Martech 2024.
Marine Technology Workshop
06, 07th June. Palma, Balearic Islnads, Spain

Operating conditions analysis for a computer vision based system for marine litter monitoring in port waters

Mariano Morell Villalonga [1,2], Manuel Espino Infantes [2], Manel Grifoll Colls [2], Carlos Garau Fullana[1], Pedro Portau Salas [1]

[1] *Maritime Engineering Laboratory of the Universitat Politècnica de Catalunya·BarcelonaTech, Campus Diagonal Nord, Building D1. C. Jordi Girona, 1-3 08034 Barcelona, Phone: 93 401 64 68, Fax: 93 401 18 61, E-mail: info.lim@upc.edu*

[2] *Garau Ingenieros SLU, Carrer de Sant Feliu, 4, Centre, 07012 Palma, Illes Balears Phone: 971 71 20 52, E-mail: info@garauingenieros.es*

Abstract – *Water pollution is a main concern for ports and coastal waters and so Port Environmental Management systems often require pollution monitoring. Computer vision offers an efficient tool for automated monitoring of waste in Port waters. An investigation has been conducted at the Port of Es Portitxol in Palma de Mallorca (Spain) to assess the effect of operating conditions of such monitoring systems and evaluate the main limitations and analyse strategies to overcome them.*

Keywords - *Computer vision, Marine Litter, Port water pollution, Monitoring Technologies.*

I. INTRODUCTION

Ports are critical zones where intense human activities on land and water converge, leading to pollution and solid waste accumulation due to low water renewal rates. This pollution, including significant plastic waste from land-based sources, adversely affects marine ecosystems, human health, and maritime industries. Traditional monitoring methods in ports, involving periodic sample collection, are costly, time-consuming, and provide limited real-time data, highlighting the need for efficient, real-time monitoring techniques [1, 2]. Computer vision, leveraging recent advances in artificial intelligence and deep learning [3], offers a promising solution for detecting floating waste in ports through automated systems using in situ cameras. This approach enables continuous, cost-effective monitoring, overcoming the limitations of traditional methods and contributing to the digitalization and environmental management of ports.

II. MATHERIALS AND METHODS

This research uses computer vision and deep learning in environmental management, particularly in monitoring and classifying water quality issues in port areas. By leveraging advanced algorithms and controlled experiments, the study contributes to the development of more reliable and efficient tools for detecting and managing pollution in marine environments.

The fieldwork took place at the port of Es Portitxol, located in Palma, Majorca, Spain. The port, characterized by its strong city relationship and a focus on sports and recreational boating, faces water quality challenges from sporadic discharges of rainwater. For addressing these challenges, Image Classification, a computer vision technique, is utilized due to its efficiency in classifying images into simple classes to monitor pollution events with less training data preparation.

The Image Classification approach employs convolutional neural networks (CNNs) trained using deep learning techniques, notably effective in analyzing visual imagery for environmental management. This method involves capturing real-time images of port water and classifying them to identify pollution events. The study uses Keras and TensorFlow software libraries for algorithm training, with the algorithm development process benefiting from both a compensated image model (V1) [4] and an advanced version (V8), which reflects improvements based on fixed camera images from Es Portitxol, aiming to enhance accuracy in detecting marine waste and spills.

The algorithms are designed to classify images into three categories: clean water, spill, and waste. However, the dataset for this study lacked images of spills, posing an additional challenge for the algorithm's reliability. Fieldwork involved deploying synthetic waste to mimic real-world pollution, allowing for controlled experiments to assess algorithm performance. Images were captured using a high-resolution smartphone camera, with pretreatment reducing resolution for algorithm compatibility.

Three experiments were conducted to evaluate the algorithms' reliability in classifying pollution based on image resolution and the distance between waste and the camera. These experiments aimed to understand the impact of image resolution

and waste-camera distance on the algorithms' precision and false positive rates. The findings are expected to provide insights into improving the algorithms for more effective environmental monitoring in ports, emphasizing the practical application of computer vision technologies in managing port water quality.

III. RESULTS AND CONCLUSSIONS

The study investigates the reliability of computer vision waste detection systems using the SPILLCONTROL project's pretrained algorithms [4]. It highlights how image resolution and distance from the camera significantly impact detection precision and false positive rates. Experiments reveal optimal resolutions for waste detection and the need for tailored algorithm training with varied image resolutions to enhance system accuracy. This research underscores the potential of computer vision in environmental management within ports, emphasizing the importance of field validation and collaboration with port managers and authorities for practical implementation and effective pollution management.

Results indicate that optimal resolutions and specific distances significantly affect detection precision, with resolutions near algorithm training resolution and closer distances improving performance. Experiments on algorithm training with different image sets reveal that training with cropped images taken in similar conditions can enhance system accuracy. The findings underscore the importance of adjusting camera resolutions and considering distance in the deployment of computer vision monitoring systems for environmental management in ports. Potential areas for enhancing the SPILLCONTROL system's performance in waste detection across various port and coastal environments were detected.

Future research directions include:

- Exploring diverse port settings to test the system's adaptability, utilizing burst photography for improved accuracy, and implementing multi-view analysis for a comprehensive understanding of waste distribution.
- Integrating the system with other environmental data sources could offer a holistic approach to marine pollution monitoring, enabling the detection of different pollution types and assessing their environmental impacts.

REFERENCES

[1] Puig, M. et al., “Insights on the environmental management system of the European port sector”, *Science of The Total Environment*, 806, p. 150550, 2022.
[2] Hossain, T., Adams, M. and Walker, T.R. “Role of sustainability in global seaports”, *Ocean & Coastal Management*, 202, p. 105435, 2021.
[3] Leonard, J.K., “Image Classification and Object Detection Algorithm Based on Convolutional Neural Network”, *Science Insights*, 31(1), pp. 85–100, 2019.
[4] Morell, M. et al., “Use of Neural Networks and Computer Vision for Spill and Waste Detection in Port Waters: An Application in the Port of Palma (Majorca, Spain)”, *Applied Sciences*, 13(1), p. 80, 2023.