Radio Signal Characterization with Convolutional Neural Networks

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Abstract

I predict the modulation of an unkown radio signal using a tiered Convolutional Neural Network architecture. Input data to the network is generic complex-form radio data, flattened to a simple vector of 2048 floating point numbers.
The model can accept radio data from any radio source that provides complex samples (either real radio hardware, or simulated sources).
The model was trained on a rich dataset of real and simulated radio signals, and was accelerated with an Nvidia GTX1080

Introduction

Radio signal characterization is the act of determining the modulation type of arbitrary radio signals observed in the environment. Accurate characterization is vital so that the proper demodulator can be used so that the orignal signal (be it audio or binary data) can be obtained.

Problem Domain

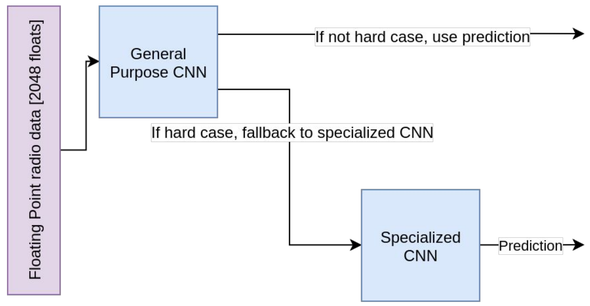
Radio characterization exhibits similarities with image recognition. Radio signals can be shifted in time and amplitude, but exhibit tell-tale “shapes”. This phenomena lends itself well to CNN’s due to their ability to recognize general patterns that are spatially invariant. CNN’s therefore seem to be a suitable solution to this problem.

Data Pre-processing

No pre-processing was necessary. The network operates on raw radio data. This is a major strength of the design.

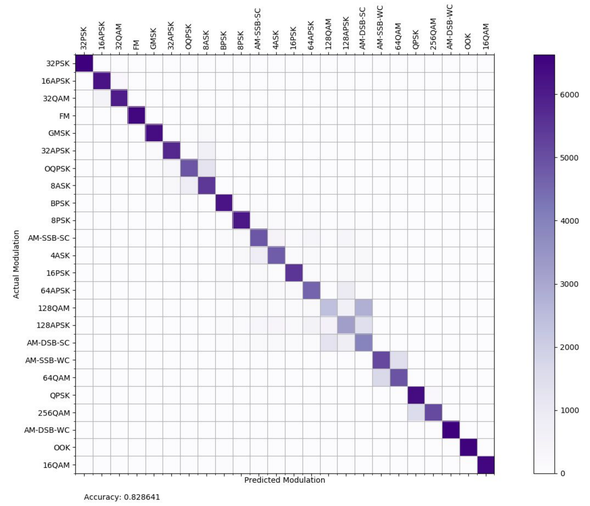
Stacked Network Approach

Certain classes of radio modulations are difficult to characterize correctly (even with state of the art methods), due to their similarity with other modulations. This problem is alleviated with the use of CNN’s that are trained specifically to differentiate between modulations for a given set of difficult classes.



Results

The CNN architecture was able to obtain an accuracy of 82.8% over a variety of moderate to strong signals of multiple modulation schemes.



Conclusion and References

CNNs and a tiered architecture allow for accurate radio signal classification of a diverse set of signals with varying SNRs. No data pre-processing nor much domain knowledge is necessary for this approach which is a strong advantage.
For further reading, please see:

Mackey S. "Radio Signal Characterization with Convolutional Neural Networks" Sacramento State University, College of Engineering and Computer Science, 2019