



IIITV-ICD

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY VADODARA –INTERNATIONAL
CAMPUS DIU

Design Project–Group Presentation

AUTOMATIC MODULATION CLASSIFICATION

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ABSTRACT

An efficient neural network techniques based on depthwise separable convolution has been proposed to classify the modulation of the received signals.

PROBLEM STATEMENT

TO IDENTIFY MODULATION TECHNIQUE ON RECEIVER SIDE IN WIRELESS
COMMUNICATION SYSTEMS

BUT WHY WE NEED THAT??



BEFORE MIDSEM

CNN ✓

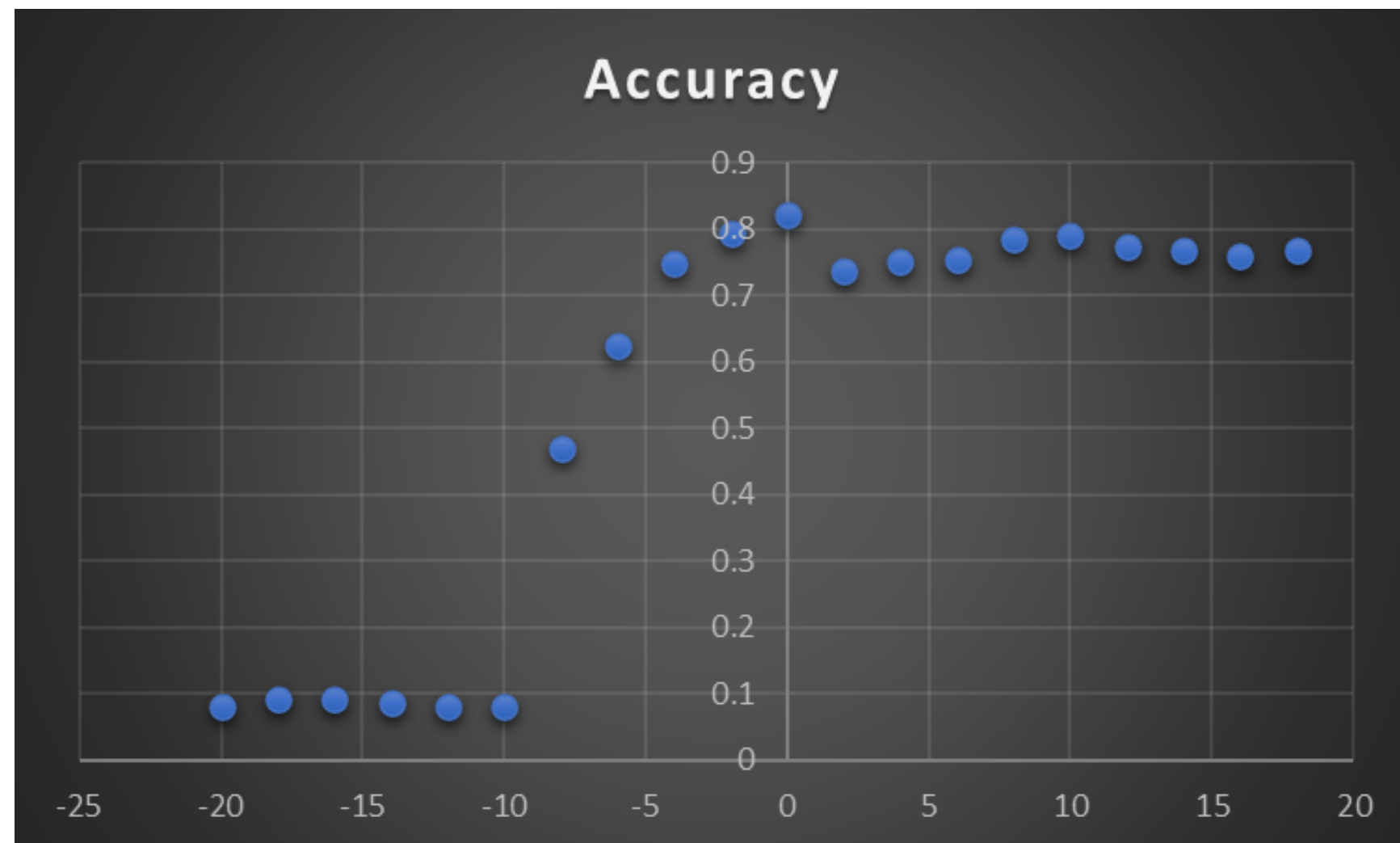
CNN - with Batch Normalization ✓

ResNet ✗

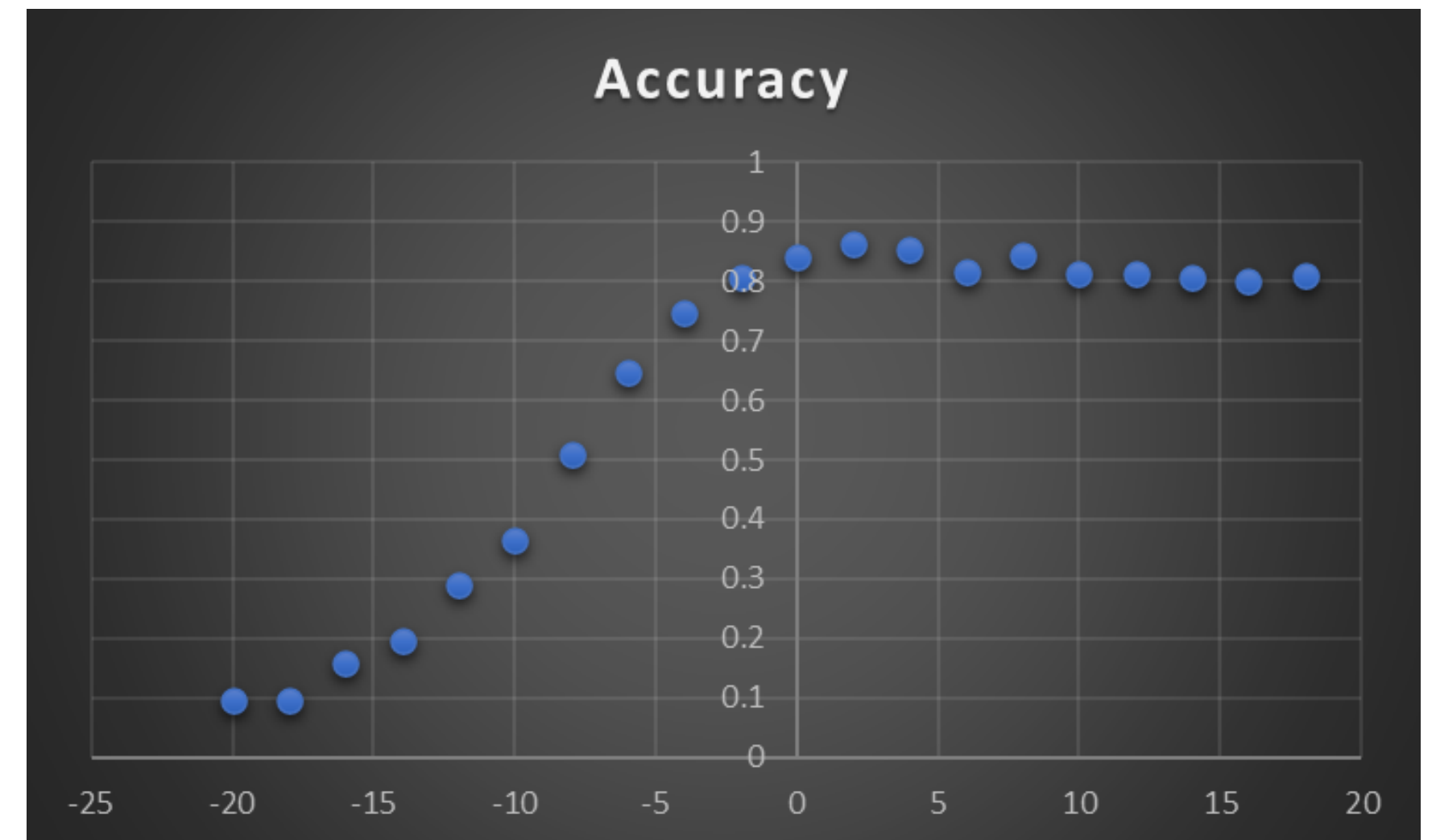
CLDNN ✗

ACCURACY

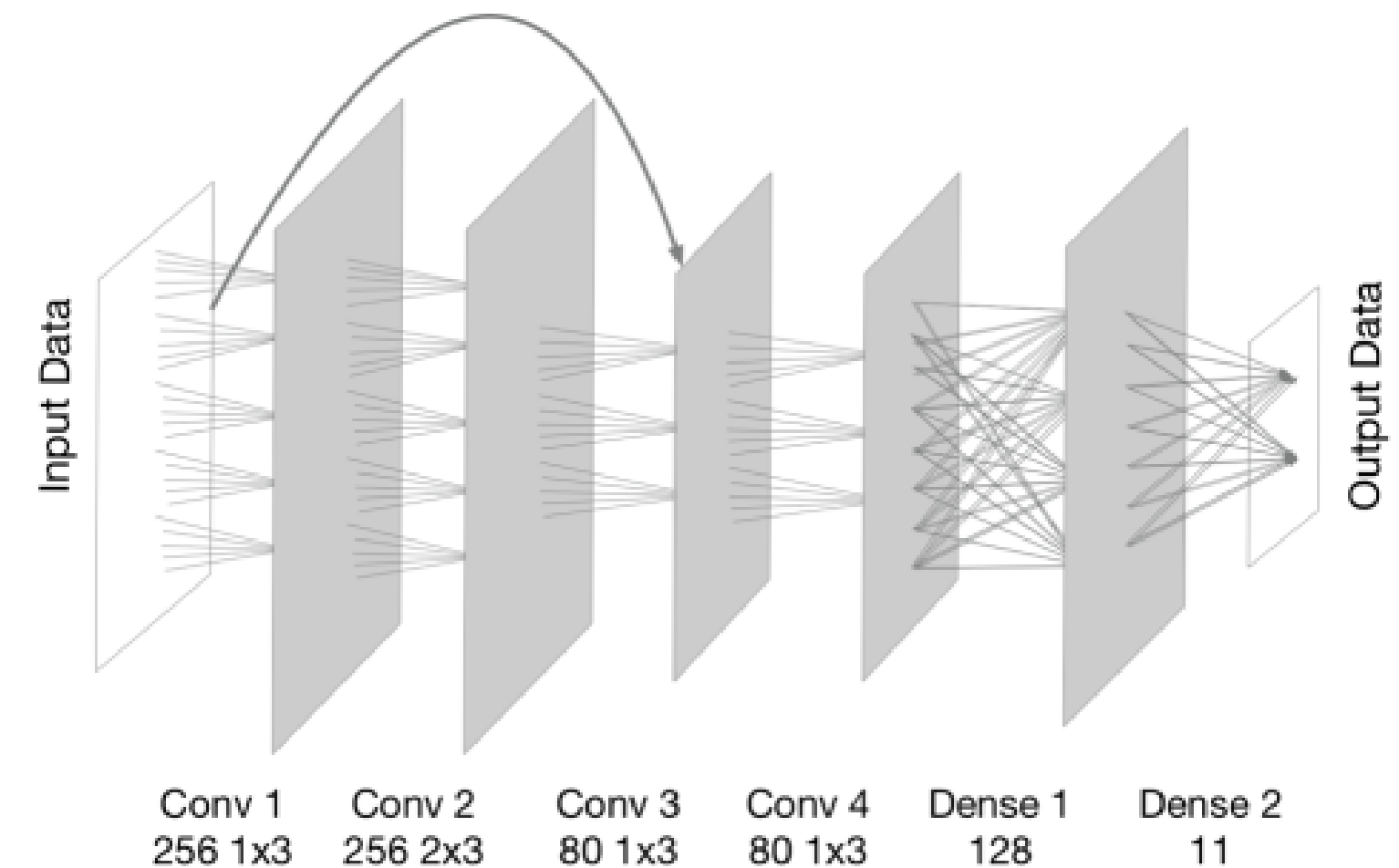
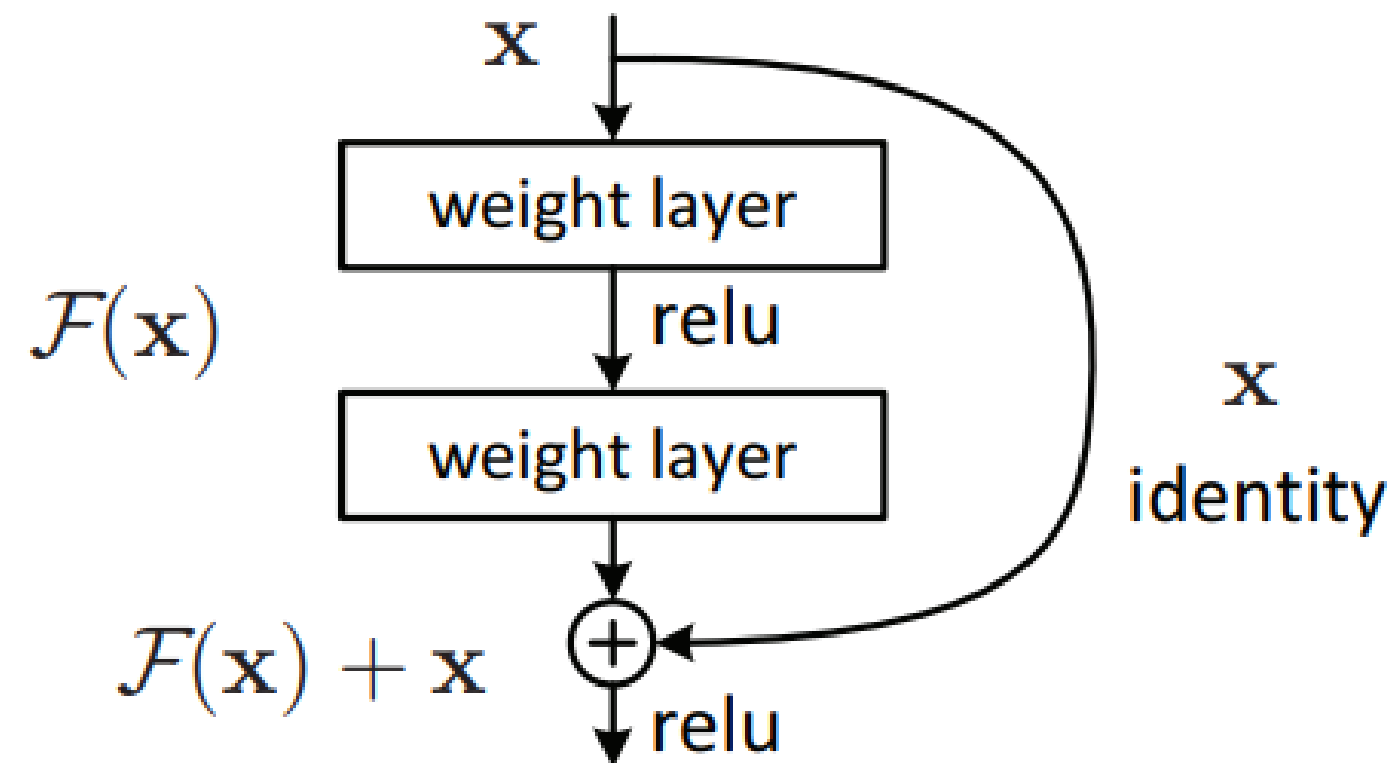
CNN



CNN with Batch Normalization



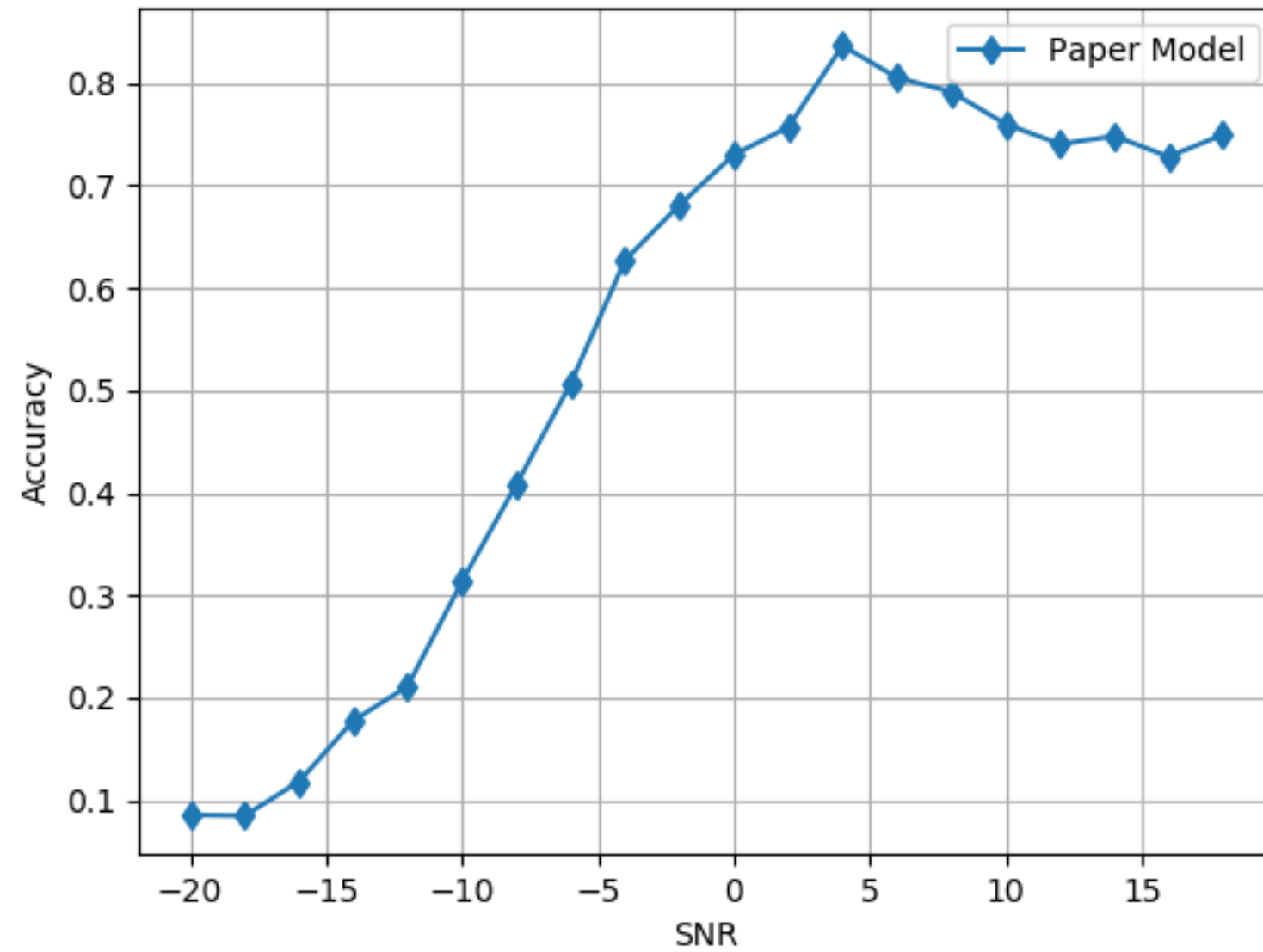
RESNET



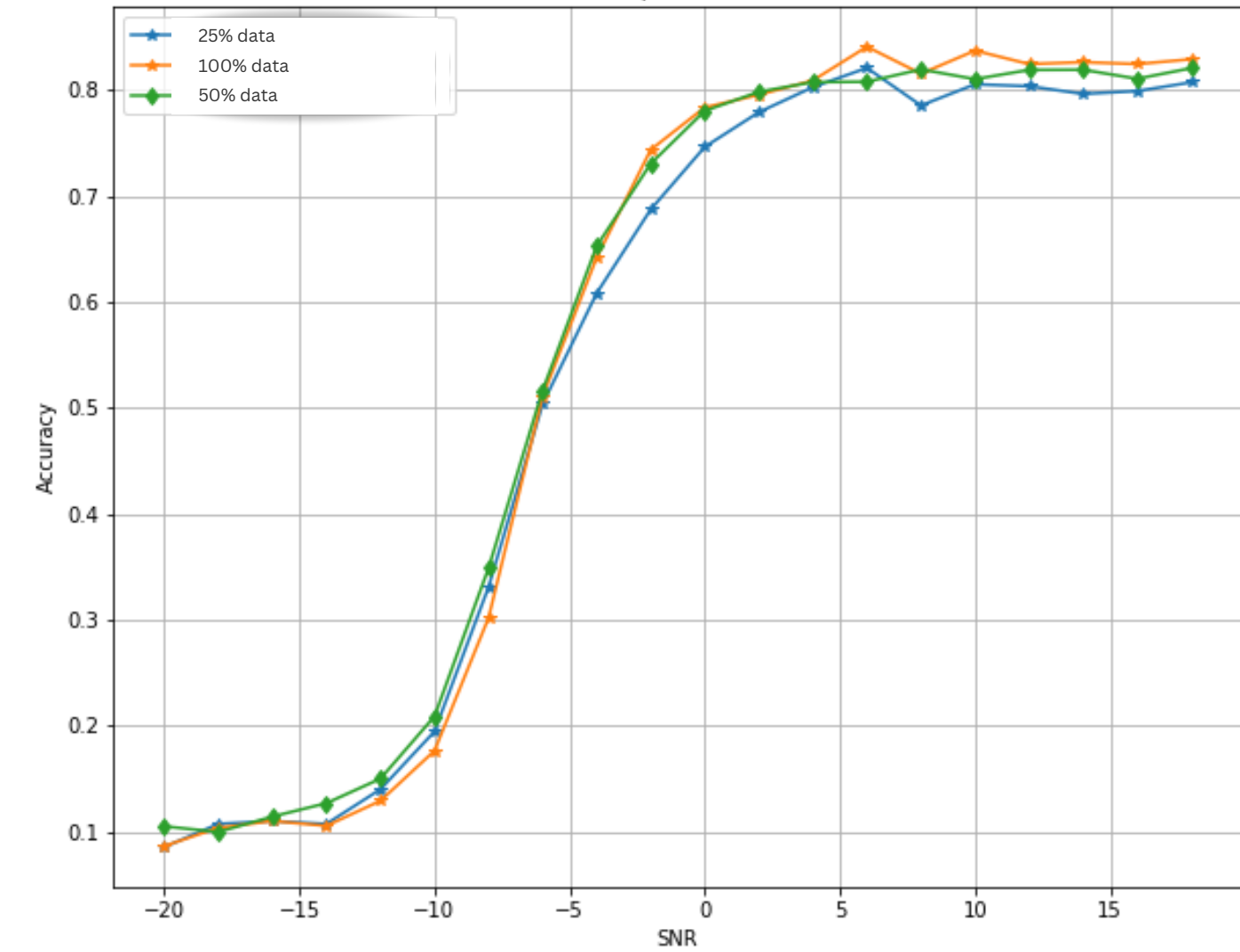
In order to solve the problem of the vanishing/exploding gradient, we introduce Residual Blocks. In this network (ResNet), we use a technique called skip connections.

ACCURACY

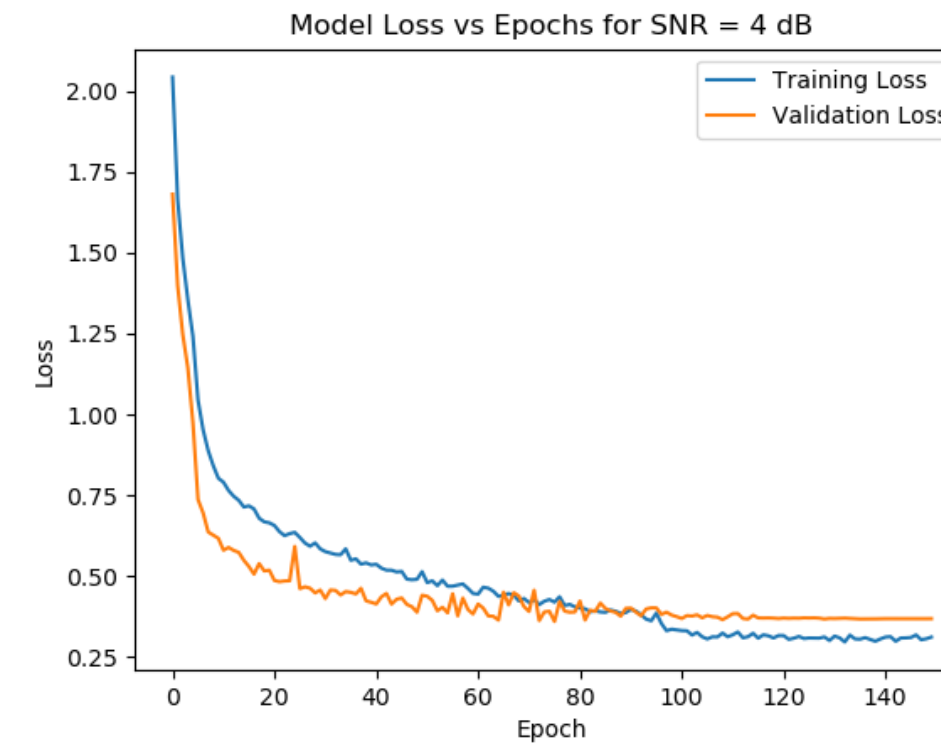
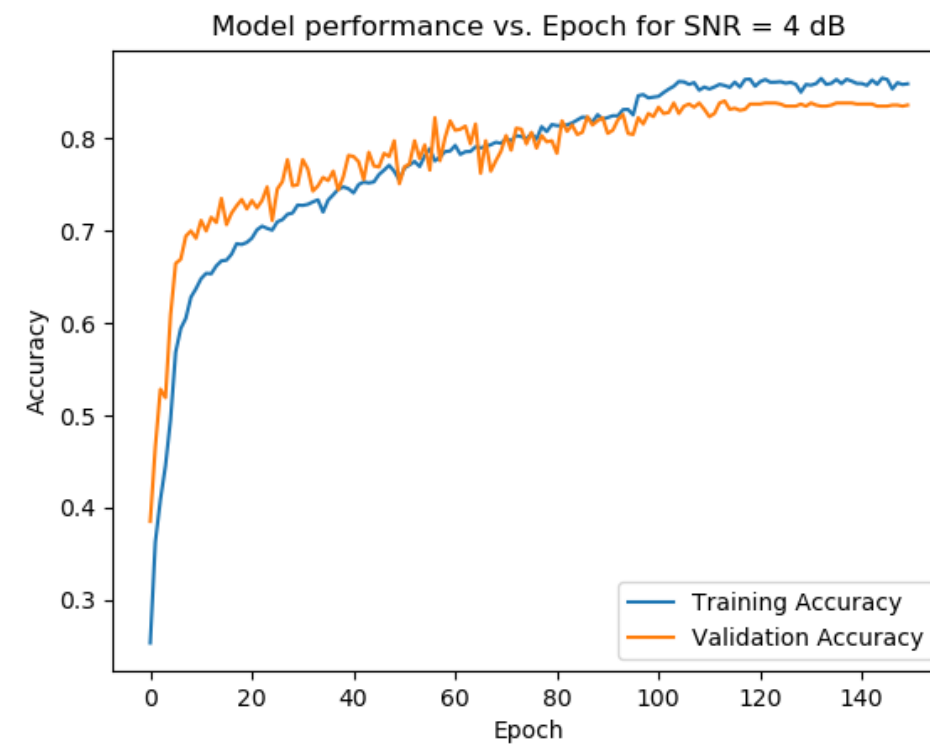
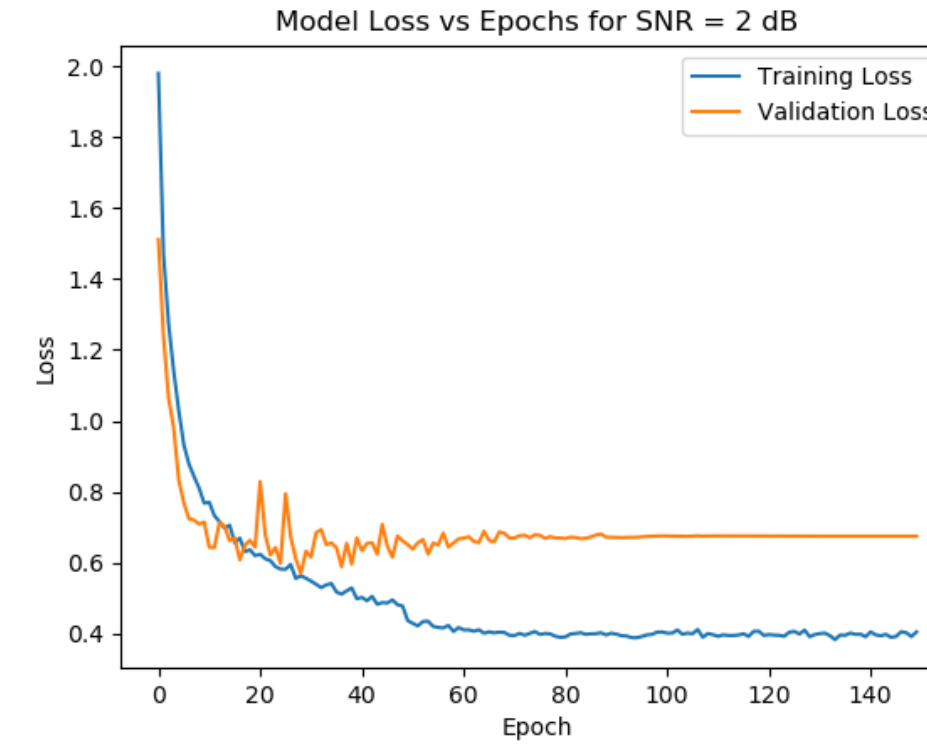
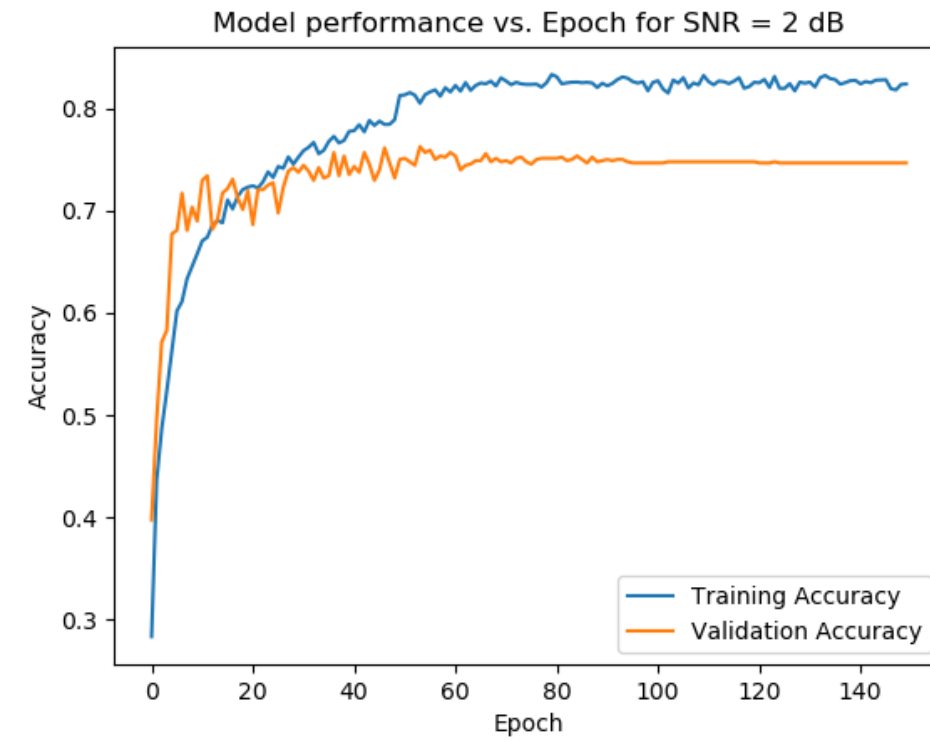
Model performance vs. SNR



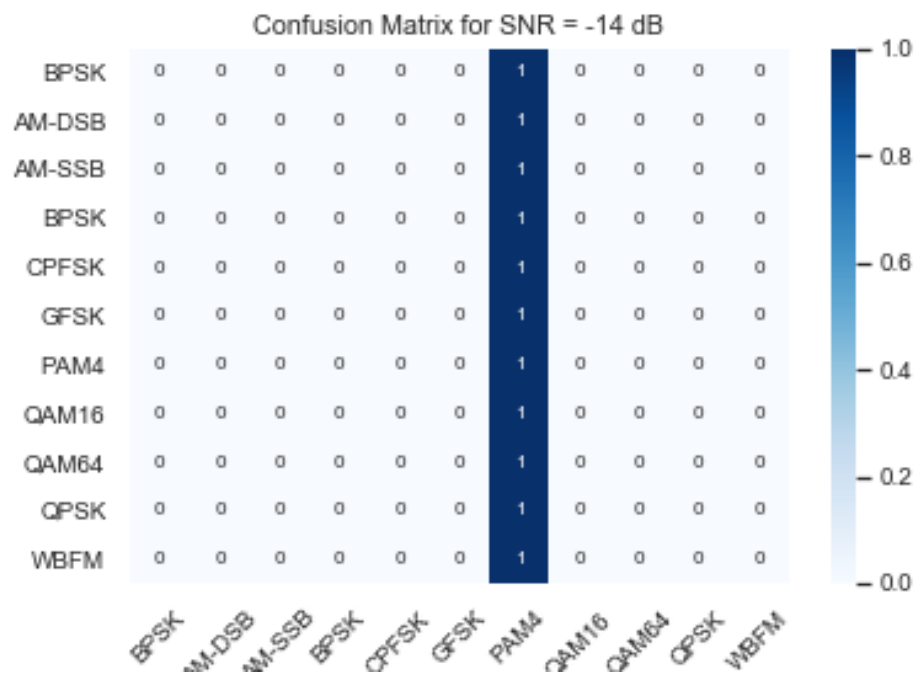
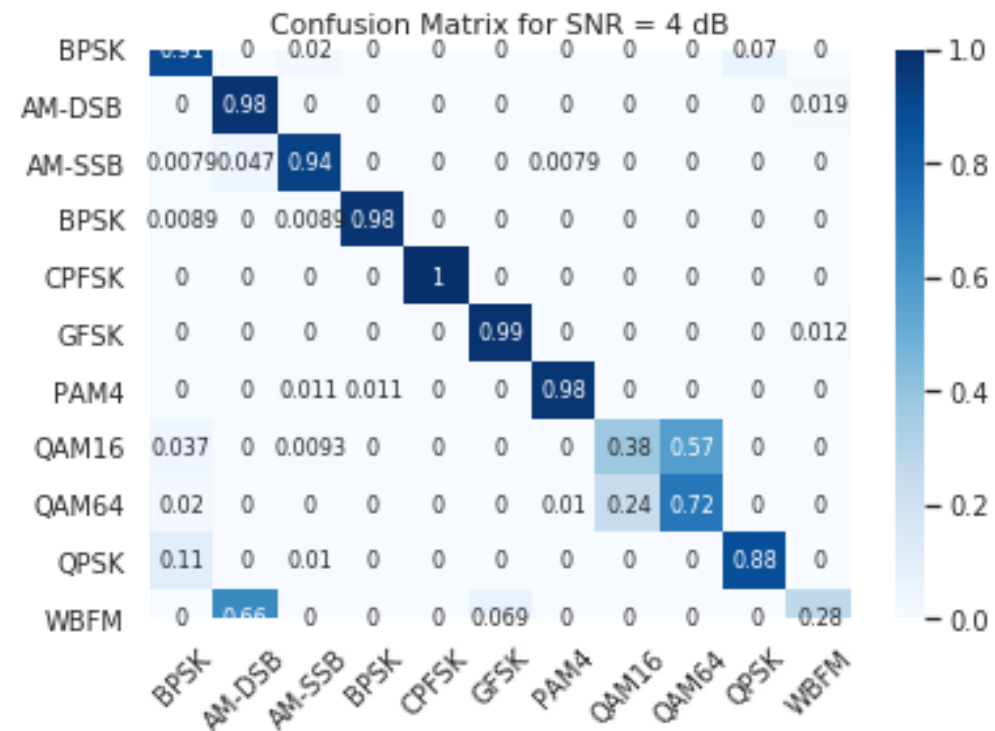
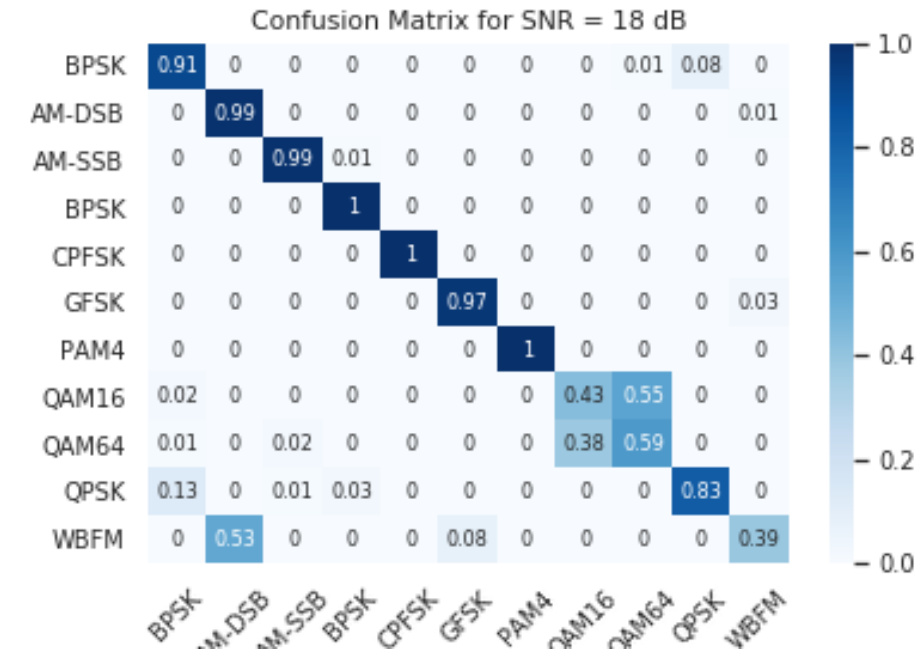
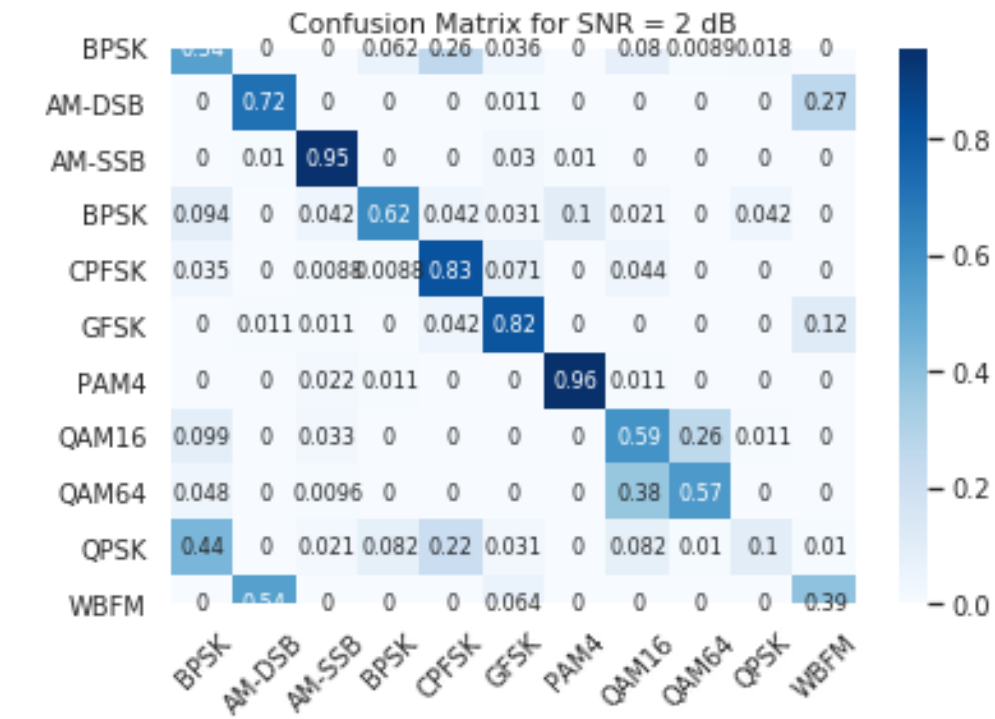
RESNET Model performance vs. SNR



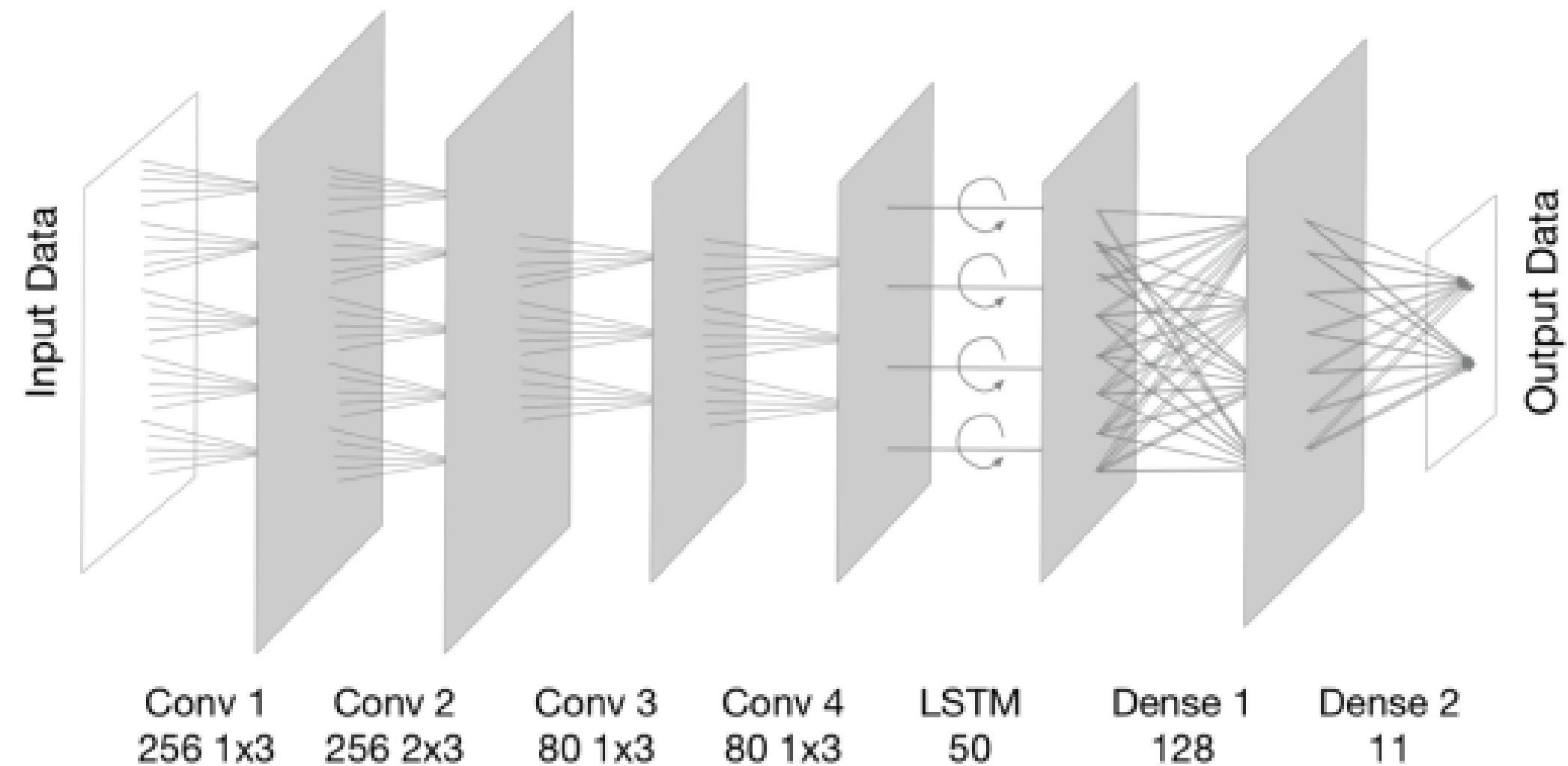
ACCURACY/LOSS vs epoch



CONFUSION MATRIX



CLDNN



It is composed of sequentially connected CNN, LSTM and fully connected neural networks.

ACCURACY

accuracy = 0.8396666646003723, snr = 2
accuracy = 0.8413333296775818, snr = 8
accuracy = 0.6541666388511658, snr = -4
accuracy = 0.8361666798591614, snr = 6
accuracy = 0.843666672706604, snr = 18
accuracy = 0.5203333497047424, snr = -6
accuracy = 0.10983332991600037, snr = -20
accuracy = 0.11233333498239517, snr = -18
accuracy = 0.8503333330154419, snr = 10
accuracy = 0.8356666564941406, snr = 4
accuracy = 0.7588333487510681, snr = -2
accuracy = 0.3283333480358124, snr = -8
accuracy = 0.8460000157356262, snr = 12
accuracy = 0.825166642665863, snr = 0
accuracy = 0.11699999868869781, snr = -16
accuracy = 0.15566666424274445, snr = -12
accuracy = 0.8445000052452087, snr = 14
accuracy = 0.2096666693687439, snr = -10
accuracy = 0.8471666574478149, snr = 16
accuracy = 0.1326666623353958, snr = -14

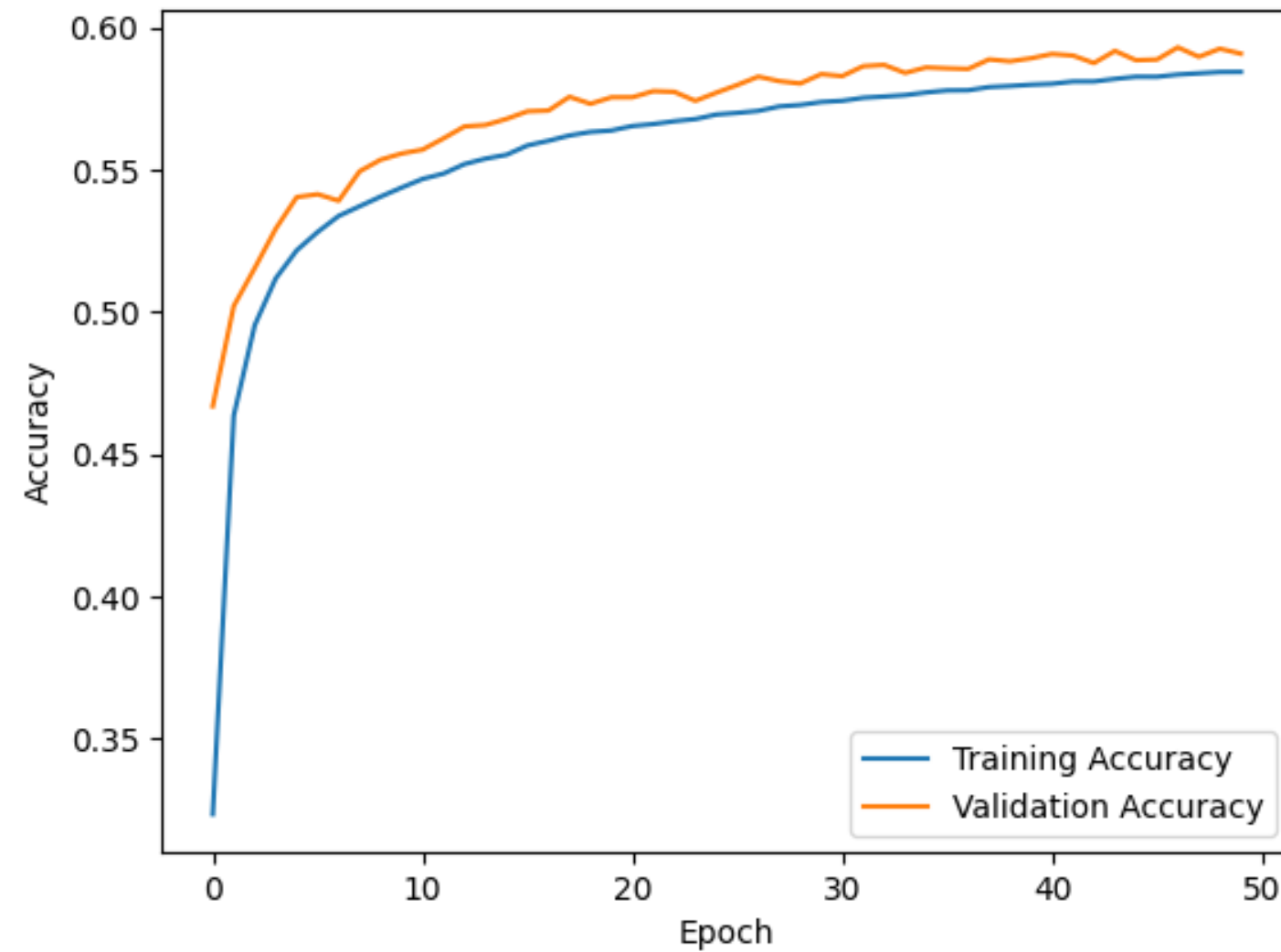
BIG DATASET

accuracy = 0.8481818437576294 , snr = 2
accuracy = 0.835454523563385 , snr = 8
accuracy = 0.6399999856948853 , snr = -4
accuracy = 0.8454545736312866 , snr = 6
accuracy = 0.8500000238418579 , snr = 12
accuracy = 0.5109090805053711 , snr = -6
accuracy = 0.0918181836605072 , snr = -20
accuracy = 0.08636363595724106 , snr = -18
accuracy = 0.8518182039260864 , snr = 16
accuracy = 0.860909104347229 , snr = 10
accuracy = 0.8218181729316711 , snr = 4
accuracy = 0.7918182015419006 , snr = -2
accuracy = 0.2800000011920929 , snr = -8
accuracy = 0.10454545170068741 , snr = -12
accuracy = 0.8336363434791565 , snr = 0
accuracy = 0.08727272599935532 , snr = -16
accuracy = 0.15636363625526428 , snr = -10
accuracy = 0.828181803226471 , snr = 14
accuracy = 0.8263636231422424 , snr = 18
accuracy = 0.10000000149011612 , snr = -14

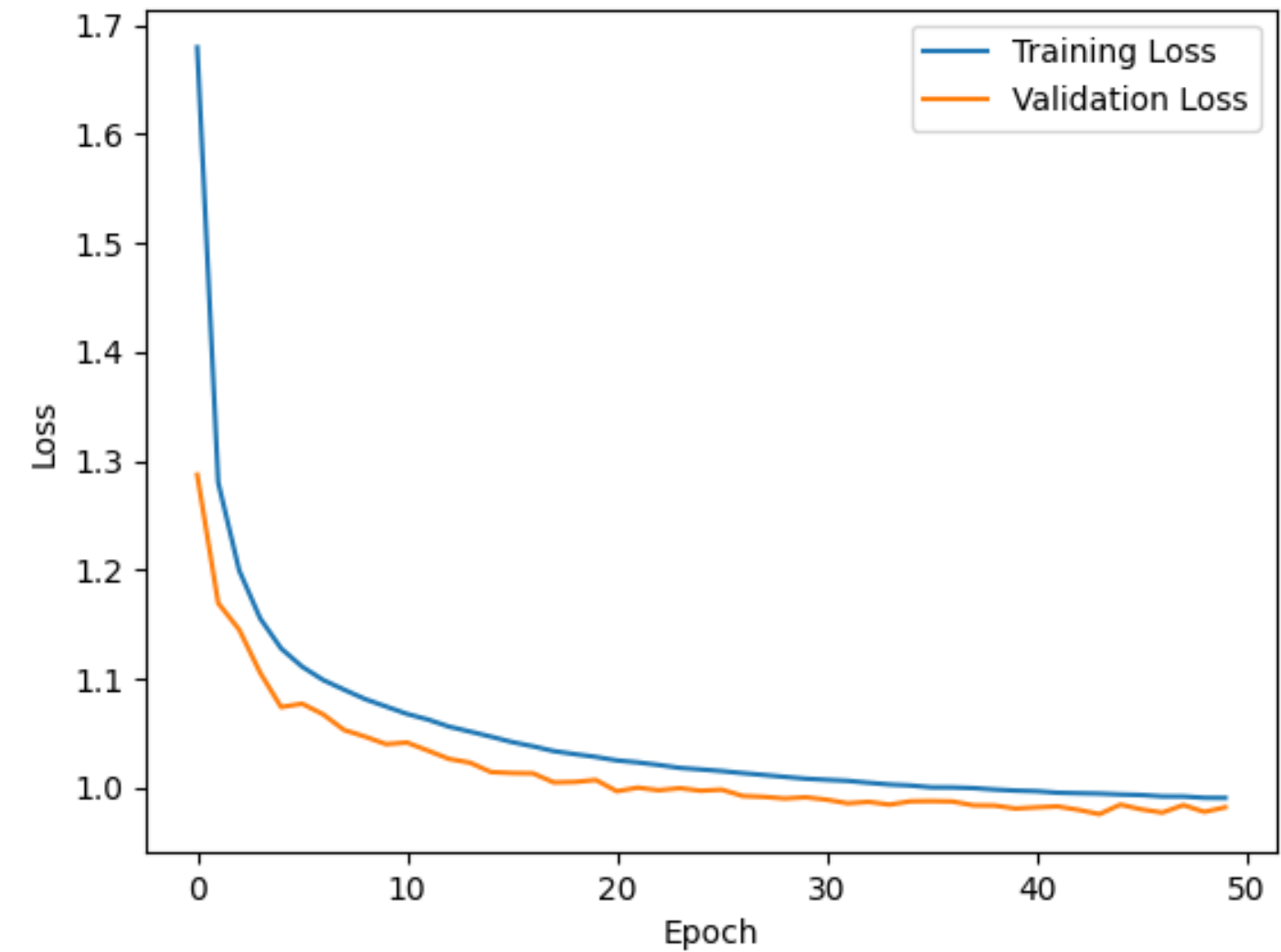
SMALL DATASET

ACCURACY/LOSS VS EPOCH

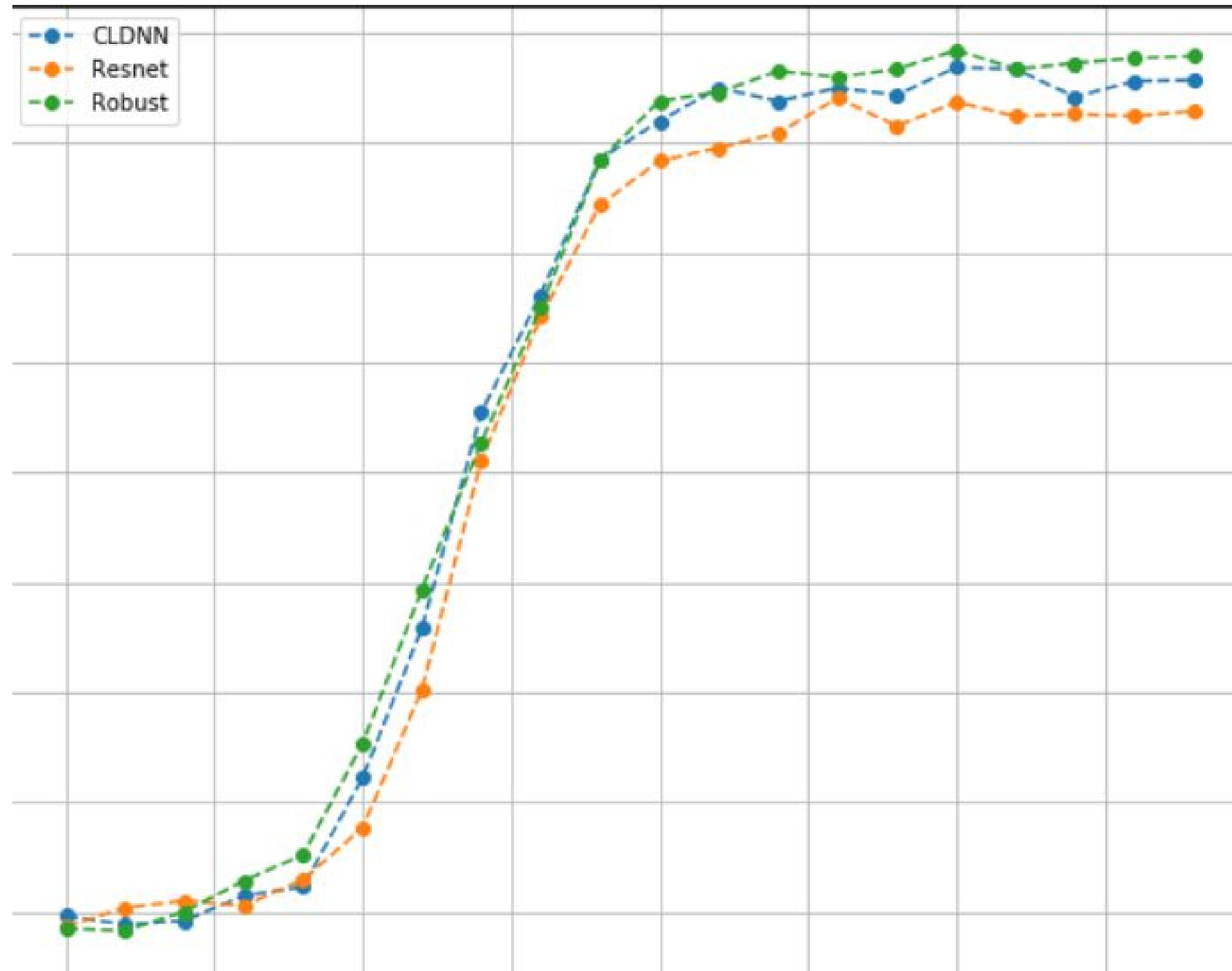
Model performance vs. Epoch



Model Loss vs Epochs



CONCLUSION



CONCLUSION

- **Multiple classifiers are built and tested, which provide high probabilities of correct modulation recognition in a short observation time.**
- **The performance of CNNs are improved from 72% to 83.3% by increasing the depth of CNNs.**
- **The average classification accuracy reaches 83.5% for ResNet .**
- **CLDNN model combines a CNN block, a LSTM block and a DNN block as a classifier that can automatically extract the spacial and temporal key features of signals.**
- **These models are capable to recognizing the modulation formats with various propagation characteristic, and show high real-time functionality.**

REFERENCES

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- [4] Corinna, C.Vladimir: Support-Vector-Machine, mach.Learning 20273–(297) (1989)

THANK YOU