Strawberry Data Collection

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1 Data Requirements

The data set should:

1. provide enough information to fit multiple use cases such as 2D segmentation, 3D segmentation, localisation and planning.
2. contain a large collection of strawberry images gathered from multiple view points, for example bottom up and side facing.
3. be longitudinal; captured over multiple stages of the harvest cycle and at varying times during the day to mitigate issues such as glare and spherical reflection.
4. contain multiple species of strawberry, categorised exclusively from one another
5. contain registered high resolution RGB images as well as the point cloud information.
6. include local information such as GPS, temperature, time, date and humidity for each frame (mentioned in section 2.1)

1.1 Acquisition Method

The data will be captured on a Intel® RealSense™ Depth Camera D400 series camera which can capture RGB and depth data at a resolution of 1920x1080 and 1280x720 respectively. Point cloud data will be captured as well as high resolution RGB data. Images and point cloud data will be captured in a straight line at a constant y distance from the row. The meta data will be captured automatically with every frame and stored in a way that pairs it uniquely to that frame. Thorvald will be used to move along and between the rows, it will also provide some of the meta-data such as GPS and basic odometry. There will be three cameras capturing frames from multiple angles as shown in figure 1.

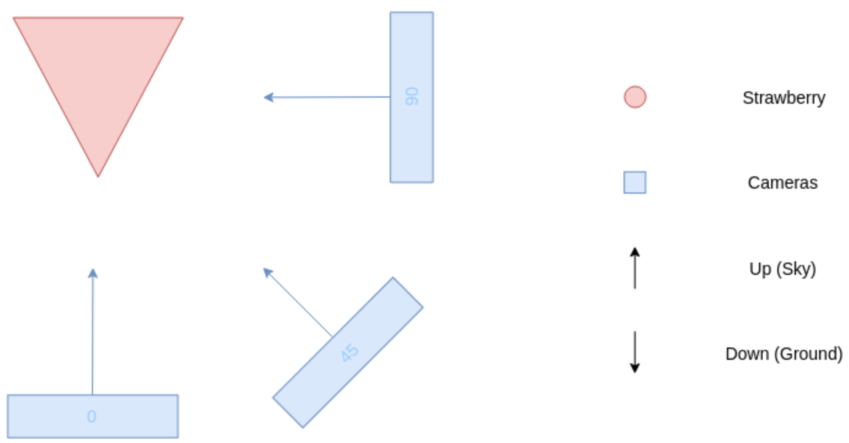

Figure 1: Data Acquisition Plan

2 Data Structure

2.1 Meta Data

To create this data using the software, execute the command 'new' before capturing data to create a new data set and follow the prompts. This should be done every data collection regardless.

1. Capture Location (GPS)
   (a) Time
   (b) Date
   (c) Orientation
2. Capture Distance from the crop (y)
3. Crop Species
4. Weather
   (a) Temperature
   (b) Humidity
   (c) etc (see 4.4)
5. Crop Row ID

2.2 File-system Format

Most data will be saved automatically in the location you specify in the 'config.json' file (discussed later). Below is the file structure created by the software, the meta data discussed above in 2.1 should manually be created at the start of data capture inside the project folder.

- Project
  - Location Meta Data.csv (Containing info listed in 2.1)
  - Camera Serial Number
    - Date (ex 2019_11_17)
      - Camera Meta Data.csv
      - Time (ex 17_00_30_600)
        - rgb_8UC3.png
        - colourised_depth_8UC3.png
        - depth_16UC1.png
        - ir_left_8UC1.png
        - ir_right_8UC1.png
        - point_cloud.ply
        - rgb_8UC3_meta.csv
        - depth_16UC1_meta.csv
        - ir_8UC1_meta.csv

3 Suggested Plan

The average growth cycle of a strawberry plant can take two to three months to complete, below is a diagram that shows the growth stages broken down into an estimated number of days.

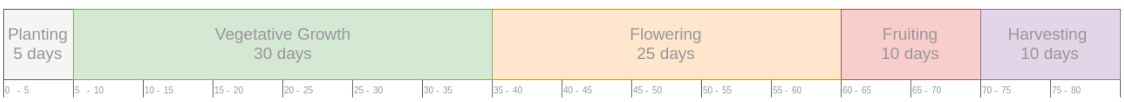

Figure 2: Strawberry Harvesting Cycle

Data collection should focus on the last two stages of the cycle; Fruiting and Harvesting.

3.1 Example Implementation

A prototype was developed and tested at the Riseholme Campus just north of Lincoln, where Strawberry poly-tunnels had been set up. The first stages included building the camera rig shown in figure 1, developing the software discussed in 4 and tuning the parameters of each camera. The exact architecture is of the capture location is shown in figure 3. Thorvald is driven between the crop rows with the camera rig mounted on the back rail.

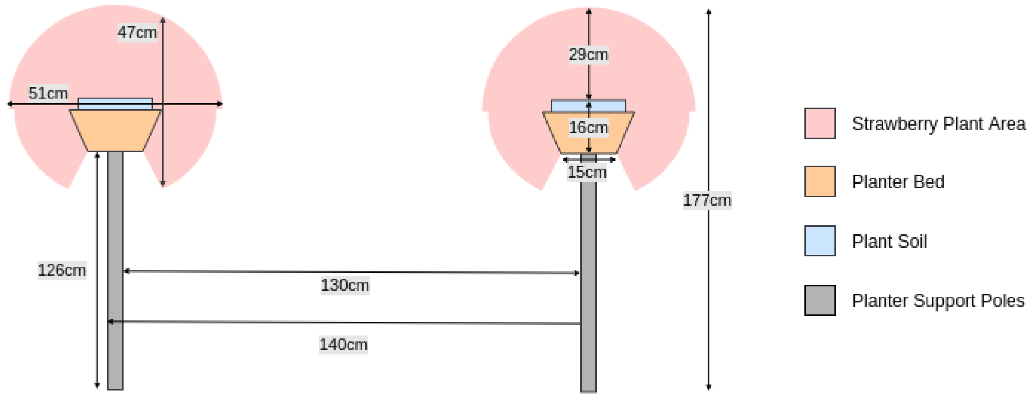

Figure 3: Riseholme Centre Poly-tunnel Measurements

Each Intel Realsense camera is mounted 0.55m away from where the strawberry calyx's are located, so that the strawberries are in the centre of the captured images. The purple region shown in 4 shows the region of interest that the camera capture should be centred around.

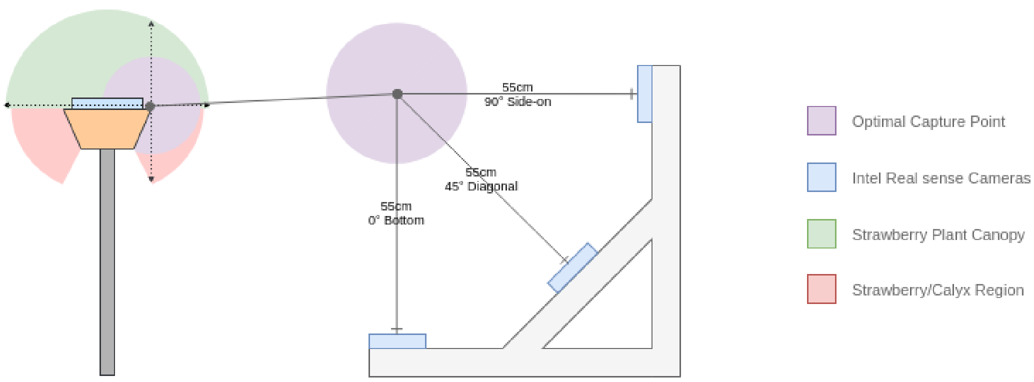

Figure 4: Thorvald Camera Rig and Capture ROI

4 Software

A software package is provided that can capture data within $\pm 1ms$ of each cameras software capture time stamp. The software will automatically log all meta data from the cameras that they provide, currently the software has only been tested with D400 series Intel RealSense cameras. Before launching the software the user can configure some options such as enabling/disabling the GUI, setting prior automatic auto-exposure balancing, resolution and frame-rate; these configuration settings are detailed in section 4.3. On launch each connected camera will be setup serially, alternatively if no cameras are connected the program will wait until at least one is. The user will be presented with a control screen detailed in section 4.2 where they have multiple options to control the data capture.

4.1 Installation

Some dependencies are required prior to installing the software, they are listed below:

1. LibRealSense - Linux installation instructions can be found here.
2. Boost - On linux run 'sudo apt-get install libboost-all-dev'
3. OpenCV - Instructions can be found on the developers page.

To install the software on your machine you must clone the repository and compile it using CMake and make. The repository can be found here.

4.2 Controls

The table below documents the control interface the user is presented with on the command line when running the application.

Key	Description
'save', 's', 'Enter Key'	Writes all output to disk
'new', 'n'	Creates new data set folder and asks for meta data input
'laser0', 'l0'	Turns laser off
'laser1 <param>', 'l1 <param>'	Turns laser on, <param> can be min(-3), mid(-2), max(-1) or any float value
'stab', 'st'	Throws away frames for correcting exposure
'help', 'h'	Displays help
'quit', 'q'	Quits

4.3 Configuration

The table below documents parameters stored in the 'config.json' file, found in the root of the project folder.

Key	Description
'save-path-prefix'	Controls which folder the data structure is save in. Final path = 'save-path-prefix' + data structure path
'project-name'	Top level filter folder for organising different data collection sessions. Final path = 'save-path-prefix' + 'project-name' + "/"
'gui-enabled'	If true all connected camera streams are displayed on screen
'stabilise-exposure'	Throws away 'stabilise-exposure-count' number of frames to stabilise the auto exposure
'stabilise-exposure-count'	Parameter used when 'stabilise-exposure' is true
'stream-colour'	Parent property controlling stream parameters for colour sensors (see 'width', 'height' and 'frame-rate')
'stream-depth'	Parent property controlling stream parameters for depth sensors (see properties below)
'width'	Sensor resolution width
'height'	Sensor resolution height
'frame-rate'	Sensor resolution frame rate
'file-names'	Contains all of the file names and extensions used for saving the files

4.4 Example Meta Data

Below is an example of the meta data that should be stored every data collection session (one hour window). The first fields up until after the notes field are created via the 'new' command on the software console. The last part is weather information and this can be generated by running the 'get_weather.py' python script, this should be ran just before the data collection when an active internet connection is available, when ran the output should be copied and pasted into the meta data file you just created.

Name (First Last)	Raymond Kirk
Contact Email	rkirk@lincoln.ac.uk
Date (DD/MM/YYYY)	21/08/2018
Latitude	52.268491
Longitude	-0.523832
Location Name	Riseholme College
Location Row ID	0
Capture Distance from Row (cm)	56
Crop Species	Snap
Notes	Front facing (side on) camera mounted at 72cm above bottom (up facing) camera
Clouds	0
Detailed weather status	broken clouds
Humidity	89
Pressure	1021.33
Pressure sea level	1030.65
Rain in the last 3 hours	
Reference time	1534839665
Sunrise time	1534827425
Sunset time	1534878665
Temperature	292.15
Visibility distance	
Weather code	803
Weather country code	GB
Weather info reception time	1534839665
Weather location ID	2639313
Weather location lat	-0.52
Weather location lon	52.27
Weather location name	Riseley
Weather status	Clouds
Wind degree	220.0
Wind speed	4.02336