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Convolutional Neural Network on Radio Modulation Recognition

In signal processing, there are many ways to modulate a signal, depending on the signal type (digital or analog) and function (radio, radar, etc). Identifying a specific signal modulation is essential to decode or identify a threat in a signal. For the sake of this project, radio signals will be used for simplification. As described in "Modulation Recognition Analysis Based on Neural Networks and Improved Model," convolutional and residual neural networks were built and compared on accuracy. [4] For this project, I will code the convolutional residual network with a linear layer as described in this paper in Python. On optimizing this design, I plan on adding an extra linear 256*64 layer while using the stopping criterion of no change or decrease in accuracy over a given number of epochs. I plan on using the ML2016.04C dataset from DeepSig as described in the third paragraph.

In "Modulation Recognition Analysis Based on Neural Networks and Improved Model," "the Neural network was constructed by the PyTorch framework. For CNN, three convolution layers are added, the ReLU function is used as the activation function, and the dropout mechanism is introduced. The results are maximized for pooling, and the final output is obtained by SoftMax classification after calculation…Therefore, We mainly add linear layers with different parameters on the basis of the original network to observe whether the performance of CNN can be improved to a certain extent in the experiment." [4]. I plan on following this design with three linear 256*64 layers with different parameters placed before the final output is obtained by SoftMax classification. For training, I plan on using the stopping criterion of no change or decrease in accuracy over a given number of epochs. I plan on using batch stochastic gradient descent as a optimization training algorithm with a minibatch size of 64 as described in the "Stochastic Gradient Descent Algorithm With Python and NumPy" blog [5]. During training, accuracy and training loss will measured after each round. The accuracy will be determined from the training set and the test set. The accuracy and training loss will be graphed and compared to the original paper.

DeepSig, a company that creates machine-learning solutions for wireless communication problems, has free, open-sourced radio signal datasets from early academic research called ML2016.04C and ML2016.10A. [1] "The RadioML 2016.10A and RadioML 2016.04C datasets provide 170163 and 220000 labeled In-Phase and Quadrature (I/Q) samples (two-dimensional data), respectively…The signals are synthesized for evaluating output under distinct signal and noise scenarios at various SNR levels with mild Local Oscillators (LO) drift, light fading, and multiple distinct labeled SNR increments." [3] The ML2016.04C dataset is used in the "Modulation Recognition Analysis Based on Neural Networks and Improved Mode" paper. In the ML2016.04C dataset, the modulation types "consist of BPSK, QPSK, 8PSK, 16QAM, 64QAM, BFSK, CPFSK, and PAM4 for digital modulations, and WB-FM, AM-SSB, and AM-DSB for analog modulations. Data is modulated at a rate of roughly 8 samples per symbol with a normalized average transmit power of 0 dB." [2] The dataset is orgainzed by modulation

type and signal to noise ratio (SNR). The signals in the dataset is in Q/I form and can be graphed and converted into amplitude and phase form by using the code and explanation at RF_modulation_classification/dataset_visualisations.ipynb at 8ff8a460adaf7fcbe48377e2781c5052df8a1608 · kwyoke/RF_modulation_classification (github.com) [6]. I plan on using 80% of the dataset for training, 10% for validation, and 10% for testing.

In the "Modulation Recognition Analysis Based on Neural Networks and Improved Model" paper, initially, the accuracies of residual neural network and convolutional neural network with an additional linear layer were similar. The residual neural network had a final accuracy of 77%, while the convolution neural network with an additional linear layer had a final accuracy of 60%. [4] If the convolutional neural network has the same accuracy or is higher than described in the paper, the project has been successful. For my results, I plan to produce generalization performance performance assessment, examples of predictions on the test set, and graphs of accuracy over epoch and loss over epochs for both the training and test sets.

References:

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[5] Python R. Stochastic Gradient Descent Algorithm With Python and NumPy – Real Python. realpython.com. https://realpython.com/gradient-descent-algorithm-python/

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