Literature review.

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Introduction

Automation is necessary in every part of the modern world. Automation in greenhouses is not an exclusion. Research in this area continues and various methods were implemented in ordinary greenhouses to solve problems with lack of workers and productivity. Methods of automation consist internet of things and robots for harvesting with computer vision. In this literature review some types of robots for greenhouse applications will be shown.

Related work

Different types of harvesting robots were introduced by many scholars in recent years to solve the lack of robot productivity compared to humans in greenhouse.

In recent years scientific researchers continue work on rail-based robots [1]-[4]. Placing the robot on the rails allows to increase the accuracy and speed of its work as the rails remove the irregularities of the ground in the greenhouse. At the same time, the placement of rails requires additional costs of money and free space between the planting areas. Also, the distance between the rails must comply with the requirements of the robot and fit between rows of plants.

Grimstad in [1] and Arad in [2] suggested using heating pipes for plants in the greenhouse as rails. This leads to a reduction in the cost of implementing the robot on the farm, but also leads to faster wear of pipes that are not designed to withstand the weight of the robot. Proposed by Grimstad and Arad harvesting robots They also have the ability to ride off the rails, but only on a flat surface. The need for this is caused by that the heating pipes are not a single circuit, but are connected to the main pipe in parallel.

The use of the monorail proposed by the authors in [3] as in previous solutions, it leads to cheaper placement of the robot in the greenhouse in compare with double rails. Heravi used a 0.06 m wide monorail, which can be placed without restrictions on the distance between planting areas. Among the weaknesses, the authors report difficulties in balancing the robot's center of gravity.

Recent work has shown large robot for mushroom harvesting in greenhouse [4]. Mobile platform with length of 7.7 m cover two planting areas at once. Robot frame moves along three rails located between the rows at the same time. This can be considered as three monorails from [3]. The authors have developed a robot for moving only forward and backward, so it is quite possible that there will be problems with moving the robot to other rails or with turning. Among the advantages of this design, it is stability and the ability to work simultaneously with two planting areas.

Another important section in the task of developing a greenhouse robot is computer vision (CV) systems. All reviewed

Authors in [5] use an Otsu algorithm to process a gray image and recognize of ripe tomatoes. CV system uses binocular vision to operate the algorithm and calculate the length. Authors report that recognition success rate of tomatoes is 99.3%. The algorithm gives great accuracy but cannot detect and classify unripe fruits.

Afonso introduced another solution of CV with MaskRCNN algorithm in [6]. Neural network with ResNet structure trained on dataset of ripe and unripe tomatoes have metrics around 80%. The authors think that this algorithm can be improved and supplemented with the classification of not only ripe and unripe fruits but also pedicels and stems.

Another system was implemented by the Department of Engineering, University of Cambridge [7]. Localization and Classification datasets was used to train YOLOv3 and Darknet Classifier structures. This system gives to authors the coordinates of the object in the image and immediately classifies it to Harvest-Ready, Immature and Infected classes. The accuracy of finding the coordinates of this system is 91% with 100% classification task accuracy on tests in the field. This system is more demanding on computing resources, which can significantly affect the price, but at the same time gives good results on metrics.

In summary, both sections: robot design and CV are necessary for the successful operation of the robot. The stability and smoothness of the robot's movements helps the CV to detect objects faster and more accurately. Each system has pros and cons. Further study of the topic is required to select the most suitable system.

References

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