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An Autonomous Passive Acoustic System for Detection, Tracking and Classification of Motorboats in Portofino Sea

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Abstract : This work describes a real-time algorithm for detecting, tracking and classifying single motorboats, developed using the acoustic data recorded by a hydrophone array within the framework of EU LIFE + project ARION (LIFE09NAT/IT/000190). The project aims to improve the conservation status of bottlenose dolphins through a real-time simultaneous monitoring of their population and surface ship traffic. A Passive Acoustic Monitoring (PAM) system is installed on two autonomous permanent marine buoys, located close to the boundaries of the Marine Protected Area (MPA) of Portofino (Ligurian Sea- Italy). Detecting surface ships is also a necessity in many other sensible areas, such as wind farms, oil platforms, and harbours. A PAM system could be an effective alternative to the usual monitoring systems, as radar or active sonar, for localizing unauthorized ship presence or illegal activities, with the advantage of not revealing its presence. Each ARION buoy consists of a particular type of structure, named meda elastica (elastic beacon) composed of a main pole, about 30-meter length, emerging for 7 meters, anchored to a mooring of 30 tons at 90 m depth by an anti-twist steel wire. Each buoy is equipped with a floating element and a hydrophone tetrahedron array, whose raw data are send via a Wi-Fi bridge to a ground station where real-time analysis is performed. Bottlenose dolphin detection algorithm and ship monitoring algorithm are operating in parallel and in real time. Three modules were developed and commissioned for ship monitoring. The first is the detection algorithm, based on Time Difference Of Arrival (TDOA) measurements, i.e., the evaluation of angular direction of the target respect to each buoy and the triangulation for obtaining the target position. The second is the tracking algorithm, based on a Kalman filter, i.e., the estimate of the real course and speed of the target through a predictor filter. At last, the classification algorithm is based on the DEMON method, i.e., the extraction of the acoustic signature of single vessels. The following results were obtained; the detection algorithm succeeded in evaluating the bearing angle with respect to each buoy and the position of the target, with an uncertainty of 2 degrees and a maximum range of 2.5 km. The tracking algorithm succeeded in reconstructing the real vessel courses and estimating the speed with an accuracy of 20% respect to the Automatic Identification System (AIS) signals. The classification algorithm succeeded in isolating the acoustic signature of single vessels, demonstrating its temporal stability and the consistency of both buoys results. As reference, the results were compared with the Hilbert transform of single channel signals. The algorithm for tracking multiple targets is ready to be developed, thanks to the modularity of the single ship algorithm: the classification module will enumerate and identify all targets present in the study area; for each of them, the detection module and the tracking module will be applied to monitor their course.

Keywords : acoustic-noise, bottlenose-dolphin, hydrophone, motorboat
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