Mission Space Lab Phase 4 Report

Team name: AstroNCS

Chosen theme: Life on Earth

Organisation name: Newham Collegiate Sixth Form Centre(The NCS)

Country: United Kingdom

Introduction

Deforestation is an increasing issue in the modern world, where the rate of tree loss annually is 26 million hectares. This negatively impacts existing major global issues like climate change, where the lack of trees decreases the amount of carbon dioxide that is absorbed which therefore contributes towards the greenhouse effect.

And despite this huge loss, there is still potential to move to a sustainable future, one way being reforestation. One of the first steps towards this goal is to identify suitable areas. This involves considering various factors before a location is declared. For example, current human land use and whether the land can support forests.

We found the HQ camera module with an infrared filter, on the Astro Pi, was suitable to capture images. NDVI (Normalised Difference Vegetation Index) is a technique to identify the density of vegetation via photographs. This works because healthy vegetation absorbs mainly blue and red light which leaves only green and infrared light to be reflected. By analysing the ratio between infrared and blue light, we can accurately determine the density of vegetation of a region. The data provided would allow us to find deforested areas which already has an appropriate amount of vegetation to support forestation.

Method

In our code, we had intended to use the HQ camera to take pictures, about every 15 seconds and then logging the Earth coordinates and time onto a .csv file. Pictures were meant to be taken with the maximum resolution of 4056x3020 pixels and saved in a folder called Images.

We calculated that the 2GB storage space may not be sufficient for the flight time. So in order to conserve storage space, we needed the AstroPi to check whether the images coordinates were in day or night before capturing the image. To achieve this, we utilised the Skyfield library to check whether the sunlight was visible on the area of the image. If there was no sunlight visible, an image would not be taken.

Experiment results

Unfortunately this year, we did not receive any results from our own AstroPi (ISS), due to a last minute error in the code. Subsequently, no images were taken during our flight time.

Thankfully the Astro Pi team allowed us to use images from a previous trial run in January 2022. From these images, we still managed to obtain a sample set of images and data.

For example, some of the images gathered were taken near the Amazon rainforest in Bolivia, South America. (Figure 1, left) We first converted the raw images into ones that show the NDVI distribution using a python script. (Figure 1, middle)

Once that had been done, we wrote a python script that ran through every pixel of the images which identified areas of NDVI within a specific threshold. It also checked the RGB colour values to prevent analysing clouds or water bodies. The areas identified by this algorithm were flagged with the colour red in the images. (Figure 1, right)

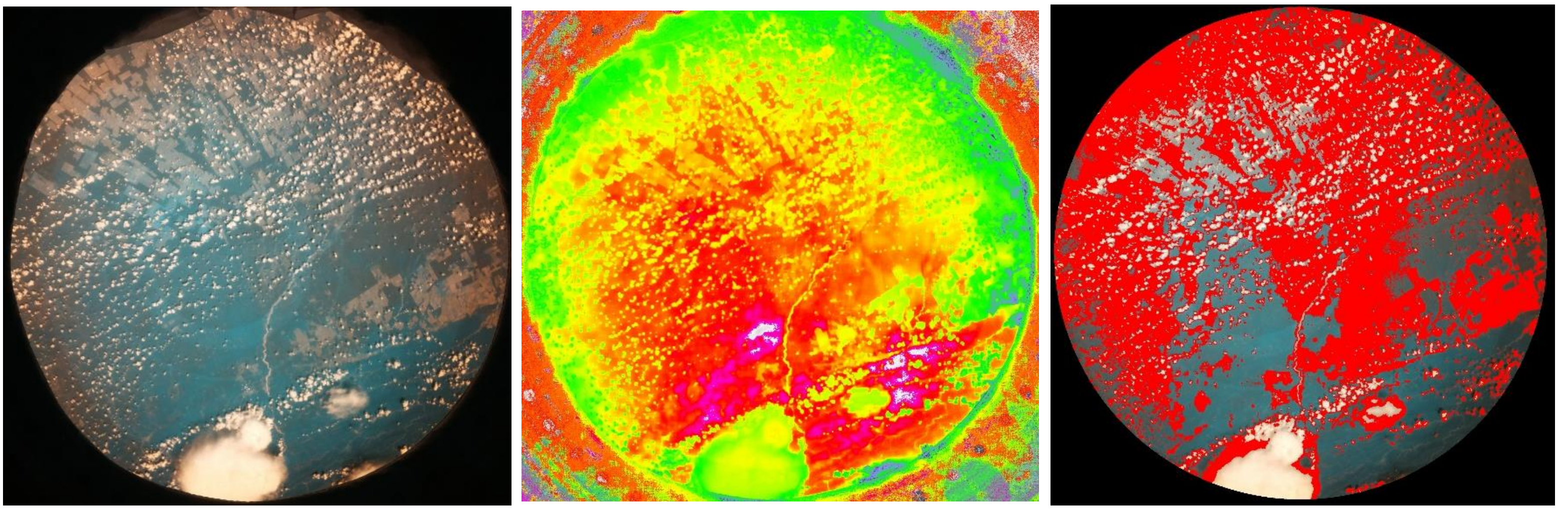

Figure 1. Original picture in Amazon (left), NDVI filter applied (middle), Highlighted red areas for deforestation (right)

The middle image shows a coloured greyscale for NDVI within the image where red shows an area with a high NDVI. The image on the right is the raw image with the only difference being that red pixels show areas of low NDVI (fewer trees).

Finally, we had another script to check these red areas in images and relate them to real coordinates (Process explained on our GitHub). This utilised sampling the area covered by a single pixel, using the ground sampling distance method (Figure 2), and bearings to relate a single pixel to its real world coordinates.

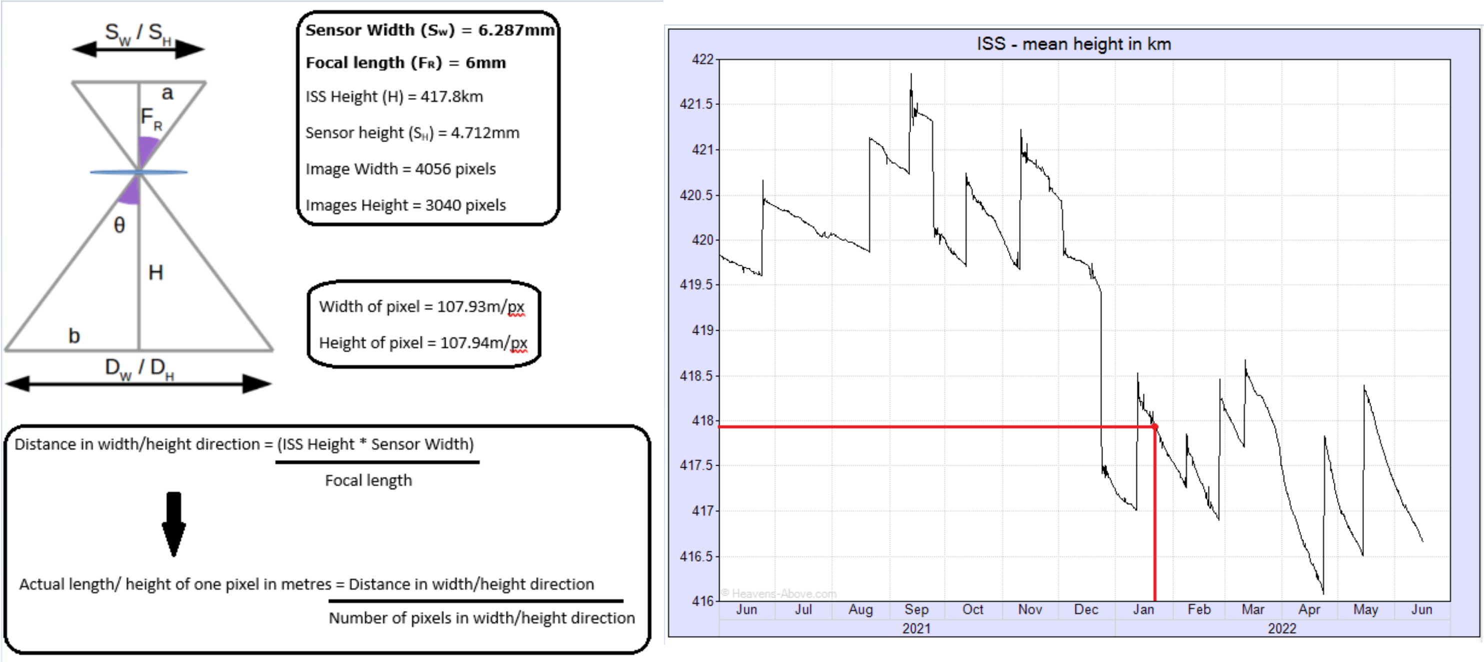

Figure 2. Ground sampling distance method (left), ISS mean height for Jan 2022 from www.heavens-above.com (right)

After obtaining its coordinates, we used data from https://lcviewer.vito.be/, which checked whether the area of each image pixel was in the Herbaceous vegetation layer (from lcviewer). This layer was used in particular because we had deemed it to have suitable conditions for forests. It had also allowed us to exclude showing areas which are being used for cropland or are built up areas. When a valid area is found, the red pixel would be replaced by a yellow pixel as shown below (Figure 3).

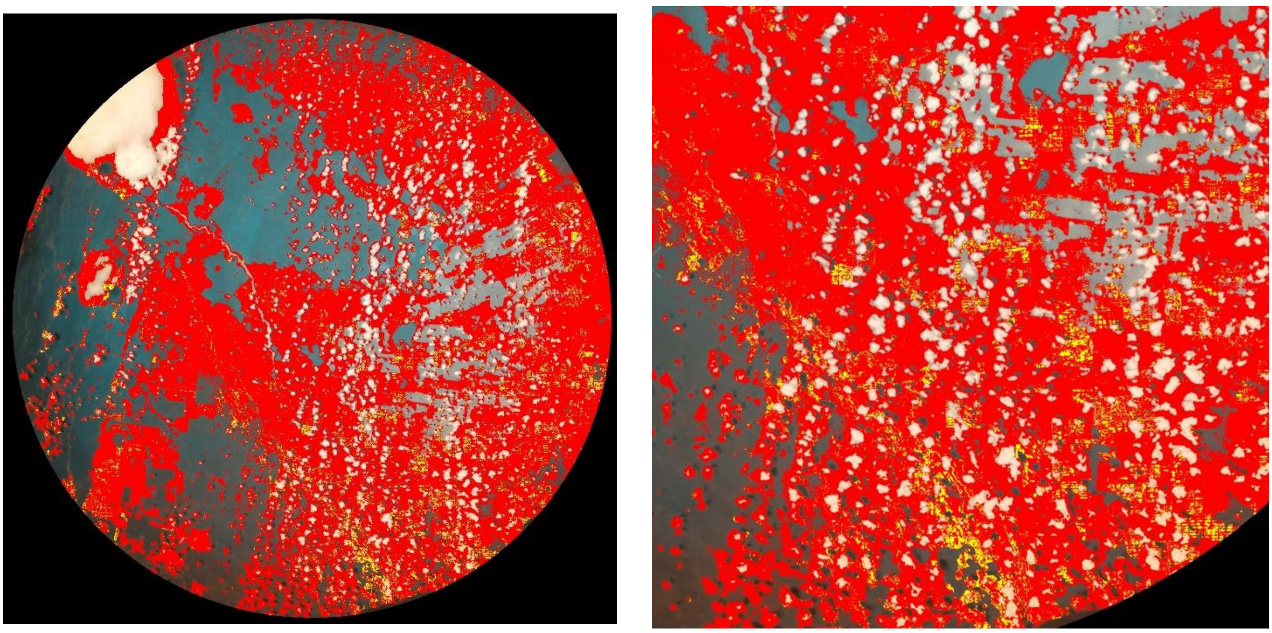

Figure 3. Original image with yellow pixels (left), Resultant image zoomed in (right)

Overall we found 10826612 pixels, where reforestation is likely possible, from a total of 39 images. This translates to ~125,000 km squared of land potentially suitable for reforestation.

Learnings

The data received from the sample images were unorganised image files with no sorted csv data files. Therefore, we had to sort the data and images into organised image files and a csv file with location data and time. This allowed for further analysis to occur.

In addition to this, in order to calculate the coordinates, the rotation of the images have to be aligned to the actual north of the earth for the map on external sources to match the coordinates. This process had to be done manually by estimating the angle difference between the north of the image and the actual north (earth) using Google Maps (Process explained on our GitHub). And then, we rotated the image using that angle difference. Next time, when collecting sensory data on the Astro Pi, the magnetometer may be used in order to obtain a more accurate angle of rotation to the north of the Earth.

Conclusion

Despite the misfortunes of the project, the striking performance of the HQ camera still managed to exceed our expectations, as deforested areas were very visible using NDVI. We also managed to achieve our goal of narrowing down possible suitable locations using various factors, such as human land use and terrain suitability.

The area measurements may have a sizeable margin of error as the method assumes the Earth's surface is flat. In addition to this, the manual technique of obtaining the rotation of the images and locating the centre point of image (the point where the Earth coordinates are, on the image) could also cause areas to be misidentified.

In addition to this, the singular areas identified may be very small individually so a scatter of pixels may also not lead to any feasible areas of reforestation in the region.

Finally, we would like to thank ESA and the Raspberry Pi Foundation for offering this wonderful opportunity, as well as the Space Wombats 2020 Astro Pi team (for publishing the ground sampling method in Figure 2, left), lcviewer.vito.be, and heavens-above.com for allowing the public use of their tools.

Also many thanks for our mentor, Dr Serena Maugeri, for mentoring us through this challenge.

The GitHub repository with more details on the code and images gathered, is at https://github.com/CREATORGAME19/AstroNCS