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Dependence of Angular Displacement of Rotating Parts of Agricultural Robots on Product Color

Almardon Mustafoqulov*, Mashrab Abdullayev, Baxtbek Usnatdinov , Najmiddin Makhkamov

"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan.
Urgench state university, Urgench city, Uzbekistan.
"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan.
"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan.

ABSTRACT: This article provides information about the intellectual sensor that separates tomato products by color and its software. By running these three programs, it is possible to control the angular displacements of the rotating mechanisms of agricultural robotic manipulators.

I.INTRODUCTION

Improving the efficiency of fruit and vegetable production, reducing the demand for manual labor ensures a high-yielding food product and its competitiveness. Despite the progress made in the field of agricultural robotics, 1 million tons of fruits and vegetables are picked by hand in open fields and greenhouses every year in our republic. Heavy and repetitive work in the fields and greenhouses during harvesting causes a sharp increase in skilled labor and, in turn, a sharp increase in costs. The robotic harvesting process needs to be simplified and the yield maximized to offset the additional automation costs. Otherwise, the plant branches become densely packed with fruit, making it difficult for the autonomous robot to identify, separate and harvest the fruit at the same time. According to data, 1.9 million tons of sweet pepper are produced annually in European countries. According to estimates, the automated robot takes an average of 6 seconds to harvest each sweet pepper fruit [1, 2, 3, 4,5, 6].

II. MATERIALS AND METHODS

Current technologies are only 33% successful and the average time to harvest each fruit is 94 seconds. Therefore, it is necessary to develop automated harvesting robots to avoid labor shortages and harvest crops on time, and this is one of the alternative methods. Fully automated robotic harvesters can help solve today's major challenges, such as overtime, labor shortages, and food safety and quality. It also provides regular information on the condition of the plants. In Dutch greenhouses, researchers have started using robots to harvest cucumbers and sweet peppers in order to prevent various diseases and reduce human labor during the manual picking process. Then, the functional model of the robot, which cleans hanging cucumber leaves with the help of special wires, was tested in field conditions. Test results showed that the defoliation robot took an average of 140 seconds to remove two leaves from a plant, which is 35 times longer than manually picking leaves from each plant [7, 8].

Types of robotic manipulators

Industrial robots: Industrial robots are robots used in industrial production environments. These are usually articulated arms specifically designed for applications such as welding, material handling, painting, and more. If we are only assessing demand, this category includes some automated guided vehicles and other robots.

*Corresponding author: mustafoali777@gmail.com

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Figure 1. Industrial robot

Agricultural robots: Processing of agricultural crops, harvesting, determining the condition of crops, etc. designed to perform such tasks. Nowadays, it is one of the most widespread industries.

Figure 2. Agricultural robot

Medical robots: Medical robots are robots used in medical and healthcare facilities. First of all, there are surgical robots. Also, some automated guided vehicles and possibly lifting aids.

Figure 3. Medical robot

Home robots: Home robots are robots used in the home. These types of robots include completely different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, cleaners, and other robots that can perform various tasks. Additionally, some surveillance and telepresence robots can be considered home robots if used in this environment.

Figure 4. Home robot

Military robots: War robots are robots used in the military. These types of robots include bomb disposal robots, various transport robots, and reconnaissance drones. Often, robots designed for military purposes can be used in law enforcement, search and rescue, and other related fields.

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Figure 5. Military robot

Toy robots: Recreational robots are robots that are used for entertainment. This is a very broad category. It starts with toy robots like a robosapien or a working alarm clock and ends with real heavyweights like robotic arms used as motion simulators.

Figure 6. Toy robot

Space robots: We would like to highlight space robots as a special type. This type includes robots used on the International Space Station, the Canadarm used on the Shuttle, as well as rovers and other robots used in space.

Figure 7. Toy robot

Service robots: Service robots are robots that are not used by other types. These can be various robots for data collection, robots created for technology demonstration, robots used for research, etc.

Figure 8. Service robot

Above, we considered the fields of use of robots, and there are many problems that need to be solved in agricultural robots, as in all robots. We focus on the field of agricultural robots.

There are some challenges that need to be addressed when designing a fully robotic harvester. The simultaneous analysis of crop detection and environmental location, algorithms of actions to be performed, and the detection and collection of various plants in dense conditions of branches and leaves pose several challenges. The function performed by a harvesting robot can be divided into three main sections: sensing (i.e. identifying the fruit), planning (i.e. coordinating the arm according to the perception of the eye) and movement (i.e. fruit grasping mechanism).

Early development of harvesting robots dates back to the 1980s, and Japan, the Netherlands, and the United States are considered leaders in this field. The first studies were conducted using simple monochrome cameras to detect fruits under umbrellas. Later, multifunctional integrated sensors for fruit detection, recognition and tracking appeared. Advances in sensing and imaging technology have led to the use of sophisticated devices such as infrared, thermal, and hyperspectral cameras. In addition to their ultrasonic sensing elements, visible light RGB (red, green, blue) cameras are widely used for object detection due to their low cost.

A decrease in the efficiency of small-power electric motors used in agricultural robot-manipulators and a sharp increase in electrical energy consumption are caused by uncontrolled angular displacements of their rotating mechanisms

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(AMBS). Therefore, improving the technical means of its measurement and control is one of the important issues. When measuring AMBS of agricultural robot-manipulators, step motors are mainly used, and we analyze the problems caused by not controlling their angular displacement.

The high income in a modern farm directly depends on the number of workers. Harvesting the ready-made crop also requires a large number of workers, but instead of these workers, the use of robotic manipulators is useful in the implementation of continuous work. Agricultural robots have reduced the US agricultural workforce by 2%. Josh Lessing has been working to overcome this problem since he founded the agricultural robotics project Root AI in 2018. This company has now developed a robot called "Robot AI Virgo", which can now detect whether tomatoes are ripe or not and is designed to selectively harvest ripe tomatoes. This defect is found in all robotic manipulators. As in all robotics, there are big problems in controlling the angular displacement of the rotating mechanisms of agricultural robotic manipulators [12, 13, 14, 21, 22, 23, 24, 25, 26, 27, 28].

III. RESULTS AND DISCUSSIONS

The software of the sensor that can recognize the tomato product based on its color was developed, and a special DGU was received from the Intellectual Property Agency of the Republic of Uzbekistan for this program[11].

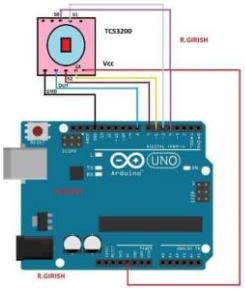

Figure 9. Connection diagram of color separation sensor to Arduino (TCS3200).

After developing a perfect sensor that separates tomato products by color, we will be able to control the angular movements of the rotating parts of agricultural robotic manipulators [9, 10, 15, 16, 17, 18, 19, 20].

Sensors for monitoring the angular displacement of rotating bodies work according to the following structure.

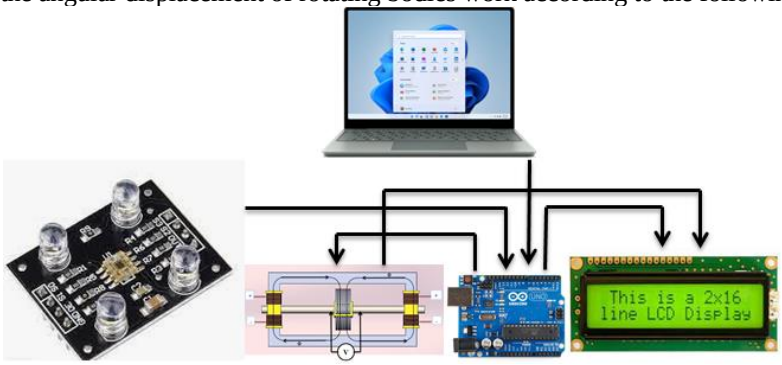

Figure 10. Structural scheme of the angular displacement measuring sensor.

An analog signal is received from the angular displacement sensor made of a ferromagnetic disk and transmitted to the Arduino board. The Arduino board converts the analog signal into a digital signal and displays it on the LCD screen. All this is done through special codes written in the C++ programming language written on a personal computer and inserted into the Arduino board.

The following figures show the experimental results for a program that recognizes red and green fruits. As we can see, the light value and graphics are changing as the colors change. And based on these results, we will be able to control the angle of rotation of the rotating parts of the agricultural robotic manipulators.

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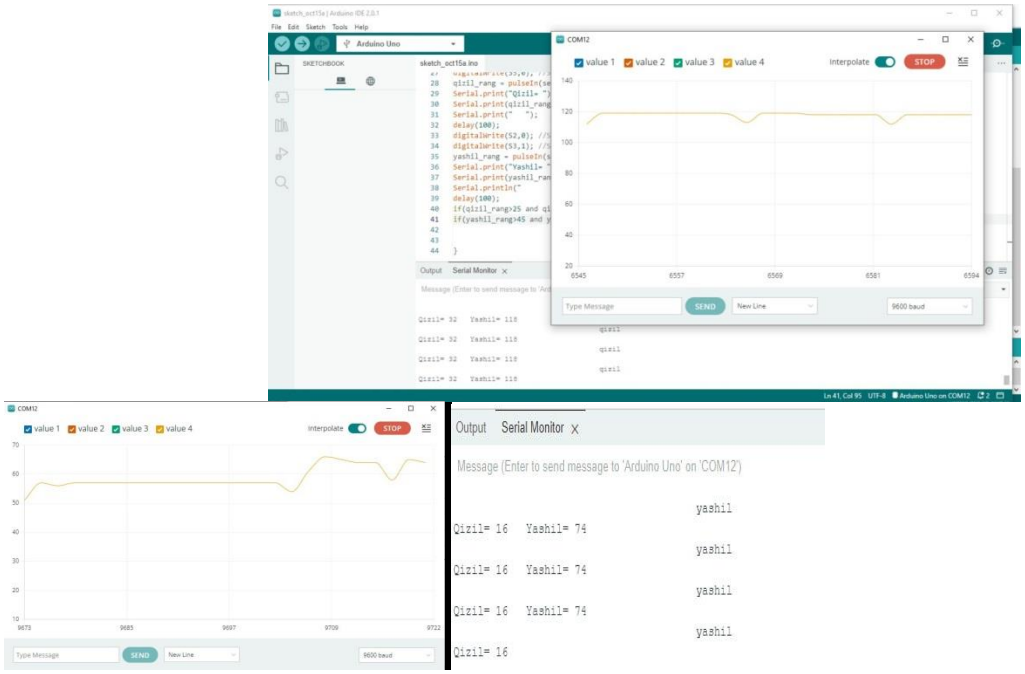

Figure 11. Sensing description of the sensor in different colors.

CONCLUSION

In conclusion, the development of devices that separate tomato products by color has a positive effect on its quality. In addition, it allows to control the angular displacement of the rotary mechanisms of agricultural robot-manipulators. This, in turn, serves to save time and especially electricity.

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