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Review Article

Robots for Harvesting Fruit and Vegetables

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Abstract
Selective harvesting, labor cost reduction, optimal harvest scheduling, and increased operational efficiency can all be achieved with robotic harvesting. Robotic harvester users can optimize production efficiency and revenues using these features. For fifty years, there has been a notion to harvest fruits and vegetables using machinery. Many prototypes have been created by researchers working together throughout the globe.

Keywords: Robots, Harvesting, Fruits, Vegetables, Production, Profit.

Introduction

Fruits an essential food for human life and an important economic crop [20]. Automation in agriculture is a technological advancement that can assist fulfill the growing demand for more food production of higher quality and productivity while using less resources [1], [14]. In an effort to save labor expenses, humans have long sought mechanization in crop management and harvesting [13]. When a crop reaches its mature stage, harvesting normally takes place. However, harvesting a huge yield quickly is challenging, labor-intensive, and time-consuming. The creation and application of mechanical systems capable of finishing the harvesting processes is a solution to these issues. Among these systems are mechanized fruit harvesters, which use a traditional electro-hydraulic control mechanism to shake fruit trees and nuts to encourage mature fruit or nuts to fall from the trees. With a shaker head that can reach in the direction of the tree to be harvested, these harvesters usually need to be driven to a spot close to the tree. The shaker head has motor [16] that drives the shaking action and moveable jaws [9–12, 15, 17] with pads that clamp the tree [2]. The next step toward sophisticated, automated automation will involve integrating artificial intelligence to improve farming's robustness, precision, and selectivity. This is particularly true when it comes to harvesting high-value crops like capsicums, which need to be harvested several times in a growing season. In addition to saving a great deal of effort, harvesting tasks can be automated to handle fruit gently [3]. One of the main challenges to the development of intelligent automated crop management systems is the unsatisfactory performance of computer-sensing technology. Computer-assisted vision has been used to localize objects for decades, and its successful implementation in numerous industries has been demonstrated [4]. But the use of these technologies in agriculture is still relatively new [5, 6]. This is because creating the massive amounts of comprehensive, annotated agricultural data needed to create these automated crop management systems is both challenging and impractical [4].

For contemporary agriculture, autonomous robotic harvesting is an intriguing but difficult technique. Several subsystems, such as crop identification, motion planning, and deft manipulation, must be integrated in order to develop such systems [7]. The end effector is a crucial component of any robotic fruit picking system. The robot touches and interacts with the crop using its end effector. As a result, the crop's handling and detachment depend heavily on its design [3].

Figure 1: Fruits and Vegetables Harvesting Robots Arm

RELATED WORKS

The automated fruit harvesting systems for sweet pepper, tomato, apple, and kiwifruit are reviewed in this article as an illustration of how intelligent autonomous harvesting robots in horticulture have advanced recently [8]. An overview of the use of machine vision in fruit and vegetable picking robot localization and recognition is given in this article. First, the benefits, drawbacks, and functions of various machine vision algorithms and visual sensors—such as monocular, stereo, structured light, multispectral, and multispectral cameras—as well as image segmentation, object detection, and three-dimensional reconstruction algorithms—are discussed in relation to the identification and positioning of fruit and vegetable picking robots. The state of machine vision as it stands now and the difficulties it faces in identifying and locating robots that pick fruits and vegetables are then briefly discussed. Some of these challenges are the following: picking uncertainty brought on by complex working environments; recognition stability under varying lighting conditions for the same crop; recognition and localization relying on previous information in the presence of fruit overlap and occlusions from leaves and branches; and fast recognition stability under complex background interference. Good results have been obtained in the current research on algorithms handling different types of occlusion disturbances and complex background interference. Fruit and vegetable recognition and placement are significantly affected by different lighting conditions, with a minimum accuracy of 59.2%. This essay concludes by outlining potential future research avenues to tackle these issues [18]. The quality, speed, and efficiency of fruit and vegetable harvesting robots are closely correlated with the accuracy, speed, and resilience of object identification and recognition. This paper presents and evaluates some typical approaches in order to investigate the state of development of object detection and recognition strategies for fruit and vegetable harvesting robots based on digital image processing and conventional machine learning. This essay also illustrates the difficulties of the present and possible advancements in the future. The goal of this work is to serve as a reference for next studies on item identification and recognition methods based on traditional machine learning and digital image processing for fruit and vegetable harvesting robots [19]. To ensure that readers have a thorough understanding of harvesting robots and their concepts, this paper provides a brief introduction to the construction and functioning of harvesting robots. After that, the research findings on harvesting robots conducted both domestically and internationally are methodically compiled, and the development of the field is thoroughly examined from three angles: the quick and precise identification and placement of target fruits, the consequences of robot harvesting, and the use of harvesting path planning in robot harvesting. The results show that improving harvesting efficiency is the focus and hot spot of harvesting robot research. With the impetus of information technology, how to achieve fast and accurate recognition of multiple environments and multi-information outcomes, obtain reasonable path planning, and further optimize control strategies are all important research directions [22]. This research examines the present state of support technologies for autonomous mapping in agriculture using ground mobile robots. In contrast to other studies, we outline cutting-edge methods and tools for gathering data from agricultural settings for mapping and monitoring in particular, as well as navigation. Analyzed include cutting-edge platforms and sensors, contemporary localization methods, navigation and path planning strategies, and the future applications of artificial intelligence for autonomous mapping in agriculture. The results of this review show that a large number of contemporary mobile robots are capable of autonomous mapping and full navigation. A large amount of funding is presently being allocated to this field of study in an effort to enhance mobile robot capabilities in this difficult and demanding domain [23]. In order to close the widening gap between the need to feed a population that is expanding quickly and the scarcity of labor, intelligent robots for fruit harvesting have been actively developed during the past few decades. It is still early to tell if harvesting robots will be used extensively in orchards, despite notable advances in this field. This work evaluates the state-of-the-art of intelligent fruit harvesting robots by comparing various system architectures, visual perception approaches, fruit detachment methods, and system performances in order to identify the obstacles and suggest future research and development objectives. The potential reasons behind the inadequate performance of existing harvesting robots are analyzed and a novel map of challenges and potential research directions is created, considering both environmental factors and user requirements [24].

IMPACTS OF THE FRUIT AND VEGETABLE HARVESTING ROBOTS

1. Harvesting

Fruits and vegetables are among the crops that harvesting robots are intended to harvest. When the crops are ready to be picked, they employ sensors and cameras to determine this. Robotic arms or other instruments are then used to delicately harvest the crops without causing any damage to the produce. Robots with six axes are frequently in charge of picking. Because they are immobile robots, they are frequently used in pairs with mobile units. This device may be a robotic transport unit (RTU) or a mobile robot. Choosing the right end-effector is critical for an efficient harvesting process. It's best to use grippers best suited for the produce. For example, more delicate fruits and vegetables might require a soft gripper or suction cup. Most robot manufacturers can recommend the best gripper for the application.

2. Weeding

These machines clear fields of weeds without the need for human effort. Robots designed to eradicate weeds from the ground employ precision tools after identifying the plants using image recognition technology. Numerous robots have been developed with weeding purposes in mind. These machines scuttle across the produce in search of weeds. When it spots a weed, it stretches an arm to pluck, smother, or spray it. It is possible to combine articulated and mobile robots to perform jobs like weed control. They don't require human effort because they can find and eliminate weeds on their own while navigating across fields. These robots can also be used by farmers for other duties like planting, harvesting in certain situations, and soil analysis. We should anticipate seeing even more creative uses of mobile robots in the agriculture sector as this technology develops and big data becomes more popular. Use big data analytics, for instance, to determine the best times and locations for weeds to appear and adjust your strategy accordingly. Together with greater productivity, this combination will eventually result in farming methods that are more effective and sustainable.

3. Seeding and Planting

Crop planting is intended to be automated by these robots. Planting and seeding are laborious, repetitive jobs that are ideal for robotics. With the aid of GPS and other technology, these robots plant seeds in the ground precisely, giving each seed the right amount of depth and spacing. These jobs are usually performed by autonomous tractors and purpose-built mobile robots, particularly in large-scale farming operations. Mobile robots and articulated arms can be used in smaller-scale enterprises.

4. Fertilizing

In agricultural applications, the usage of robots for fertilization is growing. Spreading fertilizer across entire fields is a common practice in traditional fertilization systems, which can result in uneven distribution and waste. Conversely, robots that apply fertilizer can do it directly to the soil or plants, cutting down on waste and guaranteeing that every plant gets the proper amount of nutrients. With the help of sensors and mapping technology, these robots are able to navigate across fields and apply fertilizer precisely where it is needed. While some robots utilize liquid fertilizer that is sprayed directly onto the plants, others employ pneumatic devices to discharge fertilizer pellets into the soil. Farmers may promote more sustainable farming methods, boost yields, and save money by utilizing robots to apply fertilizer. Furthermore, these autonomously operating robots have the ability to work continuously, which can be very helpful during the hectic planting or harvesting seasons [21].

CONCLUSION

Robots that harvest fruits and vegetables have been the subject of extensive study. We have evaluated a number of articles about robots that pick fruits and vegetables in this study. We have also witnessed its effects.

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