Detecting plant parts of sweet-pepper using pixel classification and post-processing

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Objectives

- Detect plant vegetation in a crop row
- Classify vegetation into 5 classes
  - a. Stem (hard obstacle)
  - b. Green Fruit (hard obstacle)
  - c. Top of a leaf (soft obstacle)
  - d. Bottom of a leaf (soft obstacle)
  - e. Petiole (soft obstacle)
- Perform post-processing for green fruit detection

Background

A sweet-pepper harvesting robot is under development within the CROPS project “Clever Robots for Crops”. Plant parts must be detected and classified into hard (construction element, stem, fruit) and soft (leaves, petiole) obstacles for motion planning

Materials and methods

Imaging wavelengths:

- 447 nm – bandwidth 60 nm
- 562 nm – bandwidth 40 nm
- 624 nm – bandwidth 40 nm
- 692 nm – bandwidth 40 nm
- 716 nm – bandwidth 40 nm
- >900 nm – longpass

Figure 1. Labelling of ground truth into five classes: stem, fruit, top of a leaf, bottom of a leaf and petiole.

Pixel-based Features

NDI; Entropy; PCA; SAM; Mahalanobis Distance

Data

- 12 scenes of sweet-pepper cultivar “Viper”
- 3 million labelled pixels

Classification

- Classification and Regression Tree (CART) and feature selection
- New ‘robust-and-balanced accuracy’ performance measure that uses the St. Dev. of true-positive detection rate among scenes

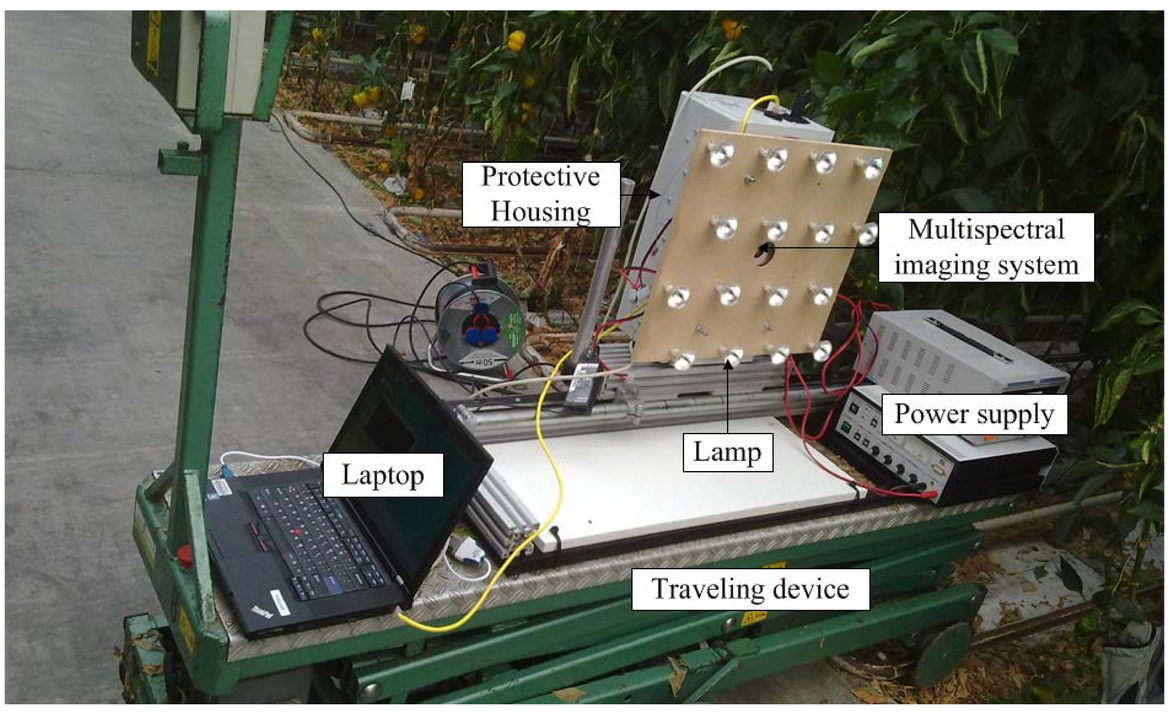

Figure 2. Imaging and halogen lighting set-up

Conclusions

- Due to robustness criteria, classification standard deviation among scenes drops by more than 50% without significant loss in accuracy!
- In continuation research, object-based features will be added to improve classification accuracy
- Green fruit detection rate is comparable to the state-of-the-art

Results

Figure 3. Original image at >900 nm (left) and threshold operation (middle). Overexposed regions (>300 pixels) are classified as hard obstacles and smaller regions are removed (right)

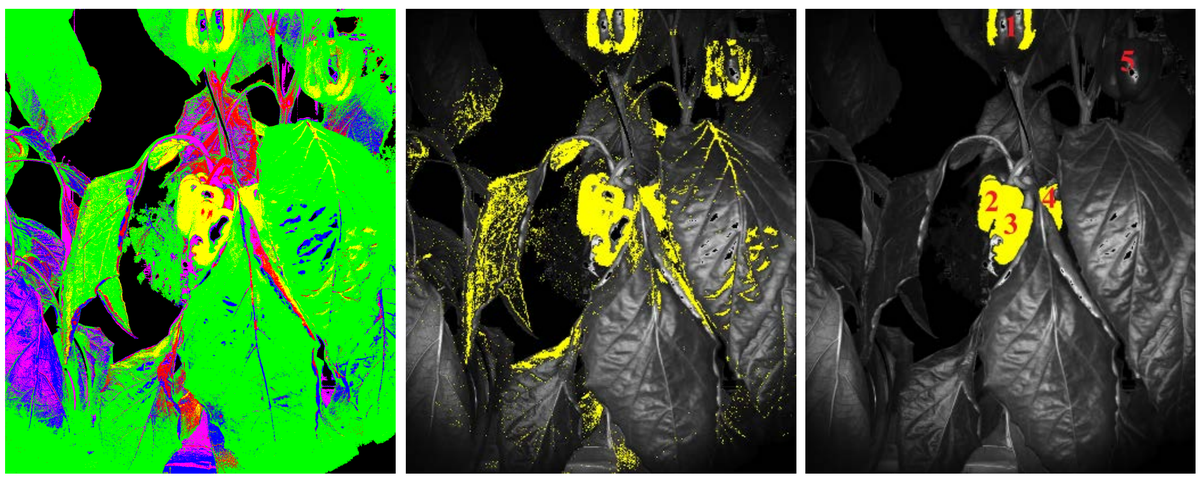

Figure 4. Classification stem (red), fruit (yellow), top of a leaf (green), bottom of a leaf (blue) and petiole (purple)

Figure 5. Classified fruit pixels (left) and the result after post-processing by a fill-up, opening, connection and area-based segmentation (right).

Figure 6. Mean and SD of True-positive rate per class.

References

Bac, C. W., Hemming, J., & Van Henten, E. J. (2013), Robust pixel-based classification of obstacles for robotic harvesting of sweet-pepper. *Computers and Electronics in Agriculture*, 96, 148-162

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