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Applications of Robotics and UAVs in Orchards for Fruit Picking †

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Abstract: Due to the intense seasonality, high labor intensity, and high cost, picking fruit and vegetables typically requires a significant amount of personnel, material resources, and time. The fruit and vegetable picking is a critical role in the agricultural production chain. At the same time, the world is facing the challenge of an aging population. As a result, the requirements of current agricultural output cannot be addressed by using the traditional ways of picking. The robots picking have been widely utilized in the domains of fruit and vegetable production due to increases in labor productivity, picking efficiency, cost, and other aspects related to the industry. Therefore, the structural characteristics and target recognition methods for the end-effectors of picking robots will be thoroughly summarized. This study will ensure that the future direction of structural development and recognition methods that are matched with fruit and vegetable picking are more visible.

Keywords: robotics; smart farming; horticulture; UAV; fruit picking

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1. Introduction

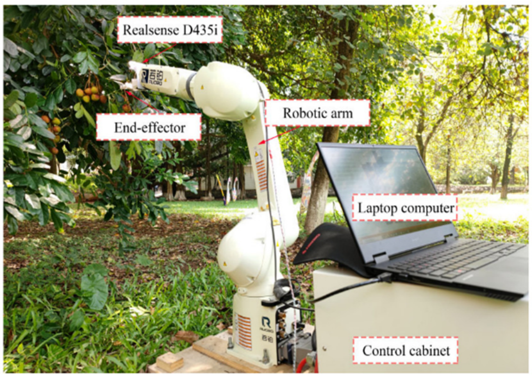
The rapid growth of the world population is the increasing challenge to achieve sustainable agriculture management as long as the human population continues to grow. It is anticipated that throughout the next few decades, the human population would increase by forty percent, reaching 9.7 billion by the year 2050. Because of this, it will be necessary to double the amount of fruit production leading to enhance the agriculture land multiple times. Despite this, it is anticipated that employment in the agricultural sector would fall by one-half by the year 2050, which will result in a shortfall of five million labor farmers. As a result, almost 10% of the world's fruit cannot be harvested, an amount that is equivalent to the yearly consumption of the European Union [1].

The harvest is a seasonal, low-paid, repetitive, and labor-intensive occupation with limited employment prospects. Older farmers are retiring, and their young ones have no interest in replacing them. Labor deficits cause harvest delays, and fruit harvested with a delay of few days degrades in quality and may lose as much as 80% of its market worth. Therefore, worldwide growers lose an estimated USD 30 billion per year in potential sales from non-harvestable fruits [2]. Consequently, crop management has evolved dramatically during the past few decades. Specifically, ground and aerial robots have been implemented in agriculture, indicating their ability to meet the rising food demand by automating previously laborious agricultural processes, such as harvesting [3]. Therefore, robotic systems have been developed to compensate the human shortage, to raise the pace of harvesting, and to enhance the efficiency.

In conventional manual harvesting, the laborers use their hands to remove leaves and branches, hold the fruit, and extract it from the plant by pulling it away, occasionally with the use of a cutting instrument. Manual harvesting requires experience; an untrained farmer may unwittingly cause damage to the plants. However, the kinematics of the human hands and body, sense of touch, and muscular power endow people with innate grabbing ability and a high degree of rapid adaptation to various crop shapes and textures for delivering the appropriate detachment force. However, human abilities are limited only by fatigue. A robotic system, on the other hand, can harvest constantly, precisely, and tirelessly with regularity. Therefore, researchers attempt to imitate human harvesting techniques, resulting in kinematic models for the movement of robotic arms and the building of sophisticated end effectors with the requisite sensors for crop manipulation [4]. In addition, recent changes in dietary needs and the production of biofuels on croplands have contributed to the existing strain on the world's food supply [5].

2. Use of Robot Picking in Agriculture

Agriculture is an issue of big data without big data. Nearly half of conventional agricultural inputs (fertilizers, insecticides, fungicides, herbicides, etc.) are often wasted because they are applied in excess or in the incorrect location (between rows rather than on plants themselves). In the future, commercial farms may be operated by robots that can detect, spray, and harvest specific pieces of fruit, even when their objectives are grapes, peppers, and apples that are the same color as the surrounding leaves as shown in Figure 1 [6]. For many crops, harvesting is the most labor-intensive task, but even proponents acknowledge that no machine has been constructed that comes close to matching human sensory motor control [7]. Robots could potentially provide a timely supply of labor in many locations where there are insufficient temporary workers available during the harvesting cycle.



(**a**)

(**b**)

Figure 1. *Cont.*

(**c**) (**d**)

Figure 1. The use of robot in agriculture (**a**) Robot picking the Lichi [8]; (**b**) the testing of robot picking in a lab [9]; (**c**) robot picking the eggplant [10]; (**d**) proposed prototype for cotton picking [11].

3. Use of Drones for Fruit Picking

Agricultural robotic systems consist of an autonomous mobile platform, a light multi-degree-of-freedom mechanical arm, a force feedback system with a flexible end effector, a multi-sensor machine vision system, a drive control system, an intelligent decision system, and supplementary software and hardware. The arm of the drone has been programmed to grasp the desired object. A position is assigned to the drone, which is watched by the controller (human) via the camera attached to the drone. Once the location of the drone has been established according to the controller's instructions, the drone's speed is slowed, and the end effector opens and grips the desired object using suction cups attached to the effector's inner lining. This procedure is repeated until the controller obtains the desired object through a number of trials. The working environment of a fruit harvesting drone's visual components is quite complex. The object items vary in size, form, type, and surface roughness. Background and sunlight of the vegetation continuously alters. Vision-based harvesting robots must be able to sense and adapt to diverse crop varieties or environmental changes, gather information, detect targets, and train autonomously. Additionally, the robots should be capable of sophisticated reasoning and decision-making. It is a clever machine for human–computer interaction. Additionally, the robotic system should have a network transmission feature for transferring cropped photographs to a data center or server.

4. Conclusions

Today, technology is essential in every sector of society's growth, from construction to transportation to aerospace to communications to defense. Even time-honored industries such as farming need technology (in this case, smart farming) to increase output while decreasing labor requirements. However, smart farming necessitates substantial outlays of capital, enhanced coverage and connectivity, and more bandwidth to process the massive amounts of data generated by a huge number of remotely installed sensors and devices. The first steps toward a robotic future in horticulture and precision agriculture are the creation of a vision and the prediction of possible outcomes. Predicting the rate at which farmers and businesses will embrace new technologies requires a clear vision of the future, some thought about whether or not that future is desirable, and some research into historical data. Understanding what is being predicted and how these predictions offer for democratic interaction with the farmers who are meant to participate in technology transitions is becoming increasingly important. In this study, we adopt the assemblage approach to emphasize the importance of recognizing the intricate material entanglements within which anticipatory assembly occurs in order to include farmers as active actors in technology transitions.

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