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A CASE STUDY: A REVIEW ON AGRICULTURE ROBOT

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Abstract: A review is portrayed in agriculture robot technologies. Agriculture robot or "agribot" is used for agriculture purposes. Increasing agriculture requires innovative technologies to increase efficiency and decrease labor. The usage of robots in agriculture increments productivity and reduced the operating costs and time of agriculture. Every field of agriculture can be seen that the usage technology of robots such as plowing, harvesting, and seeding purposes. Many robots are used in agriculture like Demeter, Weed control Robot, Forester robot, and Fruit picking robot, etc. Some great flying robot technology is used in the agriculture field. Drones are an example of a flying robot and are used for spraying pesticides. The recent paper review discusses the progress of robot agriculture in different fields in agriculture. The paper also discusses the future scope of the robot in agriculture in another country.

IndexTerms **– Agribot, Irrigation, Automation, spraying, California-based.**

I. INTRODUCTION

Bangladesh is a major agricultural country. About 87 percent of rural households rely upon agriculture for at least part of their income [1]. Agriculture is the principle of life. Agriculture provides us with food, fodder, and fuel. An agricultural robot, define as an agribot, is a robot designed for use in the agriculture industry. Agribots automate tasks for farmers, boosting the efficiency of production, and reducing the industry's reliance on manual labor [2]. Govt. should be a priority on robotics agriculture because if compared to the other globalization, the usage System of agriculture robots is less. So, it is necessary to make some advancement in this field [3]. Recently, many agricultural tasks have been computerized by several programs and technologies such as robots which are accessible remunerative [4]. This kind of robot is helpful and also user friendly. Nowadays, several industrial applications like material handling, material transfer; processing, inspection & quality control have been used by robots. In recent years, agriculture was most obvious of the idea of mechanization and there are many success stories of usage robotic in the agricultural field. The aim of usage robots in agriculture to improve food quantity and productivity, reduce labor costs and time. The main reason for robotic agriculture is the unavailability of sufficient skilled manpower in the agricultural sector and it affects the growth of developing countries [5]. The usage of the robot in agriculture has lots of purposes. Significant value to farmers is provided by the use of robots in agriculture activities. Now robots are successfully used in agriculture like seeding, Irrigation, harvesting, weed control, grove supervision, and etc. significant value to farmers is provided by the use of robots in agriculture activities. When robots are used in the agriculture field, the robot can collect data from the environment by use censor, and analyzed the data, take decisions based on data, send commands to take action, automatically stop the robot. Agricultural robot sensors play a key role.Recent emerging applications are robots or drones for weed control. Now need to find more new ways to improve efficiency. Agribot has been designed for agricultural purposes [6]. As one of the trends of development on automation and intelligence of agricultural machinery in the 21st century, all kinds of agricultural robots have been researched and developed to implement a number of agricultural production activities in many countries [7]. The advent of "agribot" system in the agriculture field which gives us the scope to develop new agricultural equipment based on simple machines can do the right thing, in the right place, at the right time in the right way. Using robots in agriculture can reduce air pollution and control the environment. Such robotics developments can increase the validity of a task during long periods of work and able to reduce negative impacts on the environment linked to agronomic activities [8]. If using a drone for spraying, it will achieve more accurately, so that it can reduce fertilizer which areas it too much. Furthermore, such automation can improve the farmer's comfort, the vehicles itself is performed as the tracking task [9].

Importance of an agribot

1) To protect from harmful effects chemicals through spraying.
2) To reduce production cost, improve quality produce and less need for manual labor.
3) The agribot do not get tired, it can work to 24 hours nonstop.
4) The agribot rarely make errors and offer high speed to do work.

5) The agbots performs agricultural operations autonomously such as fruit picking, spraying and weed control,soil test, precision and efficiency increase.

2. Advent of robot in agriculture

The first agriculture robot was developed in 1920, with research to incorporate automatic vehicle guidance into agriculture beginning to take shape [10]. This research of agriculture robots led to the advancements between the 1950s and 60s of autonomous agricultural vehicles [10]. Its concept wasn't perfect because still need some capable system to guide their path [10]. Robots in agriculture are continuously developed by technologies as well [10]. It was not until the 1980s, after the development of the computer, that robot guidance became possible [10].

3. Purpose of use robot in agriculture

Many engineers tried to develop the driverless agribot like a tractor in the past but couldn't have successful to develop as they could not able to embrace the complexity of the real world. Most of them make it an industrial style of farming where everything was known and the agribot could work completely in predetermined ways, like a production line. Food is a serious issue. From the worldometers.info source, today's world population is 7.8 billion as of March 2020 [11]. The world population is projected to reach 9.9 billion by 2050, an increase of more than 25% from the current 2020 population of 7.8 billion [12]. In the farming sector day-by-day, manpower is reducing and opportunities in other sector's manpower are increasing rapidly. If it continues like this, No manpower will not get found for farming. The average age of an American farmer is 58 years old. The average organic farmer is 52 years old [13]. But the young generation want to run away from farming. If robots are used in agriculture, we will be able to replace manpower. As mentioned by Automation Society, IEEE Robotics, automation and Robotics can play a significant role in society for meeting 2050 agricultural production needs. Now robots have played a key role in the agriculture field for increasing efficiency and reducing industrial production cost and product. Usage of a robot in the agriculture field it can.

4. Four agribots revolutionizing the farming industry

Now a day usages agribot in the agriculture field are being integrated across the world to assist farmers and improve productivity in every aspect of the industry; here are three of the most innovative robots available right now.

4.1 The soil monitor

A small company that is based in Portsmouth, UK – agribot Tom, lives onsite and monitors crop and soil consistency, digitalizing the production [14]. It can collect data on the plan by plan basis, Keeps an eye on the development of each plant. It's an autonomous robot. When it is out of charge, the robot return to a kennel replaces its battery for a fully charged one. Over the day gigabytes of data are collected and downloaded for analysis. The agriobot actually knows that exactly where a farmer's plants are, whether they are germinated and what they need. The significant task of this robot is it can even suggest what fertilizer and chemicals are needed to maximize crop yields.

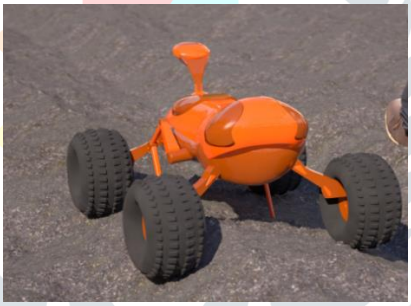

Fig 1: The soil monitor robot

4.2 Demeter

Demeter robot is able to cut crops look like normal harvesters, and can drives by itself without any human supervision. Demeter, our retrofitted New Holland 2550 Speed rover [15]. It has two navigation systems, one camera-based and one based on a GPS (Global Positioning System). There is some reason for the Demeter robot why the use of two separate navigation systems. This navigation system has some advantages, can be used without an a priori map of the area and can double as an obstacle detector, while the GPS system is better at preventing positioning error from accumulating indefinitely. In the future, the navigation systems become more tightly integrated, exploiting the complementary nature of the two will provide a significant increase in the overall robustness of the harvesting operation. In position-based systems are used the post data from the machine controller to guide the machine in the field along planned paths. From a differential GPS, the pose data is fused together, wheel encoder (dead-reckoning), and gyro system sensors. The camera system has three inter-dependent modules: crop line tracker, an end-of-row detector, and an obstacle detector. Tracking the crop line provides the end-of-row detector with information to make the difference between cut and uncut crop. The end-of-row detector then acts to constrain the training of the crop line tracker. In order for the perception modules to correctly function, an image preprocessor detects and corrects for image distortion caused by shadows [15]. Will be urbanized that will permit reapers to totally reap an arena without any manual control.

Fig 2: Demeter robot

4.3 Weed controller

Weeds are agricultural production which is controlled by herbicides. No herbicides can be used in organic farming, weed control is a major problem. There is much equipment used to control the weed between the rows, lots of manual labor are still required to control weed in the rows. This is especially the case for crops that are slowly growing and shallowly sown like sugar beet, carrots, and onions. In 1998, on average 73 hours per hectare, sugar beet was spent on hand weeding in the Netherlands [16]. The navigation system has four functions. *Firstly, the weeding robot should constantly be determined if it is located in- or outside the field*. Secondly, if within the field, it should determine if it is on one of the headlands or not. Thirdly, in case it is not on the headlands, it should navigate along the row and perform the intra-row weeding. Fourthly, if the weeding robot arrives on the headland, it should stop the intra-row weeding and start to navigate to the next crop rows to be weeded [17]. From earlier research [18] it is expected that the quality of detection of this method is at least as good as the quality of detection of other methods. The combination of methods like pattern, color, the shape is expected to have a potential for a higher quality of detection. Just pattern recognition is chosen because it is expected to be sufficient. To determine the weeding robot GPS is used because to see the robot is within the field or not. *In principle, there are three main areas within the crop environment that require different types of treatment: The inter-row area(the space between the crop rows), the intra-row area*(the space between the plants within the row), and the close-to-crop area that is within the leaf and root envelope [19].

Some advantages of usage weeding robot:

The weed control robot can be removed more than 90 percent of the weeds in the row. As a result, the costs per hectare may be at least comparable to the costs of hand weeding. It can be controlled damaged to the crop is as low as possible. The soil pressure under weed always has comparable less than hand weeding. The weed control robot is energy efficient, safe for people, animals, and property. It is limited noise production. The weed control robot has a reliable function anyone can be used easily.

Fig. 3Weed controller robot

4.4 Micro spraying

*Micro spraying takes the concept of a spray boom down to the centimeter 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 be recognized as individual weed plants and locate their leaves for treatment (see weed mapping). Tests were carried out by a human operator to identify and treat individual weed plants that resulted in reducing the application of glyphosate from 720 grams per hectare down to about 1 gram per hectare for an infestation of 100 weeds per square meter and maintain acceptable efficacy [19]. *If this same approach can be carried out by an autonomous micro sprayer then there will be significant economic and environmental advantages*. Within the close-to-crop area, great care must be taken not to damage the crop nor disturb the soil [19].The leading agronomic benefits of micro-irrigation are:

- Uses less water.
- Reduces pest problems.
- Surface crusting is reduced.
- Joint management of irrigation and fertilization.

Fig. 4 Micro spraying

Future of Agribots

FOUR ROLES ROBOTS WILL PLAY IN THE FUTURE OF FARMING

The internet era means anything in our lives can be linked to the Wi-Fi connection and the same applies can be used for farming. For example, Farmers can help conserve water by using a Wi-Fi-enabled moisture sensor for only watering parts of the field that need it most. Cow tags can be linked to GPS to track their vitals remotely. A field and only spray plants that need a boost, saving farmers product and money.

In this agricultural revolution, there are many mind-blowing devices. *Here are just five different types of robotics in development or already hard at work in fields.*

Weed pulling

Prior to the 1900s, in the farmer's world, there would be no weed and weeds were tackled with plowing, or tillage explains Lie hold. Use of the plowing releases carbon dioxide into the air as a result increases soil erosion and requires more fertilizer. Currently, no-till farming, or not disturbing soil through tillage, is gaining popularity, but that means herbicide use is skyrocketing. With increased herbicide use, more weeds become resistant to chemicals[20].

Enter one solution: Farm Wise's massive weed pulling robot. This agri-bot looks more like a Zamboni than farm equipment. The California-based team trained machine-learning cameras using millions of images so that the robot can differentiate between crop and weed. The robot is trained to spot the center of each crop so it doesn't disturb its growth when it goes in to snag a weed [20].

Fig. 5 weed pulling

Vision Robotics – Planting and Seeding

Vision Robotics' technology reportedly integrates algorithms with sensor technology to bring automation to lettuce farming and vineyards. Specifically, computer vision able to generate 3D maps and models of areas of interest and then to complete various tasks within those parameters. For example "thinning" is a farming process where seed can be adequately spaced apart during planting to allow for optimal crop growth. The vision robot is a time-consuming process. "Vision Robotics" is automated and results are shown (Fig. 6 Vision Robotics) in the example image below:

Fig. 6Vision Robotics

Future initiatives appear to include the development of precision weed removal technology using herbicides and the company is actively seeking strategic partners. Vision Robotics has not published an anticipated timeline for this effort[21].

LiDAR for Farm Fields

Small rover-like bots are designed to tackle problems on a variety of terrain, from our living room carpeting to our lawns. Now, they're in farm fields too. Earth Sense'sTerraSentia rover is about the same size as a robotic lawnmower, but souped-up with the machine learning and visual programming of NASA's moon and Mars rovers.

In fact, TerraSentia, developed at the University of Illinois at Urbana-Champaign with support from the U.S. Department of Energy's ARPA-E, uses LiDAR—or light detection and ranging—technology to collect data from a field's hard-to-reach understory. It's a simpler version of the technology that NASA is using on its rovers to study the surface of the moon and Mars and that deep-sea remotely operated vehicles used to study the ocean floor [20].

TerraSentia can "collect data on traits for plant health, physiology, and stress response," from the Earth Sense website. Its creators hope to soon program the bot to measure young plant health, corn ear height, soybean pods, and plant biomass as well as detect and identify diseases and abiotic stresses, according to the site. So far, it's been deployed in corn, soybean, wheat, sorghum, vegetable crops, orchards, and vineyards [20]

Fig. 7 Micro spraying

Drones

"Disruptive technology" that can change agriculture, Lie hold puts drone technology on par with the 1918 invention of the Waterloo Boy tractor, which propelled farming away from the horse-and-plow days of the past. Drones aren't particularly new tech at this point; they've been used commercially since the early 1980s.Drones use in agriculture are not exactly new farming either, having been used to capture aerial photography of fields for years. However, developing new applications for unmanned aerial vehicles has quickly become a pioneering space for agriculture. *Major uses for drones right now include 3D-imaging, map-building, and crop monitoring*. Precision Hawk, headquartered in Raleigh, North Carolina, notes that it can take 11 hours to sample an acre of crops on foot. *They promise, "With their bird's eye view and advanced sensors, a drone can gather data on 500 to 1,000 acres in less than a day[20]".* . In the future, drones could be used for soil analysis, planting, crop spraying, irrigation, and crop health analysis, as MIT Technology Review lists. [20]

Fig. 8 Disruptive technology

Types of Agricultural Robots:

Agricultural robots offer a service which is completely professional and these are the ones with automating the tasks which are found di cult for a human. These robots are used in the farms. These robots are used in several applications and agriculture is one among those applications.

The farmers face a lot of problems while working in the field. Cost is the main thing in order to keep the farmer in the competitive market and for that the cost of operations has to be reduced at a maximum level. Robots are the ones which offer services in a professional way and can automate the tasks which are very difficult manual. These are used in the agricultural lands and they are also completely autonomous.

The agriculture industry faces a lot of problems. Pricing needs to be competitive on a global scale, creating constant pressure to reduce operating costs. Meanwhile. The population has been growing very rapidly, which is pressurizing the farmers for the rise in the yield. In this, agricultural robots will play a major role in supporting the farmer to address all the challenges which he is facing There are several types of robots which are being used in the field of agriculture and there are many new solutions which are getting developed with time. Out of all those, 8 types of agricultural robots have become popular and those are listed below:

Precision Agriculture: Robots used in this field of agriculture are basically used in the farms which are small and even vineyards. These will follow the techniques of precision agriculture. Moreover, they are mostly used to monitor the respiration of soil in an autonomous way, the activities of photosynthesis, and all the biological aspects.

Monitoring the pollution: Few robots in the agricultural field have been equipped for the sake of monitoring the pollution which will be created by the agriculture process mainly at the ground level. These specific robots play an active role in calculating the content of the emission of carbon dioxide and nitrous oxide in order to help the farmers in reducing the footprint of the environment.

Livestock Ranching: A new variety of agricultural robots have been introduced to herd the livestock in huge ranches. These agricultural robots also play an active role in monitoring the animals in the livestock and make sure that the health of the animals is good and there is a sufficient amount of space for them to graze.

Control of weeds: The agricultural robots which have been designed in order to control weeds can perform navigation in the form in an autonomous way and can spray the herbicides on the targeted points in order to avoid or eliminate the weeds. This particular approach will decrease the exposure of crops to herbicides and helps in preventing the growth of weeds which are resistant to herbicides.

Automation of nursery: These agricultural robots come to great help in the nurseries related to crops and these are mainly used to move the plants around the greenhouses which are large. These agricultural robots also give very good efficiencies to the crop nurseries and also help them to address a shortage in the growing labour.

Harvesting of the crop: In order to harvest the crops, there are agricultural robots which specialize in working round the clock for quick harvesting. You can observe that in many of the cases, to complete the same work, it would take approximately 25 to 30 workers. Harvesting of fruits: The agricultural robots at the starting were used to harvest the fruits along with the crops. The harvesting is a bit difficult for agricultural robots. So, new agricultural robots have been designed which are equipped with the system of vision which is advanced so that they can identify the fruits and pick them without causing any damage.

Seeding and planting: This application is the one which has been emerging. The agricultural robots with vision systems which are three dimensional (3D) are now able to plant and seed the crops for good growth. These are also working very accurately. They are mainly used for farming lettuce and also in the vineyards. The agricultural robots are unique in both the functioning and also the form. The agricultural robots are offering great support to the farmers by improving the efficiency of the farm and raising the yield

Applications of Robotics in Agriculture:

The industry of food is revolutionized by the introduction of agricultural robots and automation. Farming is the main source for food and automation in agriculture is increasing the strength of it. In the coming five to six years, the use of agricultural robots and drones are estimated to increase by $30 billion There are many real issues in the agriculture of the present day. The farming methods which are followed traditionally will make it hard to meet the efficiencies which are required by the present trend of the market. The farmers who are part of the countries which are already developed have been suffering.

Nursery Planting: Nurseries are the places where young plants are formed from the seeds which are planted in the outdoors later. The plants in the nursery are mostly sold to the consumers and gardeners directly, but they are also a beginning of the journey of food for few crops. There is a requirement of the automation in a nursery. HETO Agrotechnics and Harvest automation are the companies which are providing solutions for seeding, warehousing the plants which are living in greenhouses, and also potting in an automated way.

Crop Seeding: The plants which give food to start their life as a seed in the agricultural field. For sowing the seeds, the traditional methods are to scatter them by using a broadcast spreader which will be attached to a tractor. This spreader will throw many numbers of seeds all around the field, whereas the tractor helps by driving steadily and following a single path. This traditional method is not considered to be an efficient one as the seeds get wasted. Precision seeding which is done in an autonomous way will help in combining the robotics with geomapping. A map will be generated which gives information about the properties of soil such as the quality of soil, the density of soil, etc. at each and every point of the agricultural field. A tractor with a seeding attachment which is robotic will start placing the seeds at accurate locations and at correct depths so that every seed will get a better chance for growth.

Monitoring the crop and giving analysis:

- It is very difficult to monitor the crops grown in huge fields. Technologies like geo-mapping and new sensor are helping the farmers to get high levels of information about the crops which they are growing. The drones and robots which are at ground level will give a way to get this data in an autonomous way.

- Companies which manufacture drone such as Precision Hawk are offering farmers few with the packages which are a combination of robotic hardware and analysis software. This will help the farmer to take the drone into the agricultural field, start the software through a Smartphone or tablet and get a view of the crop which has been collected in real time.
- Robots which are ground-based, such as BoniRob will provide the farmers will detail observations as they would be able to get very much close to the crops. Some of these agricultural robots can also be used for several other tasks such as fertilization and weeding.

Fertilization and Irrigation:

- Irrigating the crops and fertilizing them will require a lot of water in the traditional method and it is considered to be not that efficient.
- Precision irrigation, which is assisted by the robot will decrease the water, which is wasted by targeting a few particular plants.
- Robots which are ground-based will navigate among the crop rows in an autonomous way and pour the water directly at the base level of every plant.
- The advantage of robots is that they would be able to go into the areas where the other machines of agriculture could not go. To take an example, the growers of corm always face issues as the plants will grow rapidly and they get less time to fertilize them in a reliable way. Robots will help to solve this issue as it drives among the corner rows and provides nitrogen to the plant base of every plant.

Crop Weeding and Spraying:

- It is not efficient to spray pesticides and killers of weed onto the agricultural fields as it will cause harm to the environment. Robots will help in this situation by providing efficient methods.
- Micro-spraying is a method which will mainly decrease the amount of herbicide in the growing of crops. The robots which involve in micro-spraying will make use of the technology of computer vision for the detection of weeds and then start spraying the targeted amount of herbicide onto the crop. AG BOT 11 is an agricultural robot which takes power from solar energy and this robot uses this technology.
- Few of the robots which perform weeding will not use any chemicals. For example, RoboCrop is the one which uses the vision of a computer for the detection of plants as it will be moved by tractor. It will automatically convey water to the spaces in between the plants in order to uproot the weeds.

Thinning and Pruning:

Thinning is a method which involves decreasing plant density in order to give every plant a better chance for growth. Pruning is a method which involves cutting off the plants back parts so that there would be an improvement of growth in them.

The thinning robot which is called as Lettuce Bot is an agricultural robot which makes use of the vision of a computer for the detection of the lettuce plants by driving on them and deciding which one to remove and which one to retain. Pruning is a very tough task and the automation of pruning is done in the industry of the brewery. Wall-Ye is the robot which has been introduced to the wine industry and it has the ability to prune the grape vines. The same company also developed a robot which can prune blueberries too.

Harvesting and Picking:

- Harvesting the crops like corn, wheat and barley are a bit easy. Harvesting can be done by making use of a combine harvester which can be automated. Few more crops like soft fruits are very difficult for harvesting as they need manual skill in performing tasks.
- The project, called Clever robots for crops which have been funded by the EU is the one which is making very good progress on a few applications of harvesting. This harvesting includes apple harvesting, sweet pepper harvesting etc.

Growth of Robotics Through 2025

Boston Consulting Group (BCG) points out that spending on robots worldwide is expected to grow from $15 billion in 2010 to $67 billion in 2025. The $52 billion increase in 15 years is a compounded annual growth rate of 10%. They attribute this growth to a convergence of falling hardware prices, performance improvements, and easier application software combined with increased flexibility and finesse. This results in robots being useful in a much broader set of applications than you might traditionally think of – such as automotive assembly and welding. In fact, there's an interesting graph you should take a look at that splits worldwide spending on robots into four categories: military, industrial, commercial, and personal. In 2015, BCG estimates about $11.0B in spending is for 1.2 million industrial robots, of which 40% (~ $4.4B) are used in automobile factories[22].
The graph shows(Fig. 9) the rise of the robotic market in the coming years [23].

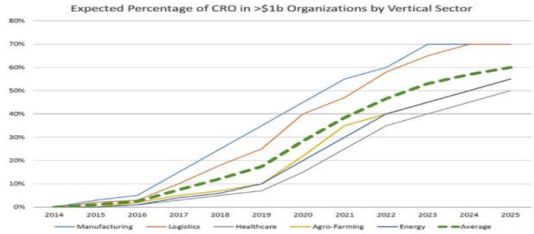

Fig. 9The rise of the robotic market in the coming years

Conclusion:

Usage of agribot in agriculture is immense for productivity enhancement. The machine can sense the higher quality product accurately such as (color, firmness, weight, density, ripeness, size, etc.). By using agribot we can save time, efficiency, manpower, wastage of resources. Agribot works at a much cheaper price. Using agribot we can bring youth into farming. In this review, we have presented the necessity, advantages, applications, and success of using Agribots in agriculture. This paper given brief the usage and outcome of using robots in agriculture. so, we can use Agribots in our country instead of farmers especially in developing countries like India, Paraguay, Albania, Guinea, USA, etc.

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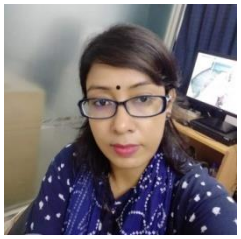

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