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Radar Waveform Generation Adaptive to Spectral Environment

Keywords

Cognitive Radar, Neural Networks, Radar Waveform Synthesis, Variational Autoencoder

Description

Modern radars are increasingly being deployed in environments which are not static but vary dynamically. For example, radars may operate in parts of the frequency spectrum that are occupied by dynamic communication signals that rapidly allocate frequency bands to different users. A radar transmitting in these fast-changing environments needs to adapt flexibly to the restrictions imposed by the current situation. Concretely, a radar capable of varying the spectral distribution of its energy can maximize its performance when placing spectral notches at occupied frequency bands in order to avoid interference with other users of the electromagnetic spectrum.

In previous work, we have used a concept from machine learning, concretely a variational autoencoder (VAE), for the synthesis of simple non-linear frequency-modulated radar waveforms. The VAE was modified so that the learning was based on waveform function characteristics instead of the waveform functions themselves. The waveform function characteristics were represented by the signals' matched filter output, which is called the ambiguity function.

Goal

This master thesis shall extend the previous work and examine the use of a modified VAE for the task of generating radar waveforms with situation-specific spectral characteristics. One goal is to modify the existing VAE such that the training is then based on the spectral image of the training waveforms instead of the ambiguity function. Besides the modification of the VAE, the work includes the generation of suitable training and testing data. Furthermore, different network configurations shall be examined and compared by evaluating the structure of the corresponding latent spaces. In the end, the final evaluation shall answer the question whether the decoders from the modified and trained VAEs can generate new radar waveform modulations that possess required spectral characteristics, even though they were not represented in the original training data.

Requirements

- Interest in Radar Signal Processing and Machine Learning
- Python programming skills recommended, but not mandatory
- Optional: first experience with TensorFlow and Keras

Reference Paper

Charlish, Alexander, and Schwalm, Carolin. "Generating NLFM Radar Waveforms using Variational Autoencoders." *2022 IEEE Radar Conference (RadarConf22)*