

# 6.4212 Project Preproposal

## Apple Picking Robot

Udayan Bulchandani

October 21 2023

### Motivation

Many attempts have been made to build robots capable of performing agricultural harvesting tasks, but for many crop varieties there are no robotic solutions on the market that come close to matching human capabilities. Agriculture presents a challenging environment for robots to operate in, with complicated obstacles. Robots must navigate uneven terrain and pass through foliage without damaging crops, though some allowable deformation of foliage is often required to complete a particular task. The task itself may require fine manipulation of an object that is easily damaged if applied forces are too great. This problem presents challenges across perception, motion planning and control.

### Project

This project will focus on the sub-problem of motion planning in the context of apple picking. Concretely, given a model of an apple tree, and a rigidly mounted Kuka iiwa next to the tree, the completed system should be able to perform the necessary movements to pluck an apple off the tree. This will involve planning a path through foliage and branches, which may require deformation of some branches to be completed successfully.

The tree will be modelled as randomly generated "tree" of rigid links connected by compliant spherical joints. Leaves and apples will be modelled as similar rigid links. Different branches will have different joint stiffness - some will tolerate deformation more than others, and some will be too stiff for the iiwa to deform.

### Motion Planning

A two-pass approach to motion planning will be explored. In the first pass, a trajectory will be generated that ignores collisions with more compliant branches and foliage, using some sensible threshold for compliance. In the second pass, for each compliant branch that was previously ignored, a modification will be made to the initial trajectory that involves "nudging" that branch out of the way.

Simplifying assumptions will be made to make this problem more tractable, but these can be relaxed depending on project progress. For example, as each branch is deformed, the overall tree will deform, which may introduce new collisions into the planned path, and move the target apple away from its expected location. One solution would be to perform repeated iterations of motion planning during execution.

### Picking

The 'pick' action will require a torque to be applied along an axis aligned with the apple's stalk. Force applied to the apple's surface should remain below some threshold. This project aims to use the SCHUNK WSG gripper to perform the picking action. The gripper trajectory required for the pick will be included as part of motion planning.

### Perception

The perception problem will be ignored for in this project. It will be assumed that the precise location and compliance of each branch is always known by the motion planner. Again, depending on project progress, this assumption could be relaxed. Deep learning could be applied to identify individual branches

and estimate their compliance from RGB-D data.

### **Prior Work**

Investigation of prior work is ongoing. Review papers like this one suggest that most work in this area focuses on either perception, or detaching the fruit from the tree. One particularly relevant piece of work explores using a dual arm setup in which one arm brushes aside foliage.