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A Review on Applications of robotics in Agriculture

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Introduction

Over past few decades, the agriculture industry has faced new challenges. Previously, self-sufficiency in food and rural migration to cities were the significant concerns. With the advancement of science, more challenges now threaten this industry. Food security is a global concern. Governments worldwide are facing unprecedented rise in demand for food, human population is growing rapidly, but land and agriculture resources remain the same, and in some cases it's even shrinking. The projected world's population to grow to more than 9.15 billion by 2050 (Kondo *et al*., 1996). Therefore, the challenge for the next decades will be to supply the needs of the expanding world population by developing a highly productive agriculture management, also at the same time preserving the quality of the environment (Rubens *et al*., 2010). Most of the developing countries including India facing agricultural labour shortage problem. A major portion of youths from village migrating to urban for led better life. As a result, agricultural operations gets delayed in the peak seasons due to a labour shortage.

Robotics

Robotics and Autonomous Systems (RAS) are set to transform global industries. These technologies will have greatest impact on large sectors of the economy with relatively low productivity such as Agri-Food (food production from the farm through to and including manufacturing to the retail shelf). Automation of agricultural operations is demand of the time to improve the productivity with the help of tools and technology. In recent years, the development of robotics in agriculture has experienced increased interest. In the field of

agricultural autonomous vehicles, a concept is being developed to investigate if multiple small autonomous machines would be more efficient than traditional large tractors (Blackmore *et al.,* 2004). These vehicles should be capable of working 24 hours a day all year round, in most weather conditions and have the intelligence embedded within them to behave sensibly in a semi-natural environment over long periods of time, unattended, while carrying out a useful task. Moreover, such a system may have less environmental impact if it can reduce over- application of chemicals and high usage of energy, such as diesel and fertiliser, by control that is better matched to stochastic requirements. There are a number of field operations that can be executed by autonomous vehicles, giving more benefits than conventional machines.

The robotics plays a major role in various fields such as industrial, medical, military applications etc. The robotics field are gradually increasing its productivity in agriculture field. Some of the major problems in the Indian agricultural are rising of input costs, availability of skilled labors, lack of water resources and crop monitoring. To overcome these problems, the automation technologies were used in agriculture. The automation in the agriculture could help farmers to reduce their efforts. The robots are being developed for the processes such as fruit picking, monitoring, irrigation, etc. All of these functions have not yet performed using a single robot. In this the robots are developed to concentrate in an efficient manner and also it is expected to perform the operations autonomously. The proposed idea implements the robot to perform the functions such as planting, irrigation, fertilization, monitoring, and harvesting of a crop. These functions can be integrated into a single robot and then performed. The robot is expected to perform the functions such as detection of presence of pests, spraying of pesticides, spraying of fertilizers, etc there by providing safety to the farmers and precision agriculture.

Robotic technology in agriculture

A robot is an automatic device that performs functions normally ascribed to humans or simply a machine in the form of human. It is a machine that senses the environment, processes and responds to the sensor's information with a computer command. They are man-made mechanical devices that can move by themselves and whose motion must be modelled,

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planned, sensed, actuated and controlled by programming. It will perform its task or functions day and night without complaining. Most of the robots have at least five parts viz; sensors, effectors, actuators, controller and common-effectors (arms). Robots never grow tired but can still have a risk of malfunctioning when maintenance is not conducted properly. Agricultural robotics is the logical proliferation of an automation technology into bio-systems such as agriculture, forestry, green house, horticulture (Karthik & Chandra, 2014).

In the future, the number of robotics used in agricultural field is expected to increase considerably as autonomous robots (using solar energy power) is able to work for many hours without pause. (Karthik & Chandra, 2014). A photoelectric and a capacitive sensor were tested for localizing cutting along the row and proved to be suitable to be included in intra-row weeding machine (Assirelli*et al*., 2015)

Flying micro robots are the products of reverse-engineering mechanics of insects which are specially designed to scout battle fields, search for victims trapped in rubble and record images in agricultural fields. A micro robot consists of propeller which has the ability to fly and land precisely on its target, and it is expected to be used in agriculture for the control of insects and weeds.

TYPES OF ROBOTS

a. **Mobile robots**

Mobile robots are able to move and perform a task such as search areas, a prime example is the Mars explorer which is specifically designed to roam the Mars surface, searching in collapse buildings or dangerous areas, mining etc.

b. **Rolling robots**

Rolling robots are robots that can move quickly in searching areas. They have wheels and are usually helpful in flat areas. They are mostly used in excavations and drillings.

c. **Stationary robots**

Stationary robots perform their task without moving an inch. They are commonly used in industries and plant housing.

d. **Autonomous robots**

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Autonomous robots are self-supporting robots that run programs that give them command on to perform an action, learn new behaviours, walk or avoid obstacles.

e. **Remote robots**

Remote robots are simply robots that perform actions under human guidance. However due to limited memory and brain capacity, an autonomous robot cannot perform a complicated task. Such activities are best performed by humans with real-brain power using remotes to control robots.

APPLICATIONS OF ROBOTICS IN AGRICULTURE

Data scouting at different stage of crop growth

Yield in a given field may vary in space depending on a combination of factors such as nutrient availability, soil moisture, rooting depth, pest pressure, weed density, crop maturity and others. Good agricultural practice needs an application of optimum input at appropriate time series. Continue monitoring and data collecting related to crop NDVI, Biomass, Leaf area index, crop growth rate, water stress are an important parameter for optimizing the variable input parameters in different stages of crop growth and also crop health. Crop physical status monitoring would be less expensive and timelier if an automated system could remain within the crop canopy for continual monitoring (Akhila Gollakota and M.B. Srinivas, 2011).Real-time management of inputs like fertilizers, herbicides, at variable rate could be achieved by sensing the different parameters of the crop measured in the field by and processing it for further application part using microprocessor or microcontroller. As the robotic vehicle continuously monitor the crop canopy it is easy to identify crop diseases and pest attack at an early stage in patches or selectively. Also, it can monitor weed density, water stress at a different stage of crop growing periods.

Intercultural operation

Weed competes with the crop for sunlight, space, and nutrients. To control weed species, a large number of herbicides and chemicals are used in agricultural fields, which results in drinking water contaminated and environmental pollution. Currently, the excessive use of herbicides damages the health of people, animal etc. According to the weed science research, about 33% of the total losses by agricultural pests are caused by weeds on (Amruta and Kavita Joshi, 2016).Therefore, it is important to identify the weeds from the crop and

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selectively spray herbicides to optimize the chemical application. There are various techniques developed all over the word for distinguishing weed from the crop. In the conventional weed control system, the herbicide is sprayed uniformly over the field which may damage crop condition. Machine vision systems present a great potential to be used on data collection for precision agriculture, where images would be used to extract information. The autonomous agricultural robot can accomplish intercultural operation using the machine vision-based technique. It can be achieved by mapping the weeds in selectively or in patches by image processing method, in row crop, the patch identification in between the row can help to distinguish the weed. There is specific shape reorganization method are applicable for classifying the weeds by its shape this method is more accurate in weed identification method. Another method is colour segmentation for identifying weeds. Based on all these techniques weed maps is generated. Detecting weeds selectively from a field with the application of proper methods of image segmentation technique and post processing the segmented data finally, optimize the application part of chemicals in the field. Based on the map generated appropriate weeding technique is considered for weeding. There are different operational methods for removing the weeds like mechanical chemical application. Identifying the actual position of the weeds mechanical weeder can be incorporated in removing weeds by partial tillage operation at 2 to4 cm depth. Removing of weeds from between the row is easy as compared to removing weeds from intra-row which required high-speed sensing device and high- speed
mechanisms to push rotary blades or chemical spray for intra row application.

Fertilizer

Crop nutrient is a basic and important component of sunlight, water for its growth and increasing productivity. The rational use of fertilizers and fertilizer technology has as ignificant effect on the development of agricultural (Tilman, 1999). Among the various nutrients, soil nitrogen is one of the important parts of agricultural production, Nitrogen has been perceived as a critical nutrient for productivity of crops but it also has important factors of environmental contamination. A major portion of the input fertilizer is lost by leaching, and contaminates freshwater, marine ecosystems when high rates of N fertilizers are applied to agricultural fields (Tabile*et al*., 2010) There are variations of nutrient in quantity within the

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small area of the field. Traditional measurements of soil nitrogen are very difficult and laboratory method by which nutrient map is generated. Which helps in pre-assessment of the actual requirements of International Conference on Emerging Technologies in Agricultural and Food Engineering27 – 30th December, 2016, Agricultural and Food Engineering Department, IIT Kharagpur 273 fertilizer in the field. That involve in the uniform rate of application of fertilizer over an entire field. This map used as asite-specific management tool that allows the producer to vary the rate of application of crop input across a given area. Variable-rate technology has a potential to optimize the input that further enhance the benefits of operator and maintain soil environmental health. Most of the Variable rate technology are GPS base few are available on control system based on reckoning up track distance for a variable rate fertilizer applicator without GPS. Nitrogen variability in an area is defined by grid area mapped by GPS latitude and longitude. According to a position of pre-defined grid area nitrogen output is fixed in controlling unit. While during the time of final fertilizer application controlling unit have control over the motor rpm which directly responsible for opening are of metering unit or its rpm that is calibrated with the input amount of fertilizer requirement at that particular grid.

Harvesting

Bulk harvesting is the common trend of harvesting in India. This process of harvesting suitable for few selective crops, so fearsome crops like cotton where the maturity of cotton ball achieves at the different time period in a single plant (Reid *et al*., 2001) therefore in this case selective harvesting of a cotton ball is important. Other than the cotton cereal pulses crop are get matured in patches selectively. Harvesting immature crop effects its quality. Therefore, selection of mature crop for harvesting needs certain threshold parameter to define the range of maturity level for defining crop as mature. Selective harvesting needs sensing technology for collecting information of crop which needs to be processed through microprocessor or microcontroller and finally define the status according to which decision support system supply command to the mechanical mechanism to harvest of defined crops. Broadly there is two part of work first is to sense the crop status and according to that harvesting of a selective crop is done which is the second part of this complete process.

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