EPSRC CDT in Distributed Algorithms

PhD Project: Using machine learning and artificial intelligence to improve the tracking of vessels in sonar spectrograms

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Project Description

This PhD project explores creating an AI model that can correctly classify quiet targets in waterfall (sonar) data. Currently, waterfall data is analysed by human operators; however, this is time-consuming and expensive; these human operators outperform traditional automated passive contact follower algorithms, such as the Kalman and Alpha-Beta filters: these filters are susceptible to the abundant underwater noise and struggle with crossing tracks and quiet contacts. In contrast, humans can use their experience to learn how to mitigate the challenging aspects of the task. An automatic detection and tracking model that is more accurate and robust than traditional methods would reduce the human operator's workload.

Although machine learning and artificial intelligence approaches seem ideal for this task, there are challenges. For example, the model must perform in real-time: the waterfall display is updated line-by-line each second. Whilst the model can use the previous rows of data, it must solely rely on the time vs bearing (waterfall) data. The model may also need to be trained on large volumes of synthetic data due to the lack of real and unclassified data and may require distributed training and techniques such as transfer learning. Other methods could include using generative adversarial networks to generate extra synthetic waterfall data based on confidential real data. The current waterfall simulation needs to be developed as it does not exhibit any multipath or sidelobe effects seen in real data. Improving data scarcity and quality is considered a significant component of this project.

Previous work has shown that AI models, specifically Long Short-Term Memory (LSTM) neural networks, can outperform classical filtering techniques on simple waterfall simulations. These models need to be adapted to work effectively with the broadband sonar data to efficiently produce tracks that are less susceptible to transient noise, more stable and can, potentially in combination with post-processing, correctly resolve crossing contacts.

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