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Goal on Recurrent Neural Autoencoding in the Costal Echolocation Acoustic Dispersion Arena

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Introduction

In the littoral warfare domain, automated target recognition is critical because distinguishing mundane objects from mines can be a matter of life and death. This is preliminary research into applying convolutional autoencoding to the littoral sonar space, with the goal of disentangling the reflection noise common in underwater acoustics and allowing recognition of target shape and material. The magnitude Fourier transforms of the TREX13 dataset were used to train the autoencoders. Clusters representing the known variable of measurement distance between the target and the sensor were discovered in the encoding space. A 16-dimensional encoding vector space appeared adequate, and the space was shown to generalise well to unknown data.

The oceanic acoustic environment presents many unique challenges to autonomous target characterization that are not found in other signalling domains. Reflections from the ocean's surface and seafloor, as well as clutter like fish, rocks, and bubbles, add noise and echoes that significantly reduce clarity. Automatic target recognition tasks necessitate the robust definition and selection of features for underwater signals. We want to use deep learning techniques to provide new methods of target representation and analysis, specifically using different types of autoencoders. Deep learning has recently achieved success in the underwater sonar domain, where it was used to automate sonar processing.

Description

Our ultimate goal is to create a model that can provide robust insight into acoustic backscattering returns for object detection and mine detection. This would entail, at a bare minimum, object detection and ordinance classification in the absence of noise, to be used in conjunction with an autonomous underwater vehicle [1-3]. The goal of informing object classification, also known as automated target recognition (ATR), via geometric characteristics detected in an acoustic signal is of particular interest in maritime search and rescue. Unlike other applications such as natural language processing, the cost of data collection for ATR training purposes is extraordinarily high due to the nature of the maritime environment, requiring days of on-water tests to collect a limited set of sonar returns on relatively similar targets within a target field.

Because of the high cost of data collection, other methods of data collection are required, such as the development of simulated data, the aggregation of heterogeneous datasets, and physics-based parameter characterisation during the ATR process. Among these data-centric approaches, physics-based methods hold the most promise due to the model's direct involvement in the learning process [4,5]. While acoustic imagery is frequently unavailable in maritime applications, engineering parameters related to a target's shape, size, and other characteristics are often known. The interaction between these physical characteristics and sonar returns opens up the possibility of training algorithms to detect these physical features with greater accuracy for a given amount of training data than other methods.

Conclusion

This is because the physical characteristics are directly involved without the secondary approximations that may occur when training on simulated data. The autoencoder is the key concept to apply to acoustic backscattering data. Since then, many variations and extensions of this concept have emerged, but the core idea has not changed. Unsupervised training of a network is used to reduce high-dimensional inputs to lower-dimensional encodings, similar to the classic principal component analysis (PCA) technique. This key dimensional advantage motivates the use of the autoencoder for compact yet effective feature representation of sonar backscattering from small targets, such as those considered in this work.

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