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Noise-Resistant Feature Extraction from Measured Data of a Passive Sonar

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Abstract

In this paper, two different methods for the classification of passive sonar data based on time-frequency methods are studied. In the first step, two passive sonar signal classifier systems are implemented using the Short-Time Fourier Transformation (STFT) approach and Short-Time Fractional Fourier Transformation (STFrFT). The performance of the proposed classifier for passive sonars in the presence of an increased amount of noise is investigated in this study. The results showed that the classification system based on STFT has better efficiency in classifying the original signals. The method based on STFT showed more resistance to noisy signal classification so that the accuracy of the classification system was reduced by a smoother slope than the STFT classification system. The loss of accuracy in the STFrFT-based method for increasing the noise level is -0.15, while for STFT-based method is equal to -0.37.

Keywords: Feature extraction, Short-Time Fourier Transformation (STFT), Short-Time Fractional Fourier Transformation (STFrFT), Sonar Data Classification.

1. Introduction

Passive sonar in underwater environments is commonly used for tracking and detection of marine vessels. To classify sonar signals, related staffs are trained to take appropriate decisions by observing the visual information obtained from the spectrograph and accurately receiving the sound obtained from the target. This task places a heavy burden on these users. Therefore, designing an automated system to classify passive sonar targets to reduce the workload of sonar users is essential. There are ongoing researches to extract useful and accurate information from measured data in passive sonars. The main challenge from the practical aspect is the noisy environment and its effect on the measurement from sonar equipment (Liu et al., 2010).

Four categories of maritime vehicles for the purpose of classification are considered by researchers. These categories are defined based on the amount of noise radiated from surface ships and submarines (Zeng et al., 2013). The dominant noise sources are Propeller Cavitation Noise (PCN), Blade-Rate Tonal (BRT), Piston-Slap Tonal (PST), Gear Noise (GN), injector noise including low-frequency radiations of the hull, drift speed, impeller blade speed, and the location of machine components. Maritime vehicles are identified and classified based on the injector noise or apparatus noise, including base frequency radiation from the vehicle body (Rajagopal et al., 1990). The classification and exposure of a practical passive sonar signal based on STFT is a conventional method for the active sonars. The application of the Finite Impulse Response Neural Networks (FIRNN) in the passive sonars concerning the feature extraction in continuous mode and different classification approaches for the received transient signals by passive sonar, is shown in (Ward et al., 2000; Farrokhrooz, 2005; Liu et al., 2010). The features of the scattered acoustic noise of ships are extracted by the probabilistic neural network (PNN) as a classifier from a model based on the regression method with appropriate order and coefficients (Farrokhrooz et al., 2011; De Seixas et al., 2011). The benefits and weaknesses of the extracted features from the energy spectrum density and higher-order characteristics are examined in (Zeng et al., 2013) and then combined the estimation of the acquired characteristics and calculated spectrum to extract the discernible features.

In data transition, the compressive sensing has been proposed to store the information in the optimum memory space with the fewer number of samples required by the