Updates 4 Aug

Recap from previous weeks

- CNNs semi-successful at modulation classification with features: I/Q data, amplitude-phase data, and constellation image, when applied on radioML dataset
- But time characteristics yet to be explored fully (LSTM)
- Also, radioML dataset too clean → see how DL models perform on more realistic datasets
- Also think about how to deal with superposed signals, changing signals etc

Summary of updates

1. Dataset generation process
2. Model performance on new datasets
3. Classification on superposed signals

1. Dataset generation with Matlab

- Created three datasets: easy, medium, hard
- 8 digital modulations, 1024 points, -10dB to 30dB

1. Easy – Only AWGN
2. Medium – AWGN + Rician Fading + light clock offset
3. Difficult – AWGN + Rician Fading + realistic clock offset and Doppler effect

1. Data generation process for M-ary mod scheme

1. Source msg: Generate random symbols from 0 to M-1 with unif distribution, and convert to I/Q complex form
2. Upsample to get 8 samples per symbol
3. Filter with root-raised cosine filter with roll-off factor 0.35
4. Apply channel effects
5. Normalise and extract 1024 samples

1. Important parameters and channel effects

- Sampling freq: 200kHz; Carrier freq: 902MHz
- Rician fading: 3 paths with delay [0, 9E-6, 1.7E-5] (s)
  - Gains [0, -2, -10] (dB)
  - Kfactor 4
- Max clock shift (ppm)： Light – 0.001 Heavy – 5
  - Affects frequency offset: f_offset = -fc*(clkshift/1M)
  - Affects sampling rate: fs_new = fs*(1+clkshift/1M)
- Max Doppler shift (Hz): 4

1. Justification for channel parameters

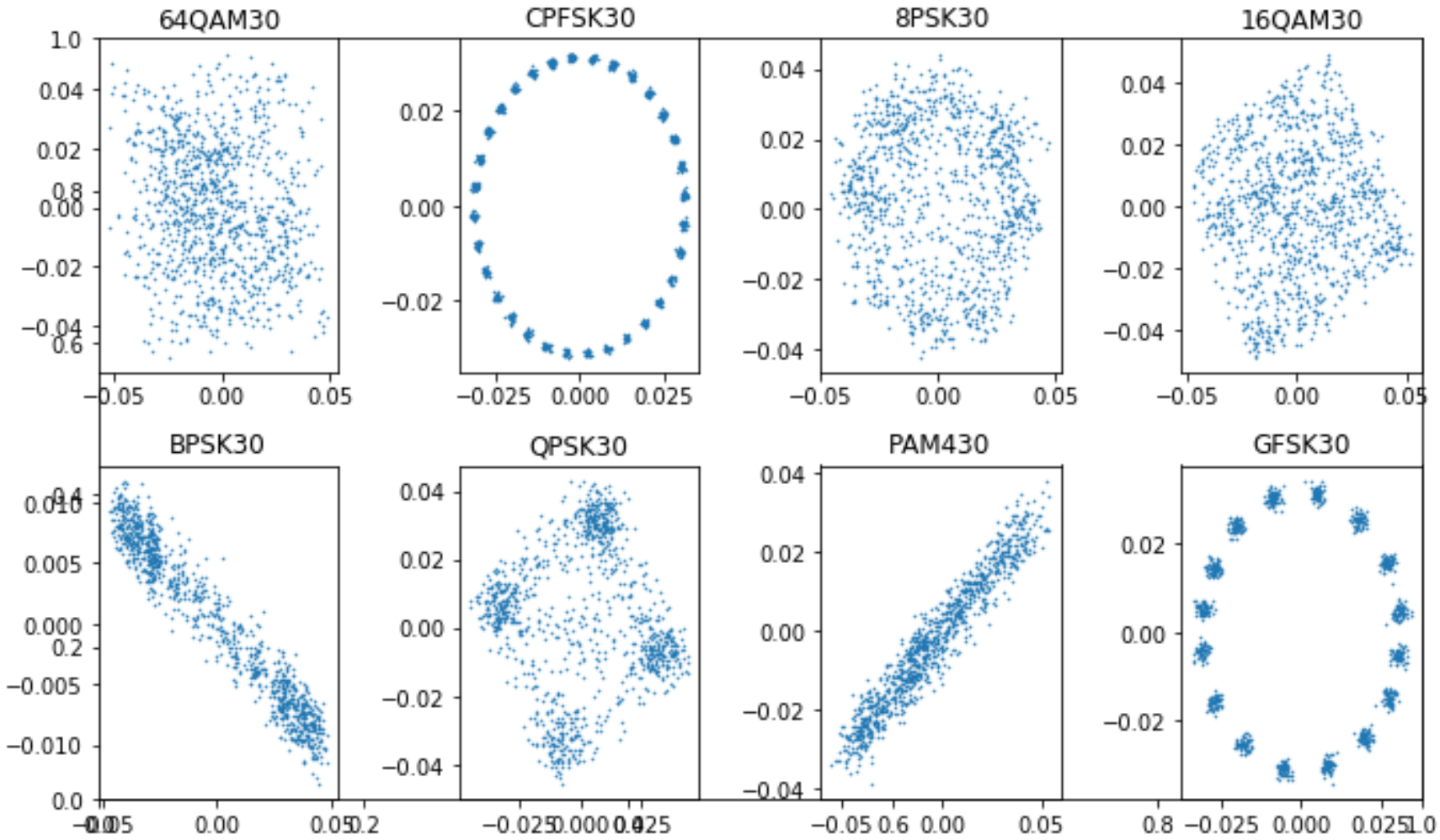
- Rician fading:
  - Path delay of E-5 s typical of outdoors RF propagation, path length difference of ~km
  - Gains arbitrary → but can be calculated using path loss model?
  - Kfactor 4 typical for Rician fading, 0 for pure Rayleigh

Max clock shift (ppm)：

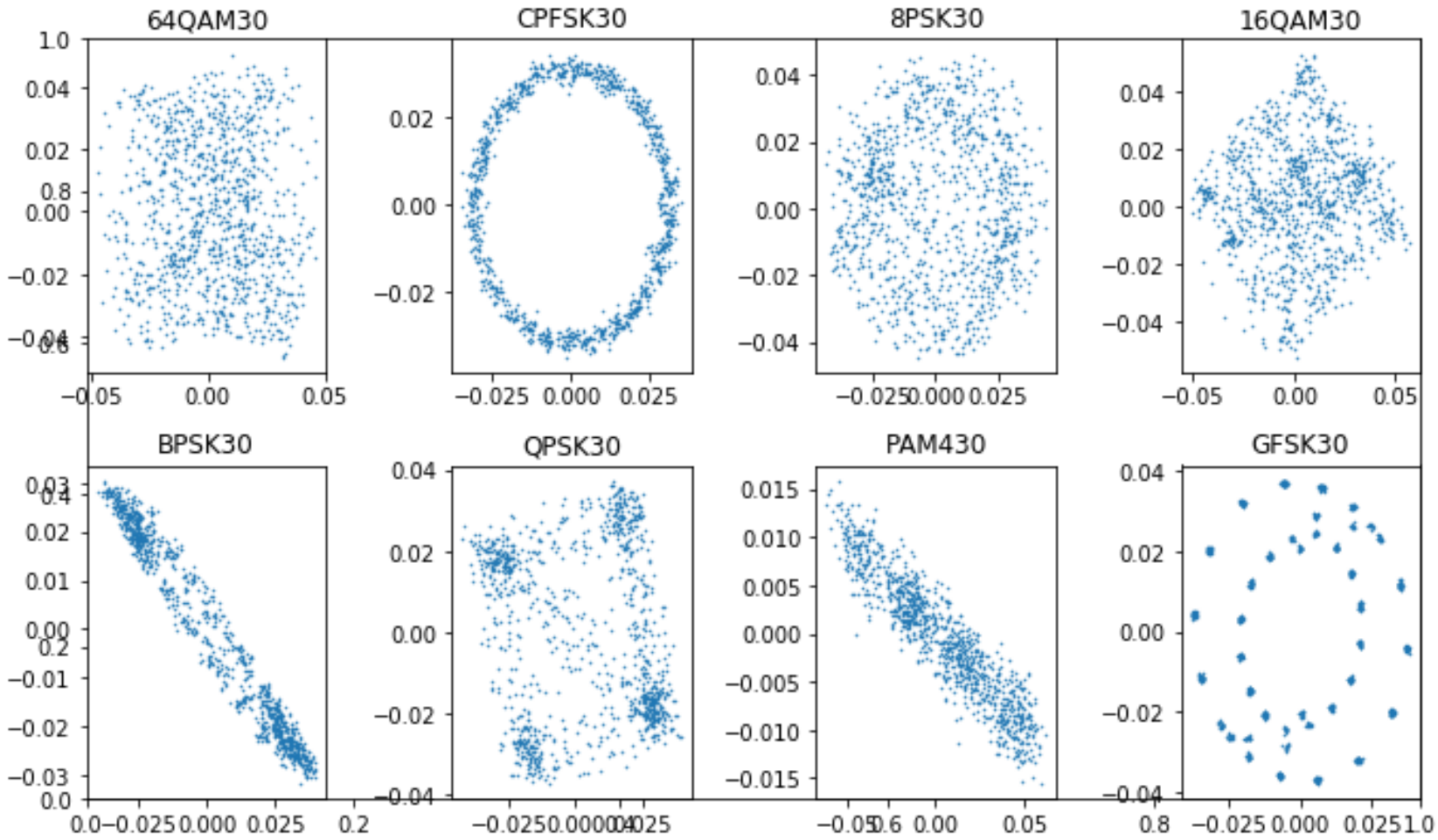
  - Not sure what is typical for RF… 0.001ppm gives nice constellations, at 5ppm constellations degrade significantly

- Max Doppler shift: 4Hz correspond to walking speed given f_c

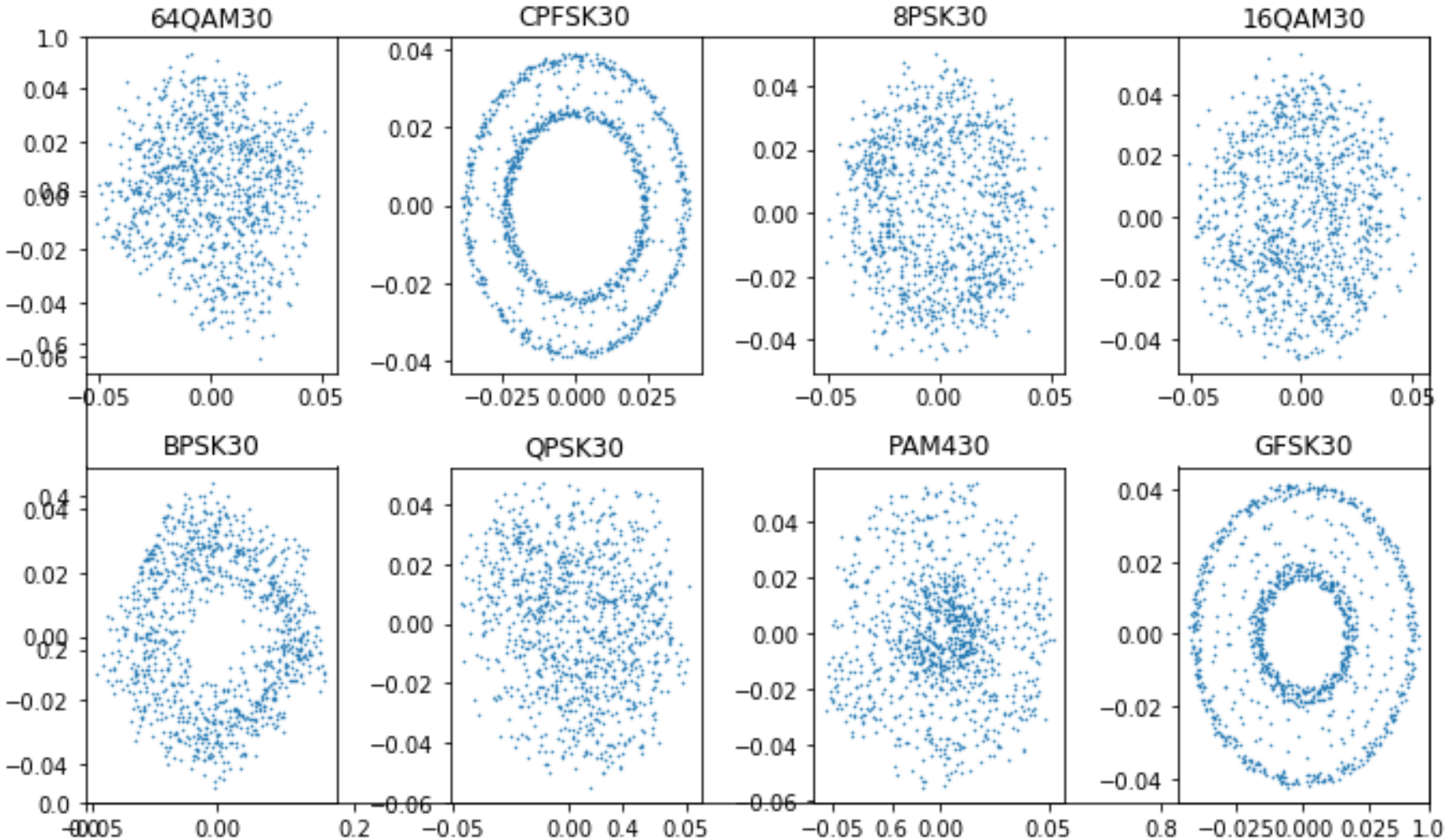
1. Easy Dataset – only AWGN



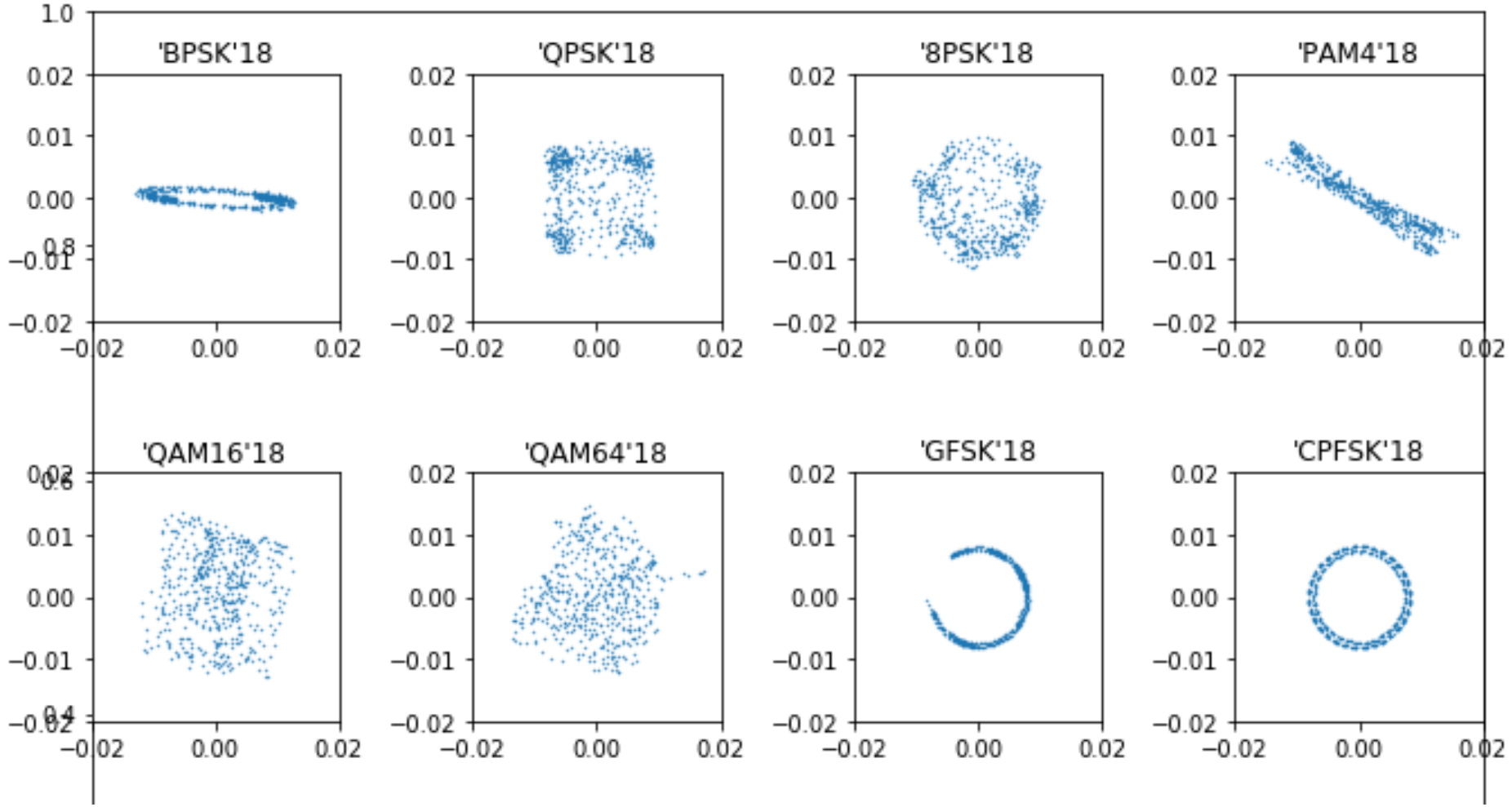
1. Medium Dataset – AWGN, fading, light clock shift



1. Hard Dataset – AWGN, fading, heavy clock shift, Doppler



1. RadioML


'BPSK'18
'QPSK'18
'8PSK'18
'PAM4'18
'QAM16'18
'QAM64'18
'GFSK'18
'CPFSK'18

1. Observations on Matlab dataset

- Clock shift and Doppler have huge effects on how constellation look
  - Hard dataset indistinguishable at 30dB except for FSK
- SNR different for Matlab dataset and RadioML dataset
  - 30dB for Matlab looks about as clean as 18dB for RadioML

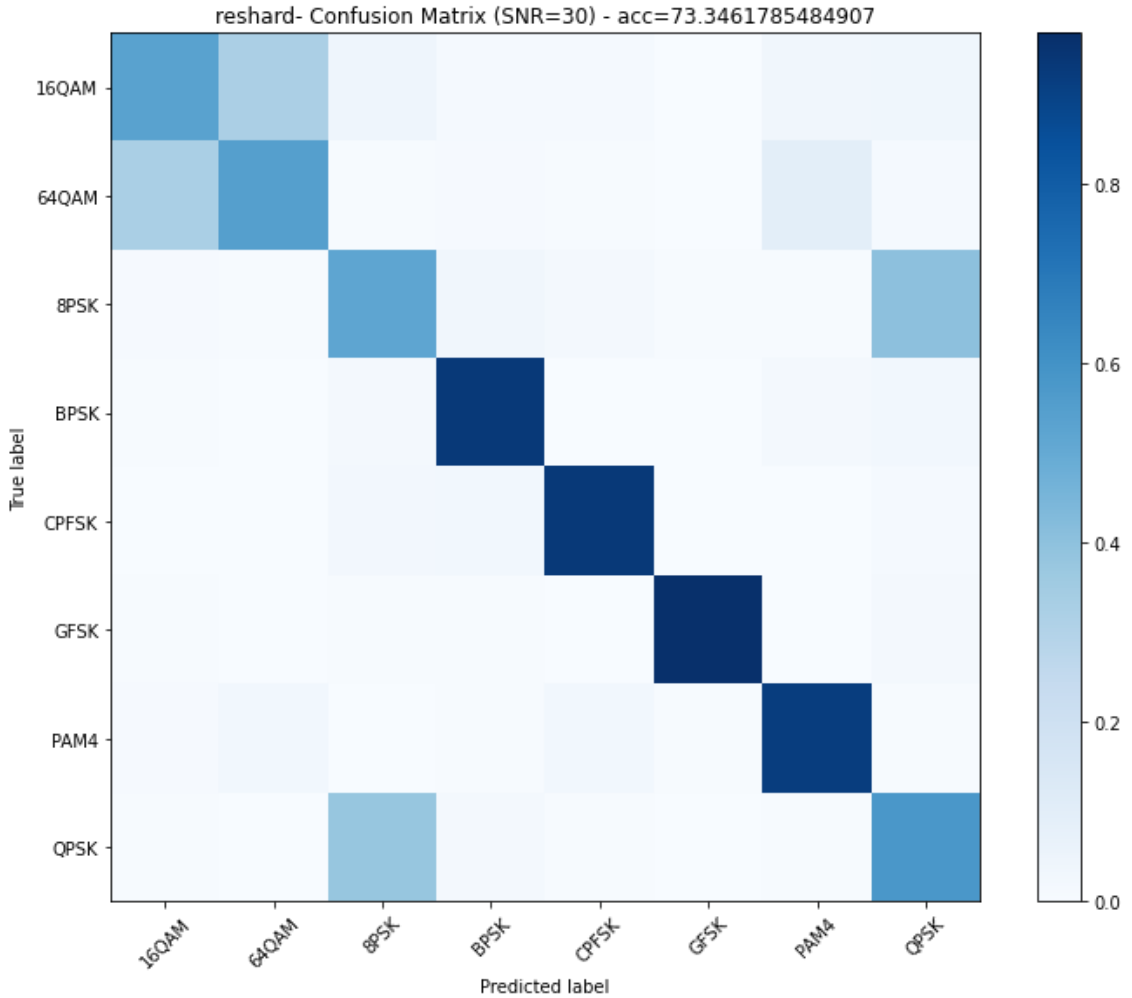
2. Preliminary training with Matlab data

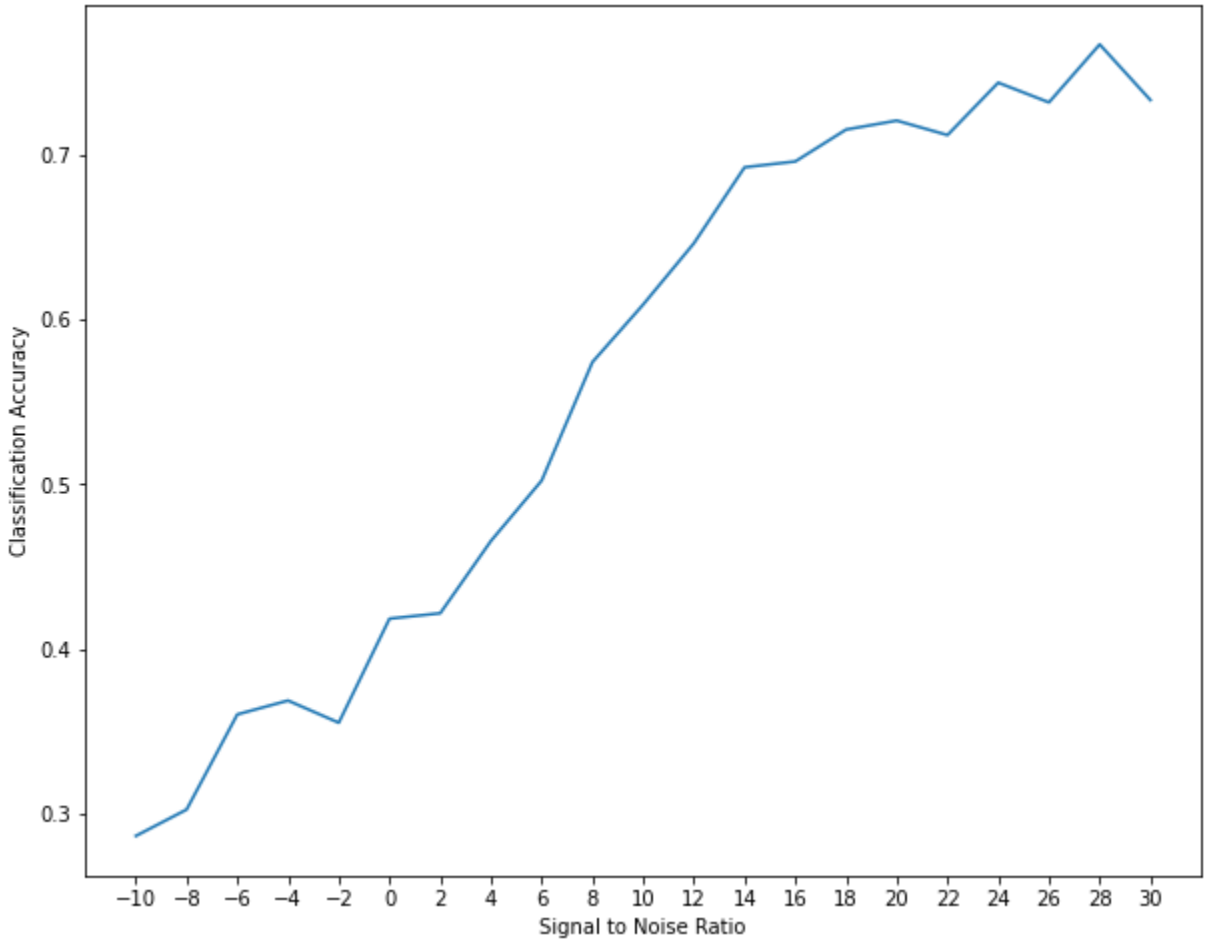
- To test ability of models in more realistic conditions and also adaptability to another dataset

- Should try evaluating models trained on RadioML with Matlab datasets (after I figure out how to normalise the same way)
- Try training on hard Matlab dataset

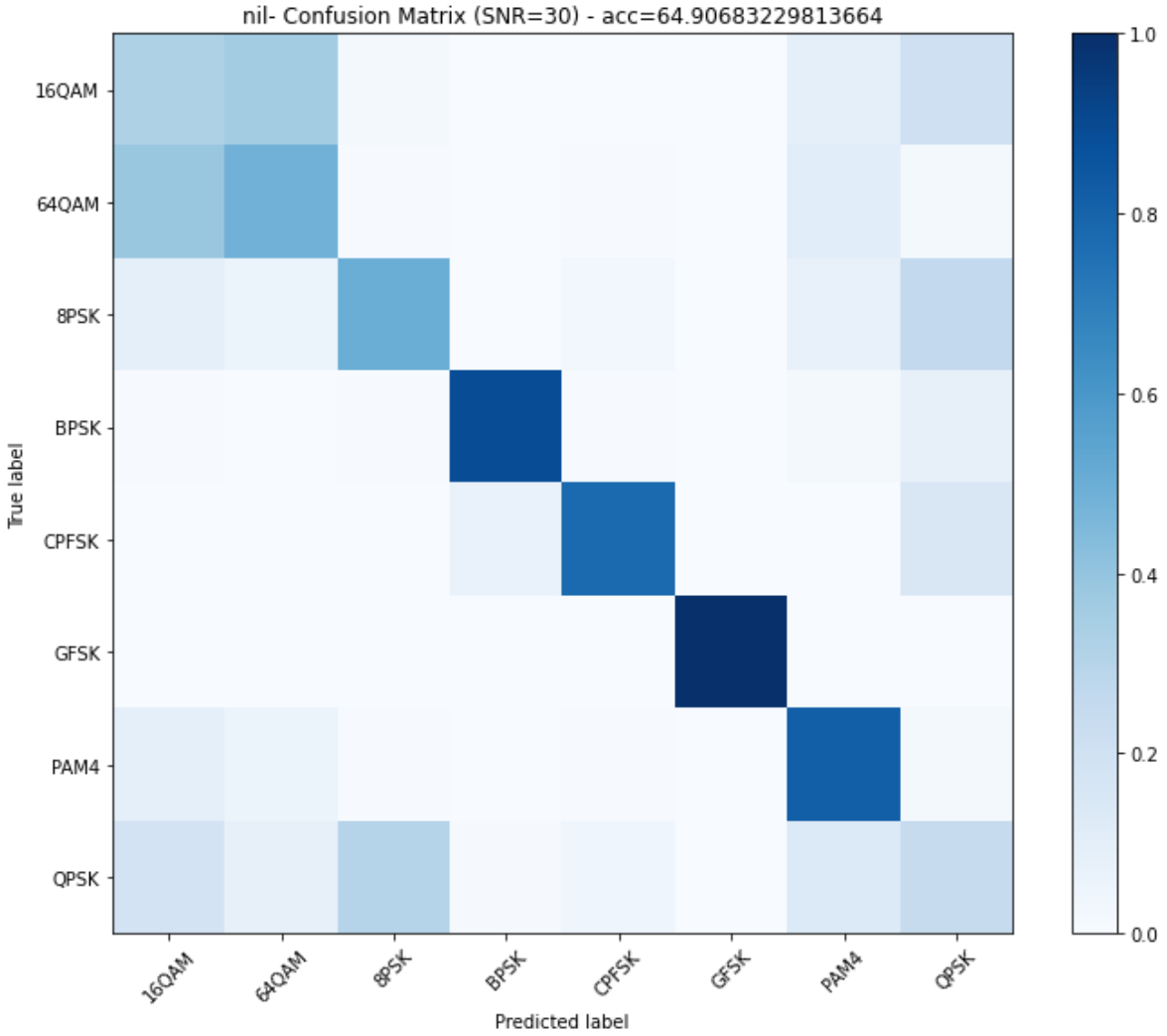
2. Train and test on hard dataset

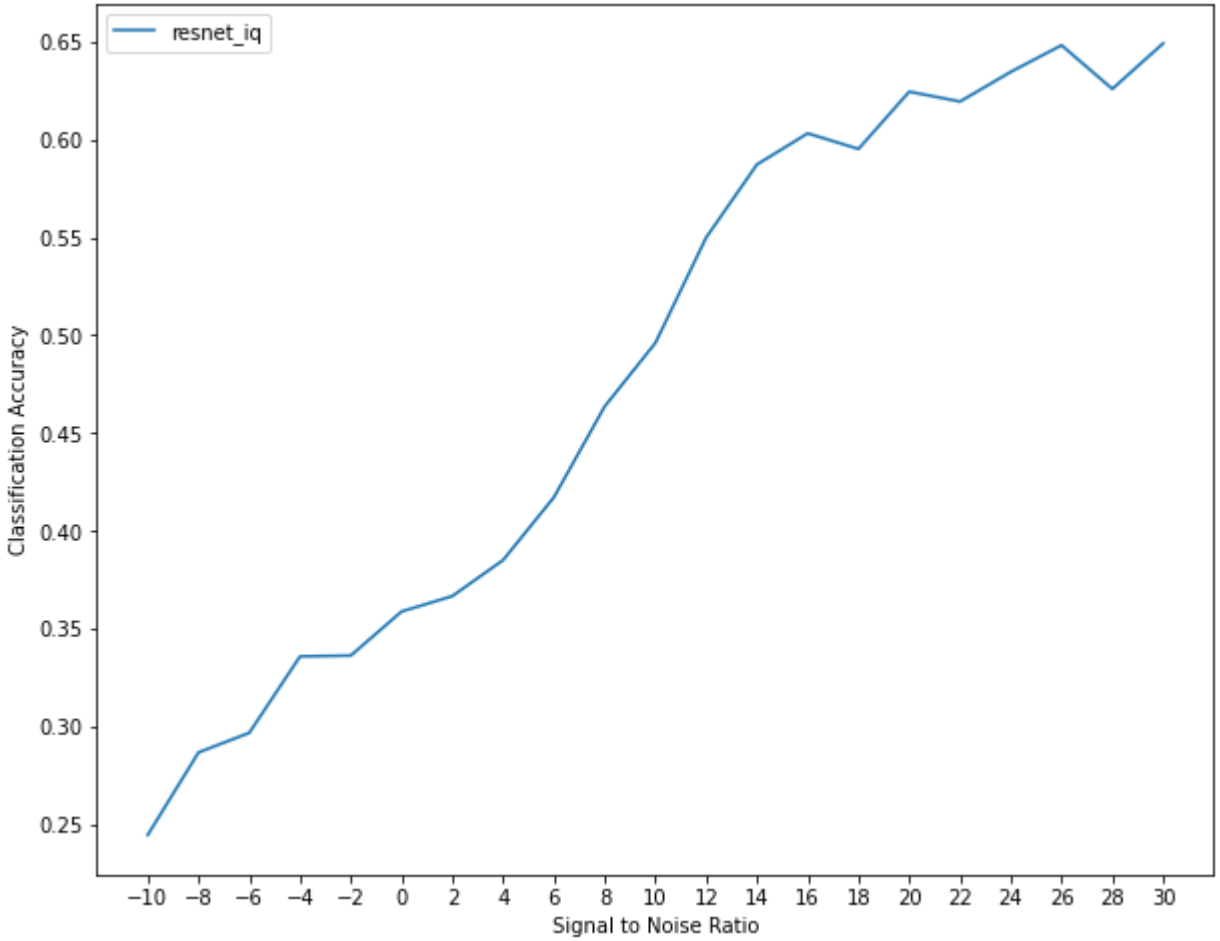
- Used ResNet on raw I/Q data, 69 epochs





2. Evaluate model trained on hard dataset on medium dataset





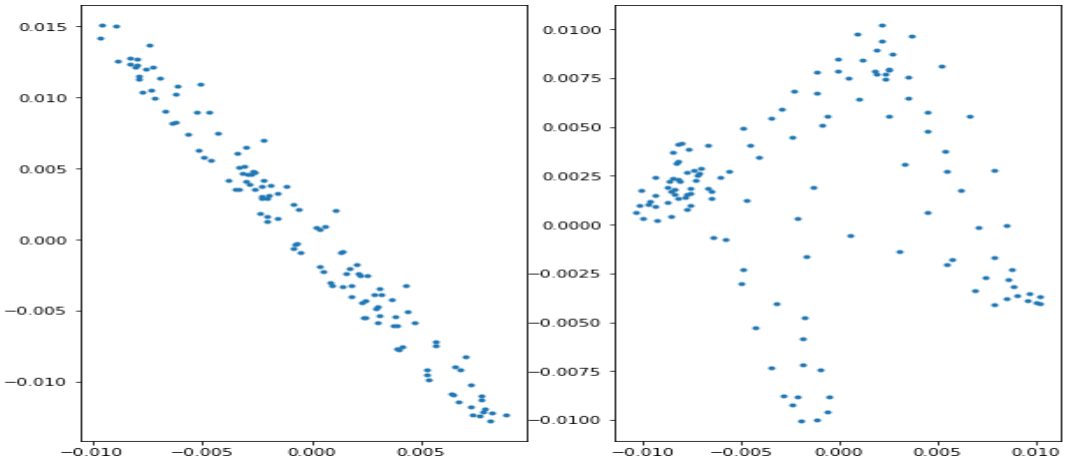
2. Comments on training with hard dataset

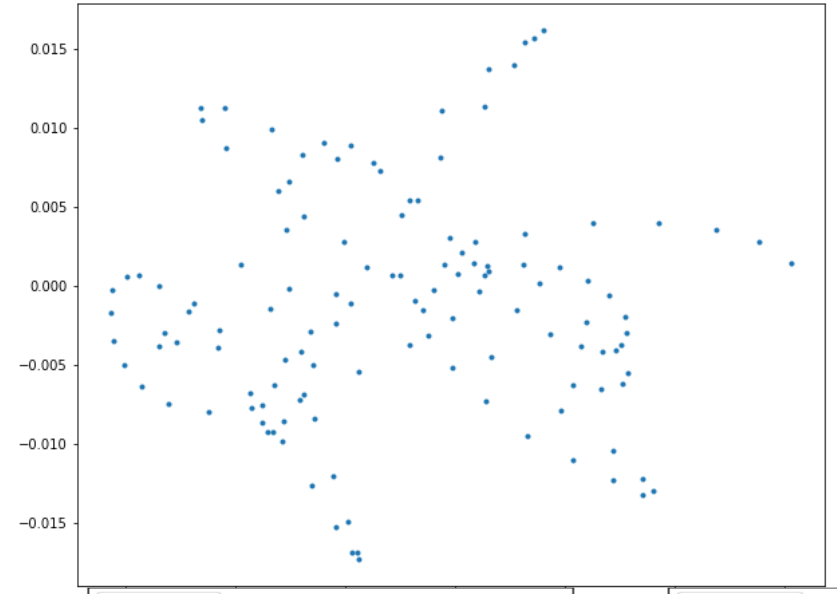
- Surprisingly good performance given how bad the constellations looked
- Confusion between QAMs and higher PSKs, expected.
  - Not sure whether training on constellation images will help here
- Training on hard dataset works quite well on medium dataset, even though constellations can look very different due to clock shift and doppler (see BPSK)
  - Is it because there is time information/ other patterns not visible from constellation diagram?

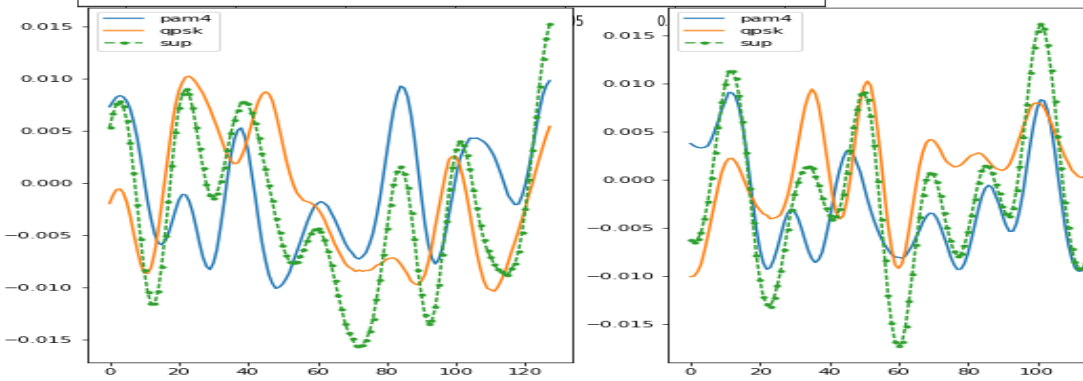
3. Dealing with superposition

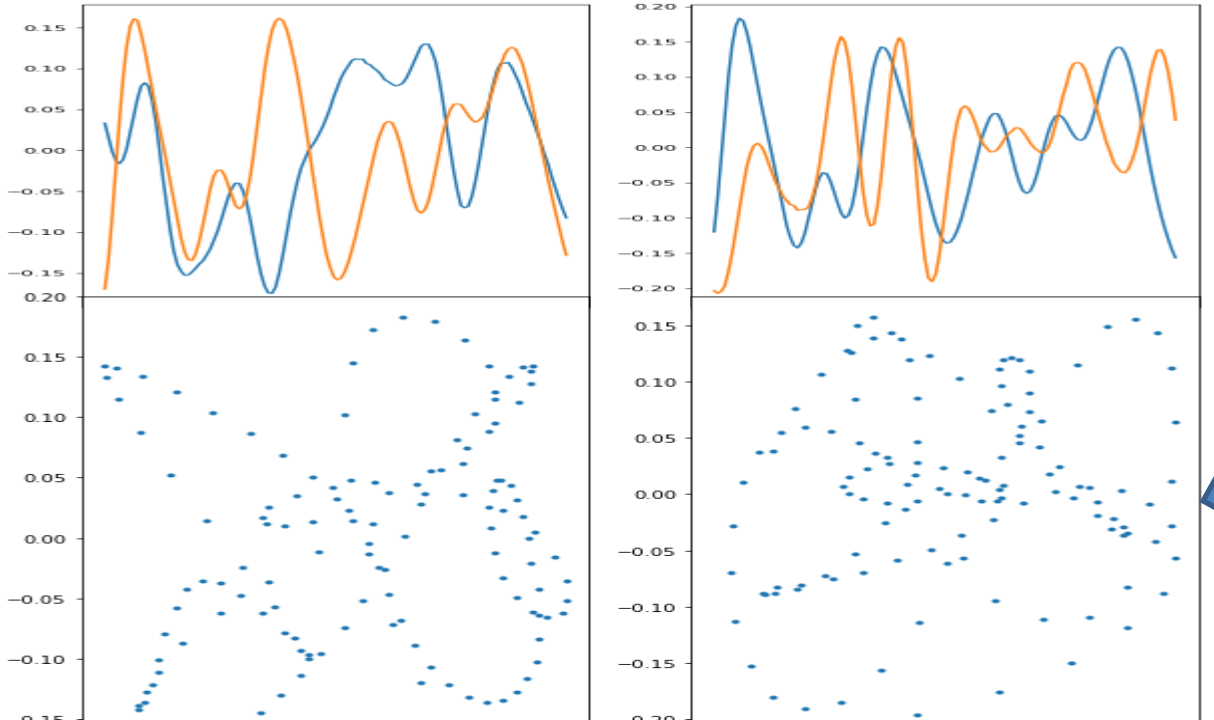
- How to simulate superposition?
  - Linear combination of signals?
- Possibly try Independent Component Analysis? Or PCA?

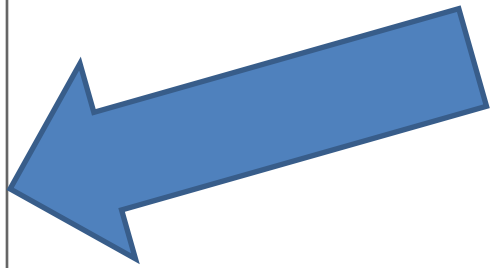
3. Superposition











3. Superposition preliminary

- Fail… Model treats everything as PAM4 for some reason

Next Steps

- Matlab dataset generation: Simulate more environments, foliage, rain, look at parameters used by other papers for channel simulation
- Training model on diff datasets:
  - Try if training on clean works well on dirty dataset (normally what we do)
  - Try training on dirty constellation image and see whether it still works well
- Start thinking about concluding, forgo superposition
  - Constellation image works best when data is clean. How about when dirty?
  - How different noise types affect classification accuracy