• Software development and integration
• Hardware to software interface
• Control of the robot arm

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How everything fits together

“Software blows life into the dead hardware”
Software overview

- **Software is used for:**
  - **Top-level control**
    - Deciding how to move the arm, when to grip, when to move the platform etc.
  - **Image analysis**
    - Finding the peppers in the images
    - Finding the stems in the images
  - **Low-level control**
    - Get data from sensors such as cameras
    - Control the arm, gripper, and platform
  - **Communicate with the operator**

- Software is also used in a simulator to speed up development
Simplified flowchart for top-level control

- Move along a path of waypoints
- Take image and detect (ripe) fruits
- While fruits left to harvest:
  - Select one of the fruits
  - Move the arm to center the camera on the fruit
  - Move close enough to the fruit
  - Harvest the fruit
  - Select the next fruit in the list
- When all fruits in the image have been harvested:
  - Move back to where we detected fruits last time and continue searching from there
Simplified flowchart for top-level control

1. Start
2. Move to next waypoint
3. Waypoints left? (No → End)
   (Yes → Take image)
4. Take image
5. Fruit detection
6. Select fruit
7. Fruits left? (No → Move to fruit)
   (Yes → Fruit unreachable?)
8. Fruit unreachable? (No → Harvest fruit)
   (Yes → Select fruit)
9. Harvest fruit
10. End
A simulation environment was built using ROS MoveIt and visualized using RViz, a 3D visualization tool for ROS. Speeds up program development, integration, and testing.
Main task:
- How should the joints be set to move the gripper to a wanted position?

Problems:
- There are several ways to be in the same position!
- Some are very bad and cause crazy movements of the robot arm

Solution:
- “Motion planning”
How to harvest the fruit

- When a fruit is found in the camera image
  1. Move around the fruit until the stem is behind
  2. “Visual servoing” towards fruit:
     - Center the fruit in the camera image
     - Move a small steps towards the fruit, until close enough
  3. Harvest by moving the knife down to cut the peduncle
User interface

- Gives feedback to the user and enables start and stop of the robot
- Also allows for easy testing of some functionality
  - E.g. Platform, gripper
Team

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