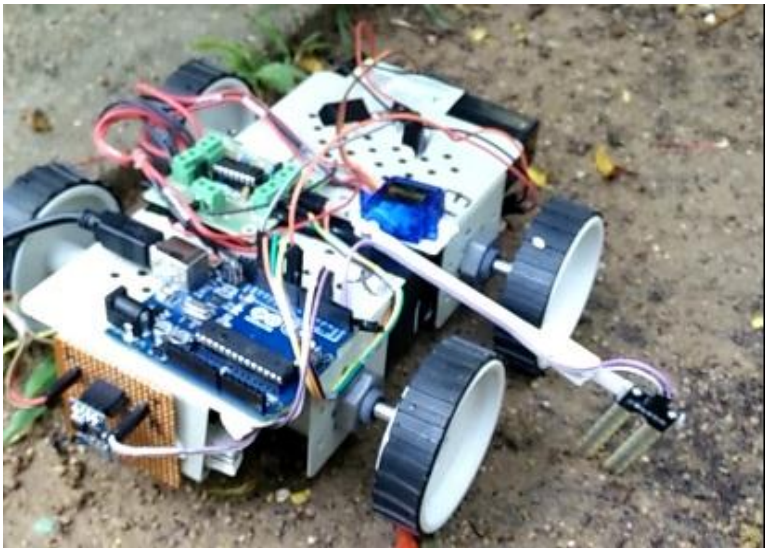

Fig.4: Robot while taking the readings.

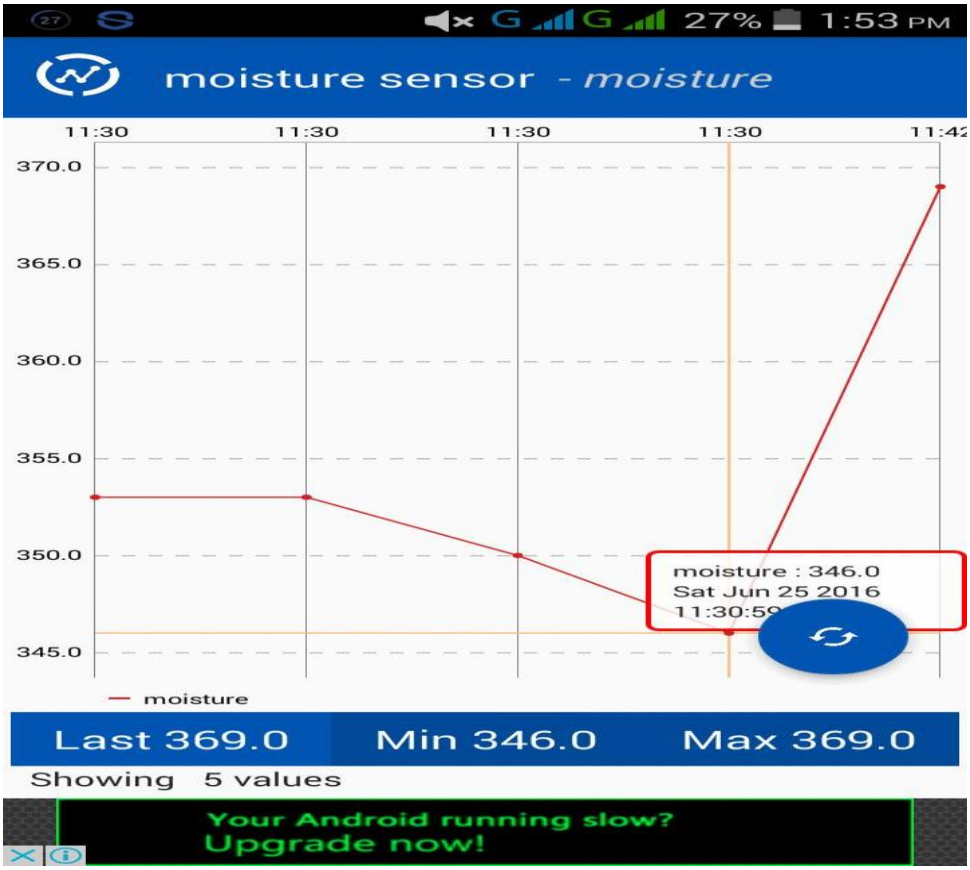

Fig.5: The graph, which can be viewed by the farmer.

The above figure (Fig.5) shows a screen shot of the moisture values, shown in the form of a graph in the companion application 'Thingsview'. Any application can be developed and connected to the cloud platform. The graph is shown as a simple line graph and is easy to comprehend. This makes the device user friendly.

6. CONCLUSION AND FUTURE WORK

Precision farming can be adopted into the Indian farming methods. There are certain geographical, economical and technological constraints for the full-fledged usage of precision farming in India. A major drawback is the lack of awareness. The need of the hour is for economical and robust solutions. The prototype developed by us was able to achieve certain level of these constraints. In the long-term, these types of solutions have the potential to better the lives of those who use them. Despite their focus on the farming production process, such apps motivate users to embrace evolving communication skills and technologies by directly linking them to their livelihoods. Plus, a growing number of mobile tools are being developed to help Indian farmers scale up by going online to market and sell their products. Applications can be developed which help in connecting agricultural buyers with local farmers, thus eliminating middlemen who would reduce the farmers' margins—are quickly gaining traction. A companion application can be further developed to keep track of multiple fields at once, to give weather reports etc. Also, the prototype developed by us can be further improvised in such a way that it is capable of spraying fertilizers or insecticides autonomously. This reduces the risk that the farmers faced on being exposed to such harmful chemicals. The opportunities are limitless.

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