Detection of macroplastics in fluvial environment

PhD program in Civil and Environmental Engineering

Author: Irene Cortesi
Department of Civil and Environmental Engineering
Laboratory: GeCo Lab - Geomatics

Abstract: Plastic is the third world's most produced material by industry, but people recycle only 9% of it. The other parts are either burned or accumulated in landfills and in the environment, the latter being the cause of many serious consequences. This motivated several works aiming at the development of methodologies and automatic or semi-automatic tools for plastic pollution detection, in order to enable and facilitate its recovery. This research deals with the problem of plastic waste automatic detection in fluvial and aquatic environments. The rationale is that of exploiting the well-recognized potential of machine/deep learning tools in object detection applications. Two different methods have been identified for this purpose: Method 1 and Method 2. The first one is based on characterizing the spectral signature of objects in the scenario, considering multispectral and thermal image pairs. A machine learning approach was used for the classification process in this case. Instead, Method 2 exploits a deep learning approach applied to RGB images from a mini UAV.

Method 1

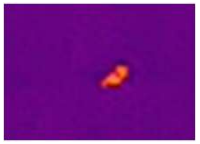
Keywords: river, multispectral and thermal imagery, single image, machine learning

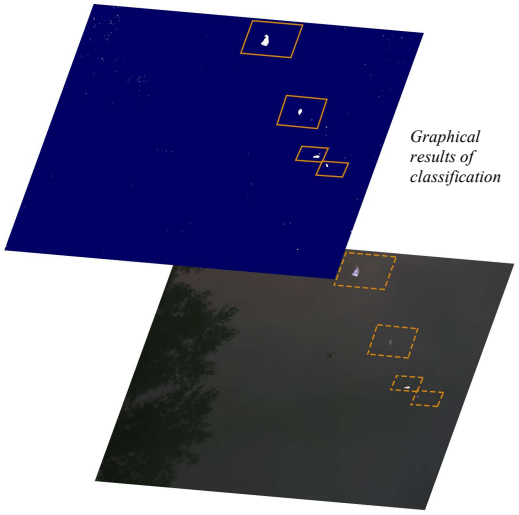
Data acquisition: the equipment used in this research includes the MAIA-S2 multispectral camera and the DJI H20T thermal camera, which were mounted on a DJI Matrice 300 drone. The study areas identified included portions of rivers in the Tuscany region (Italy). The area mapped by the individual images usually included a few elements: the river water, plastic samples (differing in size, color, texture, and polymer), and in some cases river banks and vegetation. The plastic objects were artificially introduced by means of fishing line to enable them to be retrieved

Methods and results: this work, which aims at plastics detection on rivers, is based on the use of a multi-step random forest approach, where the results are obtained by means of the cascade of two pixel-based classifiers and of an area-based selection criterion. Characterizing the spectral signature of objects in the scenario is of fundamental importance as classification is based on spectral similarity considering bands in the visible, near and thermal infrared.

Plastic sample in RGB

Plastic sample in thermal





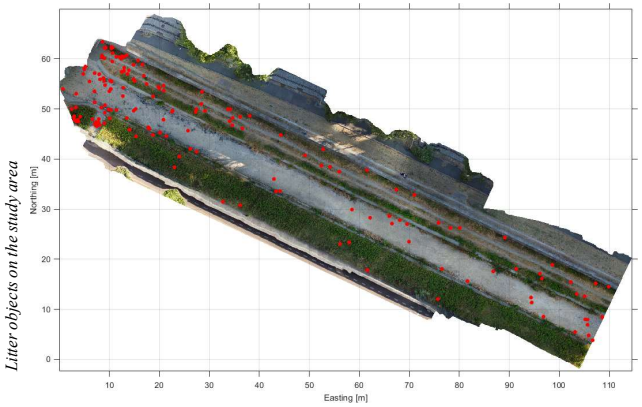
Graphical results of classification

Method 2

Keywords: river banks, RGB imagery, orthomosaic, deep learning

Data acquisition: the study area has been identified as a portion of 100 m long of the Mugnone River (Florence, Italy). More than 150 litter objects have been identified in the area with a variable spatial density. The RGB imagery has been acquired by means of a DJI Mini 2 UAV flying at varying altitudes over the area of interest.

Methods and results: the proposed method is based on the use of a deep learning approach to detect litter objects from orthomosaic generated by mini-UAV RGB imagery. Quick object detection has been implemented using a Yolo v4 network: transfer learning from a Yolo v4 network, originally pre-trained with the COCO (Common Objects in Context) dataset, has been done with some hundreds litter images taken from a public database. The procedure for litter detection described is validated on a portion of the case study.



Numerical results of plastic detection

Accuracy [%]	Precision [%]
70.6	85.7

Recall [%]	F1-score [%]
80.0	82.8

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References: Cortesi, I., Masiero, A., De Giglio, M., Tucci, G., & Dubbini, M. (2021). Random Forest-Based River Plastic Detection with a Handheld Multispectral Camera. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, 9-14. Cortesi, I., Masiero, A., Tucci, G., & Topouzelis, K. (2022). UAV-BASED RIVER PLASTIC DETECTION WITH A MULTISPECTRAL CAMERA. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences. Cortesi, I., Mugnai, F., Angelini, R., & Masiero, A. (2023). Mini Uav-Based Litter Detection on River Banks. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 10, 117-122.