SWEEPER

Sweet Pepper Harvesting Robot

GRANT AGREEMENT Number 644313

Deliverable number: D5.10
Deliverable title: Image databases #4 with different crop conditions (corresponding to WP6) available for analyses

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References

Grant	EU Framework Programme for Research and Innovation Horizon 2020 Grant agreement no 644313 “Sweet Pepper Harvesting Robot” SWEEPER
DoA	Sweet Pepper Harvesting Robot GRANT AGREEMENT Number 644313 Annex 1 Description of Action
SWEEPER D1.1	Sweeper Data Management Plan, version 1, M6
SWEEPER D5.3	Image Database #2 with different crop conditions available for analyses
SWEEPER D5.7	Advanced software for obstacle detection and localization algorithms

Definitions - Abbreviations

Definitions or Abbreviations which are needed for understanding this document are listed here.

Abbreviation	Description
none	

Data Management Plan

This project works according to the H2020 guidelines for Data Management, as set out in the Data Management Plan (D1.1-Final version, M36). This deliverable also refers to the following data:

Data type	Description
Images DB#4	Sweet Pepper images of optimal crop according to WP6

Executive Summary

This deliverable reports on image database #4 consisting of images obtained from the Fotonic F80 RGB-D camera in experiments conducted in a greenhouse in IJsselmuiden, The Netherlands in June 2017 with peppers from the Gialte cultivar (E20B.0132, Seed company - Enza Zaden). The database is intended for development of the advanced sensing algorithms with particular focus on depth data and maturity evaluation.

Contents

1. Introduction

SWEEPER Project and Objectives

The main objective of the SWEEPER project is to put the first generation greenhouse harvest robots onto the market [DoA-B; 1.1]. The project will achieve this by lifting up proven fundamental research results of a sweet pepper harvesting robot developed in the FP7 project CROPS, with a Technology Readiness (TRL) to a market ready level (TRL=9), which means the actual application of the technology is in its final form and under mission conditions, such as those encountered in operational test and evaluation environments.

The SWEEPER project is a partnership between Umea Universitet in Sweden, Ben Gurion University of Negev in Israel, Proefstation voor de Groenteteelt in Belgium and from the Netherlands Wageningen University & Research Centre, Irmato Industrial Solutions Veghel B.V. and sweet pepper grower De Tuindershoek BV.

The project is organized into 8 work packages. The general objective of WP5 is to research and develop the sensing system of the SWEEPER robot in order to detect the fruit and provide the necessary information for reaching and harvesting it. The work to be carried out will start with formulation of methodologies for data collection and evaluation (T5.1) and datasets. These datasets will serve for development of algorithms for fruit detection and localization (T5.2), obstacles detection and localization (T5.3) and fruit maturity (T5.4) will be developed. Extensive benchmarking (T5.5) will complete the work of this WP5.

This deliverable reports on the goals, composition, and content of image database #4 and is part of T5.1. A total of 156 scenes with 936 fully registered RGB-D images were acquired with the Fotonic F80 RGB-D camera in the IJsselmuiden greenhouse in the Netherlands on peppers from the Gialte cultivar (E20B.0132, Seed company - Enza Zaden). The peppers were from the 12th harvesting cycle. The database is intended for the development of the advanced sensing algorithms with particular focus on depth and maturity evaluation.

2. Dataset design, protocol, and content

Scene labeling

For the maturity evaluation a labeling protocol was performed prior to acquisition. The tagging included visual evaluation of the peppers available in the working greenhouse row and classification of them into 4 classes according to the following:

- Class 1: Non mature. Under 10% Yellow coloring. (Blue label)
- Class 2: Non mature. 10%-50% Yellow coloring. (Light blue label)
- Class 3: Mature. 50%-90% Yellow coloring. (Pink label)
- Class 4: Mature. 90%-100% Yellow coloring. (Orange label)

Example of the classes are shown in Figure 1.

Figure 1: Labelled maturity classes.

Acquisition protocol

Since the Sweeper robot is likely to observe the sweet pepper plant from various angles and distances, a set of 3 angles were selected for acquisition. The acquisition protocol utilized the selected sensors and illumination, the selected sweeper manipulator, and custom-made software, to collect data twice, once with the maturity labeling and once without. This provided a reference image for the maturity analyses (the image with maturity label) and an image for the detection and maturity analyses (the full peppers as acquired without blocking the view by the labels). This was performed in the following way:

- Sensors and illumination were mounted on the tip of the manipulator (Fanuc LR mate 200iD, 900mm 7L version) that was programmed to move between 3 predefined configurations that cover 3 viewpoints at 3 azimuth angles from the plant. As plants in different rows did not grow at equal distances from the greenhouse rail system, the horizontal distance of starting position from plant rows was increased when necessary in order to avoid collisions. Robot co-ordinates for each of the 3 positions were derived empirically to enable the following three viewpoints (Fig. 2): (a) Right – offset to right, looking towards center, (b) Center – looking ahead, (c) Left – offset to Left looking towards center.

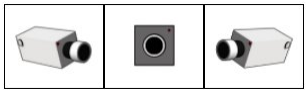

Figure 2: Schematic description of the three viewpoints.

The exact robot values for each of the viewpoints were as follows:

Center	0.29, 0.12849/0.22849, 1.2799, 0.0, 0.0, 0.707, 0.707
Right	0.36655, 0.12/0.22, 1.2395, 0.12063, -0.10677, 0.82702, 0.53859
Left	0.1465, 0.12/0.22, 1.200, 0.055305, -0.1102, 0.37059, 0.92058

*Blue marks alternative values used for plant rows closer to the rail system

- The Fotonic color camera was set to its lowest possible shutter speed and its depth sensor calibrated for optimal results in the 10-60cm range. EFFILUX flash controllers were set to produce 500 mA pulses with a duration of 100μs.
- Upon completion of all viewpoints, the robot moved to the homing position, the labels were removed and another cycle of viewpoints was performed on the same scene. Upon completion of the two acquisition cycles of the same scene the platform was moved to a new location to face a new scene, and the entire sequence of operations restarted.

Figure 3 presents the hardware as mounted in the field. Sample images obtained with the acquisition protocol are shown in Figure 4.

Figure 3: The gripper with the Fotonic camera, illumination and suction cups.

Figure 4: Several sample images under the described protocol with and without labeling.

3. Public web access and graphical user interface

All data of the fourth Sweeper image database (Sweeper DB#4) will be available publically at DOI[1] through a web interface at the following URL:

http://icvl.cs.bgu.ac.il/lab_projects/agrovision/DB/Sweeper04-Private/#/scene

A snapshot of the main screen and the intuitive user interface is shown in Figure 5. This web interface is similar to the web interface used for DB#2 (D5.3), and allows going through the scenes, viewing the tagged and untagged image, viewing the depth map and downloading the original set.

[1] The dataset will be released under this DOI under the conditions described in the Data Management Plan (D1.1 - Final version to be available at M36).

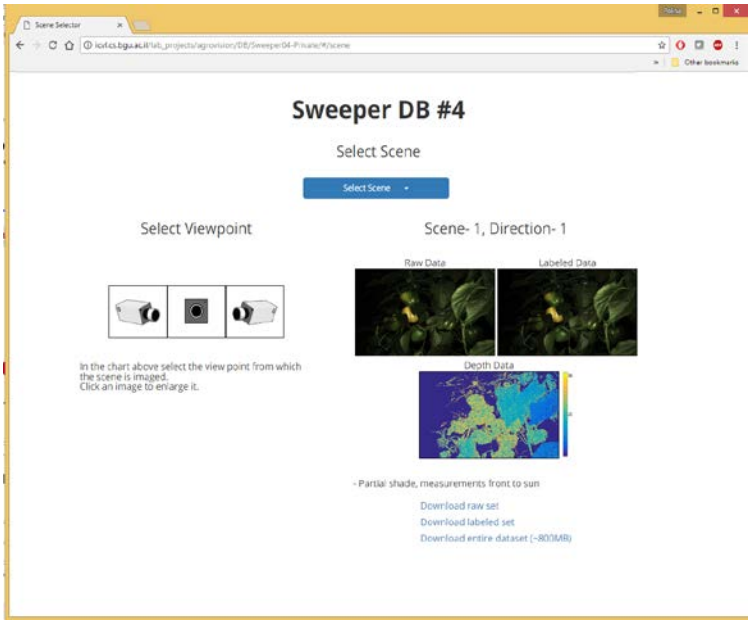

Figure 5: A snapshot of the interactive web interface to the Sweeper DB.

4. Conclusions

The first version of the integrated advanced sensor system was used to collect a database of images for algorithm development. The system includes the Fotonic F80 RGB-D camera camera, as well as integrated illumination that is strobed during short exposures. A total of 156 scenes with 936 fully registered RGB-D images were acquired in the IJsselmuiden greenhouse in the Netherlands with peppers from the Gialte variety.