SWEEPER
Sweet Pepper Harvesting Robot

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Executive Summary

During two visits to the grower’s greenhouse (July and Sep 2015), the first set of field data was collected and organized. While deliverable 5.1 is the dataset itself, this short report describes its design and content, and how to publicly access it.
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1. Introduction

Sweeper detection and localization algorithms are designed to be data-driven. To facilitate this approach, the Sweeper research plan includes no less than 4 data collection sessions to serve algorithm design for both the basic and advance system. In July and Sep 2015, teams from BGU, DLO, and Irmato met and collaborated in the Grower's greenhouse, to make initial sensor evaluation (in July) and then run the first systematic data collection (in Sep) that resulted in the first dataset of sweet pepper greenhouse scenes as eventually acquired by the Sweeper robot. According to the research plan, this dataset, as well as the forthcoming ones, should be made public both for the Sweeper community and the research community in general. The rest of this short document describes the content of this dataset and how to access it.

2. Dataset design and protocol

The Sweeper robot is likely to observe the sweet pepper plant from various angles and distances (as much as the space between aisles permits). In addition, illumination conditions may vary from direct sun light to complete darkness (during night time). To facilitate data collection under all these conditions we designed an acquisition protocol that utilizes the selected sensors, the selected sweeper manipulator, an available artificial illumination sources, and custom-made software, to collect data in the following way:

- Sensors were mounted on the tip of the manipulator (Fanuc LR mate 200iD, 900mm 7L version) that was programmed to move between 15 predefined configurations that cover 5 viewpoints at each of 3 distances from the plant. Since on the ground it was found that the furthest and highest viewpoint pushes the limits of the arm, that viewpoint was discarded, leaving 14 viewpoints for each scene.

- The manipulator itself was positioned on a lift that was manually moved along the aisle and lifted to the proper height to face scenes with sweet peppers.

- At each such viewpoint, an image was taken from the RGB-D Fotonic sensor, and from the iDS camera. Furthermore, images from the latter were taken both under natural illumination, and under strobed artificial illumination.

- Upon completion of all viewpoints, the robot switched to a homing position, the platform was moved to a new place to face a new scene, and the entire sequence of operation restarted.
Figure 1 shows the sensory rig and the robot in the aisle.

![Figure 1: The sensory rig on the top of the robotic manipulator are mounted on the platform in the greenhouse](image)

Note that all RGB image from the IDS and Fotonics were taken under custom-made automatic exposure control. The automatic exposure mechanism was designed to adjust camera exposure interval in order to maximally match the resultant histogram to a desired canonical structure (that was measured from a large set of images that were judged “good” by a human observer and were not over or under saturated). While the present procedure only attempted to optimize histogram peak position, future version will try to optimize the entire histogram and consider regions of interest other than the center. The canonical histogram used is shown in Figure 2.
Figure 2: A canonical histogram that the auto exposure procedure was attempting to obtain by adjusting the exposure time of the camera. The present version of the auto exposure mechanisms attempted to adjust exposure time in order to obtain an image histogram with peak position that matches the canonical histogram. Future version will attempt to optimize additional features of the histogram.

3. Dataset Content

Given the mechanisms and protocol as above, the data collection session included 1.5 days of collection with the robotic arm, including one night session. More specifically, the first Sweeper datasets includes

- A total of 43 scenes, each constituting 14 consistent viewpoints.
- At each viewpoint, 4 images are available (see Figure 3)
  - An RGB image from the Fotonic camera
  - A registered depth image from the Fotonic camera
  - An RGB image from the iDS camera (not registered with the Fotonic) under natural illumination
  - An RGB image from the iDS camera under artificial strobed light.
- Of the 43 scenes
  - 8 were taken on a cloudy day in the afternoon
  - 2 were taken during night time
14 were taken under direct sun light from behind the fruit (and thus directly into the lens)
19 were taken with the sun behind (and above) the sensors.

![Fotonic RGB](image1)
![Fotonic Depth](image2)

![iDS RGB natural light](image3)
![iDS RGB Strobed light](image4)

Figure 3: One sample of the 4 images taken from a single viewpoint.

4. Public web access and graphical user interface

All data of the first Sweeper DB are available publically through a web interface at the following URL:

http://www.cs.bgu.ac.il/~icvl/lab_projects/agrovision/DB/Sweeper01/

A snapshot of the main screen and the intuitive user interface is shown in Fig. 4. This web interface allows interactive browsing through the dataset, and it provides downloading features of a single image, a single image set (from a given viewpoint), or the entire dataset in one click of a button.
Figure 4: A snapshot of the interactive web interface to the first Sweeper DB.
Appendix A: Backup images

The robotic manipulator arrived at the greenhouse and due to some technical problems it was set up by Irmato for the experiment relatively late, leaving essentially one day for systematic data collection. In order to ensure that data is collected even if the manipulator does not work, an earlier effort of data collection employed a manual rig as shown in Figure 2. This rig (made by DLO’s Bart van Tuijl) was placed on the platform, its viewpoint fixed, and images were acquired as the platform was moved along the aisle. Thus, unlike the data described above, each scene acquired included only a single set of images. Overall, 320 scenes were imaged this way (each constituting a set of the sort shown in Fig. 3) and this backup data is available from BGU upon request.

Figure 2: The sensory rig on the top of the manual rig – a contingency setup that was used before the robotic arm was utilized.