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Robust recognition and characterization of man-made objects in shallow water using time-frequency analysis

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For underwater sonar, time-frequency analysis, in particular Wigner-Ville analysis, has been shown to be a relevant tool for discriminating a man made target (shell) from a natural one of the same shape (solid) and even to estimate some target characteristics (shell thickness, shear velocity..). This processing tool takes advantage of the evolutional, time dependent aspect of the echo spectrum. The estimated time-frequency patterns can be used for detection and wideband classification of sonar echoes in order to reduce false alarms. In particular, the so-called "coincidence pattern" appearing for specific frequency range is a robust time-frequency signature of man-made shells. A time-frequency analysis will be presented to understand echo formation mechanisms using a standard spherical shell model target model. The influence of the medium parameters as well as the source-receiver configuration will be investigated in free space and then extended to the case of a shallow water waveguide. The proposed approach will be tested using target scattering data collected during Experiments for Validation of Acoustic modeling techniques (EVA) sea test on the north shore of Isola D'Elba, Italy. Application to mine-hunting sonar systems will be discussed.