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Emerging trends in farm automation: a detailed review

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ABSTRACT

The rising food prices in recent years leads to the cascading effect on the entire Indian economy. India cannot dream about two digit growth rate unless the revitalization of the agriculture sector. The shackled rural economy will be freed and its engine needs to expedite by convergence of technology under changing environment. Indian population is expected increase in the coming years meanwhile India needs to keep up its food production. The land area available to agriculture is not expected to increase rather it will decrease due to rapid expansion of habitation. Hence there is need to increase productivity of agriculture and yields per hectare. Water shortage results in less than sufficient irrigation will be another major challenge to combat in the years to come. Affordable modern irrigation techniques will result per drop more crop. Indian farmer needs realistic crop protection technology which will reduce per hectare usage of agrochemicals resulting low production cost and improving yields. Mitigating the digital divide for supporting planting decision to selling their produce at the wholesale market will be the game changer in agriculture. This article provides a detailed review of emerging trends in farm automation using agriculture robots and Internet of Things. The topic includes natural resource variability, variability management and potential of technologies in modernizing agriculture.

Keywords: *Farm Automation, Mobile application, Internet of Things, Sensor based irrigation.*

1. INTRODUCTION

The objective of this paper is to investigate emerging agriculture technologies that will extend the reach of Indian agriculture sector to new horizon. Indian agriculture sector will be empowered by adopting low cost farm automation. In coming future [1] our fields could be tilled, shown, tended and harvested by fleets of co-operative autonomous farm machinery by land and air. Driverless tractors [2] can be designed to follow pre programmed routes. Drones [3] equipped with optical sensors can monitor crop health and soil condition. Instead of prescribing field fertilization before application it will inform precise amount needed to the application machinery. Drones can also be used for spraying crops with pesticides and herbicides. Supervisory control and data acquisition [4] for gathering data from fields will results efficient irrigation and optimal input for production. Air and soil sensors addition to the automated farm will enable real time understanding of farm. With the application of Internet of Things we can save on seeds, minerals, fertilizers, pesticides and herbicides by reducing overlapping of inputs at variable rates throughout the field.

2. TRANSFORMING AGRICULTURE THROUGH FARM AUTOMATION

With the time human race has learnt to harness animal power. Man as a power source a mere 0.1 HP (0.075 KW). Harnessing power of animal man discovered that they could be more productive. Along with the development of external combustion engine their ability increased in terms of productivity. Today with modern farm machinery they achieved even more. The agriculture value chain as shown in fig 1 includes all the steps involved from preparation of soil to harvest and post harvest processing.

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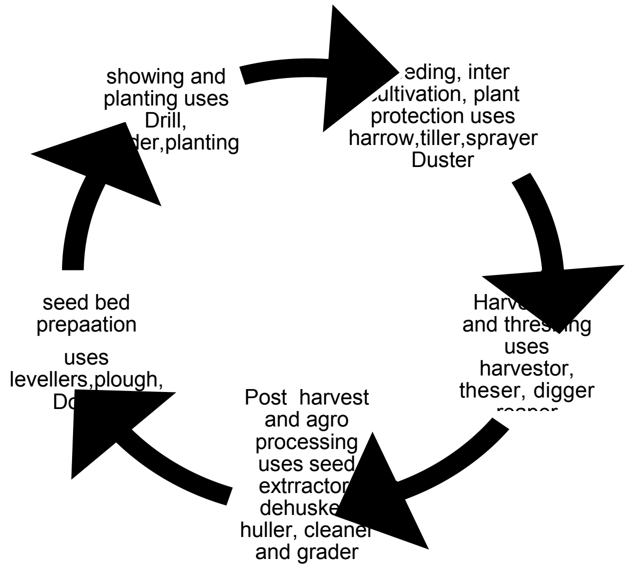

Fig 1: Agriculture value chain and types of farm equipments

For every step in production life cycle uses different equipments which has ability to enhance the efficiency of the farming process. Farm mechanization not just reduces labor time and post harvest loss but also help to cut dawn production cost in long run. Since we know that human as a control element is fallible. Hence, it leads to the confusing the control process of farming process. The time has come to check on quality and productivity and makes agriculture profitable business. In recent the innovation in farm automation is very much required to break the yield barrier, utilize inputs more efficiently and higher value of cropping pattern for sustainable agriculture farming.

I. Evolving Farm automation

The rate at which new technologies are evolving it is prudent to expect traditional farm machinery will become obsolete and new approach of farming process be adopted. With the advent of Internet of Things agriculture will be smarter. Smart agriculture application based on Internet of Things will improve decision making capability.

A. Space base Positioning System

The precision farming has been made reality by combing the Global Positioning System (GPS) and Geographic Information System (GIS). These technologies enable the coupling of real time data collection with accurate position information, leading to efficient manipulation and analysis of large geospatial data. GPS based application can be used for farm planning, field mapping, soil mapping, tractor guidance, variable rate application and yield mapping.

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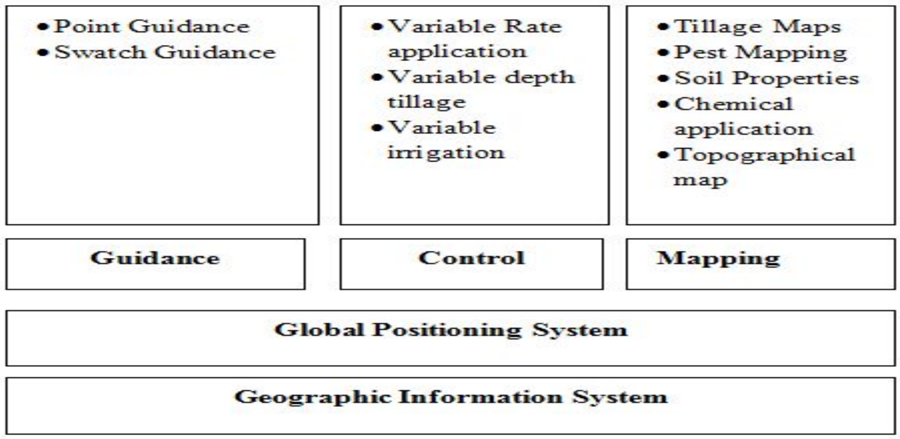

Fig 2: Building Blocks of space base position system

Site specific crop management focuses on utilizing spatiality reference data to improve resource application and assist agronomic advice to better suit the specific requirement.

B. Wireless communication

For smart agriculture operation, establishing vehicle to vehicle and vehicle to farm residence communication is required to manage logistic task and ensure safety. The transferring data wirelessly can help working status of these machines and allows dynamic reallocation of task. ZigBee [5] is low cost, low power, wireless mesh network technology standard. The low cost allows the technology to be widely deployed in wireless control and monitoring application. The low power usage allows long life of the smaller batteries and mesh networking provides high reliability with high range. ZigBee standard allows the identification of pest in crop, draught or increase in moisture. Having such information at real time automated actuation device can be used for controlled irrigation. ZigBee nodes can obtain the temperature humidity and illumination information in real time and transfer to remote monitoring center.

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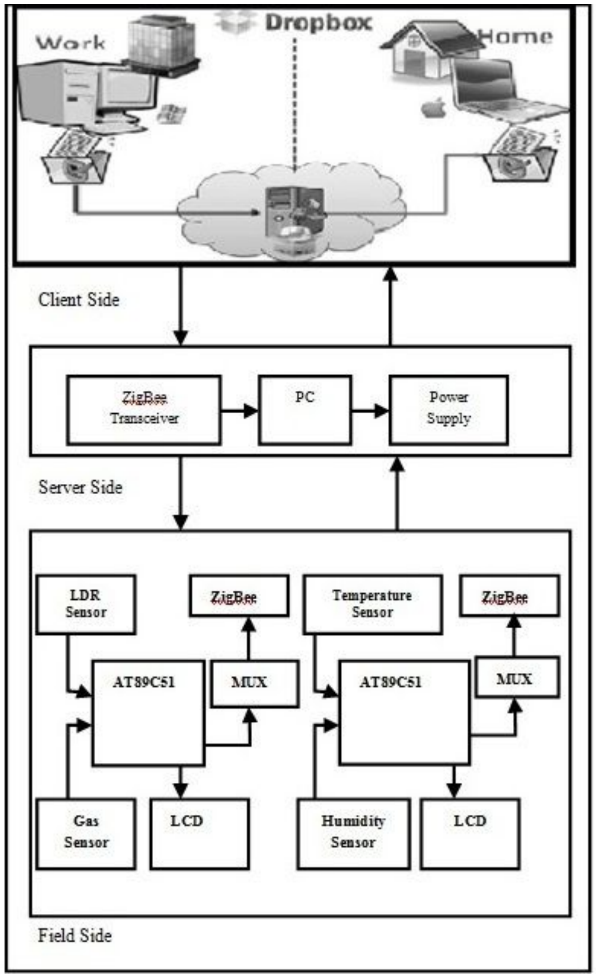

Fig 3: Technology Stack of ZigBee implementation in agriculture.

Today Wi-Fi available is available in most business, industrial and public sites with high speed internet connection. Wi-Fi provides a communication range in order of 20m-100m with data transmission rate in order of 2-54 Mbps at 2.4 GHz frequency of ISM band. The wireless sensor network will play vital role in future agriculture. The overview of wireless sensor network is shown in fig 3.

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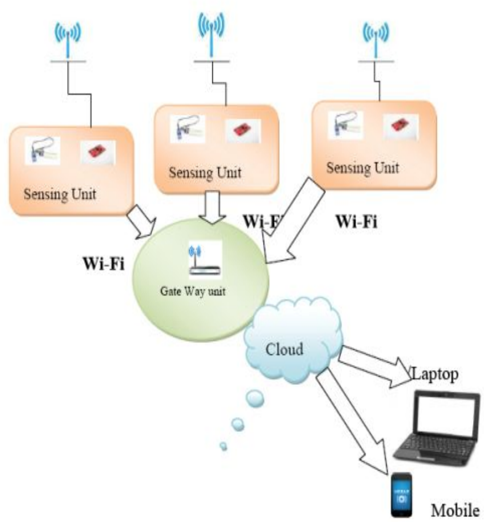

Fig 4: Overview of wireless sensor Network.

The wireless sensor network [4] unit gathers the information from the sensors deployed in farm and communicates with each other via gateway unit and sends the measured data to a cloud for further processing.

C. Agriculture Robots

The complex agriculture environment combined with intensive production requires technology which can deal with unstructured nature of external environment and maximum chances of failure. In recent years lots of researchers are working on agriculture robots. Agriculture robots are not the new term coined in recent days but it all started in 1980. Kawamura and coworkers developed fruit harvesting robots. Since then many works has been carried out in this field but only few can be used commercially. In 1980 the potential of computer and image sensor vision was the game changer. In that decade, a program for robotic harvesting of orange was successfully developed at the University of Florida. During 1997, agriculture automation had become a major issue with the advocacy of precision farming. Rapid advancement in electronics, computers and mobile computing has revolutionized the agriculture automation. As we know that robots are machine that can be programmed to do certain tasks which consist of manipulator like claw, hand or tool attached to mobile body or a stationary platform. Autonomous robots work completely under the control of computer program. They often use sensors to gather data from their surroundings to navigate. Agriculture robots [6] can be classified into harvesting or picking, planting, weeding, pest control and maintenance robots.

Agriculture has to be done in unstructured environment. The plant appears to be similar in description but they are different in engineering terms. The work objects are located in environment subject to natural variation form place to place and over time. The main obstacle is nature as we know that nature is not uniform.

The number of agriculture robots [7] are increasing and jobs they can do now is more versatile with the advancement of hardware and software. The new robots are getting smaller. Now we can use these robots for combating plant diseases that causes damages to crops. Fungi are the most common causes of crop damage. To kill fungal disease you need fungicides. They attack leaves which are needed for photosynthesis and therefore decrease productivity. Robots can treat plant that have been infected and meanwhile destroy them if it is necessary instead of covering entire crop with fungicides. Robots can also be used in weeding [8,9,10]. Robots can pull weeds from farm or cut top. All the waste can be collected and limiting the use of herbicides chemicals that may destroy the inhibit growth of plants. Herbicides are intended to kill weeds but many times it may damage crop. Robots can also be used spraying pesticides which will reduce the application of chemicals.

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The flying robots are trending in the agricultural sector. These robots are controlled by the hand held device. Since this type of robot can fly therefore it can reach its destination quickly. The idea of flying robots for the agriculture is to perform quick overview of the entire field with the help of camera and attached sensors.

Fig 5: Flying robots with sprayer

The above fig 4 shows the flying robots on the agricultural lands which consist of sprayer attached so that the flying robot. This robot has been designed to capture image of the land as well as the spraying techniques are also embedded. Flying robots can fly over the field and monitor plant health from above. It will hover from plant to plant or section to section and ensures dropping just enough fertilizers or spaying right amount of pesticides, herbicides or fungicides. These are equipped with sensor to analyze the plant or section that needs more minerals nutrients. These sensors measure the amount of red light and nearer infrared heat that is reflected by the leaves. The reflectance value are used for calculation is known as Normalized Difference Vegetation Index (NDVI). Healthier crop have higher NDVI value. Such sensor can also be mounted on fertilizer sprayer to ensure each sprayer delivers right amount of fertilizer depending on health of individual plant or section.

3. LATEST AGRICULTURAL ROBOTS

Some of the popular agriculture robots [11] used worldwide is listed as following.

A. HV-100

The HV-100 is programmed to identify which size pot to look for, using a 3D Laser Interferometry Detection and Ranging (LIDAR) sensor as shown in the fig 5.

Fig 6: HV-100

It can lift a payload of 22 lb (10 kg) with high placement accuracy, performing up to 200 moves per hour. The machine requires only minimal training and setup, features a quick swap rechargeable battery is designed to work on rough terrain and operates in all weather and lighting conditions, 24 hours a day. If a human crosses its path, it will immediately stop to avoid a collision. It enables growers to create a sustainable workforce of robots, working safely alongside people to increase efficiency, reliability and plant quality. Harvest’s robots can perform as much manual

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labor as required by each grower, creating more capacity for human workers to focus on other tasks. The robots can also increase plant quality by optimizing placement in the fields and reducing non-labor production costs including the use of water, pesticides, herbicides and fertilizers.

B. MIT Robot Gardener

The students at Massachusetts Institute of Technology have designed a mobile robot which can maintain the soil humidity and pick the ripe fruits. A network of sensors attached to each plant monitors the soil humidity and call the robot water. The robot communicates wirelessly with the plant sensor.

Fig 7: MIT Robot Gardener

C. Agrobot SW6010

This robot looks similar to tractors. This machine uses sensors and robotic arms to detect ripe berries and pick these up from ground.

Fig 8: Agrobot SW6010

D. The Asterix project

The Asterix projects developed autonomous robots for automatic weed control in row crops.

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Fig 8: The Asterix project

D. AgBot II

Agbot II is a robot designed for farmers to take decision on the use of herbicides, pesticides, fertilizers and watering.

Fig 9: AgBot II

D. Hamster Bot

The Hamster Bot is an autonomous robot that can roll over cropland without harming.

Fig 10: Hamster Bot

Inside the ball there is range of sensors which can collect information about soil temperature, composition, moisture and plant health.

D. Autonomous Robot Tractor

This self-steering tractor is capable of wide range of maneuvers made with high accuracy. In an uneven and inconsistent terrain, a big problem is raised by the change of tractor direction. This robot uses an application able to calibrate the direction according to each terrain type.

Fig 11: Autonomous Robot Tractor

D. OZ

OZ is an autonomous electric robot designed to automate the way we grow a plant, maintain and harvest row crops.

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Fig 12: OZ Electric Robot

E. LettuceBot

The LettuceBot combine computer vision and robotics to act 90 times per second with a precision of ¼-inch.

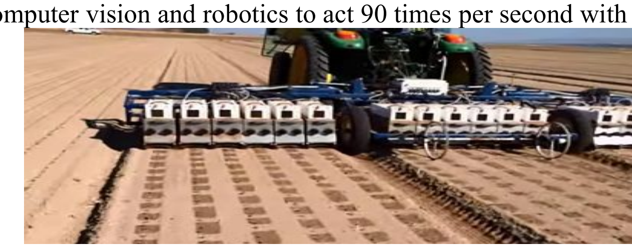

Fig 13: LettuceBots

F. Bee Bot

This small flying robot is inspired by bees and is used for pollination.

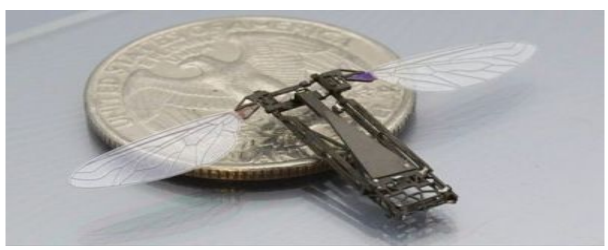

Fig 14: Bee Bots

E. Vine Robots

Available as a prototype, the robot uses advanced sensors and artificial intelligence to manage the vineyards. The robot provides data about water status, production, vegetable development or grape composition.

Fig 15: Vine Robots

F. Conic System Pro-300

Conic is a specialized sowing robot for greenhouses able to sow 1,000 trays an hour.

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Fig 16: Conic System Pro-300

G. Gripper Inspired by Octopus

This robot arm moves vegetables back and forth on a party tray. It has blue fingers that curl around any piece of broccoli and lift it up to an adjoining compartment.

Fig 17: Gripper Inspired by Octopus

H. BoniRob

BoniRob is a modular platform that can host a large variety of tools for agricultural chores.

Fig 18: BoniRob

4. Conclusion

The farm automation is partially successful in structured environment. Farm automation is difficult to achieve in diverse scenario. Hence there is need to design and develop different system for each product. Application for one type may or may not be feasible another crop. The recent trends in farm automation will empower Indian farmers provided the technology is affordable.

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