Mission Space Lab Phase 4 Report

Team Name: **Reforesting Entrepreneurs**

Chosen theme: Life on Earth

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Introduction

Every year we destroy around 15.3 billion trees worldwide. Deforestation is a tremendous problem for the human population as it is a major contributor to the loss of biodiversity and soil across the world. Global warming is further enhanced and, with the removal of transpiration as a source of rain, local climates are severely altered with extreme temperatures and a lack of precipitation.

According to a study completed in Zurich's ETH University [1] if we reforest a surface area the size of the USA we could mitigate the climate issue, as well as the regulation of regional climates, make a home to thousands of species and capture CO_2 in the atmosphere.

Favourably, there is a growing global concern over this issue that is turning the table with different organisations, agencies, NGO's and governments starting to invest in massive reforestation plans. A major concern these groups are facing is finding locations suitable for planting.

Our team has consequently decided to focus on this topic: search for potential locations that can be reforested using Astro Pi Izzy's camera in the ISS with further satellite data to obtain results in almost real-time.

Method

Several studies show that the four main variables that affect if an area is eligible or not to reforest include soil moisture, elevation, slopes and chlorophyll concentration [2-3].

To tag an area as potential, our program verifies *in the ISS* that the calculated averages of these four variables are all within acceptable limits (Figure 1):

1. NDVI (Normalized Difference Vegetation Index. NIR-Red/NIR+Red): between 0 and 0.4 units. Inferior values correspond to water, snow and clouds. Superior values correspond to areas already concentrated in chlorophyll (i.e. forests), that don't require afforestation efforts [4].
2. Soil moisture: above 12.5%, an ideal quantity for loam soil [5] plant growth [6].
3. Height: between 0 and 3500 metres [2].
4. Slopes: below 19.4% [7].

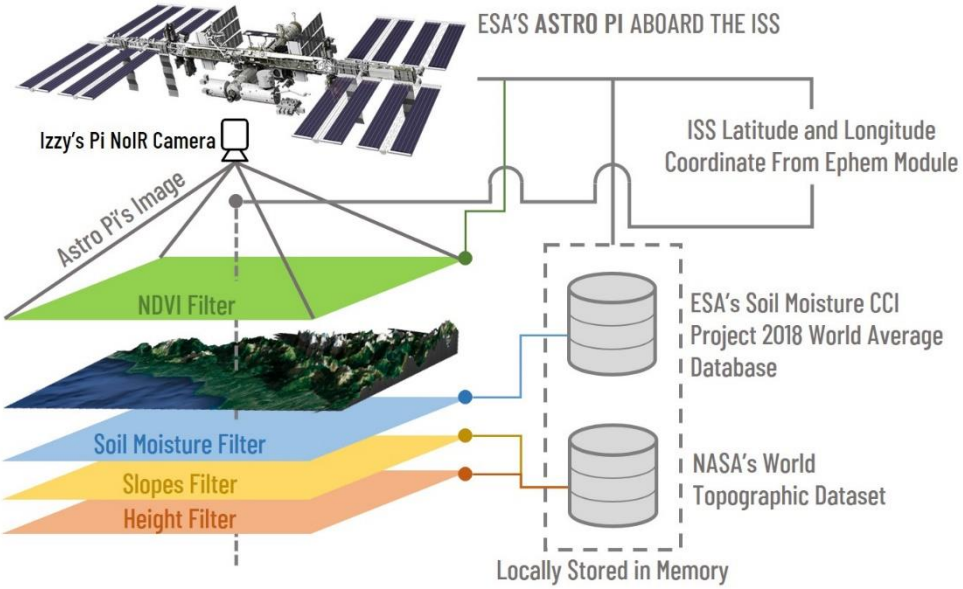

Figure 1: Graphical Representation of Code Operation

Night-time photos are rejected. The latitude and longitude coordinates are obtained when taking a photo. The average NDVI value is determined with image processing techniques. Average soil moisture is calculated by fetching an array of 11×11 soil moisture values from ESA's database [8] (procedure shown in Figure 2). Similarly, average height and slopes are calculated using NASA's Topographic Dataset [9].

Non-night photos are stored along with results (in a .csv) of this *real-time-in-situ* processing, improving the efficiency of the experiment. However, the short 3-hour data collection window along with Izzy's processing speed proved to be performance-limiting factors.

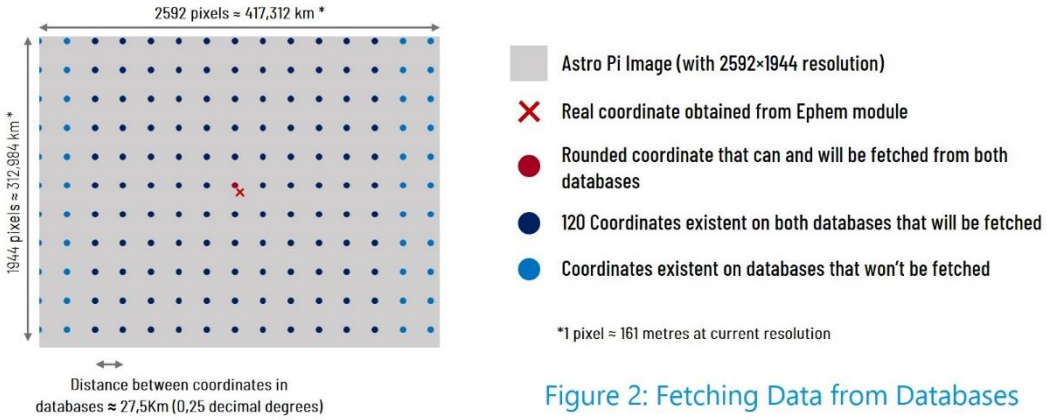

Figure 2: Fetching Data from Databases

Results

During the 161-minute running time, the code managed to produce 63 images (Figure 3), of which 36 were automatically discarded as night-time photos (shown in red). From the 27 non-night photos, 19 were caught at sea (some of which had caught islands) (shown in blue). Three images were mistakenly classified as night, due to reflected light (shown in yellow) and another two images were completely covered in clouds (also shown in yellow). One of the two remaining photos resulted positively, being flagged as potential (shown in green)!

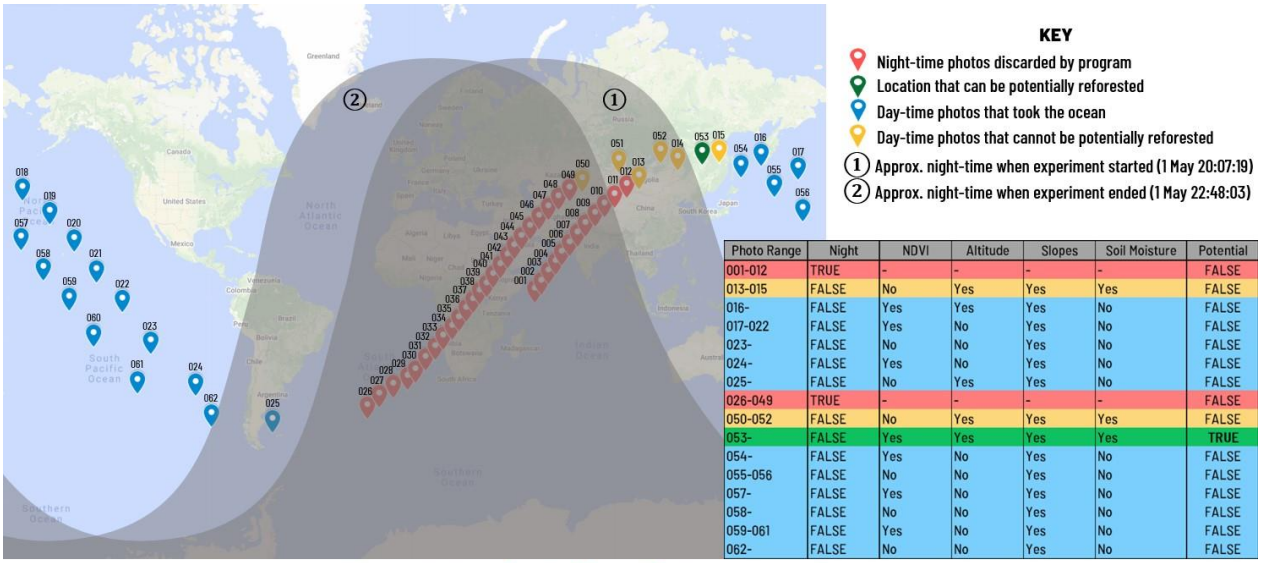

Photo Range	Night	NDVI	Altitude	Slopes	Soil Moisture	Potential
001-012	TRUE	-	-	-	-	FALSE
013-015	FALSE	No	Yes	Yes	Yes	FALSE
016-	FALSE	Yes	Yes	Yes	No	FALSE
017-022	FALSE	Yes	No	Yes	No	FALSE
023-	FALSE	No	No	Yes	No	FALSE
024-	FALSE	Yes	No	Yes	No	FALSE
025-	FALSE	No	Yes	Yes	No	FALSE
026-049	TRUE	-	-	-	-	FALSE
050-052	FALSE	No	Yes	Yes	Yes	FALSE
053-	FALSE	Yes	Yes	Yes	Yes	TRUE
054-	FALSE	Yes	No	Yes	No	FALSE
055-056	FALSE	No	No	Yes	No	FALSE
057-	FALSE	Yes	No	Yes	No	FALSE
058-	FALSE	No	No	Yes	No	FALSE
059-061	FALSE	Yes	No	Yes	No	FALSE
062-	FALSE	No	No	Yes	No	FALSE

Figure 3: Results Table With Corresponding Map

We can observe from the table that the variable *slopes* have produced a "Yes" acknowledgement in every non-night photo. This data may be biased as a consequence of low resolution in the local databases stored in Izzy's memory, as the distance between coordinates is large (as seen in Figure 2) when compared to the changes in altitude between those coordinates.

The "Yes" *altitude* acknowledgement in images that correspond to sea (such as image 016 and image 025) were discovered to be caused by islands.

From the unlucky orbit (as seen on Figure 3), with most of the photos taken at night or at sea, we have obtained a place (image 053) in Siberia (50.908, 128.533) that may be reforested.

The location happens to have an average NDVI value of 0.01 units, an average height of 204 metres with a mean slope of 0.1% and an average soil moisture of 27.2%. All conditions have been met!

These results prove that the experiment has worked: real-time detection of locations that can be reforested is possible.

The complete results table is found at this link: https://github.com/NeoStellarator/Reforesting-Entrepreneurs

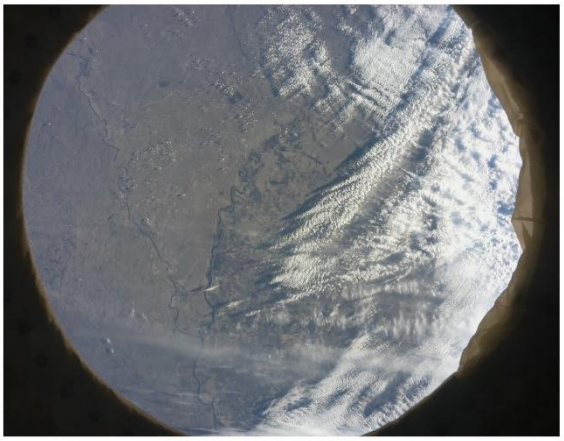

Figure 4: Image 053 (50.908, 128.53325)

Conclusion

Our code has been a success. It has managed to discard night-time photos and distinguish ocean and cloud-covered images in our unfortunate orbit. More importantly, we have successfully discriminated a location that can be reforested from four variables!

The next step would be to do a ground survey of this location aiming to verify whether the locations flagged by this code really are suitable for reforestation.

This experiment suggests that it is possible to handle existing satellite imagery and data to identify locations that can be reforested in real-time.

The main limiting factors in the project are the limited number of samples possible in each orbit and the inability to identify unsuitable slopes. The first can be easily remedied by accumulating data over multiple orbits using faster computational devices. The second could be solved by using a higher-resolution (and therefore larger memory occupying) database in which the distance between data points is minimal.

Our aspiration is to have an automated system producing a map of the globe, where each pixel is colour coded to indicate its suitability for reforestation in today's climate, as a tool to help prevent further climate change.

References

[1] The global tree restoration potential. 10.1126/science.aax0848.
[2] Land Area Eligible for Afforestation and Reforestation. 10.1007/s11027-007-9087-4.
[3] Identifying priority areas for reforestation… 5. 10.1504/IJGW.2013.053486.
[4] Earth Observing System Home. Retrieved from https://eos.com/ndvi/
[5] Lockhart & Wiseman's Crop Husbandry Including Grassland (Ninth Edition), 2014
[6] "What Is My Target Moisture Level?" https://url2.cl/qjnlw .
[7] Research Gate: Relationship between Topographic Variables…
[8] ESA CCI SM project: https://www.esa-soilmoisture-cci.org/node/236.
[9] NASA Topographic Dataset: https://url2.cl/29Zf5