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Tyndall-effect-based optical monitoring of micro-plastic pollution in aquatic environments

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Abstract

The paper presents the development and validation of an experimental system for monitoring microplastic pollution in aquatic environments, based on the Tyndall effect and artificial intelligence techniques. The proposed system uses a laser light source and a video acquisition module to detect light scattered by microplastic particles, with data processed in real time on the NVIDIA Jetson Orin Nano Developer Kit (SBC) platform. Mathematical models and discrete algorithms are developed for correlating the optical signal with the concentration of microplastics, and the performance of the method is improved by integrating artificial neural networks such as CNN and LSTM. The experimental results, presented in the form of images and quantitative graphs, demonstrate the system's ability to identify the presence of microplastics and dynamically monitor concentration variations. The proposed solution offers a fast, non-invasive, and scalable approach with high potential for continuous monitoring of the aquatic environment.

Keywords*: aquatic environments; computer vision; edge ai; environmental monitoring; intelligent systems; light scattering; microplastics; optical monitoring; real-time processing; tyndall effect; water pollution*

References:

1. R. C. Thompson, Y. Olsen, R. P. Mitchell et al., "Lost at Sea: Where Is All the Plastic?", *Science*, vol. 304, no. 5672, pp. 838, 2004, DOI: 10.1126/science.1094559.
CrossRef Google Scholar

2. M. Cole, P. Lindeque, C. Halsband, and T. S. Galloway, "Microplastics as contaminants in the marine environment: A review," *Marine Pollution Bulletin*, vol. 62, no. 12, pp. 2588–2597, 2011, DOI: 10.1016/j.marpolbul.2011.09.025.
CrossRef Google Scholar

3. A. L. Andrady, "Microplastics in the marine environment," *Marine Pollution Bulletin*,

vol. 62, no. 8, pp. 1596–1605, 2011, DOI: 10.1016/j.marpolbul.2011.05.030.
CrossRef Google Scholar

4. L. Van Cauwenberghe and C. R. Janssen, "Microplastics in bivalves cultured for human consumption," *Environmental Pollution*, vol. 193, pp. 65–70, 2014, DOI: 10.1016/j.envpol.2014.06.010.
CrossRef Google Scholar

5. S. Wright and F. Kelly, "Plastic and Human Health: A Micro Issue? ", *Environmental Science & Technology*, vol. 51, no. 12, pp. 6634–6647, 2017, DOI: 10.1021/acs.est.7b00423.
CrossRef Google Scholar

6. M. Löder and Y. Xiang, "Methodology Used for the Detection and Identification of Microplastics—A Critical Appraisal," in *Marine Anthropogenic Litter*, Springer, Cham, pp. 201–227, 2015, DOI: 10.1007/978-3-319-16510-3_8.
CrossRef Google Scholar

7. A. Käppler, D. Fischer, S. Oberbeckmann et al., "Analysis of environmental microplastics by vibrational microspectroscopy: FTIR, Raman or both? ", *Analytical and Bioanalytical Chemistry*, vol. 408, no. 29, pp. 8377–8391, 2016, DOI: 10.1007/s00216-016-9956-3.
CrossRef Google Scholar

8. S. Primpke, M. Lorenz, R. Rascher, and G. Gerdts, "Reference database design for the automated analysis of microplastic samples based on Fourier transform infrared (FTIR) spectroscopy," *Analytical and Bioanalytical Chemistry*, vol. 409, pp. 1499–1511, 2017, DOI: 10.1007/s00216-018-1156-x.
CrossRef Google Scholar

9. H. A. Leslie, S. H. Brandsma, M. J. van Velzen, and A. D. Vethaak, "Microplastics en route: Field measurements in the Dutch river delta and Amsterdam canals," *Environment International*, vol. 101, pp. 133–142, 2017, DOI: 10.1016/j.envint.2017.01.018.
CrossRef Google Scholar

10. A. Hidalgo-Ruz, L. Gutow, R. C. Thompson, and M. Thiel, "Microplastics in the marine environment: A review of the methods used for identification and quantification," *Environmental Science & Technology*, vol. 46, no. 6, pp. 3060–3075, 2012, DOI: 10.1021/es2031505.
CrossRef Google Scholar

11. S. Mintenig, I. Int-Veen, M. Löder, S. Primpke, and G. Gerdts, "Identification of microplastic in effluents of waste water treatment plants using focal plane array-based micro-Fourier-transform infrared imaging," *Water Research*, vol. 108, pp. 365–372, 2017, DOI: 10.1016/j.watres.2016.11.015.
CrossRef Google Scholar

12. J. Appel, M. Valentino, L. Miccio et al., "Explainable deep-learning detection of microplastic fibers via polarization-resolved holographic microscopy," arXiv preprint arXiv:2601.15769, Jan. 2026, DOI: 10.48550/arXiv.2601.15769.
CrossRef Google Scholar

13. D. Ho and H. Feng, "Shedding Light on the Polymer's Identity: Microplastic Detection and Identification Through Nile Red Staining and Multispectral Imaging (FIMAP)," arXiv preprint arXiv:2502.17997, Feb. 2025, DOI: 10.48550/arXiv.2502.17997.

CrossRef Google Scholar

14. M. Lambert Surhone, T. Miriam Timpledon, F. Susan Marseken, "*Tyndall Effect*," VDM Publishing, 88 p., 2010, ISBN: 978-613-0500-351.
Google Scholar

15. V. Ababii, V. Carbune, V. Sudacevschi, G. Marusic, R. Braniste, S. Munteanu, O. Borozan, "A system for detecting and monitoring microplastic pollution in aquatic ecosystems," In *Akademos*, 3 (78), 2025, pp. 23–30, ISSN 1857-0461, DOI: 10.52673/18570461.25.3-78.02.
Google Scholar

16. M. Born and E. Wolf, "*Principles of Optics*," 7th ed. Cambridge, U.K.: Cambridge Univ. Press, 1999.
CrossRef Google Scholar

17. M. I. Mishchenko, L. D. Travis, and A. A. Lacis, "*Scattering, Absorption, and Emission of Light by Small Particles*," Cambridge, U.K.: Cambridge Univ. Press, 2002.
Google Scholar

18. J. T. O. Kirk, "*Light and Photosynthesis in Aquatic Ecosystems*," 3rd ed. Cambridge, U.K.: Cambridge Univ. Press, 2011.
CrossRef Google Scholar

19. F. P. Scalcon, R. Tahal, M. Ahrabi and Y. Huangfu, "AI-Powered Video Monitoring: Assessing the NVIDIA Jetson Orin Devices for Edge Computing Applications," In *2024 IEEE Transportation Electrification Conference and Expo (ITEC)*, pp. 1–6), DOI: 10.1109/ITEC60657.2024.10598994.
Google Scholar

20. Z. Zhang, H. Jiang and H. Singh, "NeuFlow: Real-time, High-accuracy Optical Flow Estimation on Robots Using Edge Devices," In *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 5048–5055, DOI: 10.1109/IROS58592.2024.10802353.
Google Scholar

21. "Case Studies: Real-World Applications of NVIDIA® Jetson Orin™ Nano," *ProxPC Blog*, 2025. [Online]. Available: https://www.proxpc.com/blogs/case-studies-real-world-applications-of-nvidia-jetson-orin-nano.
Google Scholar

22. "Develop AI-Powered Robots, Smart Vision Systems, and More with NVIDIA Jetson Orin Nano Developer Kit," *NVIDIA Technical Blog*, 2023. [Online]. Available:, https://developer.nvidia.com/blog/develop-ai-powered-robots-smart-vision-systems-and-more-with-nvidia-jetson-orin-nano-developer-kit/.
Google Scholar

23. M. A. B. Sarker, M. H. Imtiaz, T. M. Holsen and A. B. M. Baki, "Real-Time Detection of Microplastics Using an AI Camera,' *Sensors*, 24 (13), 4394, 2024, DOI: 10.3390/s24134394.
CrossRef Google Scholar

24. K. H. D. Tang, "The Role of Artificial Intelligence in Microplastic Pollution Studies and Management," In *Recent Progress in Science and Engineering*, 1 (4), 2025, pp. 1–10, DOI:

10.21926/rpse.2504016.
CrossRef Google Scholar