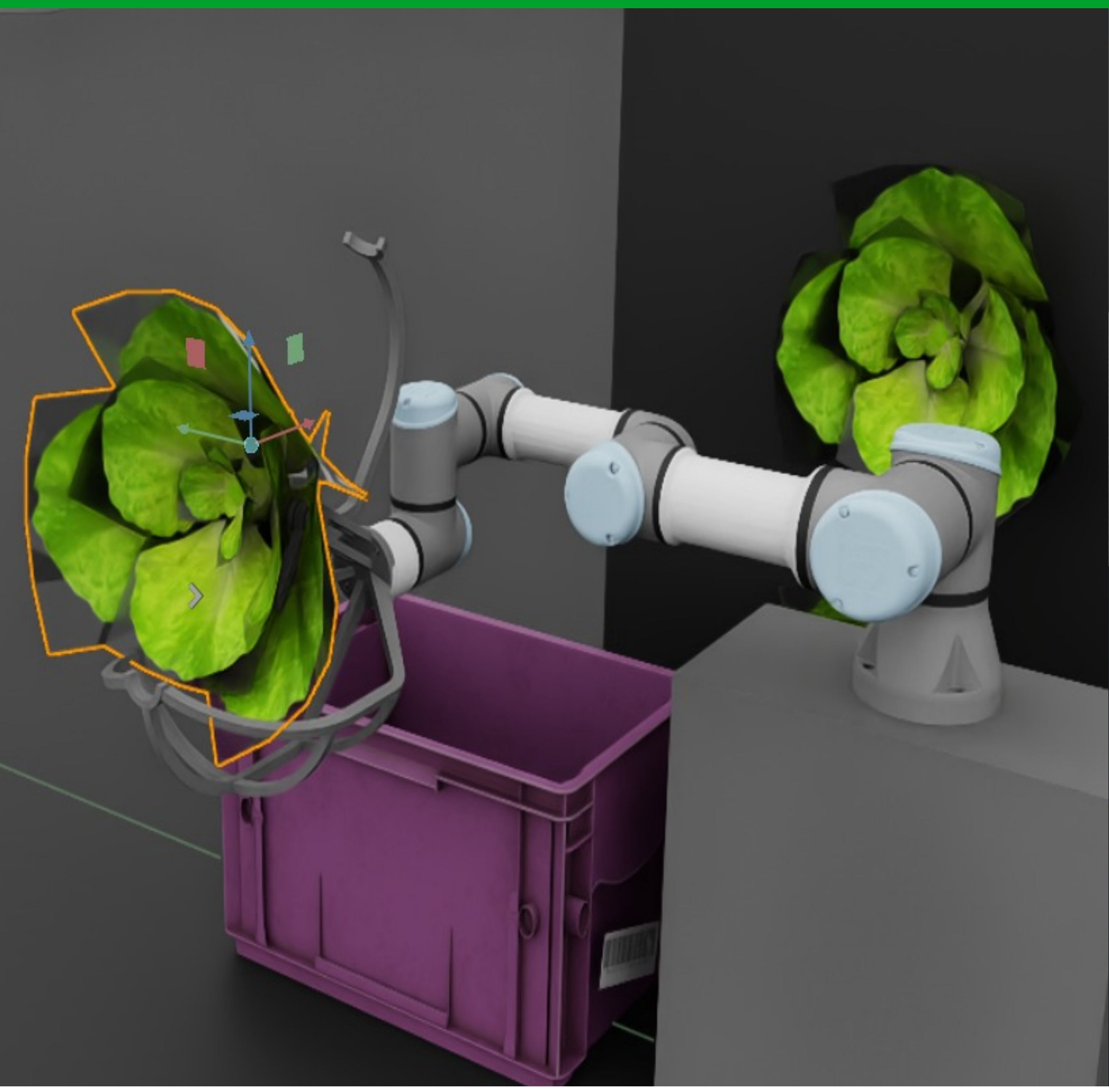
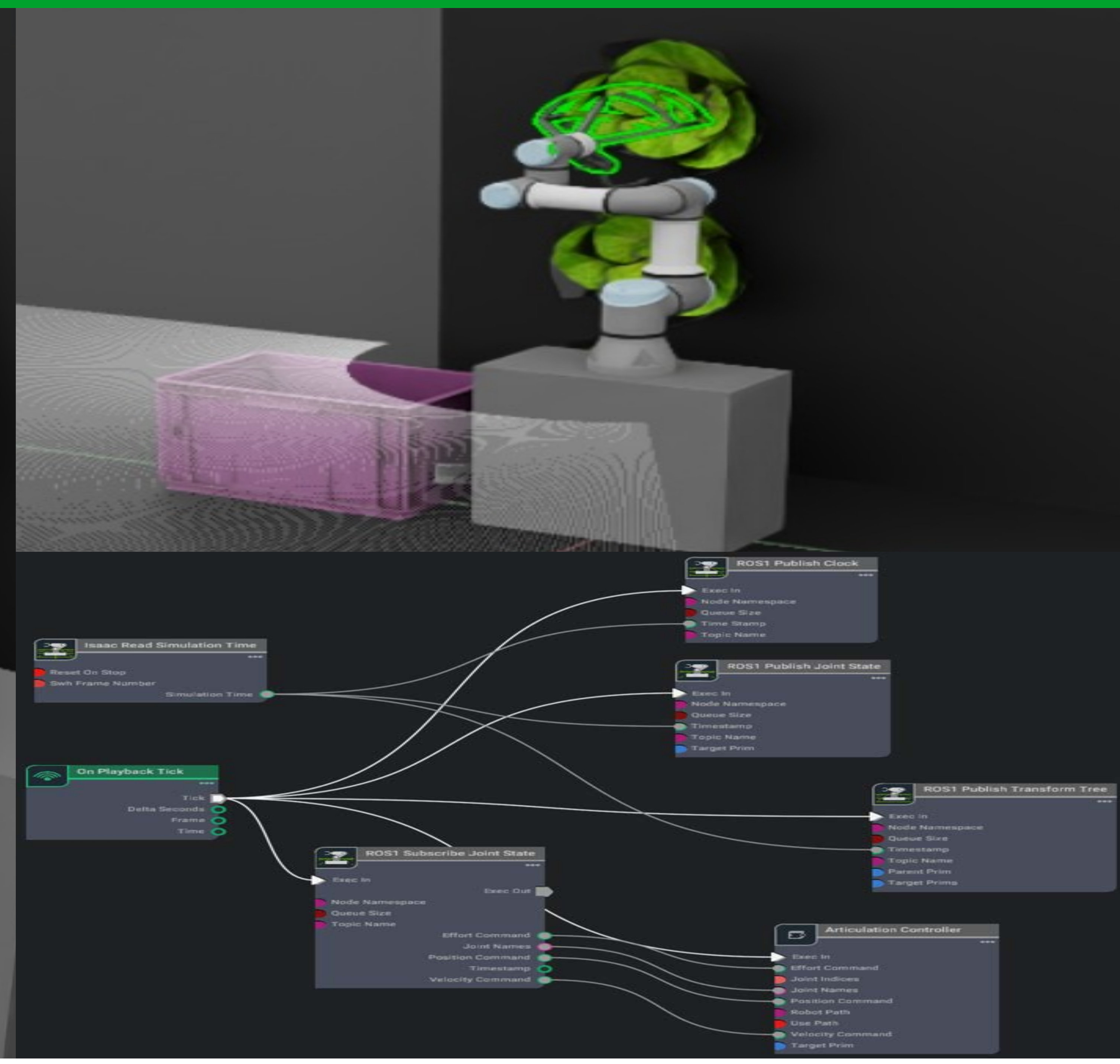
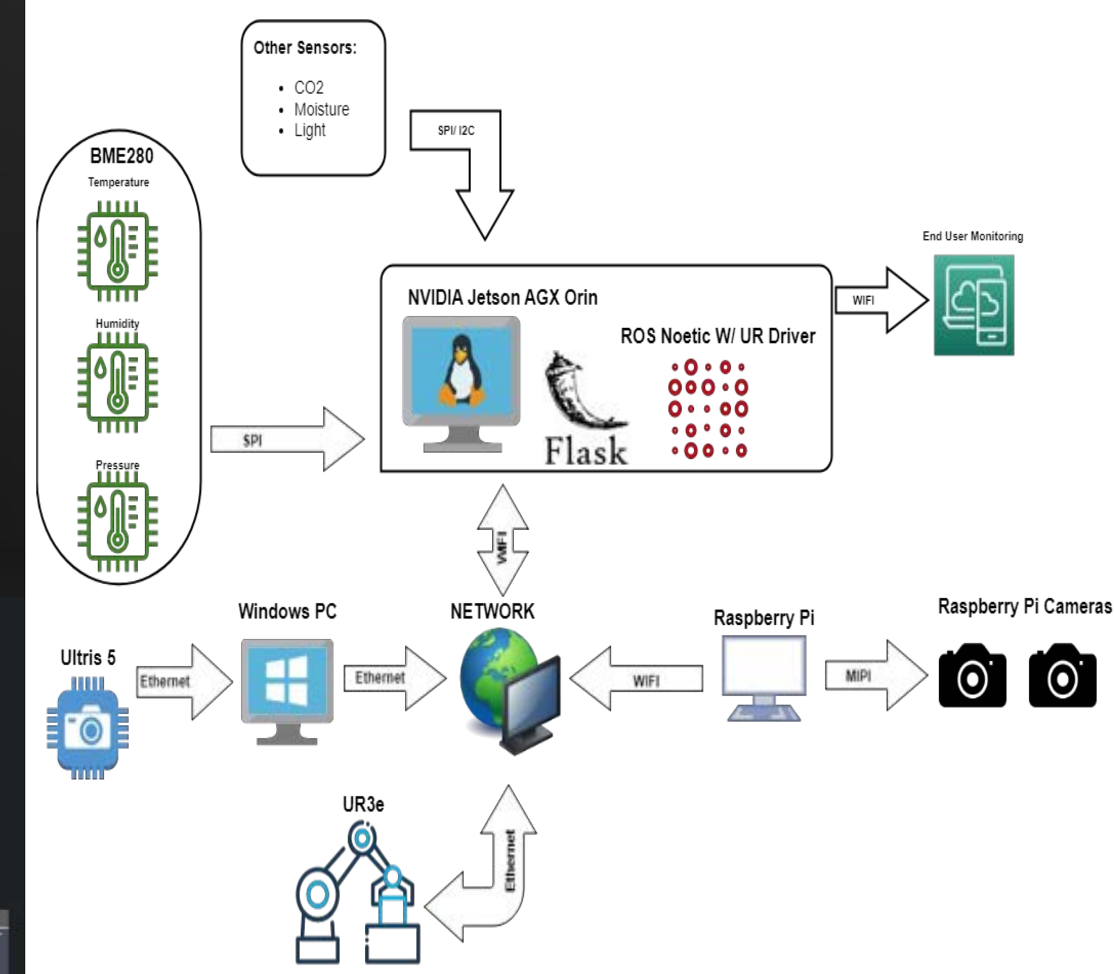
ARCS
AUTONOMY RESEARCH CENTER FOR STEAHM

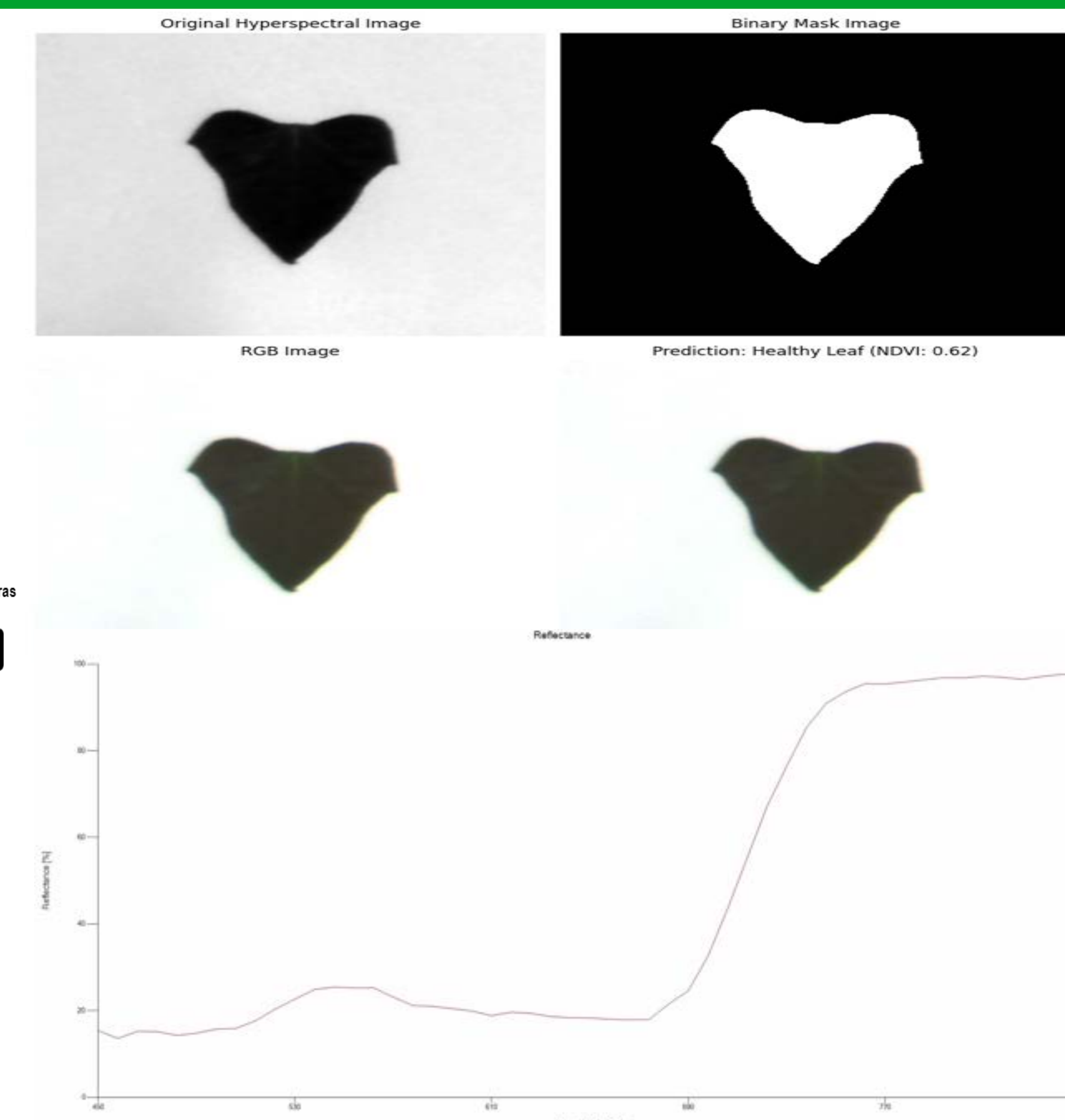
Autonomy for Sustainability

Astro Cultivators: Vertical Farming









Synopsis

- Autonomous Robotic System for Crop Harvesting. The system leverages a robotic arm that is integrated with depth cameras, temperature sensors, and Computer-Aided Designed (CAD) end effectors to autonomously harvest crops inside a freight farm container.
- A hyperspectral camera captures detailed spectral data to assess plant health. The data is processed through a 3D Convolutional Neural Network (CNN) machine learning model, which classifies crops as healthy or unhealthy based on spectral patterns.
- The system employs depth cameras, temperature sensors and other environmental monitoring tools to enable precise real-time navigation and operation of the robotic arm. The sensors and machine learning models allow the robotic arm to navigate its surroundings and harvest crops with minimal human intervention.

Research Objective

- Optimize agricultural techniques for growing nutrient-rich produce essential for maintaining the health and well-being of astronauts during extended space missions. The system will also address terrestrial agricultural challenges by adapting the autonomous system to controlled environments such as vertical farms and urban agricultural settings.
- Implement and train machine learning models that facilitate autonomous crop monitoring and plant health assessment. These models will enable the system to operate independently, making real-time decisions based on image classification, object detection, and plant health for both space and terrestrial applications.
- Train deep learning model responsible for trajectory and path prediction of the robotic arm throughout the harvesting motion. This model will account for and train based on positioning of a RealSense depth camera and LiDAR sensor with reference to the robotic arm and end effector.

Research Approach

- Test and verify the accuracy of Object Detection and Image Classification model performance based on the hyperspectral and RGB data. RGB data is used to detect the crops, and the hyperspectral data is used for plant health diagnostics.
- Execute harvesting motions utilizing the joint trajectory controller while recording simulated LiDAR sensor, depth camera, and RGB camera to have strong examples of desired behavior to guide deep learning agent.

Research Results and Products

- Hardware Components: NVIDIA Jetson AGX Orin Development Kit, UR3e Robotic Arm, Cubert S5 Hyperspectral Camera, Intel RealSense Depth Camera, LiDAR sensor, temperature sensor, humidity sensor and RGB camera.
- Software Components: Robot Operating System (ROS), NVIDIA Omniverse (IssacSim), Nvidia JetPack SDK, Python, PyTorch, OpenCV, YOLOV7, Flask, Apache Web Server.

Commercialization and/or Societal Impact Opportunities

- **Application:** Food plants monitoring system
- **Key Values:** Home, school, and community garden/nutrition monitoring system that is low-cost and controlled with a mobile phone in real-time.
- **Potential Customers:** Home gardeners, schools, community gardens, food desert residents.

Team Names & Collaborators

ARCS Students:
Troy Israel, MS, Comp Engr; John Vega, MS, Soft Engr; Jade Dergevorkian, BS, Comp Sci

Faculty:
Dr. Bingbing Li, Manufacturing Systems Engineering; Dr. Xunfei Jiang, Computer Science; Dr. Annette Besnilian, Director, Marilyn Magaram Center for Food Science, Nutrition and Dietetics (MMC); Andreas George, Project Coordinator (Garden), MMC

Collaborators:
LAPD PALS, CSUN Institute for Sustainability

COMP 490 Senior Design Students:
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MSE 614 Intelligent Manufacturing Student:
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Citations

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