**Machine Vision for an Elderberry Robotic Harvester**

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**Abstract:**

The growth rate and the market size for American Elderberry is increasing day by day. This growth, however, is being restrained by the inefficient current solution of manual labor harvesting. With no other solution available for this industry, our goal is to develop a robotic harvesting solution where it will solve the efficiency, expensiveness, and insufficient labor problems that come from manual harvesting. The first step in developing our robotic harvester was to build a camera system in which the robot will perceive its surroundings to detect, classify its ripeness, and localize elderberry clusters. We used the Intel RealSense D345i depth camera for this system due to its ability to capture RGB information as well as recognize the 3D location of objects. In order to have a robust system that can perform the specific perception tasks, it was necessary to create a large dataset of elderberries which we successfully did with an in-lab-built data collection system. With our custom dataset, we chose YOLOv7 machine learning model to perform object detection on elderberry clusters. Detection results are promising with just 104 labeled images used for training, returning an mAP metrics of 84% and object validation loss of 2.7%. These results showcase the high possibility and great potential for developing a robust robotic harvester for elderberry, which will eliminate the harvesting struggles currently faced by the industry and enhance the growth of the American Elderberry market.

Abstract:

The market and demand for American elderberries are increasing dramatically in recent years. This growth, however, is being restrained by the inefficient current solution of manual labor harvesting. Our goal is to develop a robotic harvesting solution that will be selective and efficient in the harvesting process. In this project, we focused on developing a machine vision system based on a depth camera and artificial intelligence. The function of the machine vision system is expected to detect, classify, and localize ripped elderberry clusters, and send this information to the actuation of robotic arms. In this preliminary study, the depth camera was used to manually collect imagery data in both laboratory and field conditions. A total of 2000 images were collected at 3 varieties, fields, and growth stages. Meanwhile, color stand for ripeness color reference was used in 100 images where the maturity level was manually accessed, and 15 manual 3D coordinate measurements were collected at the field plus 216 measurements collected in the lab. To recognize fruit clusters, we chose the state-of-the-art YOLOv7 deep learning model due to its record speed and accuracy in object detection. Randomly selected images were labeled using labelImg software. All the labeled images were divided into 70:10:20 for training, testing, and validation respectively. Results showed that, with just 104 labeled images used for training, validation, and testing, returned an mAP metrics of 84% and object validation loss of 2.7%. These results showcase the high possibility and great potential for developing a robust robotic harvester for elderberry. We will continue our work by finishing the design of the camera system, testing classification models to accurately judge cluster ripeness levels, and extracting the 3D coordinates of the detected clusters.