# Identifying Ripen Fruits Using Hyperspectral Imagery

Challenge Week Deliverable

Sansayan Gajanithy

# Project Outline

In the last decade, the global population has increased, and governments have started to research and develop new solutions to manage the high demand on resources including producing plans to increase and sustain a large demand of food supply. According to the UK government's Future of Food and Farming report, the key goals to balancing and sustaining a high food demand include sustaining production using science and technology and reducing food wastage [1]. The Project is Identifying ripened and rotten fruits using the Hyperspectral Imager (Specim fx10e), which will help us to understand spectral information in fruits across the electromagnetic spectrum. Certain processes will be able to notify us of the lifespan of fruits in their early stages and help us to decide whether the fruit is unripe, ripe or rotten. This will reduce food wastage. The demand for this project is very high as the research and development sector in spectral imaging has been well supported by governments to make positive changes in the agricultural and food processing industries. The use of hyperspectral imagery on mapping grape varieties in South Australia conducted by Adelaide University is an example which helped the comprehensive study of health issues in grape crop varieties in vineyards and the early recognition of such health factors, which will help to sustain greater yields [2]. The hyperspectral imager will act as a tool to steadily identify the consequences affecting the lifespan of fruits without pigmentation by providing spectral information. Avocados and kiwi are the main sources of fruits that will be studied in this project. The further key element explored will be the evaluation of the environment which affects the hyperspectral imager, which may affect the spectral data. Thus, a conclusion can be drawn on the set of best environmental factors such as ambience and temperature for hyperspectral imagers.

# References

[1] Foresight. The Future of Food and Farming (2011) Final Project Report. The Government Office for Science, London. Available at https://assets.publishing.service.gov.uk/media/5a7bf9f840f0b645ba3c5efe/11-546-future-of-food-and-farming-report.pdf

[2] F.M. Lacar, M.M. Lewis and I.T. Grierson Department of Soil and Water, Adelaide University “Use of Hyperspectral Imagery for Mapping Grape Varieties in the Barossa Valley, South Australia” July 2001.

# Background reading

[1] Eufrat Tsaqib, Feb 19 2019 “Hyper spectral image processing with Python” available https://eufat.github.io/2019/02/19/hyperspectral-image-preprocessing-with-python.html

A project on hyperspectral image processing with the use of the sensor fx10 and spectral python. The project explained on the image processing with spectral python.

[2] Specim FX10 / FX10e - User Guide 1.5 , Specim, Spectral Imaging Ltd

This is an older version of the user manual for the fx10e sensor. In this user manel, there are information given on the imagers components, how to power and connect the fx10e, information on the spectra that the sensor can output and LUMO scanner which is the SDK used to operate and record data on the imager.

[3] Specim fx10 – user manual 2.2 , Specim, Spectral Imaging Ltd

This is the newer version of the imager and it is very similar to the previous user manual but in this version, there are information regarding other SDK such as SpecSensor SDK, which is a SDK developed by Specim based out of C/c++ language support. Although the user manual for this SDK is not found anywhere.

[4] MathWorks , Inc. “Getting started with hyperspectral image processing” available https://ww2.mathworks.cn/help/images/getting-started-with-hyperspectral-image-analysis.html

A guid into stages of hyperspectral image processing, Raw Data – representation – preprocessing – spectral unmixing – Interpretation. This is also the place where I discovered the file formats which imagers output.

[5] Loredana Buzura, Monica Loredana Budileanu, Adriana Potarniche, Ramona Galatus, October 2021 " Python based portable system for fast characterisation of foods based on spectral analysis".

This project based on the quality of coffee beans and fruit purees. This project extracted substances and then used a spectrometer to record spectral data. Then it used a Nvidia tx2 to analyse.

[6] Leon Amadeus Varga, Jan Makowski, Andreas Zell - Apr 2021 Germany "Measuring the ripeness of Fruit with Hyperspectral Imaging and Deep learning"

This is an identical project to my project as they have also used Specim Fx10. This project also have used avocados and kiwis for analysis.

[7] Sushma Barma, Sumanjali Damarla, Sudheer Kumar Tiwari- November 2020 "Semi-Automated Technique for Vegetation Analysis in Sentinel-2 Multi-Spectral remote sensing images using Python"

Spectral analysis project on vegetation in Krishna and Godavari regions of India. This project game an understanding of spectral cubes, which are bands of images which are overlayed on top of each to create a spectral cube.

[8] S. Le Mouélic, F. Chauvet, M. Giraud, E. Le Menn, Caroline Leynia, Olivier Barbet – June 2013 "Investigation of a painting dating the French revolution using visible and near infrared hyperspectral imagery".

Identifying mineral pigmentation in painting using HySpex spectral imagers.

[9] Randall B. Smit January 2012 "Introduction to Hyperspectral imaging" available https://www.microimages.com/documentation/Tutorials/hyprspec.pdf

This covers the concepts of Hyperspectral imagery and information regarding the spectral data sets.

# Project Objectives

- To be able to establish connectivity between the Hyperspectral imager and PC and operate the Imager.
- Record data set of ripened and rotten fruits using the Hyperspectral imager and export spectral data into python using spectral Python packages for analysis.
- Plot per-pixel spectra of the recorded data from the Hyperspectral Imager.
- Perform an evaluation of the Imager system on whether the amount or colour of ambient lighting has a significant effect on the captured wavelength and set guidelines for how the imager is best used for data capture.
- Analyse and identify ripened and rotten fruits from the prerecorded data sets using Spectral Python.

# Specific deliverables to be achieved by the oral interview

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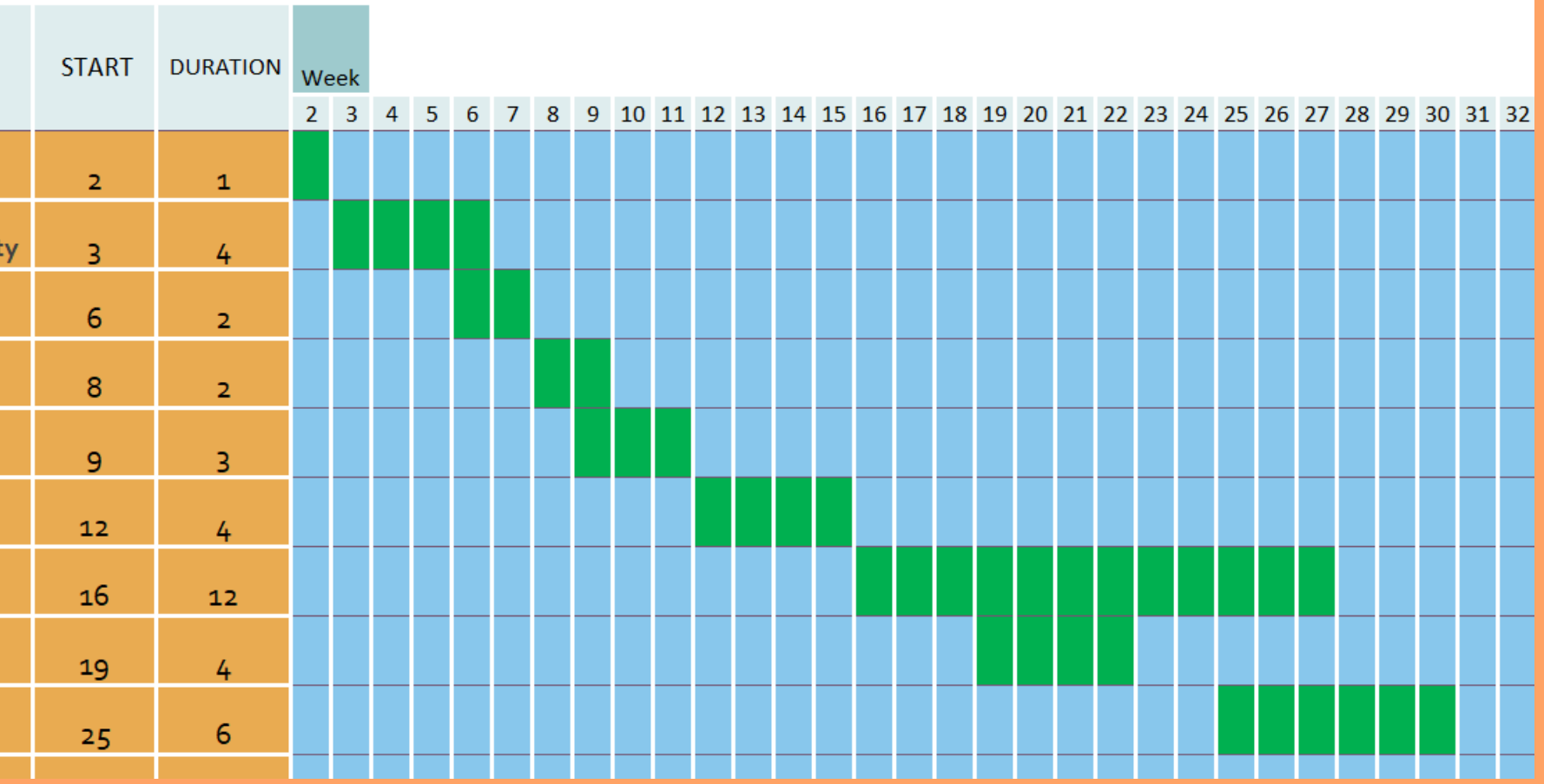
# Risk Register

| RISK | LIKLIHOOD | SEVERITY | MIGITATION |
|---|---|---|---|
| PERSONAL | | | |
| **Illness:** severe and extended period of illness | Low | serious | Seek medical help immediately and claim extenuating circumstances for the period of illness. |
| Stress and Mental Health issues | Low | Serious | Seek advice immediately and relax yourself by meditating. If mental health issue is severe, seek counselling. Claim extenuating circumstances. |
| Global & National | | | |
| Global Pandemic: Either new variant of covid 19 resulting in lock down to study from home | Moderate | High | Work and study from home and use recorded data from the web and perform analysis. Use VM horizon in need of a power machine. Keep up with the module supervisor on the project using Zoom. |
| Teaching and Staff Strikes: Strikes due to disagreement between university union and teaching union resulting in disruption of the project access. | Moderate | Low | Pre plan such these events to arrange any meeting earlier. Any technical equipment access means an alternative task should be carried out to compensate the project timeline. |
| System interruption | | | |
| Faulty in computation device resulting in data loss | High | High | Regularly backup data in safer location and evidence every step undertaken in the project. |
| Problems in assignments due to connection and system issues | Moderate | serious | Always start the assignments early and finish early before the deadline. Backup and hand in temporary assignment document and update. |
| System corruption when downloading spectral Python Packages. | Moderate | High | Backup data regularly and use Linux virtual machine when installing spectral python. |
| Health and safety | | | |
| Injury by burns and irritation caused by the hot bright filament lights of the Hyperspectral Imager | High | Serious | Wear specialised glasses and gloves given to protect from such injuries |
| Falling over by wires and electrocution. | Moderate | High | Keep wires organised and be aware of the environment. |
| Hardware and software | | | |
| Hyperspectral Imager being expensive, and no replacement will be given. | Moderate | serious | Approach with extreme care when working with imager and understand the subsystem before performing an operation to avoid damaging the Imager |
| Network and connection issues | Moderate | High | Run diagnostics and understand and resolve issues. In the instance of no possible independent solution seek help from the IT services and maintenance. |
| Common | | | |
| Back pain by staying in sitting positions and extensive screen time leading to heading to eye discomfort and shoulder pains | Moderate | Moderate | Relax, meditate and take regular breaks when undertaking the project and lead a balanced healthy lifestyle by walking and excising. Sleep well. |
| Intellectual property and property rights | | | |
| Project leading to similar projects that had been commenced earlier and project structure looking similar. | Moderate | High | Make background research on similar projects and understand and undertake independent work and lead a creative and leading-edge project. |
| Disagreement over project rights and licensing. | Low | High | Keep evidence of the project to prove the right to own the project sources and materials. |

# Gantt Chart

## Identifying Ripen fruits using Hyperspectral imager

| | Sprints | START | DURATION |
|---|---|---|---|
| 0 | Challenge week deliverable | 2 | 1 |
| 1 | Hyperspectral imager Operations and connectivity | 3 | 4 |
| 2 | Record data of the fruits using Hyperspectral Imager | 6 | 2 |
| 3 | Export images into spectral python | 8 | 2 |
| 4 | Analysis 1 | 9 | 3 |
| 5 | Winter Research | 12 | 4 |
| 6 | Analysis 2 | 16 | 12 |
| 7 | Evaluation of Imager system | 19 | 4 |
| 8 | Project Report and presentation | 25 | 6 |



# Creating virtual environment for python and installing spectral Python packages

```
sg21642@stemlab075-lx:~$ ls
Desktop    Downloads  Music     Public     Videos
Documents  M-Drive    Pictures  Templates
sg21642@stemlab075-lx:~$ python3 -m venv env
sg21642@stemlab075-lx:~$ ls
Desktop    Downloads  M-Drive  Pictures  Templates
Documents  env        Music    Public    Videos
sg21642@stemlab075-lx:~$ source env/bin/activate
(env) sg21642@stemlab075-lx:~$ which python
/tmp/home/sg21642/env/bin/python
(env) sg21642@stemlab075-lx:~$ deactivate
sg21642@stemlab075-lx:~$ which python
/usr/bin/python
sg21642@stemlab075-lx:~$ source env/bin/activate
(env) sg21642@stemlab075-lx:~$ which python
/tmp/home/sg21642/env/bin/python
```

```
sg21642@stemlab075-lx:~$ source env/bin/activate
(env) sg21642@stemlab075-lx:~$ pip install spectral
Collecting spectral
  Downloading spectral-0.23.1-py3-none-any.whl (212 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 212.9/212.9 KB 4.6 MB/s eta 0:00:00
Collecting numpy
  Downloading numpy-1.26.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (18.2 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 18.2/18.2 MB 58.5 MB/s eta 0:00:00
Installing collected packages: numpy, spectral
Successfully installed numpy-1.26.0 spectral-0.23.1
(env) sg21642@stemlab075-lx:~$ ls
Desktop  Documents  Downloads  env  M-Drive  Music  Pictures  Public  Templates  Videos
(env) sg21642@stemlab075-lx:~$ cd
(env) sg21642@stemlab075-lx:~$ cd env
(env) sg21642@stemlab075-lx:~/env$ ls
bin  include  lib  lib64  pyvenv.cfg
(env) sg21642@stemlab075-lx:~/env$ cd lib
(env) sg21642@stemlab075-lx:~/env/lib$ ls
python3.10
(env) sg21642@stemlab075-lx:~/env/lib$ cd python3.10/
(env) sg21642@stemlab075-lx:~/env/lib/python3.10$ ls
site-packages
(env) sg21642@stemlab075-lx:~/env/lib/python3.10$ cd site-packages/
(env) sg21642@stemlab075-lx:~/env/lib/python3.10/site-packages$ ls
_distutils_hack           numpy-1.26.0.dist-info  pip-22.0.2.dist-info  setuptools-59.6.0.dist-info
distutils-precedence.pth  numpy.libs              pkg_resources         spectral
numpy                     pip                     setuptools            spectral-0.23.1.dist-info
```

[1] Creation of virtual environments available https://docs.python.org/3/library/venv.html

[2] spectral Python0.21 documentation available https://www.spectralpython.net/

# Exporting Images into Spectral python

```
from spectral import *

img = open_image('city.jpg')
```

```
---------------------------------------------------------------------------
OSError                                   Traceback (most recent call last)
Cell In[3], line 3
      1 from spectral import *
----> 3 img = open_image('city.jpg')

File ~/env/lib/python3.10/site-packages/spectral/spectral.py:119, in open_image(file)
    116 except:
    117     pass
--> 119 raise IOError('Unable to determine file type or type not supported.')

OSError: Unable to determine file type or type not supported.
```

When trying to export a regular image in spectral python, I found difficulties in opening this image. After some research, I found out that the spectral python only used to analyse spectral information data which are the imager's outputs ,a binary and HDR files [4].

[10] Prediktera AB, "Description of hyperspectral file format" available Prediktera_Evince_Breeze_hyperspectral_file_format.pdf

Prediktera are a spectral SDK provider. This documentation provides information on spectral imager output, a binary file and what information are encrypted in the binary file like bands and wavelengths.

# Testing with Spectral Python

```
In [41]: from spectral import *
         import numpy as np

         img = envi.open('man.hdr','man1.bin')


         img.__class__
Out[41]: spectral.io.bipfile.BipFile

In [26]: print(img)
                 Data Source:   './man1.bin'
                 # Rows:            64
                 # Samples:         64
                 # Bands:          224
                 Interleave:       BIP
                 Quantization:  32 bits
                 Data format:   float32

In [27]: img.shape
Out[27]: (64, 64, 224)

In [30]: pixel = img[50,60]

In [31]: pixel.shape
Out[31]: (224,)

In [32]: bands = img[:,:,5]

In [33]: bands.shape
Out[33]: (64, 64, 1)

In [34]: #full image loading

         arr = img.load()
         arr.__class__
Out[34]: spectral.image.ImageArray
```

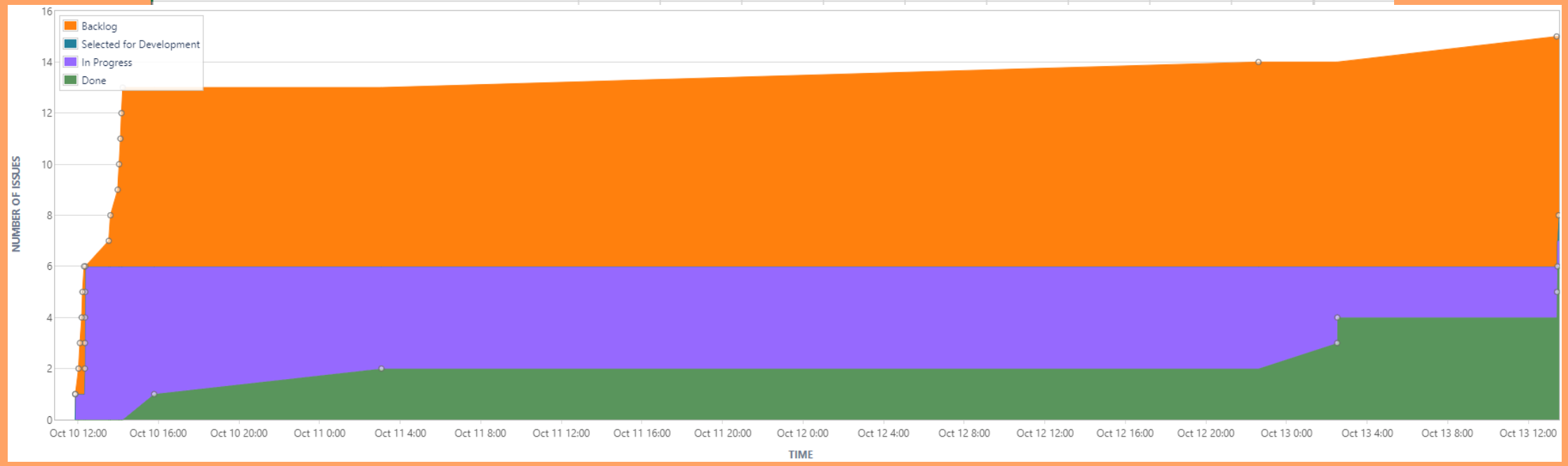
```
In [35]: print(arr.info())
                 # Rows:            64
                 # Samples:         64
                 # Bands:          224
                 Data format:   float32

In [36]: arr.shape
Out[36]: (64, 64, 224)
```

The sample Data provided has been loaded into python and has been tested on information on the data, which can be accessed. Although, Information of the image can be extracted , the output could not open the image and the exploration plotting the data was not explored. These processes will be explored in following developments. Further study on Matplotlib will be made to plot the data sets.

# Project Management – Atlassian JIRA

| Summary | Issue key | Issue id | Issue Type | Status | Project ke | Project na | Project ty | Project le | Custom fi | Priority |
|---|---|---|---|---|---|---|---|---|---|---|
| Risk register | D301007-4 | 154233 | Task | Done | D301007 | 23-24_CE3 | software | sg21642 | | Highest |
| Gantt chart | D301007-3 | 154231 | Task | Done | D301007 | 23-24_CE3 | software | sg21642 | | High |
| Getting Images into spectral python | D301007-6 | 154238 | Task | In Progres | D301007 | 23-24_CE3 | software | sg21642 | | High |
| Presentation | D301007-5 | 154235 | Task | In Progres | D301007 | 23-24_CE3 | software | sg21642 | | High |
| Project Outline | D301007-2 | 154225 | Task | In Progres | D301007 | 23-24_CE3 | software | sg21642 | | High |
| Hyperspectral imager Operations and connectivity | D301007-7 | 154262 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | Sprint1 | Highest |
| Record data of the fruits using Hyperspectral Imager | D301007-8 | 154267 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | sprint2 | Highest |
| Evaluate on different environments with the image | D301007-1 | 155034 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | Sprint7 | High |
| Project Report and presentation | D301007-1 | 154323 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | Sprint8 | High |
| Winter Research | D301007-1 | 154320 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | sprint5 | High |
| Export images into spectral python | D301007-9 | 154317 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | Sprint3 | High |
| Analysis1 | D301007-1 | 154319 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | Sprint4 | High |
| Analysis2 | D301007-1 | 154321 | Epic | Backlog | D301007 | 23-24_CE3 | software | sg21642 | sprints6 | High |
| Challenge week deliverable | D301007-1 | 154214 | Epic | In Progres | D301007 | 23-24_CE3 | software | sg21642 | Sprint0 | High |



# Key areas to learn!

- Improve on Spectral python skills
- Do more research on spectral data e.g., graphs and mapping technologies
- Refresh the Imagers user manual again.
- Start a logbook.
- Read on Matplotlib in order to plot the hyperspectral data which is exported into python using spectral python packages.

# Thank You;