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Robotic agriculture

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ABSTRACT

Agriculture is humankind's oldest and most economic activity. Agriculture provides the food, fibre and fuel necessary for our survival. As the global population is increasing, agricultural production must be twice over if it is to meet the mounting load for foodstuff and bio-energy. Developed agriculture needs to find new ways to improve efficiency. Applying robotics technology in agriculture is a very new concept. The main objective of autonomous 'agribot' is efficient utilization of resources, save money, time and to reduce labour work. Develop the agriculture smart robots which do right thing in right place at right time with right amount in process of farming. Agribots to perform agricultural operations autonomously such as ploughing, cultivating (seeding), mowing, fertilizer application, spraying pesticides, finding diseases or parasites, and performing mechanical weeding and harvesting. Agribots equipped with cameras and sensors that are used to detect all parameters. The types of robots *viz*., Demeter, Seed mapping robot, Weed control Robot, Forester robot, Horticulture Robot, Fruit picking robot, Drones and Driverless tractor. In this some are field robots and some are mobile robots. Field robots are modifying themselves according to the required situation. Mobile robots are those which have mobility with respect a medium. Although existing manned operations can be efficient over large areas there is a potential for reducing the scale of treatments with autonomous machines that may result in even higher efficiencies in agriculture. In India, about 80% of population is dependent on agriculture. Nowadays GPS and

GIS used in precision farming but still need advance technologies. Therefore, if the farmers are empowered with support of robots, the agricultural output of the nation can improve radically. These robots can play a big role in promoting Green Evolution.
Key words: Agribot, seed mapping, robot weeding, selective harvest, driverless tractor

INTRODUCTION

India's record of progress in agriculture over the past four decades has been quite impressive. But, still now some of the problems are to reduce the potential of Indian farming, *viz*., raising input costs, availability of skilled labours, dwindling water resources, over usage of fertilizers and lack of proper crop monitoring (Kumar, 2007). The mentioned crisis can be eradicated and Indian farming and agriculture sector can be improved for a very large extent by the use of Robotics (*automation technologies in agriculture*) with smart intelligence devices. A robot is a mechanical, artificial agent and is usually an electromechanical system. It is a device that, because of software programming, makes complicated tasks easy to perform. Agricultural robotics is the use of automation in bio systems such as agriculture, forestry and fisheries (Blackmore *et. al*., 2004). Smart robots which do Right thing in Right place at Right time with Right amount in process of farming. Applying automation to agriculture has helped create several advancements to the industry while helping farmers save money and time (Zanwar and Kokate, 2012). Agricultural robots are capable of collecting crop and soil samples, which allows them to be able to accumulate data close to the crops. This agricultural robots are perform agricultural operations autonomously such as ploughing, cultivating (seeding), mowing, spraying pesticides, finding diseases or parasites, and performing mechanical weeding and harvesting (Blackmore, 2005; Singh *et al*., 2015). Agricultural robots are equipped with cameras and sensors that are used to detect all parameters (Saman and Muhammad, 2010). In India, about 70 per cent of population is dependent on agriculture. Therefore, if the farmers are empowered with support of robots, the agricultural output of the nation can improve radically (Reddy *et al*., 2016).

SCOPE

Agriculture is humankind's oldest and still its most important economic activity, providing the food, feed, fibber and fuel necessary for our survival. The global population expected to reach 9 billion by 2050; agricultural production must double if it is to meet the increasing demands for food and bio-energy. Given limited land, water and labour resources, it is estimated that the efficiency of agricultural productivity must increase by 25% to meet that goal, while limiting the growing pressure.

AGRIBOT

Agribot is a robot designed for agricultural purposes. It is designed to minimize the labour of farmers in addition to increasing the speed and accuracy of the work.Agricultural robots come equipped with cameras and sensors that are used to detect weeds and other forms of stress. It performs the elementary functions involved in farming *i.e.* harvesting, spraying, seeding and removing the weeds. And they gradually appear advantages in agricultural production to increase productivity, improve application accuracy and enhance handling safety (Singh *et al*., 2015).

DEMETER

Demeter is a robot that can cut crops like wheat and alfalfa. It is named for the Roman goddess of agriculture. Although, it may look like a normal harvester, Demeter can drive by itself without any human supervision. Unfortunately, people get tired and bored, and their productivity goes down. With a robotic harvester, however, it never gets tired and can operate 24 hours a day.

Demeter has cameras on it that can detect the difference between the crop that has been cut and crop that hasn't. This information tells it where to drive, where to put its cutter head, and when it has come to the end of a crop row so it can turn around. Demeter has a cruise control function. An operator can ride along with it. Demeter can drive, steer, and control the cutter head while the operator can focus on other tasks. The Demeter robot can also be driven by remote control. Or, Demeter can be taught a path and then follow that path using its on board sensors and computer control systems. It can follow the path with an accuracy of up to 3 centimetres (Karthik and Chandra, 2014).

SEED MAPPING

Seed mapping is the concept of passively recording the geospatial position of each seed as it goes into the ground. It is relatively simple in practice as an RTK GPS is fitted to the seeder and infrared sensors mounted below the seed chute. As the seed drops, it cuts the infrared beam and triggers a data logger that records the position and orientation of the seeder. A simple kinematic model can then calculate the actual seed position (Griepentrog*et al*. 2003). The seed coordinates can then be used to target subsequent plant based operations.

Ehsani*et al*. (2004) tested the accuracy of this type of system for automatic mapping of maize seedin an agricultural field. They found, on an average, seeds were automatically mapped within 34 mm of a plant at germination (a range of 30–38 mm). Griepentrog*et al*. (2003) tested a precision seed planting system capable of automatically creating a seed map of a sugar beet field using RTK GPS for location sensing and optical seed drop sensors.

SEED PLACEMENT

Placing seeds are that they get maximum air, light and water. A hexagonal or triangular seeding pattern or less space in row and more between rows may be applied by using robots.

***1.* Robotic Seed Sowing**

The process of sowing crops such as sunflower, baby corn, groundnut and vegetables like beans, lady's finger, pumpkin and pulses like black gram, green gram *etc*. The plantation of seeds is automatically done by using DC motor. The distances between the two seeds are controlled. It is also possible to cultivate different kinds of seeds with different distance. When the Robot reaches the end of the field we can change the direction with the help of remote switches (Dattatraya*et al.,* 2014). The whole process is controlled by Microcontroller. It should be reduce the human effort and increase the yield.

***2*. Rhex robot (Seeding and Fertilizing)**

The measurement of the moisture of soil, temperature of soil and pH value of soil, performing of the seeding and fertilizing in agriculture field is designed in the agriculture Robot. Instead of using line follower, obstacle detecting sensor in the proposed system camera is used for live streaming. Agriculture robot can be control by the internet using raspberry pi. Live steaming can see by computer by typing ip address of raspberry pi and password then it can be control the robot by pressing controlling key in the system Rhex rover robot is replaced by the wheeled robot.

Rhex rover having 6 legs, in which 3 legs can move instantly at a time and other 3 legs at next time. It can move like a cockroach using 3leg moves at time. Synchronous between legs are maintain by using IR sensor and feedback sensor therefore its can operate in agricultural field easily. Seed and fertilizer can be drop to field by using solenoid switch in seed dispenser and fertilizer dispenser. LDR is used for indicating seeds and fertilizer in the dispenser by glowing the LED. If seeds and fertilizer is empty then led stop glowing (Shivaprasad*et al*., 2014).

***3.* Reseeding**

Reseeding is the concept of being able to identify where a seed was not planted, or that a crop plant has not emerged and a machine can automatically place another seed in the same position. This concept could be extended to transplanting a seedling instead of a seed if the surrounding plants are too far advanced. A reseeder would have the ability to insert individual seeds/plants without disturbing the surrounding crops. Conventional seeders could not then be used as they create continuous slots in the soil.

"GREEN SEEKER" ROBOT

"*Green Seeker*" By John Solie-Oklahoma State University. He introduced the "green seeker sensor" that was developed at Oklahoma state university. This smart machine reads a plant's needs and then applies precisely the amount of fertilizers needed. The green seeker shines light at red and near infrared wavelength on the plants. That light is absorbed by the plant and some of the light is reflected back up into the sensors. The sensor measure the amount of light reflected off the plant, and determines the amount of fertilizer that the plant is needed. By using this we can know how much amount of fertilizer is needed by plant and applicator.

The report from the Oklahoma farmer "Tom Denker" has used green seeker in his wheat fieldhe used to spread 37 kg of nitrogen fertilizer per acre. But, with the use of *Green seeker* Tom Denker has used only 10 kg and hence 75% decrease in the use of fertilizers. "It is great technology and a great savings" (Mohiuddin, 2015).

GANTRY ROBOTIC SYSTEM

The robotic gantry could apply both liquid sprays and fertilizer and be able to regulate itself according to current weather conditions. If it became too windy then the gantry could just stop and wait until conditions improved. Sensing systems could be mounted on a trolley that could move along the spray boom as in the crop scouting section.

The gantry consists of three linear drives to position the robot at any given co-ordinate in its working envelope. A typical plot of agricultural land in India is assumed to be having dimensions of 100x100 m. A gantry robot would be an optimum solution for this dimension provided it has a good traversal speed. The linear drive has to be suitable for this speed. The linear drive will also have to be precise enough as only simple sensors are to be used to maintain cost effectiveness.

There should be no possibility of slip or backlash in the drive. This robot, along with its fixture can be easily detached and attached to the frame on some other field, enabling sharing of a single robot by many farmers. Gantry robotic systems used in industries are built robustly and are expensive. Their main advantage is their capability of having a large working environment. They can also be conveniently be used for precision agriculture purpose e as manoeuvring would not be affected by the water pipe lines. But their costs need to be reduced for feasibility in agriculture Kumar (2007).

CROP CARE: CROP SCOUTING

One of the main operations within good management is the ability to collect timely and accurate information. Quantified data has tended to be expensive and sampling costs can quickly outweigh the benefits of spatially variable management. (Godwin*et al*., 2001). Data collection would be less expensive and timelier if an automated system could remain in the crop carrying a range of sensors to assess crop health and status.

It Provide automated crop surveys (Bak and Jakobsen, 2003). A range of sensors have been fitted to measure crop nutrient status and stress (multi spectral camera), weed species and weed density visible images (pan chromatic) and Crop height (Ultrasonic range finder).

***1.* Weed Mapping**

Weed mapping is process of recording the position and preferably the density (biomass) of different weed species using aspects of machine vision. One method is to just record the increased leaf area found in weedy areas as weeds are patchy and the crops are planted in rows by Pedersen (2001). Another more accurate method is to use active shape recognition, originally developed to recognise human faces, to classify weed species by the shape of their outline by Sogaard and Heisel (2002). Tang *et al*. (2000) reported by Colour segmentation has also shown to be useful in weed recognition.

Advantages

1. Strategic control work and protecting the good bush land.
2. Understanding the distribution of weeds in bush land.
3. Monitoring the spread of established weeds and the effectiveness of control programs.

4. Setting accurate distribution of weeds.

2. Robotic Weeding

Knowing the position and severity of the weeds there are many methods that can kill, remove or retard these unwanted plants (Norremark and Griepentrog, 2004). A four-wheel-drive weed-seeking robot was developed and the task of the weed-removing device is to remove or destroy the weed. Crops that are grown in rows can be weeded by running a hoe between the crop rows. An intelligent hoe uses vision systems to identify the rows of crops, and steer itself accurately between them. Weed identification is based on colour photography. The equipped robot helps production of weed maps identifying plant. This robotic weeding considerably reduces the need for herbicides (Herbicide usage by 75 to 100 per cent in high value crops).

The organic sugar beet field at the first true leaf stage show that, 99 per cent of the sugar beets were not removed and 41 to 53 per cent of the weeds were removed by the robot. Of the weeds not removed, 31 per cent were adjacent (*i.e.* too close) to crop plants and 18 per cent were growing in a location where a sugar beet seed did not germinate.

Lamm*et al*. (2002) developed real-time robotic weed control system and tested it in commercial cotton fields. The robotic weed control system was capable of distinguishing grass-like weeds from cotton plants, and applying a chemical spray only to targeted weeds while travelling at a continuous speed of 0.45 m/s. The system correctly sprayed 88.8 per cent of the weeds while correctly identifying. Astrand and Baerveldt (2002) utilized the rotating hoe type of weed control actuator in their autonomous weed control robot for sugar beets.

3. Weed Killing Robot

The weed killing robot is BoniRob. It roams through fields and finds weeds, stomping out two per second with a one cm wide drill Bosch. (2015).

4. Micro Spraying

Micro spraying takes the concept of a spray boom down to the centimetre level. It applies highly targeted chemicals and can treat small areas by selectively switching the jets on and off. It is part of a larger system that can recognize individual weed plants and locate their leaves for treatment. Within the close-to-crop area, great care must be taken not to damage the crop nor disturb the soil. One method of killing weeds close to the crop plants is to use a micro spray that delivers very small amounts directly on to the weed leaf. Machine vision can be used to identify the position of an individual weed plant and a set of nozzles mounted close together can squirt an herbicide on to the weed. Tests have shown that splashing can be reduced when a gel is used as a carrier rather than water Lund and Sogaard (2005).The usage of herbicide can be drastically reduced to about one gram per hectare for an infestation of 100 weeds per square meter. Black Nightshade (*Solanumnigrum*) 100 plants m^{-2} Glyphosate applied at 720 gm ha^{-1} to 1 gm ha^{-1}: The 94% efficacy was reported by Graglia (2004).A micro spray system is currently under development in Denmark.

Benefits of micro spraying

- This could drastically reduce the quantity of chemicals used in fields.

- Improving the quality of agricultural produce bringing in cost efficiency, and also offering a more responsible.
- Environment friendly.

ROBOTIC IRRIGATION

A robotic irrigator in the form of a mechatronic sprinkler (*to simulate a travelling rain gun*) was developed to apply variable rates of water and chemigation to predefined areas. The trajectory and sector angles of the jet were controlled by stepper motors and could be adjusted according the current weather and the desired pattern by a small computer. When the airborne water was blown down wind, the jet angles could be adjusted to compensate by measuring the instantaneous wind speed and direction (Simon@unibots.com).

ROBOTIC SELECTIVE HARVESTING

Selective harvesting involves the concept of only harvesting those parts of the crop that meet certain quality thresholds. It can be considered to be a type of pre sorting based on sensory perception. Examples are, to only harvest barley below fixed protein content or combine grain that is dry enough (and leave the rest to dry out). To select and harvest fruits and vegetables those meet size criteria.

Selective harvesting: *Two criteria*

1. The ability to sense the quality factor before harvest.
2. The ability to harvest the product without damaging the remaining crop.

Smaller more versatile selective harvesting equipment is needed. Either the crop can be surveyed before harvest so that the information needed about where the crop of interest is located, or that the harvester may have sensors mounted that can ascertain the crop condition. The selective harvester can then harvest that crop that is ready, while leaving the rest to mature, dry, or ripen *etc.*Alternatively, small autonomous whole crop harvesters could be used to selectively gather the entire crop from a selected area and transport it to a stationary processing system that could clean, sort and maybe pack the produce. This is not a new idea, but updating a system that used stationary threshing machines from many years ago. Alternatively a stripper header could be used to only gather the cereal heads and send them for threshing.

DRONES

- Drones to help farmers with weed control.
- By scanning different crop characteristics, such as height and canopy cover, the drone can communicate the areas that need attention to the unmanned rover on the ground.
- The rover then removes the weeds, applies pesticide to a specific area, or highlights areas that may need extra fertiliser to the farmer. (Robohub)

***1.* Flying Robots (Spread Fertilizer)**

- A flying robot monitors the growing condition of the crops.
- With camera equipment and an automatic fertilizing system in the front, the robot can fly autonomously and apply fertilizer independently.

- It is made by the national key laboratory of robotics of Shenyang Institute of Automation of Chinese Academy of Sciences. (Northwest China's Xinjiang Uygur autonomous region, 2011).

ROBOT DRONE TRACTORS

Robot will decide Where to plant, When to harvest and How to choose the best route for crisscrossing the farmland. These are used in America now (Mohiuddin. 2015).

***1.* Driverless Tractor**

A driverless tractor is a form of autonomous technology. It is considered driverless. The tractors use GPS and other wireless technologies to farm land without the need of a driver. The tractor uses two 6 inch dome antennas that receive signals from a GPS. Based on these satellite signals, the tractor follows a previously programmed route *via* an electronic map.

Current leading manufacturers

- John Deere
- Autonomous Tractor Corporation
- Fendt
- Case IH.

ROBOT IN HORTICULTURE

Robo is used in lawns to cut the grass in lawns. It can cut any lawn, regardless of its geometric shape. In automatic mode, a fully charged Robo-mower can typically mow a lawn of 2500 to 3200 sq.ft., depending on the number of obstacles in its path. Slopes, height of grass, humidity etc. It operates electrically on rechargeable batteries, mulching blades, whisper quiet operation and without any pollution.

***1.* Fruit Picking Robot**

The fruit picking robots need to pick ripe fruit without damaging the branches or leaves of the tree. The robots must be able to access all areas of the tree being harvested. The robot can distinguish between fruit and leaves by using video image capturing. The camera is mounted on the robot arm, and the colours detected are compared with properties stored in memory. If a match is obtained, the fruit is picked. If fruit is hidden by leaves, an air jet can be used to blow leaves out the way so a clearer view and access can be obtain. The robot arm itself is coated in rubber to minimize any damage to the tree.

FOREST ROBOTS

***1.* Treebot**

A fearless mobile robot is helping scientists monitor environmental changes in forests. Treebot consists of combine networked sensors, a webcam and a wireless net link. It is solar-powered and moves up and down special cables to take samples and measurement for vital analysis. It is very important in the biology community to understand the interaction between the atmosphere and the forest environment. The

Treebot travel through the forest canopy along specially constructed cabling, night and day.

***2*. Forester Robot**

This is special type of robot used for cutting up of wood, tending trees and pruning of tree and for harvesting pulp and hard wood and in the forests. It employs a special jaws and axes for chopping the branch.

Advantages of Robotics Farming

- Elimination of labour
- It brings us an opportunity of self employment
- It is one time investment then the expenditure of the farming will drastically.
- The use of fertilizer, pesticides, insecticides, herbicides and water consumption can be reduced in very large percentage.
- It brings revolution in the farming, agriculture and cattle grazing.
- Productivity and quality will be increased to a lot extent.
- This applications can improve environmental and energy management
- A lot of youngsters will be engaged in the farming.

ROLE OF MOBILE IN AGRICULTURE

- The smart phone become a useful tool in the agriculture sector because of their mobility and the cost of the device is accessible to all users.
- Farmer get assistance from agricultural experts and government extension workers, about market, weather and new crop diseases through Toll free number and help to increase the productivity.
- Many smart phones are equipped with sensors including accelerometer (Acceleration and rotational force), GPS (motion sensor), Light sensor (Photometer), Temperature sensor (Thermometer), gyroscope, barometer (Pressure) and cameras both front and rear facing with high resolution.
- Magri apps are used to find the disease in a leaf based on its colour but it need expert advice for identification of disease in remote laboratories by Pongnumkul*et al.* (2015).

FRONT FOOT FOR AUTONOMUS IN AGRICULTURE - INDIA

***1.* Precision Agriculture**

Precision agriculture involves the adequate and optimum usage of resources based on various parameters governing crop yield.

Wireless sensors have been used in precision agriculture to assist in

(1) spatial data collection,

(2) precision irrigation,

(3) variable-rate technology and

(4) supplying data to farmers.

Remote Sensing, Geographic Information Systems (GIS) and Global Positioning Systems (GPS) may provide technologies needed for farmers to maximize the economic and environmental benefits of precision farming.

Wireless sensor networks and its potential for agricultural applications

Two widely used variants of WSNs

1. Terrestrial Wireless Sensor Networks (TWSN)
2. Wireless Underground Sensor Networks (WUSN).

2.Thermal Imaging

- Thermal remote sensing in agriculture is gaining popularity in the recent years due to reduction in cost of the equipment and simple operational procedure.
- Potential use of thermography in agriculture includes nursery monitoring, irrigation scheduling, soil salinity detection, disease and pathogen detection, yield estimation, maturity evaluation and bruise detection.
- Thermal imaging systems are evaluated based on their thermal sensitivity, scan speed, image resolution and intensity resolution by Ishimwe *et al.* (2014).
- The use of digital infrared thermography and thermometry to investigate early crop water stress.

Disadvantages of Robotics Farming

- It is costlier to implement.
- Complexity is increased.
- Time management and skill full labour is required.
- Roberts run with power but in India power cut in the farming region is more than 65 per cent.

***3*. Timeline – Robotics In India**

Developments related to robotics from the NISTEP 2030 report:

- By 2013-2014 : Agricultural robots
- By 2013-2017 : Robots that care for the elderly
- By 2013-2020 :Nano robot
- By 2015 : To have one third of its fighting capacity provided by robots
- By 2017 : Medical robots performing low-invasive surgery
- By 2017-2019 : Household robots
- By 2035 : To have first completely autonomous robot soldiers on the battlefield

CONCLUSION

The robot for agricultural purpose an Agribot is a concept for the near the performance and cost of the product once optimized. It will reduce the workload on the farmers. This robotic which an be travelled in rough surface and based on weather condition. It improved automatic control of well defined tasks. Automated data gathering. They useful for better processing into real information. As a results, Invite Robots in Agriculture sector.

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