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Modulation Pattern detection Using Complex Convolutions in Deep Learning

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Overview

Telecommunications utilizes modulation patterns made up of sequences of complex numbers. Classifying modulation patterns is challenging because noise leads to received signals bearing little resemblance to transmitted signals. Deep learning approaches have outperformed statistical methods in this problem space, yet deep learning frameworks lag in support for complex-valued data. In this work, we study the use of complex convolutions in convolutional neural network architectures. We show the use of complex convolutions improves performance, with statistical significance, at recognizing modulation patterns in complex-valued signals with high SNR after being trained on low SNR signals. This suggests complex-valued convolutions enables networks to learn more meaningful representations, which we examine by visualizing 'one-hot' classification inputs.

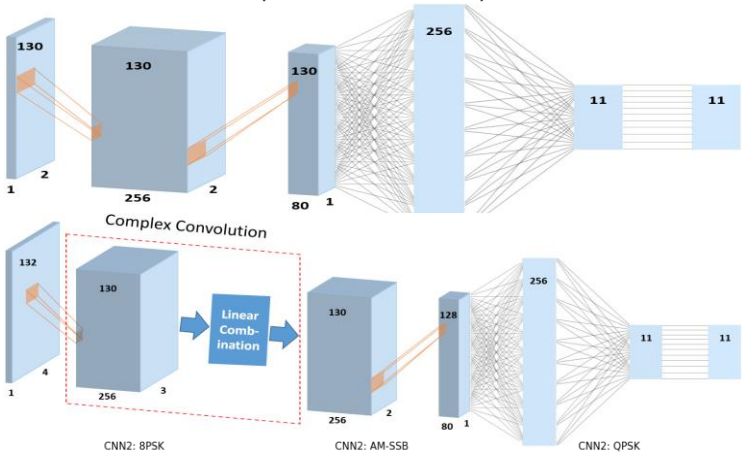
Experiments

- Dataset: RadioML 2016.10A (open source dataset from DeepSig.io)
  - 11 modulation patterns
  - SNR range (in dB): [-20,18], steps of 2 dB
  - Numerous types of noise
  - 1000 samples per modulation pattern per dB SNR
- Each of the three train/test paradigms was repeated five times on each network architecture

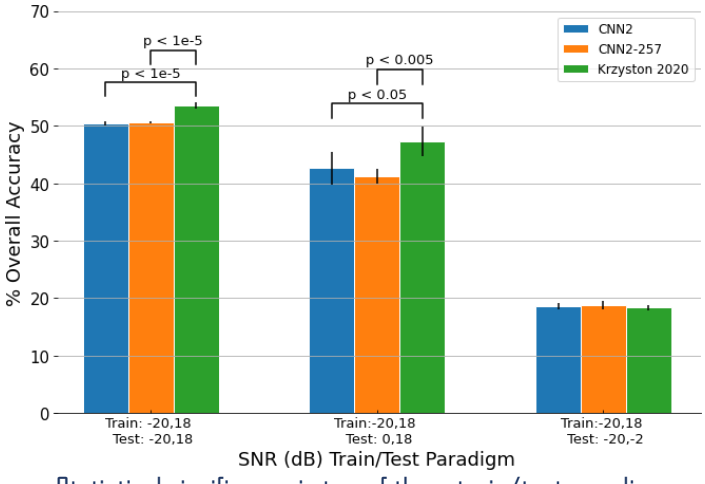
Train dB SNR	Test dB SNR
[-20,18]	[-20,18]
[-20,-2]	[0,18]
[0,18]	[-20,-2]

Architectures

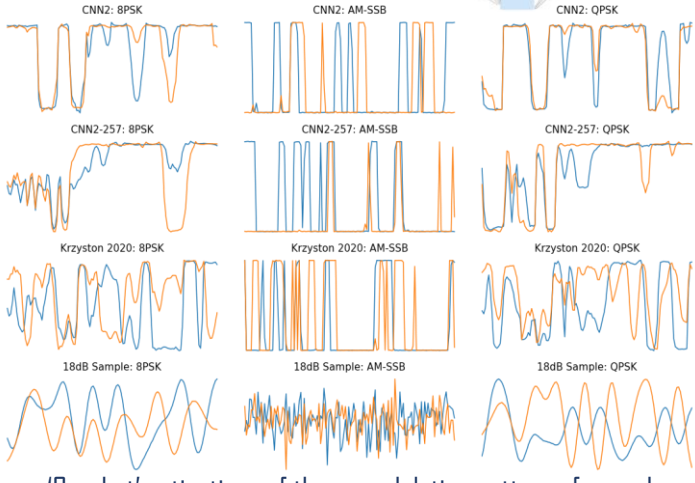
- CNN2 (O'Shea et al. 2016), shown below
- Krzyston 2020, CNN2 with complex convolution shown below
- CNN2-257
  - CNN2 with dense layer of size 257
  - More trainable parameters than Krzyston 2020



Results



- Statistical significance in two of three train/test paradigms



- 'One-hot' activations of three modulation patterns for each architecture trained on [-20,18] dB SNR with 18 dB data samples

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