frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 14 August 2023
DOI 10.3389/fmars.2023.1256183

OPEN ACCESS

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RECEIVED 10 July 2023
ACCEPTED 02 August 2023
PUBLISHED 14 August 2023

CITATION
Song H, Mehdi SR, Wang M, Liao R, Naqvi RA and Xie S (2023) Editorial: Optics and machine vision for marine observation. *Front. Mar. Sci.* 10:1256183. doi: 10.3389/fmars.2023.1256183

Editorial: Optics and machine vision for marine observation

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KEYWORDS

underwater optics, underwater imaging, image enhancement, image processing, machine learning, marine observation, object recognition

Editorial on the Research Topic
Optics and machine vision for marine observation

The aquatic ecosystem of the planet makes up a sizable amount of 71% of its surface that contain numerous living forms and an abundance of organic and inorganic resources throughout this enormous area (Issac and Kandasubramanian, 2021). Scientists and researchers have long been enthralled by the immense and enigmatic expanse of the marine ecosystems. The ocean's intricate ecosystems, diverse marine life, and the profound impact they have on our planet make understanding and monitoring these environments crucial (Maximenko et al., 2019). Both anthropogenic and natural activities have significantly increased recently, causing ecological problems in the marine environment (Huang et al., 2023). To successfully address and mitigate the resulting ecological mutilations, these disturbances call for the development of quick monitoring and mitigation mechanisms. As a result, the scientific community has been forced to explore numerous routes to push the limits of marine observation.

Underwater ecosystems have been mostly shrouded in darkness due to light attenuation, hindering comprehensive observation and data collection. But improvements in optics have fundamentally altered our capacity to perceive the underwater environment. Advances in high-resolution image capture, video recording, and spectral data acquisition have been made possible by cutting-edge imaging technology like underwater cameras, spectrometers, and hyperspectral sensors (Song et al., 2021a; Shahani et al., 2021). Through the study of species' behavior, distribution, and interactions, hidden ecosystems are revealed and scientists are able to explore marine habitats in new detail.

Automated analysis of underwater imagery has been made possible by machine vision techniques used in conjunction with optics. Computers can now extract complex traits and accurately categorize marine organisms thanks to deep learning techniques, a subset of machine learning that has revolutionized image processing and pattern identification. There are many new possibilities for marine surveillance now that machine vision systems, optics, and deep learning approaches have been combined. Automation, data analysis, and real-time monitoring are just a few advantages that machine vision and deep learning algorithms together offer. The topic of marine species tracking and identification is one of the most notable applications (Chuang et al., 2016). Massive volumes of underwater imagery may be quickly analyzed using deep learning algorithms, which can then accurately and automatically identify and classify aquatic organisms (Song et al., 2020; Song et al., 2021b). These developments are essential for following migration patterns, evaluating the health of marine populations, and spotting possible threats to biodiversity. Machine vision and deep learning speed up research efforts by reducing the time-consuming and labor-intensive process of manual identification, enabling scientists to make educated conclusions about conservation measures and policy-making.

In conjunction with machine vision algorithms, remote sensing systems can monitor changes in ocean currents, sea surface temperature, and the spread of dangerous algal blooms (Son et al., 2015). For studying climate patterns, predicting weather occurrences, and reducing the possible effects of natural disasters on coastal communities, these real-time measurements are crucial. Additionally, the monitoring of human activities and their effects on marine habitats is made easier by the integration of optics, machine vision, and deep learning. Machine vision systems can monitor and identify potential pollution, illicit fishing, and habitat devastation (Mehdi et al., 2022; Yasir et al., 2023).

Understanding and maintaining a close eye on the dynamics and health of oceans depends heavily on marine observation. We can employ machine vision, which focuses on creating algorithms and systems for understanding visual data, and optics, which deals with the study and manipulation of light, to better observe and understand marine ecosystems. For this purpose, the Research Topic "*Optics and machine vision for marine observation*" focuses to explore the intersection of optics, machine vision, and deep learning technologies and their applications in making the field of marine observation more effective. It provides a collection of recent findings, developments, and innovative strategies related to underwater sensors, imaging systems, computer vision algorithms, and data analysis techniques that leverage optics and machine vision technologies for various aspects of marine observation. The Research Topic explores the transformative potential of optics and machine vision and their applications in contributing to the advancements of marine observation systems. The Research Topic is comprised of 24 articles, collectively representing the contribution of 118 authors (Table 1).

A wide domain of research is involved in the development and implementation of optics and machine vision for marine observation, including optical sensors and monitoring systems, image processing, deep learning techniques, deep-sea illumination, spectral image analysis, etc. Several researchers address the development of underwater monitoring methods based on optical fiber sensing for real-time study of

TABLE 1 Summary of chapters published in this Research Topic.

DOI	Title	Keywords	Authors
10.3389/fmars.2022.922669	Submarine optical fiber sensing system for the real-time monitoring of depth, vibration, and temperature	optical fiber sensing, fiber Bragg grating, submarine real-time monitoring, environmental monitoring, optical fiber sensor	Liu Z, Zhang S, Yang C, Chung W-H and Li Z
10.3389/fmars.2022.1003568	PSS-net: Parallel semantic segmentation network for detecting marine animals in underwater scene	detecting marine animal, underwater scene, protective colors, PSS-net, attention technique	Kim YH and Park KR
10.3389/fmars.2022.1010565	Robust segmentation of underwater fish based on multi-level feature accumulation	artificial intelligence, marine environment, underwater computer vision, fish segmentation, EFS-net and MFAS-net	Haider A, Arsalan M, Choi J, Sultan H and Park KR
10.3389/fmars.2022.1024339	Underwater image restoration through regularization of coherent structures	underwater images, image restoration, robust regularization, coherent structures, optimization problem	Ali U and Mahmood MT
10.3389/fmars.2022.1047053	Single underwater image enhancement based on differential attenuation compensation	underwater image, image enhancement, contrast stretching, differential attenuation compensation, machine vision	Lai Y, Zhou Z, Su B, Xuanyuan Z, Tang J, Yan J, Liang W and Chen J
10.3389/fmars.2022.1030113	RACE-SM: Reliability and adaptive cooperation for efficient UWSNs using sink mobility	UWSNs, energy efficient routing, routing protocols, sink mobility, cooperative routing	Ahmad I, Rahman T, Khan I, Jan S, Musa S and Uddin MI
10.3389/fmars.2022.1056300	Underwater object detection algorithm based on attention mechanism and cross-stage partial fast spatial pyramidal pooling	Underwater Object detection, ACFP-YOLO, YOLOv7, attention, SPPFCSPC	Yan J, Zhou Z, Zhou D, Su B, Xuanyuan Z, Tang J, Lai Y, Chen J and Liang W
10.3389/fmars.2022.1031549	UCRNet: Underwater color image restoration *via* a polarization-guided convolutional neural network	Polarization, polarimetric imaging, scattering media, imaging recovery, physical imaging	Hu H, Huang Y, Li X, Jiang L, Che L, Liu T and Zhai J
10.3389/fmars.2022.1032287	RMP-Net: A structural reparameterization and subpixel super-resolution-based marine scene segmentation network	submarine exploration, underwater scene, RMP-Net, structural re-parameterization, multiscale fusion	Chen J, Tang J, Lin S, Liang W, Su B, Yan J, Zhou D, Wang L, Lai Y and Yang B

(Continued)

TABLE 1 Continued

DOI	Title	Keywords	Authors
10.3389/fmars.2022.1071618	UMOTMA: Underwater multiple object tracking with memory aggregation	artificial intelligence, underwater multiple object tracking, marine environment, long-short term memory, vision transformer	Hao Z, Qiu J, Zhang H, Ren G and Liu C
10.3389/fmars.2022.1039898	A dual stream hierarchical transformer for starvation grading of golden pomfret in marine aquaculture	neural network, transformer, starvation grading, marine image processing, behavior recognition	Zheng K, Yang R, Li R, Yang L, Qin H and Li Z
10.3389/fmars.2022.1073615	Multiscale attention-based detection of tiny targets in aerial beach images	tiny object detection, multiscale attention, feature pyramid network, attention mechanism, unmanned aerial vehicle	Gao S, Liu C, Zhang H, Zhou Z and Qiu J
10.3389/fmars.2022.1058201	The analysis and design of deep-sea lighting field based on spectral transfer function	underwater optics, underwater imaging, underwater lighting, marine observation, object recognition	Quan X, Wei Y, Liu K and Li B
10.3389/fmars.2022.1094915	Deep learning-based marine big data fusion for ocean environment monitoring: Towards shape optimization and salient objects detection	data fusion, marine big data, ocean environment, underwater saliency detection, underwater image processing	Khan S, Ullah I, Ali F, Shafiq M, Ghadi YY and Kim T
10.3389/fmars.2022.1086140	Multi-scale ship target detection using SAR images based on improved Yolov5	synthetic aperture radar (SAR), ship identification, artificial intelligence, deep learning (DL), YOLOv5S, SAR ship detection dataset (SSDD), AirSARship	Yasir M, Shanwei L, Mingming X, Hui S, Hossain MS, Colak ATI, Wang D, Jianhua W and Dang KB
10.3389/fmars.2022.1058019	Single underwater image enhancement based on adaptive correction of channel differential and fusion	underwater image processing, image enhancement, histogram stretching, color correction, fusion	Zhao Z, Zhou Z, Lai Y, Wang T, Zou S, Cai H and Xie H
10.3389/fmars.2023.1074428	Deep focus-extended darkfield imaging for *in situ* observation of marine plankton	underwater imaging, deep learning, focus extension, ocean observation, marine plankton	Chen T, Li J, Ma W, Guo G, Yang Z, Li Z and Qiao J
10.3389/fmars.2023.1117787	Energy-efficient clustering protocol for underwater wireless sensor networks using optimized glowworm swarm optimization	UWSN, energy, GSO, routing, clustering, bio-inspired	Bharany S, Sharma S, Alsharabi N, Tag Eldin E and Ghamry NA
10.3389/fmars.2023.1135058	Laser-induced breakdown spectroscopy instrument and spectral analysis for deep-ocean Fe-Mn crusts	deep ocean, marine spectral analysis, marine resource exploration, laser-induced breakdown spectroscopy, marine Fe-Mn crusts, parameter optimization	Yang G, Chen G, Cai Z, Quan X and Zhu Y
10.3389/fmars.2023.1031869	Investigating the rate of turbidity impact on underwater spectral reflectance detection	spectral reflectance, spectral imaging, turbidity, spectral detection, liquid crystal tunable filters, spectral features, underwater scattering	Song H, Mehdi SR, Li Z, Wang M, Wu C, Venediktov VY and Huang H
10.3389/fmars.2023.1135356	Identification of marine oil spill pollution using hyperspectral combined with thermal infrared remote sensing	marine oil spills, hyperspectral remote sensing, thermal infrared remote sensing, oil pollution types identification, deep learning	Yang J, Hu Y, Zhang J, Ma Y, Li Z and Jiang Z
10.3389/fmars.2023.1124185	Real-time detection of deep-sea hydrothermal plume based on machine vision and deep learning	hydrothermal plume, deep-sea, real-time, object detection, deep learning, transfer learning, YOLOv5	Wang X, Cao Y, Wu S and Yang C
10.3389/fmars.2023.1138013	An underwater image enhancement model for domain adaptation	underwater image, image enhancement, underwater dataset, domain adaptation, deep learning	Deng X, Liu T, He S, Xiao X, Li P and Gu Y
10.3389/fmars.2023.1167191	An early warning model for starfish disaster based on multi-sensor fusion	starfish disaster, multi-sensor fusion, early-warning model, self-supervised model, feature selection	Li L, Liu T, Huang H, Song H, He S, Li P, Gu Y and Chen J

environmental parameters (Liu et al.), and water quality observation based on multi-sensor fusion for early warning of starfish disaster (Li et al.). Two studies discuss underwater sensor networks and protocols for explorations of underwater resources through efficient data collection (Ahmad et al.; Bharany et al.). Numerous papers deliver improved techniques and applications of deep learning for underwater object detection while several studies highly concentrated on underwater image enhancement in support of algorithm development, validation, and verification. Multiple papers explore the applications of deep learning for underwater object detection (fish classes, and organic and inorganic submarine objects: Yan et al.; Khan et al.; hydrothermal plumes detection: Wang et al.) and image segmentation (fish: Kim and Park; Haider et al.; Chen, J. et al.). One study proposes an advanced trajectory tracking mechanism for underwater fish classes including multi-object detection (Hao et al.). Another study proposes and assesses a starvation grading model for fish class based on image processing and CNN that can benefit the field of fisheries (Zheng et al.). For aerial-based monitoring of coastal areas, a paper suggests small size objects detection technique based on CNN (Gao et al.). Papers based on spectral technologies address a range of topics including deep-sea illumination to compensate light attenuation (Quan et al.), effects of turbidity on spectral imaging (Song et al.), and spectral imaging based deep-sea mineral exploration (Yang, G. et al.). In the field of marine observation, remote sensing provides valuable insights into the state of marine environment. Two papers contributed to the field of ocean remote sensing using hyperspectral imaging and CNNs for the detection of ships (Yasir et al.), and the classification of oil spills (Yang, J. et al.). Several contributions in the field of underwater image processing include image restoration (Ali and Mahmood; color restoration: Hu et al.), and image enhancement (Lai et al.; Zhao et al.; Chen, T. et al.; Deng et al.).

The ability to monitor and understand the marine environment has changed dramatically as a result of the merging of optics and machine vision technologies with marine research. These developments have given scientists the tools they need to solve the urgent ecological problems that are being caused by both natural events and human activity. These potent tools can be used by researchers to gain insightful knowledge of the marine ecosystem, facilitating well-informed decision-making and efficient mitigation measures. As a result, the limits of scientific understanding in marine science are being widely pushed, advancing our comprehension of this complex field to unprecedented heights.

Author contributions

HS: Data curation, Investigation, Supervision, Writing – original draft, Writing – review & editing. SM: Data curation, Investigation, Writing – original draft, Writing – review & editing. MW: Data curation, Investigation, Writing – original draft, Writing – review & editing. RL: Data curation, Investigation, Writing – original draft, Writing – review & editing. RN: Data curation, Investigation, Writing – original draft, Writing – review & editing. SX: Data curation, Investigation, Writing – original draft, Writing – review & editing.

Acknowledgments

We extend our appreciation to the researchers and scientists who provided this Research Topic with their insightful knowledge. We also express our sincere gratitude to the devoted reviewers for their meticulous consideration and constructive criticism. Their efforts were crucial in determining the success of this Research Topic.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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