**Proposal for Research on Signal Classification Using Deep Neural Networks**

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**Abstract:** The objective of this research is to develop new paradigms of deep learning for signal classification using recurrent neural networks, with emphasis on electronic warfare signals-of-interest. The approach of this research is to select or design deep and recurrent architectures, develop generative and discriminative learning techniques, and integrating the risk-averting method of convexifying training criteria into training recurrent deep learning machines.

**Background:** Deep Neural Networks (DNNs) are widely used in computer vision and image classification applications, and have been demonstrated to be an effective tool for detection and classification of features in data. The literature contains numerous examples of DNN techniques applied to problems outside of computer vision, including classification of audio signals, medical sensor data, radar signatures, and many others. However, there appears to be little study on the efficacy of DNNs for use in detection and classification of radio frequency (RF) communications signals. The growing emphasis on cognitive radio and spectrum sensing demonstrates the need for effective techniques for detection and classification of RF communications signals, and DNNs show significant potential as a classifier.

**Signal Classification and Feature Extraction:** Conventional techniques for RF communication signal detection typically exploit some feature of a transmitted signal to produce a reliable detection metric. Such features may include, but are not limited to:

* Matched filtering of pulse shaped symbols
* Direct sequence correlation for spread spectrum systems
* Cyclic prefix detection
* Pilot sequences and other pre-defined synchronization sequences
* Cyclostationarity
* Time and/or frequency multiplexing

**Applicability of Deep Neural Networks:** Typical methods for signal feature extraction rely on some form of convolution, in the form of filtering, sequence correlation, or basis projection (e.g, the discrete Fourier transform). Convolution is commonly included in DNNs, suggesting that a properly trained DNN could achieve accurate classification decision results by effectively computing similar metrics as conventional classifiers. The potential advantage of DNN classification lies in the detection of non-obvious signal features and the ability of a properly designed network to combine multiple metrics into a single classification decision.

**Desired Outcomes:** Applicable research would include the study of:

* Network structures and training techniques which produce accurate classification of RF communication signal data
* Signal features which are most effectively recognized by DNN classifiers
* Performance of DNN classifiers compared to theoretical models and conventional techniques
* Methods for unsupervised training of DNN RF signal classifiers