

Studying Effects of Plastics on the Environment Using Image-Based Detection and Deep Learning Methods

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Abstract. Plastic pollution is a major environmental concern, particularly in aquatic and coastal ecosystems. Beyond cleanup efforts, effective prevention requires accurate detection and classification of waste in natural settings. Inspired by prior machine learning tools for waste monitoring (e.g., PlasticNet or DroneDeploy), this study focuses on the publicly available TrashNet dataset. The original six waste categories were re-labeled into two groups according to ecological impact: harmful (plastic, mixed trash) and less harmful (paper, cardboard, glass, metal). Two deep learning models were developed and evaluated: a custom four-block convolutional neural network (CNN) trained from scratch with focal loss, and a transfer learning model based on VGG16 pretrained on ImageNet. Results show that while the CNN achieved reasonable recall for harmful waste, the VGG16 model provided a more balanced trade-off, reaching accuracies above 82% on validation and test data. These findings confirm the potential of deep learning for automated monitoring of plastic pollution, with applications in aerial surveillance, smart waste management, and autonomous cleanup systems.

Keywords. Plastic pollution, waste classification, deep learning, transfer learning, CNN, TrashNet

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References

- Bobulski, J., & Kubanek, M. (2019, May). Waste classification system using image processing and convolutional neural networks. In *International Work-Conference on Artificial Neural Networks* (pp. 350–361). Cham: Springer International Publishing.
- Chollet, F. (2021). Deep Learning with Python (2nd ed.). *Shelter Island: Manning Publications*.
- Majchrowska, S., Mikołajczyk, A., Ferlin, M., Klawikowska, Z., Plantykowski, M. A., Kwasigroch, A., & Majek, K. (2022). Deep learning-based waste detection in natural and urban environments. *Waste Management*, 138, 274–284.
- van Lieshout, C., van Oeveren, K., van Emmerik, T., & Postma, E. (2020). Automated river plastic monitoring using deep learning and cameras. *Earth and Space Science*, 7(8), e2019EA000960.
- Xia, J., Huang, Y., Li, Q., Xiong, Y., & Min, S. (2021). Convolutional neural network with near-infrared spectroscopy for plastic discrimination. *Environmental Chemistry Letters*, 19(5), 3547–3555.
- Yang, M., & Thung, G. (2016). *Classification of Trash for Recyclability Status*. Stanford CS229 Final Report. Retrieved from <https://cs229.stanford.edu/proj2016/report/ThungYang-ClassificationOfTrashForRecyclabilityStatus-report.pdf>