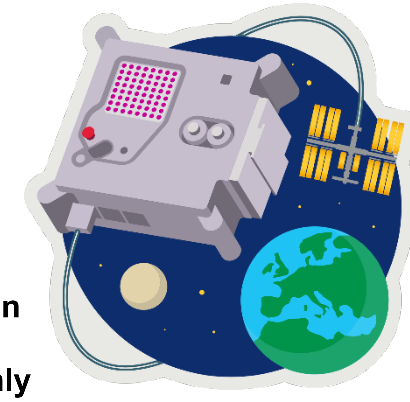
Team Name: Team PLANeTS

Chosen Theme: Life On Earth

Our Idea: **Using NDVI Analysis to Calculate Land Area, Plant Coverage & Health to Predict Vegetation Change Using Previous Historical Imaging – While Displaying the Data Gathered in a Highly Interactive UI**

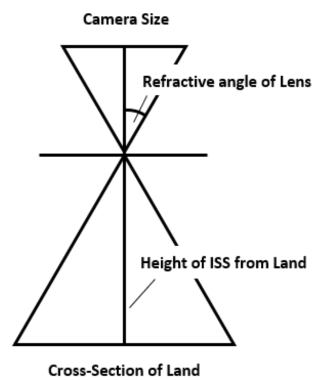


Introduction

In our experiment we utilise the Raspberry Pi's Near Infrared "Noir" Camera alongside the Normalized Difference Vegetation Index (NDVI) to quantify current vegetation (land area) and compare it with historical data. Our aim is to combine two existing datasets to train an auto-regressive model that can predict future changes in both plant coverage and health. We will take images in set intervals so when plotted on our interactive UI we can properly communicate how the measured vegetation varies with location.

Calculating Land Area

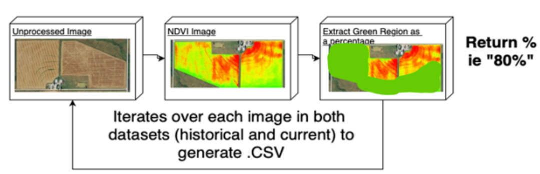
Calculating the total land area within the image that gets taken by the camera will allows us to decide how much of the land is covered in vegetation. We would first need to approximate the total photographed area within the image by using trigonometric functions – alongside data on the height of the ISS - and then divide this area between the total number of pixels found in the image. This method can is shown on the diagram to the right, where the angle of the lens and the height of the lens above the ground is used to work out the cross-sectional coverage area.



After finding the area covered by one pixel, we would need to determine the number of pixels that represent the land mass within the image by finding the coastline or edge between land and water. Edges are characterized by sudden changes in pixel intensity. To detect edges, we need look for such changes in the neighbouring pixels using software such as Sobel Edge Detection. We can find the edges (contours) of a land mass to count the number of pixels within that area and to scale our initial pixel area value by.

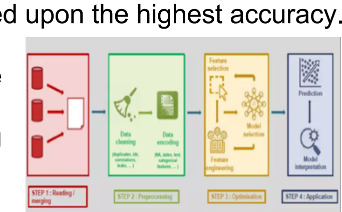
Predicting Vegetation Change Using Current and Historical Imaging

Note: since we would be using a regressive algorithm over a classification algorithm the data needs to be numerical double values. These would be calculated by taking a NDVI image and extracting number of green pixels à calculating this as a percentage of the whole image.



Employing the $PyCaret$ library to train the model using default hyperparameters to ensure minimum parameter tuning later on in the training process. We should evaluate the performance metrics using cross-validation returning the trained model object. For the regression we can blend: $MAE, MSE, RMSE, R2, RMSLE, MAPE$ (Scikit Learn) and select the model based upon the highest accuracy.

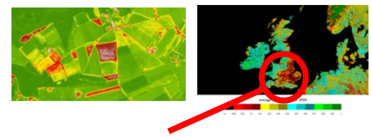
The diagram shows the steps involved in gathering the data where reading/merging is the combination of the historical and measured datasets, pre-processing is cleaning up the CSV file, optimization is the model building and the application is the prediction in the GUI as explored below.



Etymology of Team Name: PLANeTS → Planets + Plants

Calculating Plant Coverage and Health

To calculate Plant Coverage and Health we will employ NDVI (Normalised Vegetation Index). For this to work we notice how green plants contain chlorophyl stored in the chloroplasts. Green plants (not plants like Acers) don't handle infrared radiation (heat) well and aim to reflect as much as possible but unhealthy plants absorb it. A contemporary 8 mega-pixel camera with Sony IMX219 sensor (Noir Camera) can detect many types of light including IR which utilises the red optical filter allowing us to measure IR reflected and in turn measure plant health / coverage.

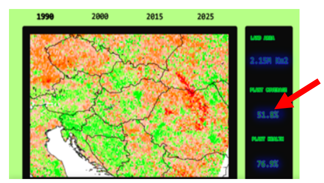


An NDVI image in an urban area has less vegetation (shown by the darkened regions), we hope to extract similar RAW data from the RPI (as this is what matches historical data)

Displaying the Data

We noticed that one of the largest issues with current experiments was a difficulty interpreting the raw data. To solve this, we hope to create a GUI that shows the collected data (historical, modern and predicted) with various statistics in a friendly and manageable UI. We have prototyped this in python (PyGame) and have provided a video/screenshots alongside the project demonstrating how it works.

The green line representing the flight path and the yellow points show the datapoints collected which when clicked expand into a detailed view.
When you hover over each yellow dot a thumbnail view appears.



In the GUI, we have the land area, plant coverage & plant health as a percentage.

In this GUI you have access to all the data points taken by the AstroPi. On clicking, the user can access a dataset, specific to that location, including the land area, plant coverage & plant health and as you click each year the image of the NDVI which changes and 2025 shows the predicted statistics.

You can see a video walkthrough here: https://www.youtube.com/watch?v=pVnqQIVK6lk
You can find the source code here (including NDVI proof-of-concept): Github

How Will We Use the AstroPi?

Various components will be utilised with our idea. The Near Infrared "Noir" Camera will be used to collate pictures of the Earth at numerous locations along the orbit to then apply NDVI analysis in order to calculate land area, as well as plant health. The plant health from this orbit can be combined with historic, modern and current data to suggest a predicted outcome in the future. The element of prediction that we aim to include would require aspects of machine learning to produce a sensible prediction; the auto-regressive model can be combined with the Coral USB accelerator to provide a more accurate and sensible prediction for future plant health, improving the validity of our results. Due to the limited storage (3GB) available on the AstroPi, to meet this requirement we will reduce the number of pictures that are taken by programmatically recognising when the orbit passes over ocean or in dark regions opposite the sun. In this way, more useful images for NDVI analysis are used, effectively using the storage capacity and gathering useful data rather than processing unwanted images. The Camera will be set to photograph the Earth at certain time intervals – which would be determined later to allow for a plentiful amount of data while not exceeding the 3GB storage limit.

Bibliography:
https://projects.raspberrypi.org/en/projects/astropi-ndvi/1 - RPI NDVI
https://learnopencv.com/edge-detection-using-opencv/ - Open CV – edge detection

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