

Robotic Mechanical Harvester for Fresh Market Citrus

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The goal of the robot harvester project's second phase, FY2004-2005, was to begin to validate Vision Robotics' concept for mapping orange trees using the scout robot. The scout will map the grove determining the tree locations, the number and size of the oranges and their approximate positions on each tree. Once a tree and its oranges are mapped, the scout will determine a picking-plan for that tree, which it will transmit to a harvester robot.

The FY2004-2005 tasks included: (1) Creation of scout design specification; (2) Partial completion, approximately 50%, of the scout virtual reality simulation; (3) Validation technical aspects of simulation from images taken in real orange grove.

The basic scout specification has been incorporated into the autonomous configuration as shown in Figure 1. The robot includes a base platform that houses the drive and steering mechanisms, the hydraulics, engine, generator, computers and holds the cameras and arms. The robot navigates through the grove primarily using the drive cameras, stereo pairs of cameras pointing forward and backward from the platform.

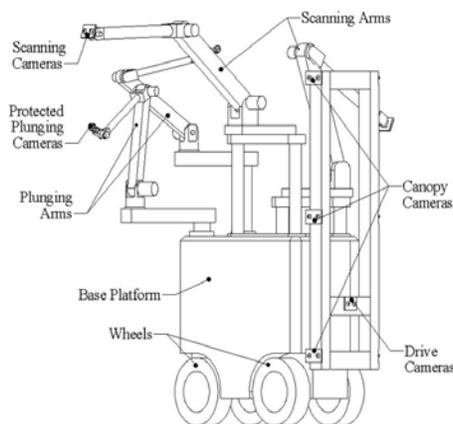


Figure 1
Scout Layout

Mapping is a three-stage process that includes: (1) Canopy extent analysis – Images taken by cameras mounted directly to the base combined to map the exterior surface of the orange trees. (2) Scanning analysis – Once the scout determines the extent of the canopy in real time as the robot moves along the row, the first set of arms scans the canopies on either side. The scanning process consists of moving the cameras over almost the entire exterior of the tree while staying within a few inches of the canopy. While only a few oranges are visible from any single viewing location, most of the oranges should be visible from the outside of the tree from at least one location. Therefore, the scanning process gives the scout enough different views to see and map most of the oranges, thick branches and openings in the canopy. (3) Plunging – Pushing cameras into the openings found during the scanning analysis to locate all oranges in the trees interior.

Vision Robotics has completed the algorithms and software for the canopy extent analysis. The canopy cameras can determine the outer shape of the tree as the virtual scout moves through the simulated orange grove.

The canopy extent analysis was validated using images taken in an actual orange grove. The testing consisted of a fixture that enabled a set of cameras to take pictures every 3” for 10’. The angles of the cameras relative to the trees could also be adjusted. In all, there were 160 images taken along a 10’ length of a row. The photographs, Figure 2, show one pair of stereo images looking perpendicular to the trees. The images are almost identical because the cameras are spaced only 4” apart. However, the small differences in the locations of the fruits, leaves and branches in the images are sufficient for the mapping algorithm to determine the shape of the tree’s canopy. Iterating through all the images enables the software to create a three-dimensional (3D) model of the trees.

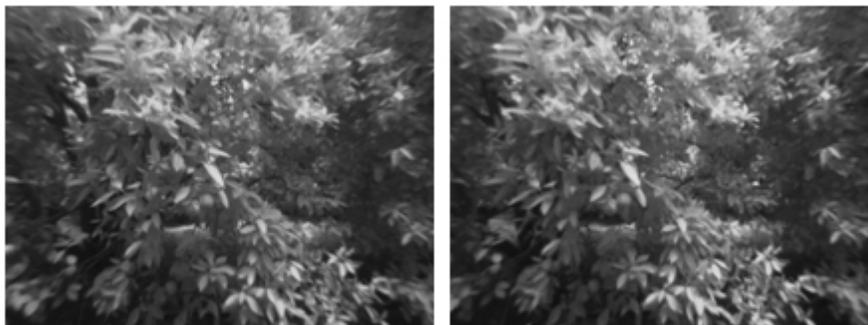


Figure 2
Stereo Images During Canopy Extent Analysis

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