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Editorial

Advances in Autonomous Underwater Robotics Based on Machine Learning

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Autonomous or semi-autonomous robots are nowadays used in a wide variety of scenarios, including marine and underwater environments. Applications such as ocean exploration and mapping, biological sampling, shipwreck recovery or industrial infrastructure inspection, among many others, increasingly involve the use of underwater robots.

All these applications rely on some universal tasks in mobile robotics. For example, estimating the robot pose, modeling the environment and taking advantage of perceptual loops to reduce drift, which constitute the well-known Simultaneous Localization and Mapping (SLAM) problem, are mandatory in most, if not all, robotic applications. Planning a path while safely and optimally guiding the robot towards its goal is also necessary to achieve true autonomy.

These tasks are particularly problematic underwater, where perceptual problems are frequent. Cameras must manage difficulties related to light interaction with water, such as a reduced sensing range, backscatter or vignetting when external light sources are used. Other sensors, such as sonar, perform better in marine and sub-sea environments; however, perceptual uncertainties and ambiguities are common.

Recent research in artificial intelligence has illustrated the power of machine learning in general and deep learning in particular to deal, precisely, with uncertainties and the overall sensing problems. Machine learning and deep learning are, thus, exceptionally well suited to manage underwater sensing problems.

Unfortunately, even though machine learning and underwater robotics are prolific research fields showing outstanding results, their intersection is an understudied area. This Special Issue is aimed at the combined use of both fields and raises the question of how machine learning can be applied to underwater robotics while paying special attention to underwater vision. Can the sensor data be improved by means of machine learning? Can navigation and SLAM algorithms benefit from it? Are there some specific underwater tasks whose performance can be improved by approaching them from the machine learning perspective?

More specifically, this Special Issue tackles the questions from three complementary perspectives. Firstly, from the underwater vision perspective, there are two well-known problems, i.e., the lack of data, mainly due to the required infrastructure to obtain them; and the quality of the images, which is affected by the underwater visual conditions. To ensure data availability, [1] proposes a method based on Generative Adversarial Networks (GAN) to create realistic underwater datasets. To improve the underwater image quality, [2] surveys several underwater image enhancement techniques ranging from the classic ones to those based on deep learning.

Secondly, this Special Issue also explores how central robotics tasks such as navigation, path planning or SLAM can benefit from machine learning in marine or subsea scenarios. In this regard, the use of deep learning to perform surface navigation is explored in the mapless [3] and the path planning [4] contexts. Additionally, classic and deep learning methods are used in [5] to provide an outlier resilient underwater visual loop detection approach aimed at robust visual SLAM.

Finally, the Special Issue provides some remarkable examples of how specific, practical, underwater robotics applications can benefit from deep learning. An improved YOLOv5 architecture is proposed in [6] to perform general underwater object detection, while [7,8] focus on artificial infrastructure detection and underwater fauna, respectively.

As a whole, the studies in this Special Issue provide a clear answer to the original question of how machine learning combines with underwater robotics, and the answer is provided in different, clear, abstraction levels ranging from low-level data processing to several high-level tasks. They further our knowledge of the use of machine learning in underwater robotics and provide a foundation upon which this field can grow.

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