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Robotics in Agriculture

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Introduction

The UN predicts that by 2050, there will be 9.9 billion people on the planet, up from 7.7 billion at the moment. The use of natural resources, which are constantly in short supply, wisely while protecting the environment, is the main challenge facing agricultural researchers around the world. Farm mechanisation is one of the key elements in developing the agricultural production system and feeding the growing world population. This has put pressure on inventors around the world to create cutting-edge agricultural equipment and machinery that can perform and comprehend complex agricultural processes and carry out all necessary operations with high levels of precision, efficacy, and environmental protection. For effective farm management, agriculture needs autonomous and time-saving technology. As traditional farm machinery is crop and topological dependent, researchers are now concentrating on various farming operational parameters to design autonomous agricultural vehicles. The primary purposes for which agricultural robots have been studied and created to date are harvesting, chemical spraying, picking fruit, and crop monitoring. Due to their use of unmanned sensing and machinery systems, robots like these can replace human labour in many situations. The primary advantages of developing autonomous and intelligent agricultural robots are to increase repeatable precision, effectiveness, and reliability while minimising soil compaction and labor-intensive tasks. The robots are capable of multitasking, have keen sensory perception, are reliable in their operations, and are adaptable to unusual operating circumstances.

Robot

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.

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Agricultural robotics

Agriculture, forestry, horticulture, and fisheries are all bio systems that use automation in some capacity. By performing the same tasks more effectively, it is taking the place of traditional methods.

Applications

Land preparation and sowing

- **Ploughing (Seed bed preparation):** primary process the top soil is mixed and turned to prepare a seed bed, burying the surface crop residue.
- **Seed mapping**: Using an infrared sensor placed below the seed chute, "seed mapping" records the geospatial position of each seed as it travels underground. Infrared beam is cut by the seed, which also activates a data logger to record the seeder's position and orientation.
- **Reseeding**: This idea refers to the ability to recognise where a seed was not planted and to automatically plant another seed in that location.
- **Seed placement**: Robots can be used to plant seeds in a hexagonal or triangular pattern, with less space between rows, so that they receive the most air, light, and water.

Crop monitoring

An application of the best input at the right time series is necessary for good agricultural practise. Crop NDVI, Biomass, Leaf area index, crop growth rate, and water stress are important parameters for optimising the variable input parameters at various stages of crop growth and also crop health, so it is important to keep monitoring and collecting data on them. Sensing the various crop parameters measured in the field and processing the data for subsequent application using a microprocessor or microcontroller could result in real-time management of inputs like fertilisers and herbicides at variable rates. It is simple to detect crop diseases and pest attacks early on in patches or selectively as the robotic vehicle continuously monitors the crop canopy. Additionally, it can keep track of weed growth and water trees at various stages of crop growth cycles.

Water management

The soil surface stays dry when the root zone is directly watered. Emerging technologies that could help with irrigation scheduling include real-time soil moisture and weather monitors, with the former being done via microwave remote sensing. Rainwater collection, effective irrigation water delivery, and the use of reclaimed water are additional ways to increase the efficiency of agricultural water use. The irrigation system consists of two sections. One component is the irrigation system, and the other is the robot. Temperature and conductivity sensors are part of the irrigation system, and a microcontroller continuously monitors the soil's temperature and moisture content before sending data wirelessly to the base station. The second section is the robot section, which includes a camera and a wireless module that allows us to control the robot in various directions.

Weed management

For nutrients, space, and sunlight, weed competes with the crop. In agricultural fields, a lot of herbicides and chemicals are used to control weed species, which pollutes the environment and contaminates drinking water. The current overuse of herbicides harms human, animal, and environmental health. Weeding tasks can be completed by the autonomous agricultural robot using a machine vision-based method. It can be done by using an image processing technique to map the weeds selectively or in patches. In a row crop, the patch identification in between the rows can help to distinguish the weed. It is possible to classify weeds according to their shape, and this method is more accurate than other weed identification techniques. Colour segmentation is another technique for weed identification. Weed maps are generated using all of these techniques. Using the appropriate image segmentation techniques, weeds can be selectively detected from a field. After the segmented data has been processed, the field's chemical application can then be optimised. A weed-hunting robot with four wheels has been created by the Danish farm research authority. Running a hoe between crop rows makes it possible to weed crops that are grown in rows. Herbicide use is significantly reduced by an intelligent hoe that uses vision systems to recognise the rows of crops and steer itself precisely between them.

Fertilizer management

The producer can alter the rate of crop input application across a specific area by using the map as a site-specific management tool. Variable-rate technology has the potential to optimise the input, further enhancing the operator's benefits and maintaining the health of the surrounding environment. Few control systems for a variable rate fertiliser applicator without GPS are available; the majority of variable rate technology is GPS-based. Grid areas with GPS latitude and longitude coordinates are used to define nitrogen variability in a given area. The

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controlling unit fixes the nitrogen output in accordance with the position of a pre-defined grid area. While the controlling unit has control over the motor rpm that is directly responsible for opening the metering unit's opening area or its rpm that is calibrated with the input amount of fertiliser requirement at that specific grid during the final fertiliser application. They'll be able to get to places that other machines can't. Application of fertiliser will be challenging for plants with rapid growth. Plant fertiliser applied directly at the base of each plant will be driven between the rows with ease by robots.

Harvesting

Sensing technology is required for selective harvesting in order to gather crop information that must then be processed through a microprocessor or microcontroller in order to define the status according to which the decision support system issues instructions to the mechanical mechanism to harvest the specified crops. In general, there are two parts to the work: the first is to sense the crop's status, and the second is to harvest a specific crop in accordance with that. Real-time data sensing and processing, as well as feeding the processed data map to the robotic vehicle harvesting, are both possible with agricultural robots. With the aid of an agri-robot, such precise monitoring and harvesting could help to reduce the burden of the labour shortage and rising labour costs while also preserving the quality of the harvested food.

Types of robots used in agriculture

- **Demeter- Robot farmer:** Demeter is a robot that can cut crops; it resembles a typical harvester but has the ability to operate on its own and without human oversight. Demeter is equipped with cameras that can distinguish between crop that has been cut and crop that hasn't. The Demeter robot can be operated remotely as well. Demeter can also be taught a path and use its onboard sensors and computer control systems to follow that path.
- **Treebots:** They are made up of a wireless internet link, a sensor, and a webcam. They used to keep an eye on forest environmental change and comprehend how the atmosphere and forest environment interacted.
- **Forester robot:** This particular kind of robot is utilised for harvesting, tending to trees, pruning them, and cutting up wood. It uses specialised axes and jaws to cut the branch.

- **Fruit picking robot:** Ripe fruit must be selected by the fruit-picking robots without harming the tree's leaves or branches. All parts of the tree that are being harvested must be accessible to robots. Utilizing video image capture, it can tell fruit from leaves. The camera is fixed to the robot arm, and the colours seen are compared to memory-stored characteristics. The fruit is chosen if a match is made.

Summary

Agricultural robotics represents a transformative leap in modern farming, addressing critical challenges such as labor shortages, resource optimization, and environmental sustainability. By integrating advanced technologies like sensors, machine vision, and automation, robots enhance precision and efficiency across all stages of agriculture—from land preparation to harvesting. These innovations not only increase productivity and reduce waste but also promote eco-friendly practices by minimizing chemical usage and optimizing resource management. As these technologies continue to evolve, agricultural robotics will play an integral role in shaping a more sustainable and efficient future for global agriculture.