Awards issued prior to January 20, 2025, were funded under previous Administrations and may not reflect the priorities and policies of the current Administration.

United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1031001

Project Title

Vision-Guided Flexible Robots for Harvesting the Interior of Tree Crops

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** COMPLETE
Funding Source NIFA Non Formula	**Grant Year** 2023
Grant No. 2023-67021-40629	**Cumulative Award Amt.** $300,000.00
Proposal No. 2022-11471	**Multistate No.** (N/A)
Project Start Date Sep 01, 2023	**Project End Date** Aug 31, 2026
Program Code [A1521] Agricultural Engineering	

Project Director

Sheng, J.

Recipient Organization

REGENTS OF THE UNIVERSITY OF CALIFORNIA AT RIVERSIDE

200 UNIVERSTY OFC BUILDING

RIVERSIDE, CALIFORNIA 925210001

Performing Department

(N/A)

Non Technical Summary

This project is motivated by an urgent need for an autonomous system to enable more sustainable agricultural production. Agricultural production is heavily labor-intensive; yet, the increase of labor costs, impact of COVID-19 pandemic, and decrease of next generation's interest in farm labor are making it increasingly difficult to find sufficient labor. Hence, automation techniques are sought to perform agricultural tasks in a timely manner. However, most progress in agricultural automation took place in relatively simple zones that are close to the ground and harvesting tree crops remains the biggest challenge due to large and unstructured canopies and rough terrains. Robotic technologies are promising to address this challenge due to their adaptability. However, their harvesting efficiency is controversial due to the inability to harvest inside the canopy.In this seed project, we will focus on 1) developing a novel soft continuum robot that can navigate in cluttered environments, integrated with a harvesting end effector, 2) developing a vision system with an array of on-board cameras that can detect crops inside the canopy, and 3)

evaluating the performance of the robot system by harvesting mandarin oranges in the lab setting and then on real trees in the orchard. Through the methods mentioned above, this seed project will generate convincing preliminary data to address the feasibility of robotically harvesting the Interior of Tree Crops and support our long-term objective of autonomous robotic harvesting in collaboration with traditional robots that are efficient to harvest surface crops. The project will benefit profitability and sustainability of the tree crop industry by mitigating labor shortage, automating harvesting, and preserving the integrity of tree canopies, and ultimately enhance the quality of life for farmers and society.

Animal Health Component

Animal Health Component: 0%

Research Effort Categories

Basic	0%
Applied	50%
Developmental	50%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
501	0699	2020	100%

Knowledge Area

[501] New and Improved Food Processing Technologies

Subject Of Investigation

[0699] Trees, forests, and forest products, general

Field Of Science

[2020] Engineering

Keywords

Harvesting, 3D Reconstruction, Agricultural Robot, Flexible Robot, Multi-Camera System, Tree Crops

Goals / Objectives

The goal of this project is to address the technical hurdle on how to harvest crops inside the tree canopywith the following three objectives: 1) Design and develop a novel flexible robot with cameras and necessary harvesting accessories, 2) Design and develop computer vision models to detect and localize harvesting targets and obstacles, and 3) Assess our to be developed technologies in engineered and real-life harvesting environments.

Project Methods

A novel robot design will be implemented systematically, and a new robot navigation system will be created by applying cutting-edge computer vision and machine intelligence. We will expand our preliminary work and develop a

robot equipped with harvesting accessories, a mobile platform, and cameras. The robot will be designed to consist of multiple telescopic cable-driven continuum structures. Unlike traditional agricultural robots, this new robot design will enable follow-the-leader navigation in unstructured environments. Deep learning methods will be used to reconstruct 3D canopy structures and identify and track branches and fruits using camera images. We will first use the cameras on the side and bottom of the tree canopy to capture multiple images along a fixed trajectory, which we will use to recover the initial 3D structure of the tree canopy. We will then continuously update the internal canopy structure using images captured by the cameras mounted on the manipulator and detect major branches and fruits. After testing the proposed technologies in the lab setting to verify the functionality of each module, we will evaluate the potential of the integrated system for avocado trees with moderate-size canopies using UCR Agricultural Operations facilities and measure the detection rate, cycle time, and damage rate of robotic harvesting.