



Long He



Azlan Zahid



Paul Heinemann



Dana (Daeun) Choi

Robotic Pruning System with Multiple Degrees of Freedom (DoF) Pruning End-Effector

Robotics and automation technologies are being extensively investigated for agricultural applications, while production operations for tree fruit crops still largely depend on manual labor. Manual tree branch pruning is a labor intensive and costly apple production task. Robotic pruning is a potential solution, but it involves several challenges due to the unstructured working environment and limited space within the tree canopy. To address these challenges, a concept of a robotic pruning system with multiple degree of freedom (DoF) end-effector was proposed by the research team from The Pennsylvania State University. This multiple DoF end-effector concept aims to develop a branch cutting mechanism capable of generating sufficient torque for apple tree pruning considering the maneuverability, spatial requirement, and machine-branch interaction to cut the branches arranged in various orientations.

Based on this concept, a pruning end-effector was developed using two rotary motors, a pneumatic cylinder, and a pair of by-pass shear blade pruning cutters. A cartesian manipulator and a control system was built for moving the end-effector to the targeted locations. A mathematical model was developed for simulation of workspace utilization and reachable points of the end-effector. The simulation results indicated that the end-effector can be aligned at a wide range of orientations of the cutter. Finally, field tests were also conducted for the validation of simulation results and performance assessment of the end-effector. The results indicated that the end-effector successfully cut branches up to 12 mm in diameter at a wide range of possible orientations in a given 3D space. This mechanism was further improved to a three-rotational DoF end-effector with an electrically driven cutter. Field tests indicated that the end-effector successfully cut branches up to 25 mm diameter with better maneuverability. The multiple DoF pruning end-effector is a core component for developing an automated pruning system for fruit trees. In the future, this end-effector will be integrated with a machine vision system for automatic apple tree branch pruning in a tree canopy environment.

