A Modular Robot System for Agricultural Applications

Christoph Schütz, Julian Pfaff, Jörg Baur, Thomas Buschmann, Heinz Ulbrich

General Idea

Agricultural tasks are manifold: Dependent on the crop, the environment and the desired plant maintenance operation, properties such as modularity, robustness, compactness or user friendly interfaces, are advantageous for the automation using a robotic system.

Therefore, several robotic manipulators have been designed and built for the requirements given by the EU-FP7 project CROPS for multiple applications, including selective harvesting and precision spraying of high-value crops such as sweet-peppers, apples or grapes.

Compact integrated drive units including motor, brake, gear and motor drivers support the modular design of the manipulator. Thus, the developed system can be used in different kinematic configurations according to the special needs of each application.

A major challenge is the simultaneous development of the robot system and its subsystems within a large distributed project like CROPS. Hence, suitable tools for testing and integration are needed.

Robot systems for three applications (sweet-pepper harvesting, apple harvesting, precision spraying) were implemented with full integration of the manipulator prototypes.

1. Manipulator Design

- Modular, multipurpose manipulators
  - Generation 1 (April, 2012)
    - 6 DOF and 9 DOF configuration
    - Integrated for sweet-pepper, apple harvesting and precision spraying
  - Generation 2 (February, 2014)
    - 7 DOF and 9 DOF configuration supported
    - Full integrated drive modules
    - Waterproof housing

Kinematic Design

- Modular Design → Arbitrary configurations
- 2 optimized configurations: 7 and 9 DOF

Communication and Control

2. Testing and Integration

Test Bed

- Testing and evaluation of path planning, collision avoidance, optimization, etc. algorithms
- Sweet-Pepper and apple harvesting
- Arbitrary positioning of plant models

Fruit Localization

- Fruit detection in lab with RGB-D camera device
- Fruit detection in 2D image using Haar features in an cascade boosting machine learning algorithms
- Move to goal pose on a straight line
- Move to fruit on a heuristic path accounting for stem position
- Online control of joint velocities
- Online control of end-effector velocity
- Playback of offline generated joint trajectories

User Interfaces

- Solution: Camera mounted on manipulator (testing in progress)

3. Applications

- Sweet-Pepper
  - Manipulator on platform in a greenhouse for sweet-pepper cultivation
- Apple
  - Manipulator mounted on tractor (CNH) in an orchard for apple harvesting
- Precision Spraying
  - Manipulator in 6 DOF configuration with protection cover on a platform for precise spraying of grapes