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Robotics in Horticulture

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A robot is an automated device that mimics human functions, or a machine in human form. A machine perceives the environment, processes sensor data, and replies with computer commands. Labour is a significant cost in horticulture, accounting for roughly 50% of production costs for fruit. Therefore, intensive horticultural crops demand specialized labour compared to broad-scale agriculture. Effective use of robots in horticulture is essential. Horticulture uses several sorts of robots, including Demeter for weed control, fruit picking robots, drones, forester robots, robot suits, and Vitirover solar robots. Robots are utilized in horticulture for various tasks such as weeding, crop scouting, micro spraying, irrigation, selective harvesting, sorting, and packing, as well as in parks, golf courts, and polyhouses.

Need of Robotics in Horticulture

- ❖ Labour is a major cost in horticulture. Hiring contributes to over 50% of fruit production expenditures. Intensive horticulture crops demand more skilled labour than broad-scale agriculture.
- ❖ Land mechanization.
- ❖ Reduce crop losses by harvesting at the appropriate time.
- ❖ Skill and availability when needed.
- ❖ Cost of labour
- ❖ Labour experience and skill level are frequently unavailable.
- ❖ Sensor-equipped machines are objective and allow for regular product monitoring.
- ❖ Similar level of output quality

Types of Robots Used in Horticulture

1. Demeter: Demeter is a self-driving robot that can cut crops and resembles a traditional harvester. It is equipped with cameras capable of detecting difference between trimmed and uncut crops. This information guides the machine's movements, including where to drive, where to position the cutter head, and when to turn around at the end of a crop row.

2. Weed controller: The four-wheel drive weed-seeking robot removes and destroys weeds. Crops growing in rows can be weeded by moving a hoe between them. Intelligent hoes use vision systems to identify crop rows and properly drive between them, eliminating the need for herbicides.
3. Fruit picking robot: The robots must avoid injuring the tree's branches and foliage while picking fruits. Robots must have access to all parts of the tree being harvested. The robot can distinguish between fruits and foliage through video image capture. The camera on the robot arm detects colours and compares them to stored attributes in memory. If a match is found, the fruit is harvested. To see hidden fruit, use an air jet to sweep leaves away. The pressure exerted to the fruit removes it from the tree but does not cause it to crash. The gripper form varies with the type of fruit being plucked.
4. Drones: A drone is a flying robot. To acquire a bird's-eye view of the landscape. Provides a quick and easy approach to monitor crop progress and identify areas for replanting or herbicide applications.
5. Forester robot: This robot is specialized for cutting, trimming, and harvesting wood in woods.
   It uses unique jaws and axes to chop the branches.
6. Robo suit: This is specifically designed for tasks such as pulling radishes.
   The suit features eight motors installed on the shoulders, elbows, back, and knees to deliver power to the wearer.
7. Vitirover solar robot: It is a smart, self-sufficient robot. This robot relies on the sun to power its electrical motors. Due to the size of the vineyards, storing energy in a battery and returning to the base for recharging was not practical. With a solar panel, this robot can work for 100 hours continuously.

Use of robotics systems in horticultural crops

Robotic Applications in Agriculture for Sowing and Planting

- The use of planting robots in agriculture represents a shift in farming operations, providing solutions for a variety of crops and planting demands. These automated systems are not confined to a particular type of agriculture, but rather cover a wide range of fields.
- Planting robots may be designed to handle fragile crops like tomatoes, lettuce, and strawberries with the precision needed for optimal growth.

Types of Planting Robots

1. Autonomous tractor robots: Seeding robots are basically driverless tractors fitted with modern navigation systems. They can conduct a variety of tasks, including planting, with accuracy and efficiency.
2. Drone planters: Drones are increasingly being employed for planting, particularly in remote places. They can disseminate seeds over a wide region, making them excellent for reforestation and large-scale grain production.
3. Robotic arm planters: Planting robots, which include robotic arms, are ideal for delicate operations like transplanting seedlings. They are especially beneficial in smaller industries, such as nurseries and greenhouses.
4. Swarm robot planters: These involve a group of miniature robots working together to plant seeds.

They are extremely useful for wide fields since they can cover large areas fast and with consistent accuracy.

5. Specialized planting robots: Seeding robots, which are tailored to certain crops or conditions, can drill holes for seeds, deposit them at precise depths, handle crops with special requirements, and even cover them with dirt. They are commonly employed in specialised crop cultivation, such as orchards or vineyards, and may contain extra functions like as harvesting or weeding.

Pruning Manipulators

Pruning involves removing tiny branches from trees and plants to maintain structure, boost productivity, and reduce disease risk. To prune a branch, a robotic manipulator needs sufficient degrees of freedom (DoF) and an end-effector that can cut the branch. Pruning manipulators were tested in two scenarios: grapevines and apple trees. These manipulators demonstrated that a light-controlled environment can eliminate visual mistakes and prismatic joints can provide a longer reach.

Fig. A Robot System for Pruning Grape Vines

Fig. A Robot System for apple pruning

Harvesting Manipulators

Harvesting manipulators, like pruning manipulators, require sufficient reach and depth of field to reach the target in the correct orientation. Additionally, the end-effector must be able to catch the target fruit without injuring it. Harvesting manipulators were employed for five products: strawberries, tomatoes, apples, sweet peppers, and iceberg lettuce. Harvesting manipulators require varied kinematic configurations for different end-effectors. Some require simply horizontal movement, while others demand more mobility to reach and grab the target.

Fig. Strawberry-Harvesting Robots

Fig. Tomato Harvesting Robots

- Robotic Apple Harvesters
- Robotic Harvesting System for Iceberg Lettuce
- Multipurpose Harvesting Agricultural Robot

Need of Automation and Robotics in Greenhouse Management

- Manufacturing facilities are becoming larger.
- Plant treatment and crop specialisation adapted to each individual.
- The labour cost is rising.
- Skilled worker shortages are becoming a big issue.

- ❖ There are health issues.
- ❖ Product purity and food safety.
- ❖ Market competition exists at both domestic and international levels.

Greenhouse farming promises higher yields and better produce quality by creating a regulated and optimized cultivation environment. This is where robotic technology comes in, supplementing human labour by automating important activities. Robotic systems can be used for operations including as sowing, watering, trimming, harvesting, and more, taking over repetitive and labor-intensive tasks from human personnel. Robotics plays a pivotal role in modern greenhouse farming, revolutionizing the way we cultivate crops. These are:

1. Automating Critical Tasks: Greenhouse farming offers higher yields and better produce quality due to the regulated atmosphere. However, handling many operations efficiently within the greenhouse might be difficult. Here's where robotic technology comes in. Robots do repetitive and labor-intensive operations like sowing, watering, pruning, and harvesting. They use sensors and AI to closely monitor plant health and environmental factors, modifying operations for optimal growth.
2. Precise Harvesting: Automated robotic arms gently select ripe vegetables, increasing harvest productivity. For example, robots with stereoscopic cameras and AI can detect ripe tomatoes and pluck them without damaging the crop. This precision ensures a high-quality yield.
3. Vertical Farming: Robots allow greenhouses to maximize their regulated space by collaborating with people. They enable greater use of vertical farming techniques, reducing resource consumption while ensuring sustainable and high-volume plant production.
4. Robotic Pollination: Pollination is required for certain crops to set fruit. Robotic pollinators have proven to be as effective, if not more so, than manual pollination. These robots optimize fruit production in greenhouses focusing on pollination-dependent crops.
5. Data-Driven Insights: Sensor-equipped robots closely monitor the health of individual plants, collecting real-time data on colour, size, leaf temperature, and moisture stress. This granular data enables new commercial opportunities based on advanced analytics and predictive modelling. Sophisticated yield forecasting models help improve production scheduling, supply contracts, storage, and logistics.

Hence, robots in greenhouses not only increases productivity and efficiency, but also paves the way for long-term, high-quality crop growth.

Conclusion

Agriculture robots can cut cultivation costs by regulating labour and making optimal use of fertilizers and pesticides. Agriculture occupations are time-consuming, risky, and need intellect and quick decision-making, thus robots can be a good substitute for human operators. The use of robots reduces farmer workload and allows field operations to be completed on time. This technique produces higher-quality crops and is best suited for future farming.

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