Structural properties of natural plant populations: assessing canopy traits with a novel software tool

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Introduction

- **Leaf Location**
- **Surface Orientation**
- **Leaf Inclination**

Graphs showing:
- Tree height in cm vs. average leaf quantity
- Frequency distribution of zenith angle
Introduction

CropSense - S9 activities

• 3-d canopy measurements in the field
• Co-registration: hyperspectral measurements (F. Pinto)

CropsSense „central experiment“ at research site Klein-Altendorf

stereo camera setup on a cherrypicker
Software developments

3-d reconstruction

Leaf angle toolbox

Camera setup

Leaf segmentation

Surface modelling

Results summary

Background segmentation
Image processing pipeline

- Stereo images
- Calibration images
  - 3-d reconstruction
  - Segmentation
    - Disparity (depth) maps
    - 3-d point cloud
      - Leaf-specific segments
    - Surface modelling
      - 3-d canopy polygon mesh

- Stereo setup
- Disparity (depth) map
- Leaf segmentation
- 3-d surface modeling
Surface model (sugar beet)

leaf inclination & leaf orientation

- leaf angle distribution
- average leaf angle
- median leaf angle

leaf area
Leaf axis model (barley)

- Leaf angle distribution
- Average leaf angle
- Median leaf angle

RANSAC-filtered and curve-fitted point cloud
Case study (sugar beet)

Sugar beet (*beta vulgaris vulgaris*)

- 4 cultivars → *variety effects*
- 2 nitrogen treatments → *fertilization effects*
- 3 measuring dates → *size / state effects*
- 2 repetitions
Case study (sugar beet)

comparison of leaf angle distributions

(average) surface inclination

surface inclination & orientation

case study: size & state effects are reflected by the distribution of azimuth angles
Case study (sugar beet)

principle component analysis (PCA) of leaf angle distributions

**states**
- (s)mall – May 30
- (m)edium – June 14
- (l)arge – September 5

**cultivars**
- (B)erenika
- (C)esira
- (M)aurica
- (P)auletta
- + 150 kg/ha nitrogen
- - 80 kg/ha nitrogen
Range of applications

*Arabidopsis*

→ diurnal leaf movement

apple trees

→ fruit size / distribution

tomato
Range of applications

*Arabidopsis*

→ diurnal leaf movement

*apple trees*

→ leaf / fruit distribution

*tomato*

→ fruit size / distribution
Leaf and fruit distribution (apple)

semi-automated fruit segmentation

corresponding depth map

3-d fruit location
Leaf and fruit distribution (apple)

- Pruning types in apple trees:
  - Manual pruning → spindle-shaped trees
  - Mechanical pruning → wall-shaped hedge

Spatial distribution of leaves and fruits
Leaf and fruit distribution (apple)

Hand pruning

Mechanical pruning
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