IDENTIFYING RIPPEN AND ROTTEN FRUITS USING HYPERSPECTRAL IMAGER

Interim Oral

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PROJECT

- Fruits undergo subtle colour changes as they ripen, which may be challenging for the human eye or regular cameras to detect.
- The project uses a hyperspectral camera (SPACIM FX10e) that can record in 200+ bands, making colour variations during ripening more noticeable.
- The plan is to capture imagery of fruits at different ripening stages using the hyperspectral camera.
- The collected dataset serves as the basis for understanding the spectrum of colours associated with fruit ripening.
- Machine learning techniques will be applied to the dataset to assess fruit ripeness by analyzing the observed color changes.
- The project aims to enhance the accuracy of ripeness assessment by leveraging the hyperspectral camera's ability to capture a wide range of wavelengths.

PROJECT OUTLINE

- Global population growth in the last decade has led to increased demand for resources, especially food supply.
- Governments, including the UK, are focusing on sustainable solutions, as outlined in the Future of Food and Farming report.
- Key goals involve using science and technology to sustain food production and reduce wastage.
- A project is underway to identify ripened and rotten fruits using the Hyperspectral Imager (Specim fx10e).
- The spectral imager provides spectral information across the electromagnetic spectrum, enabling early detection of fruit lifespan and reducing food wastage.
- Governments support for spectral imaging advancements in agriculture is driving high demand for such projects.
- Examples, like Adelaide University's use of hyperspectral imagery in South Australia, showcase benefits in mapping grape varieties and improving yields.
- The project focuses on avocados and kiwi, examining environmental factors that may affect the hyperspectral imager's performance.
- The ultimate goal is to determine the best conditions, including ambient factors and temperature, for the effective use of hyperspectral imaging in identifying fruit consequences.

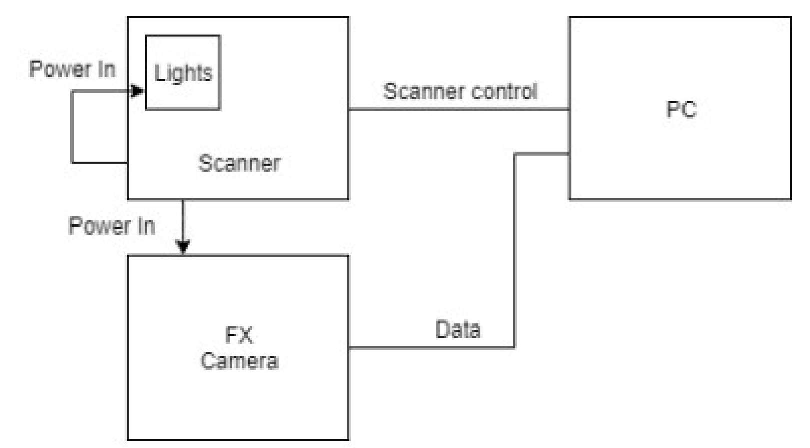
SOFTWARE INTEGRATION

- **Creation of Virtual environment:** Provides isolation for project-specific dependencies, ensuring a clean and secure environment. Guards against conflicts with the main system's packages.
- **Required Software and Libraries:**
    1. Python 3.3 -> spectral python requires python 3 for the function to work.
    2. NumPy
    3. PIL/pillow -> to display and save spectral images.
    4. matplotlib -> to plot graphs of the spectral data.
    5. Jupyter Notebook -> to do interactive computing by using a inbuilt GUI.
- **Windows Subsystem for Linux (WSL):**
    1. WSL allows using a Linux terminal on a Windows machine.
    2. **Why WSL?** Efficient programming on Linux for spectral data, enhancing compatibility with tools and libraries designed for Linux environments.
    3. Enables seamless integration of Windows and Linux environments.
- **Project Specifics:**
    1. Project involves using a spectral imager Specim fx10e.
    2. Requires SDK or pre-installed software on Windows.
    3. Utilizes WSL for efficient programming on spectral data.
    4. Mix of two operating systems for enhanced capabilities.

SPACIM FX10e IMAGER

IMAGER OPERATION

- Using Fx10e, Developed by Specim, Spectral Imaging Ltd.
- Spectral imager records up to 200+ bands of information across a range of spectrums.
- Imager can be controlled either by Lumo Scanner or specimSDK (c-based) tools.
- The imager can record a maximum of 1312 x 1082 with halogen, sunlight and LED spectrums.
- **The Imager records data by establishing a connectivity between a pc and the imager through ethernet.**
- **The LUMO scanner software has three interfaces:**
    1. **Setup → configures the imager and set preference on the data**
    2. **Adjust → the viewing format so the user can adjust the data**
    3. **Capture →Export data to the PC**
- The exported data are in ENVI format for the spectral python analysis.



IMAGER ACCESS ISSUE

1. Chapter 2 (Imager operation) and Chapter 3 (Recording data) has been interrupted.
2. The Specim fx10e imager has been hidden in a lab, where access is required.
3. The risk assessment has been completed to gain access to the imager.
    - The university has decided to go against the risk assessment and decided further strict measures must be in place. E.g. wearing a lab coat.
4. This results in delays in access to the imager and a modification to the project until the access to the imager.
5. The plan changed to use a Pre-Recorded data set from the University of Tübingen during Chapter 4 (Analysis 1).
    - Analysis 1 has been modified to include implementing an animation of the recorded data
    - The given data is in low resolution by the pixel size of the image.
    - Experiments are conducted using the mango data (64,64).
    - The Higher spectral resolution allows for more detailed and accurate identification of materials based on their unique spectral signatures resulting in the given data being less efficient.
6. Image operation and connectivity has been pushed back to further date to gain access.

Gantt Chart

Identifying Ripen fruits using Hyperspectral imager

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

Week: 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

- REGULAR TIME LINE
- INTERRUPTED
- EXTENDED
- PUSH BACK

PROJECT OBJECTIVES

	STILL UNDER DEVELOPMENT
	ACHIVED

- 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.
- Analyse and identify ripened and rotten fruits from the prerecorded data sets using Spectral Python.
- Conduct Machine learning algorithm analysis of the spectral Data to identify ripeness in fruits.
- Evaluate the Imager system on whether the amount or colour of ambient lighting or the resolution has a significant effect on the captured wavelength and set guidelines for how the imager is best used for data capture.

EXPORTING IMAGER DATA TO Spy

- The spectral data is exported into spectral python using the envi call.
- ENVI stands for “Environment for Visualizing Images”, a common file format for image processing of spectral data
    1. The spectral data are in envi format and include two files:
        - Header file (.hdr) -> metadata which contains definitions of the image
        - Binary file (.bin) -> contains the pixels values as binaries
- Clear pathways of these files are provided to the program which envi opens and loads the image into an array object.
- Spectral libraries are used.

K-means CLUSTERING

- Python uses matplotlib to plot per pixel spectral.
- The information plotted using matplotlib are cluster of wavelengths for a specific region of the image.
- Image regions are specified by defining a pixel and extending the region:
- The cluster of wavelengths is processed through K-Means
- **K-means is an algorithm used in machine learning data analysis.**
  1. **It is initialised with the number of cluster to identify data**
  2. **Figures out groups of clusters and assigns each cluster to the nearest centroid, which is the mean value**
  3. **Returns the centroid.**
- The returned data is then plotted using matplotlib with y = reflectance and x =wavelength.clusters

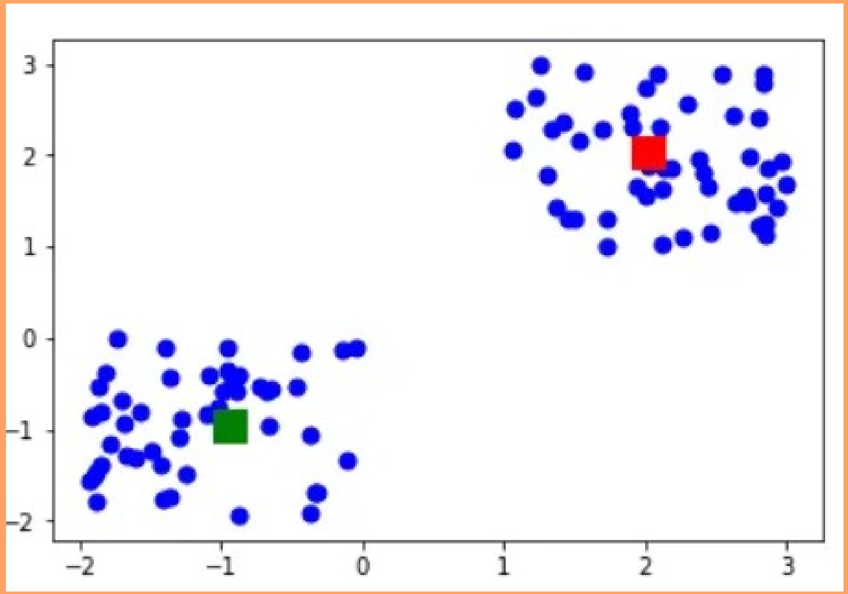


Figure 1: K-means clustering [1]

[1] Author(s): A. Sachan Title: "Understanding K-means Clustering in Machine Learning"
URL: https://towardsdatascience.com/understanding-k-means-clustering-in-machine-learning-6a6e67336aa1

SPECTRAL ANIMATION (MANGO)

The spectral data for each day must be plotted and studied. It is agreed that a certain animation in the format of GIF should be created to study the difference in daily data. First, the day plotted is specific to a region of the image as it would avoid deviation in images. The GIF is created with the matplotlib animation framework and saved a GIF using Pillow.

Mango Front data

Mango Back data

OBSERVATION OF DATA

- The observation made after the animation is that the reflectance level goes down of the wavelength. This is due to the fruit becoming more ripe day by day.
- The general structure of the data wavelength remains the same throughout the program.

Accuracy:

- Although this graph-based animation made a positive reading of the expected data, there could be more accurate and finite tests can be implemented.
- The test data of the mangos are 64 x 64 pixels, which are very low in resolution.
- As mentioned earlier Higher spectral resolution allows for more detailed and accurate identification of spectra.
- The mango data analysis is an earlier experiment and in analysis 2 it will be shifted to avocado data.
- Once the imager access issue is solved, the own recorded data used will be in high resolution.

FUTURE

Winter Research:

1. Research on SIFT on OpenCV to match image regions to avoid a deviation of the image.
2. Research on certain methods of machine learning to begin analysis 2.
3. Get comfortable with the matplotlib and algorithms which is used in analysis 1.
4. Chase down imager access to issue to gain.

Overall

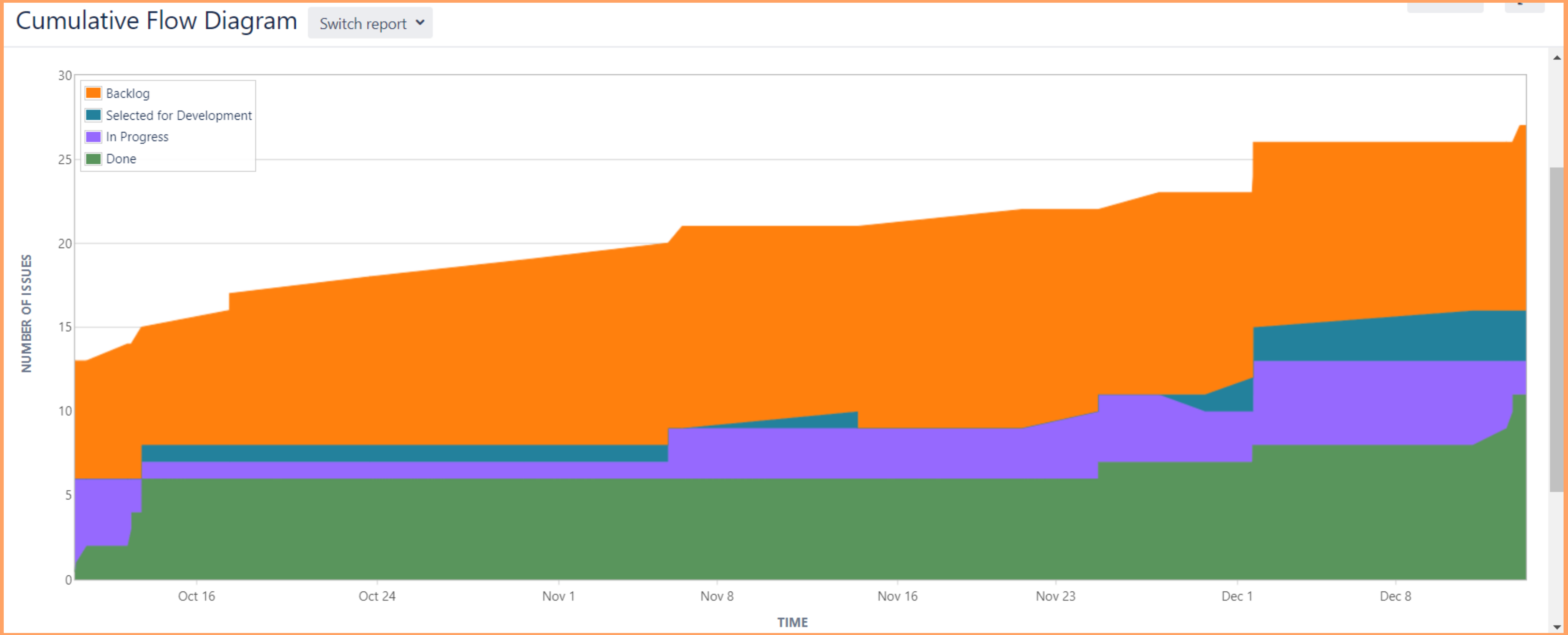
5. Change analysis to avocado data as it is a harder fruit to measure ripeness by visualising.
6. Record my data in a higher resolution.
7. Perform machine learning analysis in analysis 2.

PROJECT MANAGEMENT – Atlassian JIRA

The project management in Jira is divided into a two-level hierarchy:

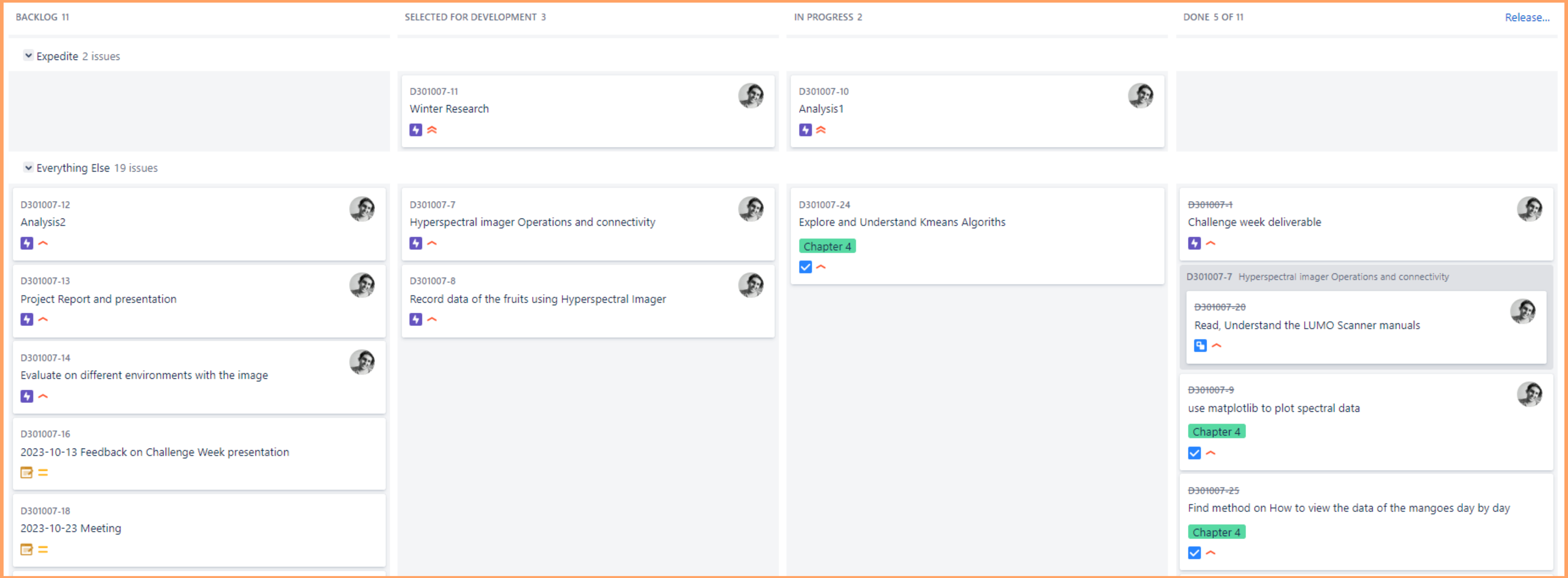
1. Epics, which are divided into chapters ranging from 1-8.
2. Each Epic contains tasks that will be conducted

The chapters ranges from image operation, recording data, analysis 1, winter research, analysis 2 and evaluation.



Summary	Issue key	Issue id	Parent id	Issue Type	Status	Project na	Project typ	Project lea	Priority	Resolution	Custom fie
Winter Res	D301007-1	154320		Epic	Selected fc	23-24_CE3	software	sg21642	Highest		Chapter 5
Project Re	D301007-1	154323		Epic	Backlog	23-24_CE3	software	sg21642	High		Chapter 8
Evaluate o	D301007-1	155034		Epic	Backlog	23-24_CE3	software	sg21642	High		Chapter 7
Analysis2	D301007-1	154321		Epic	Backlog	23-24_CE3	software	sg21642	High		Chapter 6
Analysis1	D301007-1	154319		Epic	In Progress	23-24_CE3	software	sg21642	Highest		Chapter 4
Record dat	D301007-8	154267		Epic	Selected fc	23-24_CE3	software	sg21642	High		Chapter 3
Hyperspec	D301007-7	154262		Epic	Selected fc	23-24_CE3	software	sg21642	High		Chapter 2
Challenge	D301007-1	154214		Epic	Done	23-24_CE3	software	sg21642	High	Done	Chapter 1
Project Ou	D301007-2	154225		Task	Done	23-24_CE3	software	sg21642	High	Done	
Backgroun	D301007-1	155323		Task	Done	23-24_CE3	software	sg21642	Medium	Done	
Presentati	D301007-5	154235		Task	Done	23-24_CE3	software	sg21642	High	Done	
Gantt char	D301007-3	154231		Task	Done	23-24_CE3	software	sg21642	High	Done	
Risk regist	D301007-4	154233		Task	Done	23-24_CE3	software	sg21642	Highest	Done	
Find meth	D301007-2	160742		Task	Done	23-24_CE3	software	sg21642	High	Done	
software i	D301007-2	160743		Task	Done	23-24_CE3	software	sg21642	High	Done	
Getting Im	D301007-6	154238		Task	Done	23-24_CE3	software	sg21642	High	Done	
use matplc	D301007-9	154317		Task	Done	23-24_CE3	software	sg21642	High	Done	Sprint3
Explore an	D301007-2	160741		Task	In Progress	23-24_CE3	software	sg21642	High		
Read, Und	D301007-2	158068	154262	Sub-task	Done	23-24_CE3	software	sg21642	High	Done	
2023-11-2	D301007-2	159937		Supervisor	Open	23-24_CE3	software	sg21642	Medium		
2023-11-2	D301007-2	159392		Supervisor	Open	23-24_CE3	software	sg21642	Medium		

KANBAN BOARD



GitLab

The Git lab contains all the resources of the implementation of project till date and documentation. These include:

1. Download instructions for the Pre-recorded data sets
2. Installation of the software tools
3. Experiments in spectral python
4. Documentations
5. Image and graph generated
6. Python program files Include animation of the mango files.

THANK YOU!