Review : Smart Agriculture with Internet of Things, Sensors, Cloud-Computing and Mobile Computing

Deepika A. Kadale[1]
Department of Computer Science & Engineering
MGI-COET,
Shegaon, Maharashtra, India
deepikakadale@gmail.com

Sagar R. Deshmukh[2]
Department of Computer Science & Engineering
MGI-COET,
Shegaon, Maharashtra, India
sagardeshmukh04@gmail.com

Kshitij R.Mawale[3]
Department of Computer Science & Engineering
MGI-COET,
Shegaon, Maharashtra, India
krm.mawale@gmail.com

Ravikiran G. Deshmukh[4]
Department of CSE
MGI-COET,
Shegaon, Maharashtra, India
Ravideshmukh611@gmail.com

***Abstract*—** This paper is about how the Internet of Things for agriculture is possible. Internet of things reduces the human efforts and moreover suggests the better suggestion by considering the whole circumstances. The data related to the architecture must have the ware to store, so the cloud is the best storage with which we can access that data from anywhere. The big data and data mining are recent technologies helpful for data management. There should be 3 types of modules on cloud i.e. Farmers, Government of agriculture and Marketing administration, and the vendors. Registration from the farmers, marketing with admin and the vendor side is necessary. The government of agriculture module gives the current and future weather status and the governmental offers for the farmers. All this data stores on the cloud and the data mining helps farmer in decision making. The overall process is in 3 steps sensor's sensing with RFID, data storage on cloud and data accessing from digital devices with automation. The multiple types of sensors needed for this process. The data maintenance is at cloud and data usage and action manipulation can be done from digital devices. This paper is a step towards the future scope for internet of things in agriculture.

Keywords- *the internet of things, RFID, Sensors, Cloud, Data mining, Automation*

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I. OVERVIEW

As the 21st century starts with the home automation the other sectors are also expecting comfort in their field. The Internet of things implements the automation in most of the applications like home automation, building automation, Car automation, automated robots and automated software testing. The automation in agriculture is quite interesting and will be the best for farmers to reduce the efforts and to increase the quality & quantity of the crop. There are some areas where the automation in agriculture is quite successful as defined in case study given below.

The whole economy is basically depends on the agricultural outputs, still most of the farmer are in poor condition. The environmental imbalance, irregular rainfall, no rainfall, soil deficiencies, etc. are the reasons for their condition. By taking proper precautions most of them are avoidable and for that we should be aware about the current updates and future assumptions of the environment. By using sensors we can sense the requirement of the soil, crop. The satellites are helpful for getting the future environmental conditions. Also we could be aware about any natural disaster and by taking proper precautions we can avoid or reduce loss.

The automation in agriculture is not convenient by the wired communication. Wireless systems could be helpful to automation systems. With the advancement of wireless technologies such as Wi-Fi, cloud networks in the recent past, wireless systems are used every day and everywhere [1]. This provides the great comfort for farmers to get the updates and information as well as suggestions time to time from anywhere.

II. IOT INTRODUCTION

Internet of things is a broad concept founded by the Kelvin Ashton in 1999. He is also known as the father of "Internet of Things". In 1999 the internet was the most popular new trend, Ashton tried to relate the internet with the other objects. The time when he put his idea, the presentation he had made, named as "Internet of Things". Cofounder of the Auto-ID Center, Kelvin Ashton also worked in creating a global standard system for RFID and other sensors. The Internet of thing concept come from RFID (Radio Frequency Identifiers) system only. With the help of RFID we can connect the radio sensors with the internet and the machine to machine connectivity is possible.

The Internet of things is a detection, controlling, processing and management of data, and provide the information to the user and to give the instructions to the responsive objects. IOT industry covers sensors, transmission tunnels, computation and process, industrial application and so on, which involves technologies like RFID, sensors, wireless network transmission, computation with high-performance, intelligent control and so on.[2]

In internet of things (IoT) physical objects such as devices, vehicles, buildings and other items like embedded with electronics, software, sensors, and network connectivity are in a network which collects, analyzes and exchanges data. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure.

IoT keep track of individual consumers and targeting those consumers on the basis of the information supplied by the devices. In this way, it provides a robust "personalized" system that could increases business sales and their demographic. In addition to that, with the increasing number of devices connected to the Internet the Smart Grid also expands, with conserving more energy. Devices can make decisions and adapt without human guidance to reduce their energy usage. The IoT has many advantages to businesses, individuals, consumers, the environment, and society, but as with any technology, there are always repercussions and controversies that arise.

III. NEED OF AUTOMATION IN AGRICULTURE

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Agriculture is an occupation where only the handwork doesn't give you expected outputs. The changing environmental circumstances and changing soil requirement make you to pay whole attention and keep you in stress. According to plants growth the plant's requirement also changes, and this much of things get quite troublesome in decision making. The weather forecast advice to detect the alerts and we may get the time to take the precautions.

The data updates will continuously get stored in the database which will keep the records. That data might be beneficial for the future emergency. Data stored on cloud is easy to access and we can get the appropriate results from that data analysis. According to proper analysis we may get the proper suggestions.

The automation process is the processes in which the task is performed with any applied condition. If we have to apply the automation in agriculture then we have to give the proper conditions and have to give the authority to work according to the software programed. The output from the programed software is dependent on the input given to it. The input to the software is given by the sensors. The sensors used in the Internet of Things are the RFID i.e. Radio Frequency Identifiers, temperature sensors, light sensors, moisture sensors, etc.

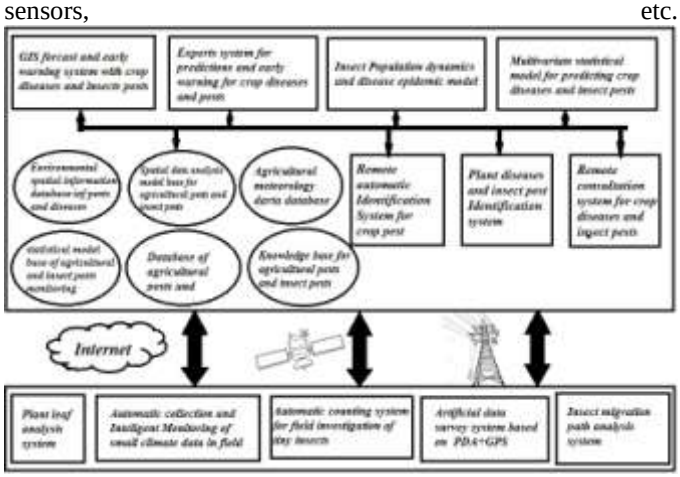

Fig 2. Agricultural disease and insect pest disasters information monitoring system [3]

Agricultural monitoring of diseases and insect pests is a complex process, and it involves some different phases and different actors. Every phase involves several kinds of operations, and every operation involves many more technologies. It includes data collection, image processing, data mining and fusion, pattern recognition, etc. Some of them, automatic data collection module mainly includes wind speed and direction, air temperature and humidity, carbon dioxide concentration, soil temperature and humidity, conductivity and video information; wireless transmission network module is responsible for the collected information quickly and efficiently and reliably to the total node; remote data transmission module is responsible for the summary of monitoring data points through the GPRS network by Internet transfer to the database; the main function of the data management module is stored in the attribute data, data entry, delete, modify, storage, retrieval and statistics etc. The data are the core in monitoring system based on IOT. The potential of using these data will reach its full extent when suitable collecting and transmitting technology and method are developed. [3]

IV. DATABASE MANAGEMENT ON CLOUD

A. *Database management on cloud*

For the IoT there should be some data storage which is convenient to access from anywhere. The cloud is the best database storage where we can store huge data which is accessible to user from everywhere.

The module shown below plays important role in decision making for the fertilizer requirements for current crop according to current soil properties for better results, crop disease prediction according to current soil properties and current weather conditions, crop yield prediction, best crop sequence analysis from the data collected over the period, best crop for corresponding soil properties, watering required according to soil moisture level. This database also provides information of region wise crop production details for each crop, total crop production for each crop in the state, based on this and current requirements for the consumers will be helpful to control the costs for each agro product.

As this database collects information over the years for soil properties and crop information details with its production amount for each farmland, inference results with data mining can be calculated for better crop sequences to be carried for best production and to preserve good soil health. As well as this database can provide suggestions to the farmers for crops to be taken on the farmland with peculiar soil properties based on previous stock of agro products and current requirements in the market. Big data analysis can be carried out to estimate future production of each product based on previous knowledge base. [6]

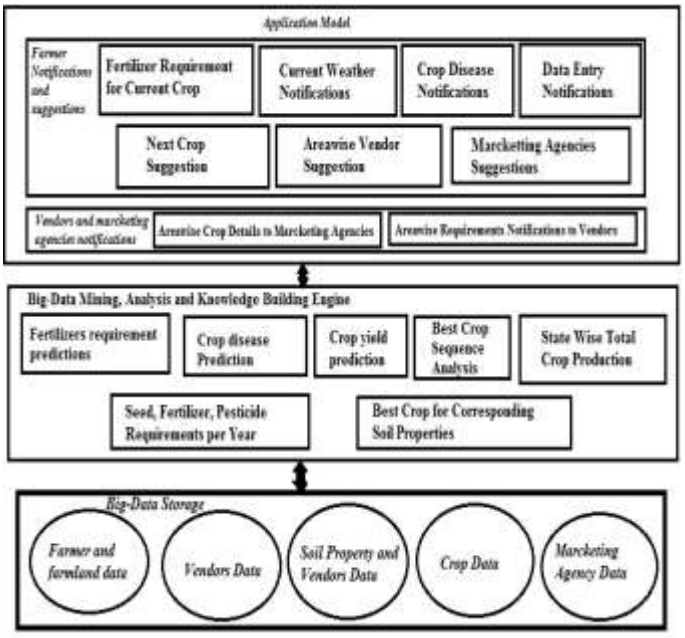

Fig 4. Agro Cloud Module. [6]

B. Sensors for automated measurements

To develop indirect measurement process which allows soil mapping, different types of sensors like electromagnetic sensors, optical sensors, mechanical sensors, electrochemical sensors, airflow sensors and acoustic sensors investigated. Electric circuits have been used by electromagnetic sensors to measure the efficiency of soil particles to conduct or accumulate electronic charge. While using electromagnetic sensors, the soil acts as an electromagnetic circuit, and changing location and conditions immediately gives the changing signal results.

1. Electromagnetic soil properties are influenced by the soil's texture, organic matter, salt content, and moisture content in it. In few cases, other properties such as nitrates or soil pH can be assumed using these sensors.
2. Optical sensors use light reflectance for checking the efficiency of soil. Optical sensors simulate human eye while looking at soil also measures near-infrared, mid-infrared or polarized light reflectance. Vehicle-based optical sensors use the similar principle technique as remote sensing.
3. Mechanical sensors can be used to estimate soil mechanical resistance (often related to compaction).These sensors use a mechanism that penetrates or cuts through the soil and records the force measured by strain gauges or load cells. Several researchers have developed prototypes that show the feasibility of continuous mapping of soil resistance; however, none of these devices is commercially available. The draft sensors or "traction control" system on tractors uses a similar technology to control the three-point hitch on the go.
4. Electrochemical sensors provide the most important information needed for quality agriculture — soil nutrient levels and pH value in soil. When soil samples are sent to a soil-testing laboratory, a set of standardized laboratory procedures is performed. Several researchers are trying to adapt existing soil preparation and measurement procedures to essentially conduct a laboratory test on the go. The values obtained may not be as accurate as a laboratory test, but the high sampling density may increase the overall accuracy of the resulting soil nutrient or pH maps.
5. Airflow sensors were used to measure soil air perm-ability. The pressure required to mix a given volume of air into the soil at fixed depth was compared to several soil properties.
6. Acoustic sensors investigated to determine soil texture by measuring the change in noise level by interaction of a tool with soil particles. A very low signal-to-noise ratio does not allow this technology to develop.

The monitoring system has the wireless sensor monitoring network and distant monitoring information system. Zig Bee sensor nodes connected in the plastics tents or greenhouse take data index in crop growing like air temperature, moisture, soil temperature, moisture, CO2 concentration etc. Zig Bee is a short range wireless communication technologies, where the date transmission and transmit all the node date to the base state where TCP/IP packaging can carry out, after which it will send them to the remote control center by means of GORS (Government Operational Research Service). The control center receives data, analyze and express them. Also, they can make parameter settings. As it crosses the threshold values of parameters, it will generate the alert messages or acousto-optic alarm. By making use of cell phone or Laptops, users can make real-time control on the environmental conditions and information at crop growing spot.

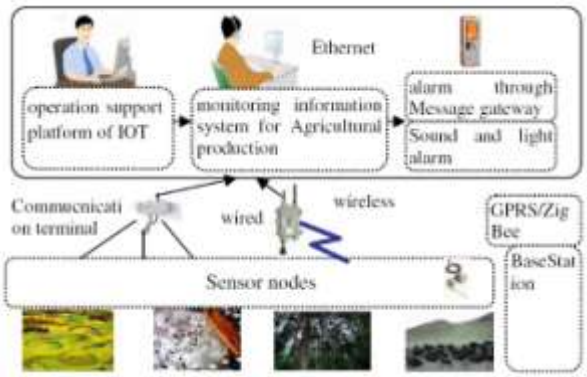

Fig 5. The system architecture of monitoring system [5]

Monitoring system is of three parts:

1) Sensor node: sending the information like atmosphere collected by the senor in periodicity to the monitoring and management center of agricultural environment by means of multiple hop transmission.

2) Gate way: Located in the edge of sensor network. Realizing the interconnection and communication between the sensor network and internet. In the gateway, we can realize the conversion from the sensor network protocol to the internet protocol.

3) Monitoring and management center of agriculture environment (user): being responsible for the information storage, procession, evaluation and so on.

One management center usually is capable of managing multiple monitoring areas. Remote control and PDA users are able to visit the data of the environmental monitoring center by means of internet and they can make real-time inquiry via the center. [5]

C. Online mobile updates

Mobile interface is essentially required for remote use of IOT. It has three parts: User Interface for farmer, agro marketing agency, agro vendors including fertilizer, pesticide providers and seed providers.

The mobile interface done with the mobile application. For accessing that application User have to register him with the few credentials including information, user type, address, geographical locations and other necessary details. If end user is farmer then has to send few credentials regarding information consisting of location and total area. The soil information per farmland is gathered through Sensors and the sensors will get the required information in return. The information is then collected and stored on cloud Big-Data storage. Also the data also keep updating on cloud when the crop cultivation is in progress. Through such applications

farmers get suggestions regarding the fertilizers, pesticides required and its amount as well as its quantity for better crop results and cost savings. Such application is useful for sending the notifications to the users. When the crop is done with harvesting, the production information of each crop will be sent to the cloud storage by the farmer with current soil characteristics after crop cultivation. This information is stored on cloud with time, location details.

Agro marketing agencies responsible for purchasing harvested crops from farmers also has to send the periodic updates related to changes in cost and their purchase requirements. Agro product vendors are responsible for selling fertilizer, seed, and pesticide and agricultural equipment's. Agro vendors have to update users related to products and cost changes periodically. Mobile application module is shown below [6].

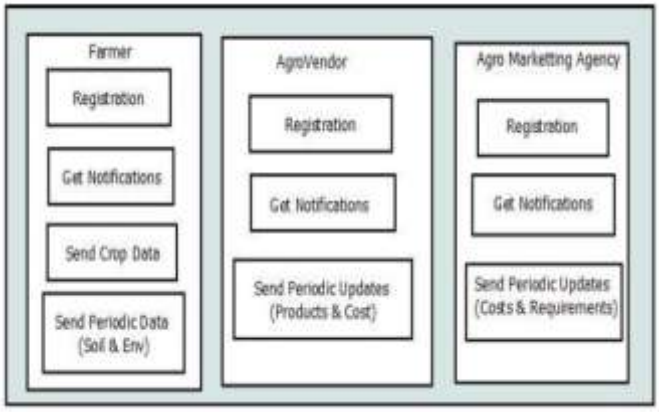

Fig Mobile App Module [6]

V. CASE STUDY

Tom Blythe, a fourth-generation family farmer who resides in Northwest Iowa. He owns about 5,000 acres of farm land and harvests everything from corn, cotton, soybeans, and vegetables to data – yes data, a lot of data. This data originates from GPS satellites, sensors on his tractors and field. They stream real-time data that is stored in cloud-based systems and which he can be easily accessed via charts and reports on his iPad.

By gleaning data generated from GPS and sensors on the field and farming equipment, and using big data analytics, farmers have been able to improve crop yields and water utilization.

VI. CONCLUSIONAND FUTURE SCOPE

In this paper we proposed a multidisciplinary approach for smart agriculture using five key technologies: Internet of Things, Sensors, Cloud Computing, Big-Data Analysis and Mobile Computing. Through soil sampling farmer will be able to get current fertilizer requirements for the crop. This is an essential requirement towards agriculture sector to improved crop production with reduced cost and need of fertilizer requirements to keep soil healthy. As the data is collected over the years for crop details and soil conditions, this model provides Big-Data analysis for best crop sequence, next crop to be cultivated for better production, total crop production in the area of interest, total fertilizer requirements, and other data of interest can be analyzed. As all the agriculture related entities are connected together, this will also facilitate the distribution of harvested crops to the agro marketing agencies and farmers will also be able to get required agriculture products and services from agro vendors. This model also offers the estimates of total production per crop region wise and state wise, total fertilizer requirements. This will be helpful to keep the cost of agricultural products in control. Through notifications farmers will also informed about current schemes for agriculture.

As automation is concern with the automatic control on machinery. Implementation of automation in IOT is in the way that the machinery will take automatic actions on the given inputs coming from the sensors. It can be used in IOT to enhance the efficiency of agricultural production and will add the comfort in farmer's life.

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