

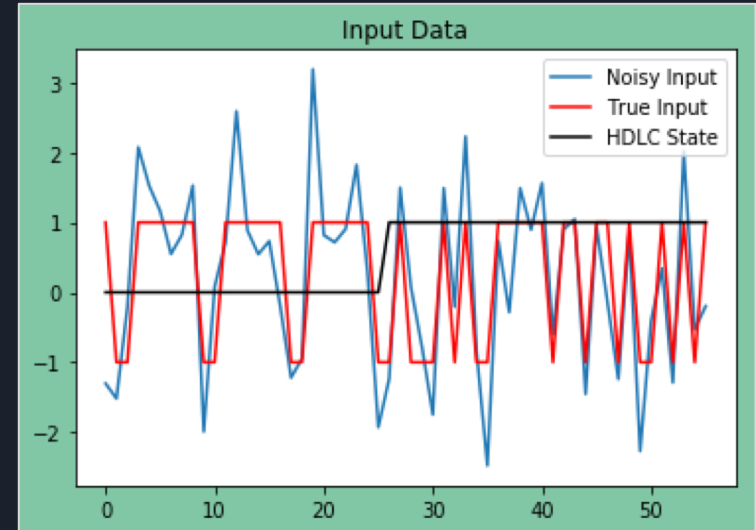
A decorative graphic on the left side of the slide consisting of two overlapping parallelograms. The front one is blue and the back one is a light greenish-blue. They are positioned diagonally, with the blue one partially covering the green one.

Improving BER with Machine Learning

by Alex

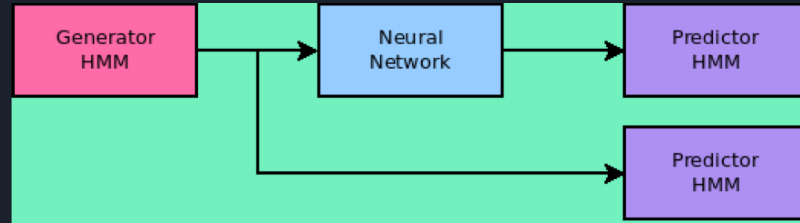
The Setup

- Binary value $X = \{-1, 1\}$ sent over the channel to get $Y = X + N$
- Generator HMM creates and muddles the data
- Predictor HMM take the data in and “guesses” what was sent
- If we aren’t sending anything (Idle) we send “-1,1,1,1,1,1,-1”



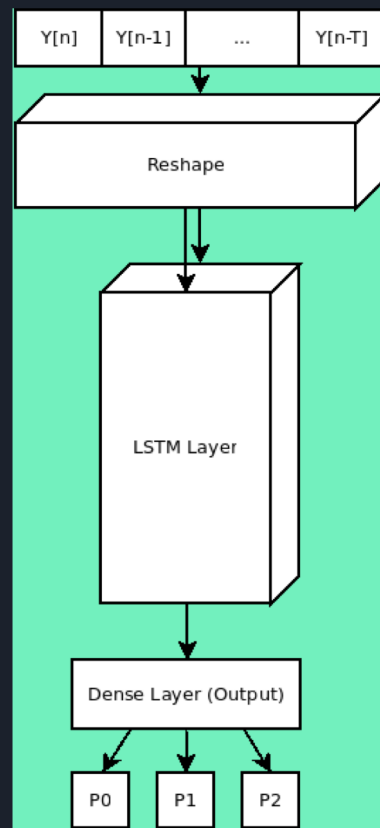
The Goal

- Using a neural network, decrease the amount of uncertainty in the P-HMM
- Strengthen the confidence in HDLC bits while leaving the random message bits untouched
- By decreasing bit error in HDLC, error correction codes should have an easier time decoding the important messages



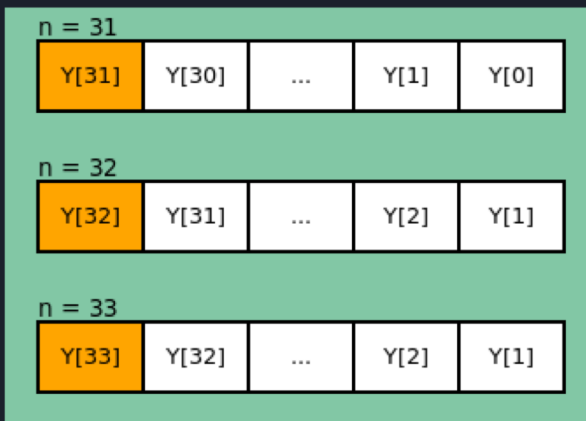
Structure

Layer Type	Output Shape	# of Params
Reshape	(None, 1, 12)	0
LSTM	(None, 32)	8320
Dense	(None, 3)	99
Total Params:	8,419	



Input Structure

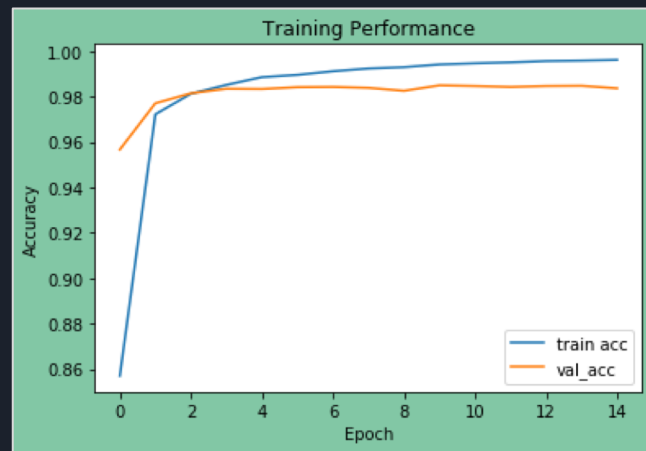
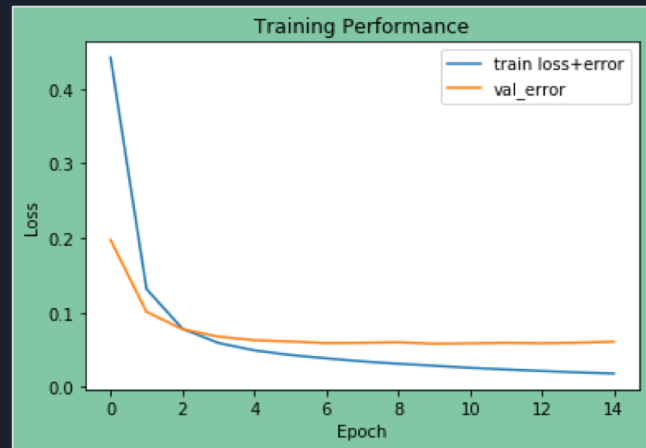
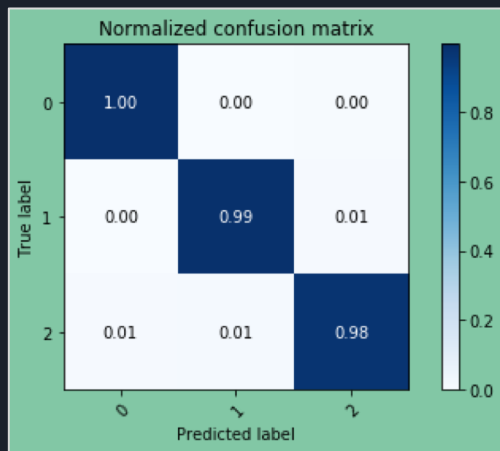
- LSTM Layer uses time to make decisions
- Feed the neural net a vector of 32 time-steps
- Decision is based on the most recent bit that came in



Input vectors at time n . The box shaded in yellow is the "bit in question": the bit we are making a decision about

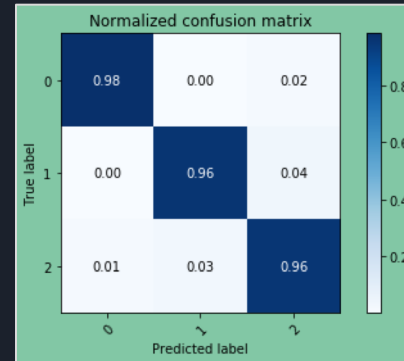
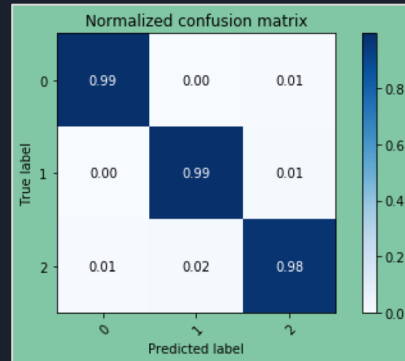
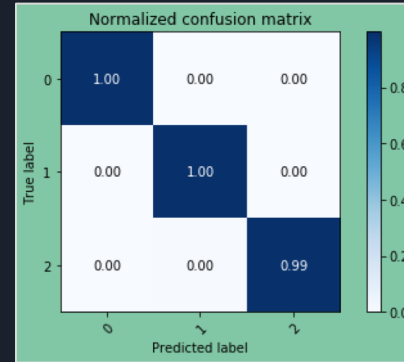
Performance

- Training Time: 41 seconds
- Max Accuracy: ~98%

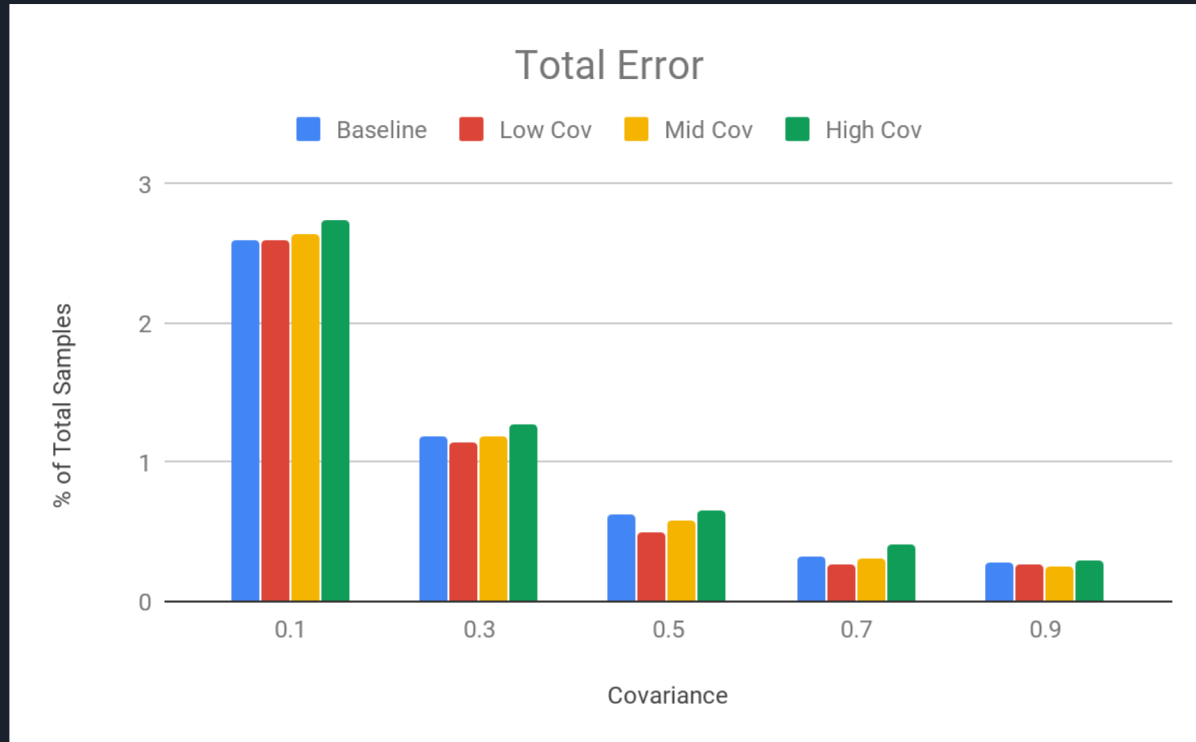


Varying Input SNR

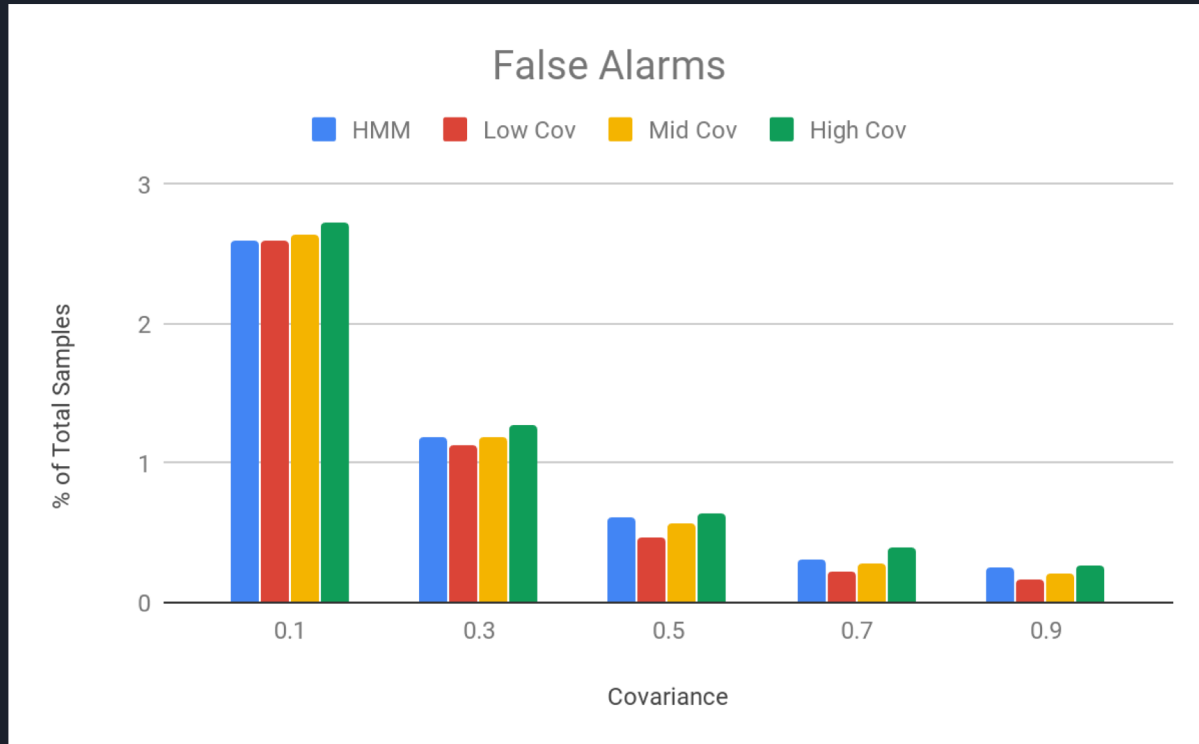
- Next, trained 3 Neural Nets on different AWGN with covariances 0.1 (Top Right), 0.5 (Bottom Left), and 0.9 (Bottom Right)



Varying Input SNR

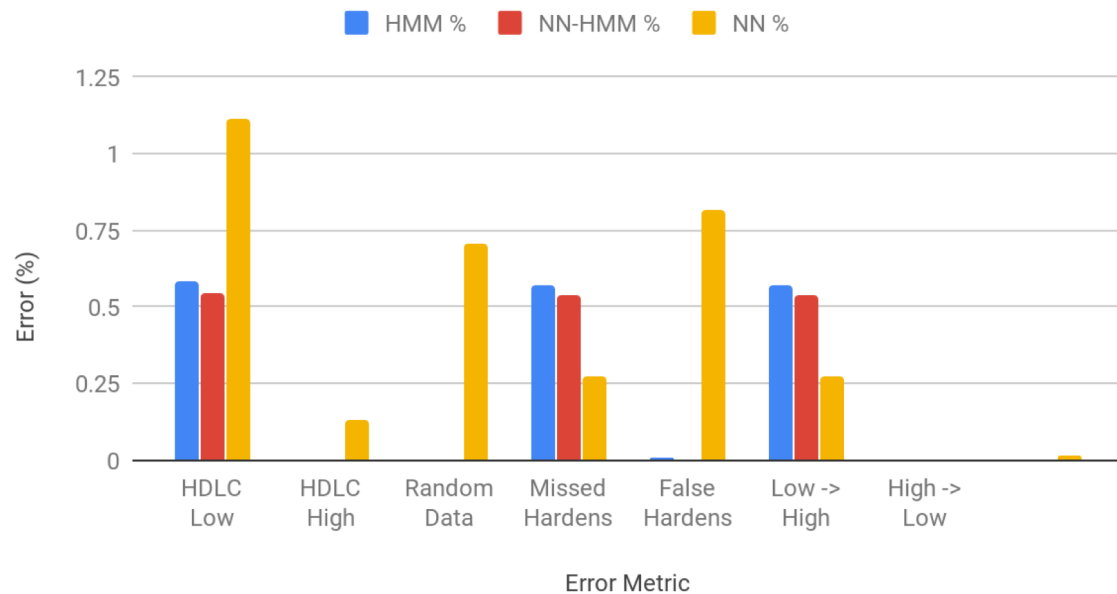



Varying Input Covariance



Error Compared to HMM

Error Metrics





Metric	HMM Total	NN-HMM Total	NN Only	HMM %	NN-HMM %	NN %
Total Error	581.7	546.2	1112.2	0.5817	0.5462	1.1122
HDLC Low	2.2	1.4	132	0.0022	0.0014	0.132
HDLC High	5.8	3.4	705.5	0.0058	0.0034	0.7055
Random Data	573.7	541.4	274.7	0.5737	0.5414	0.2747
Total Hardens	88750.1	88721	87645	88.7501	88.721	87.645
Missed Hardens	7.6	4.4	813.7	0.0076	0.0044	0.8137
False Hardens	573.7	541.4	274.7	0.5737	0.5414	0.2747
Low -> High	0.2	0.2	4.9	0.0002	0.0002	0.0049
High -> Low	0.2	0.2	18.9	0.0002	0.0002	0.0189