ESA Discovery and Preparation – OSIP

Campaign on Remote Sensing of Plastic Marine Litter

Artificial Intelligence and drones supporting the detection and mapping of floating aquatic plastic litter (AIDMAP)

D8 Executive Summary Report

Issue 2.0

Date 28 June 2022

Ref.: 2010374/Ekna/D8

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CONTRACT REPORT

The work described in this report was done under ESA contract.

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Acronyms

AI	Artificial Intelligence
AIDMAP	Artificial Intelligence and drones supporting the detection and mapping of floating aquatic plastic litter
N/A	Not Applicable
OSIP	Open Space Innovation Platform
ROI	Region of Interest

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1 Introduction

Plastic pollution is the most widespread problem affecting the blue planet. At least 8 million tons of plastic end up in our oceans every year. Waste plastic makes up 80% of all marine debris from surface waters to deep-sea sediments. Plastic has been detected on shorelines of all the continents, with more plastic materials found near popular tourist destinations and densely populated areas. Very few information is however available on the distribution, types, quantities and sources of marine plastic debris. Clearly, the lack of spatiotemporal information is unequivocally the largest source of uncertainties in global estimations of riverine plastic emissions into the oceans (Lebreton et al., 2017).

Remote sensing (RS) has the potential to complement the current lack in spatiotemporal information on plastic litter through detection and quantification of litter from image of fixed camera, drones and satellites. In the AIDMAP project, which is part of the ESA Discovery Campaign on Remote Sensing of Plastic Marine Litter, we leveraged Artificial Intelligence (AI) to detect litters in various environments by exploiting the use of high spatial resolution true colour RGB or multi-spectral (VIS-NIR) UAS imagery for potential validation and calibration of satellite datasets. RGB or multispectral drone sensors (compact and lightweight by design) are affordable hence easy to integrate on widely used drones compared to hyperspectral SWIR sensors (heavier due to design) requiring dedicated drones with large payload capabilities. One of the challenges to make such AI algorithms is preparing large quantity of training datasets to train a deep Neural Network. Therefore, there is a need to set up campaigns to gather training dataset for developing an AI application to detect litter.

In term of location for the data acquisition, the project focused on Vietnam and Belgium. Plastic waste is a very serious problem in Vietnam. Vietnam is estimated to be in the top five countries contributing to marine plastic pollution. On the beaches where garbage is regularly collected, plastic still floats significantly in the sea.

Figure 1: pictures of plastic waste taken in the Hau Loc district, Vietnam.

2 Campaigns to generate data

During the AIDMAP project we did several measurement campaigns to gather data for developing AI applications. Data was acquired from different sensors/platforms including

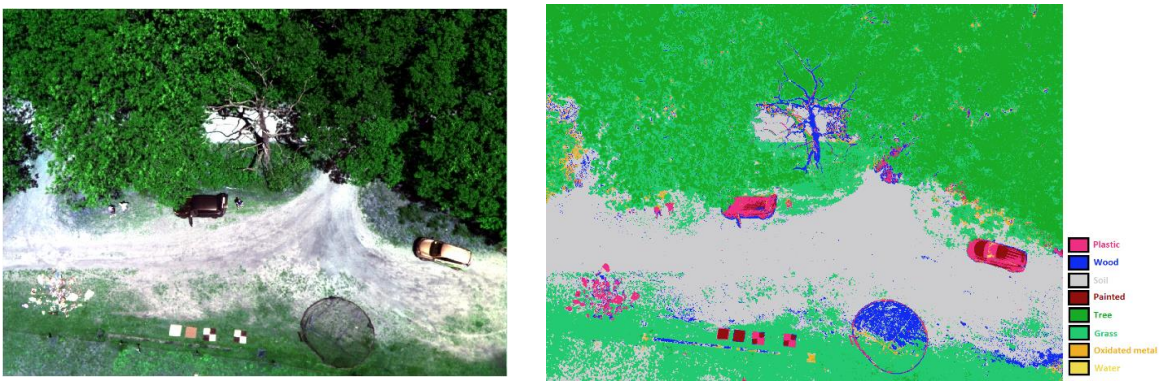
multispectral drone imagery, RGB drone imagery and RGB images from fixed cameras over canals. Data was acquired in Vietnam (two different sites near Hanoi) and Belgium. In Vietnam, we gathered additional satellite data over the same locations where we operated the drones, however, due to cloud cover, we couldn't have access to satellite imagery at the same time of drone acquisitions.

Generated dataset will be shared with the research community.

Figure 2: Artificial accumulations zone generated in Belgium and the drone used.

3 Results

Three AI algorithms have been developed for different conditions. For the first one, an artificial accumulation zone was created with real weathered plastics and wood (refer to bottom left in Figure 3a). The multispectral drone images were classified (Figure 3b) based on the spectral responses of different materials within the image using a random forest classifier. The classifier is able to detect the litter with an accuracy of over 90% to differentiate between wood and plastics within the accumulation zone.



a) RGB representation of the image b) Classification map

Fig. 3 RGB representation of a multispectral image (a) and the corresponding classification map (b).

In another case, RGB drone images from the Vietnam coastline were used. In the images, large accumulations of litter, containing plastics, rocks, vegetation and sand are clearly visible. Another AI algorithm was selected because less spectral information was available

than in the previous case. The ResNet50 model was applied to the data. This deep learning model is able to work with less data because it uses pre-trained models (called transfer learning). Figure 4 shows the results with red squares indicating the detected litter in the image with F-1 score of 92%. This algorithm is very useful to apply over coastlines to get an estimation of litter on the beach and preparing maps for clean-up activities. The approach is preferred when little spectral information is available.

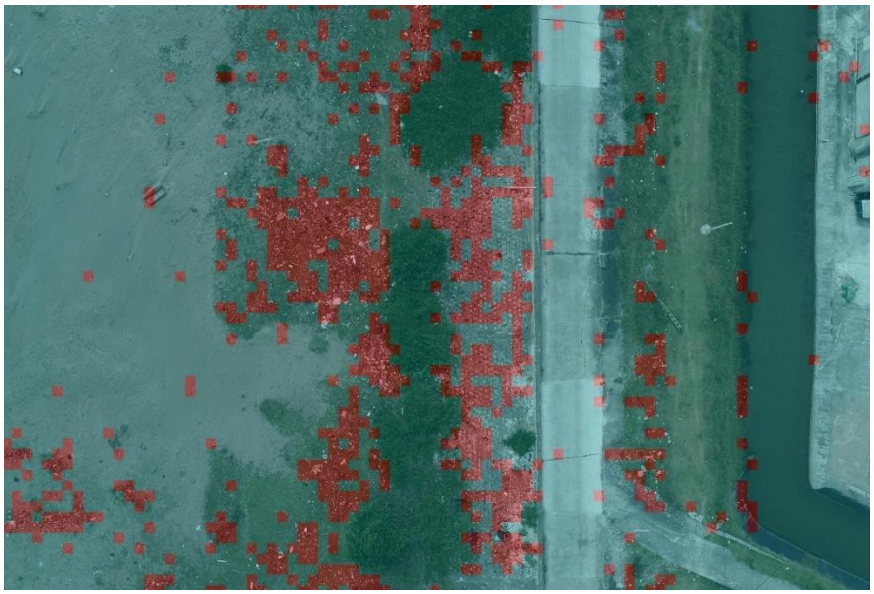


Figure 4. Detected accumulation zones in Vietnam coastline. Red masks show patches with detected litter in it.

We also focused on rivers and canals where single litter items can be detected from a fixed camera. Here, we applied another AI mode which focuses on object detection in homogeneous backgrounds named Faster-RCNN. We could obtain 91% for average precision of the model. Potential use case for this model would be the estimation of the amount of plastic pollution (floating macroplastics) from each river into the marine environment.

Figure 5. Individual litter detection from fixed cameras over a canal

4 References

Lebreton, L., Van Der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. Nature communications, 8(1), 1-10.