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Current Scenario of Robotics in Greenhouse Cultivation and Future Challenges

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Introduction

Robots have recently attracted a lot of attention. A robot, in our perceptions, is a machine that looks and acts like a human. Robots are man-made mechanical devices that can move independently, whose motion can be analysed, designed, monitored, operated and regulated and whose motion behaviour can be altered by "programming."Protected cultivation techniques are installed as a powerful tool to grow crops all over the world. They protect crops from pests and unfavourable external climatic conditions and also manipulate the micro climate for optimum crop growth and output in terms of both quality and quantity. Protected cultivation is a high-cost intensive production methodology that enables production of high-value fruit and vegetable crops such as tomatoes, sweet peppers and cucumbers, as well as flowers such as roses, chrysanthemums and gerberas and a variety of potted plants.

This type of production system has encountered with several challenges like increasing size of production facilities, increasing labour costs, increasing problems with the availability of sufficient skilled labour, increasing health problems among employees due to heavy and repetitive tasks and growing competition on national and international markets in recent decades in western societies. Automation and robots are the key solution to these problems. Further more, rising concerns about food safety necessitate the use of such technology. Additionally, precision horticulture systems, in which plants are treated on an individual basis, are growing more popular since they allow for increased quantity and quality of food output while conserving resources. Considering the prevailing shortages of human labour, the clamour for automation and robotics has grown even louder.

The production procedures that used to be done for high value crops and flowers in greenhouse horticulture are still usually performed manually. Growers put a lot of effort into operations such as crop sensing, crop care and product harvesting. Harvesting these high-value items necessitates a great deal of human intelligence, including accurate, effective and efficient eye-hand synchronisation in a complicated environment, quality, ripeness judgements, cautious handling and stabilization of a variety of sensitive products. Nowadays, machines have been introduced into greenhouse cultivation utilising mechatronics and robotics concepts. Integrated smart mechanical design with smart sensors and the "artificial intelligence" required for these challenging activities.

Need for Automation and Robotics in Greenhouse Technology

a. Manufacturing facilities are growing larger.

b. Plant treatment and crop specialization customized to the individual.

c. The labour cost is increasing.

d. Skilled labour shortages are becoming a major concern.

e. There are health concerns.

f. Product quality and food safety.

g. Market competition on domestic as well as international levels.

The Art of Greenhouse Mechanization in Present Era

Commercial solutions exist for the practices which usually running in greenhouse cultivation system such as seeding, cutting, grafting, transplanting transporting, sorting, packaging and cleaning of crop production, according to several studies. They are automated systems that are mostly dependent on mechanical engineering solutions, are inflexible to changes in working circumstances, have a small number of sensors and have little 'intelligence.' The reason is simple that the mentioned activities do not require specific attention. Plant Maintenance Operations (PMOs) like Stacking, Sticking support sticks or knotting wires, Side shoot removal, plant thinning, Fruit/flower thinning, Leaf picking, Crop protection/spraying, Harvesting (single/ multiple) are more sophisticated than the preceding operations. They need specialised treatment at the level of entire plants or plant sections. As a result, the effectiveness of PMOs is heavily reliant on human talents like as intellect, decision-making, adaptation and learning, as well as excellent coordination. It is hard to believe that there are few commercial alternatives for supporting human labour at those stages of the production cycle. These task need high-tech solutions that include superior manipulation and grasping devices, a wide range of sensors, advanced computer hardware and intelligent software capable of dealing with a changing and unstructured environment quickly and effectively. These issues are the major factor for driving limelight in the concept of agricultural robotics research during the last three decades.

Recent advancement in the field of Agricultural Robotics and principle of Mechatronics

A Strawberry Harvesting Robot

The strawberry market in Japan is significant, comparable to those of tomatoes, cucumbers and mandarin oranges. The high labour intensity for harvesting, along with high economic return of this commodity, explains very well the long tradition of research into robotic strawberry harvesting. Three CCD cameras are carried by the robot. The scene is illuminated with a square led array. The fruits are detected and located using stereo vision from two cameras. The end-effector is placed in front of the fruit once it has been spotted. The present prototype has a picking efficiency of 6.3 seconds and a 52.6 percent success rate.

A Cucumber Harvesting Robot

Work on a cucumber harvester is under trial at Ehime University in Japan. The machine is made up of a mobile platform that runs on the greenhouse's hot water heating pipes. In this concept, two fascinating elements leap out. To begin with, the cucumbers are grown on an angled trellis system that extends forward toward the robot. This results in fruits that hang freely from the crop, making them easily visible and accessible. Second, instead of employing camera technology to identify and locate the fruits, the robots utilise laser range sensors and ultra sound sensors in this growing system.The fruits are detected using a scanning motion of the manipulator.

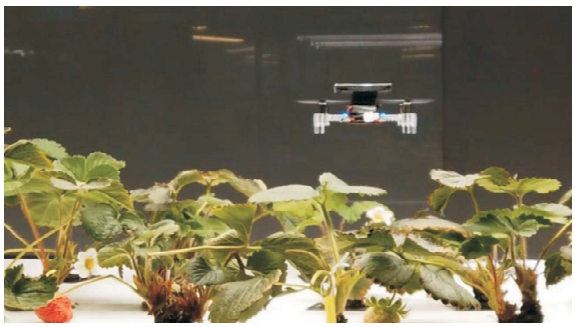
A Sweet Pepper Harvester

"Sweeper" is the example of recent advancements in agricultural robotics. It is the first completely automated sweet pepper harvesting platform in the world. It's a fruit harvesting assembly made up of an autonomous mobile platform with an end-effector and a capturing device. The Sweeper project's ultimate objective is to bring the first functioning sweet pepper harvesting robot to the market.The Sweeper examines plants with the camera system positioned on the end-effector, scanning slightly upwards for ripe fruits. It has a success rate of 49% in harvesting ripe fruits with modified crop, and only 20% with the commercial (current greenhouse growing) system. The average time to harvest one fruit with SWEEPER is 15 seconds.

Polybee: A Revolutionary Drone in Protected Cultivation

Polybee is an autonomous drone which has been designed as a pollination tool that works in both indoor and greenhouse environments for strawberries, peppers, tomatoes and egg plants. Bumblebees are commonly used to remove pollen from anthers and onto the stigma in these self-pollinating crops. Polybee employs aerodynamically controlled pollination to remove pollen, whereas bumblebees pollinate by landing on the bloom (as indicated by small "bruises" on the blossoms). This also helps in crop registration applications, which allow producers to check crop status and growth metrics, in addition to delivering autonomous and constant pollination.

Harvey: A working robot for container crops



In greenhouses and on huge nursery farms, Harvey robots distribute and collect container-grown plants. Harvey robots have

moved over three million plants since their inception and more farmers have embraced them since then. It is a very effective tool in greenhouse cultivation for reducing the labour cost.

Robot makes the greenhouse cultivation more automated

Technical Challenges in Robotics

Although greenhouse technology offers a more regulated environment than outdoor agricultural production, the unstructured crop environment creates several technological obstacles for robotics implementation.

Design and Operation of Robotic Systems

The robot must be endowed with sophisticated sensing, planning and action skills to accomplish rapid and reliable operation in the complex and dynamic greenhouse environment. The identification and categorization of things, as well as the assessment of their condition (readiness or maturity of fruits and flowers) and the positioning of objects in the 3D environment, all need sensing. To deal with the significant variability and occlusions, sophisticated algorithms are necessary. To decide on activities and adapt to changing environmental and agricultural conditions and requirements, intelligent planning is essential.

Modifying the Working Environment

Optimizing the work environment to best match the robot is a standard approach before introducing an industrial robotic into a new production setting. A distinct farming technology, the high-wire cultivation system, was used for the cucumber harvester created in Wageningen, the Netherlands. This growing approach made fruits more visible and accessible than in a traditional cucumber farming system allowing for autonomous picking with a high success rate.

Contextual Challenges

Market Size

First and foremost, from the standpoint of enterprise management, the robots must fit into the production system. Second, the market for robot systems in protected agriculture is fragmented, i.e., a wide range of goods are grown, all of which appear to require various levels of automation.

Robots and Enterprise Management

Robotics, mechanization and enterprise management are inextricably linked. To commence with, the demands of the technology to be developed are dictated by corporate management and the relevant business case. Second, and alternatively, the technology should be integrated into the enterprise's process flow, product flow and utilization of human and equipment assets.

Conclusion

It can conclude that the reason behind the slow progress of robotics and automation in the field of agriculture is due to unpredictability in the working environment of the robot, as a result of biological variability and the typical structure of the developing systems utilized. To minimize unpredictability the operation should be simplify, progress in the field of greenhouse robotics will rely not only on robot technological advancements, but also on crucial innovations in growing systems and plant breeding.

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