Machine Learning – Project Report
30.07.2026

G2Net – Detecting Continuous Gravitational Waves

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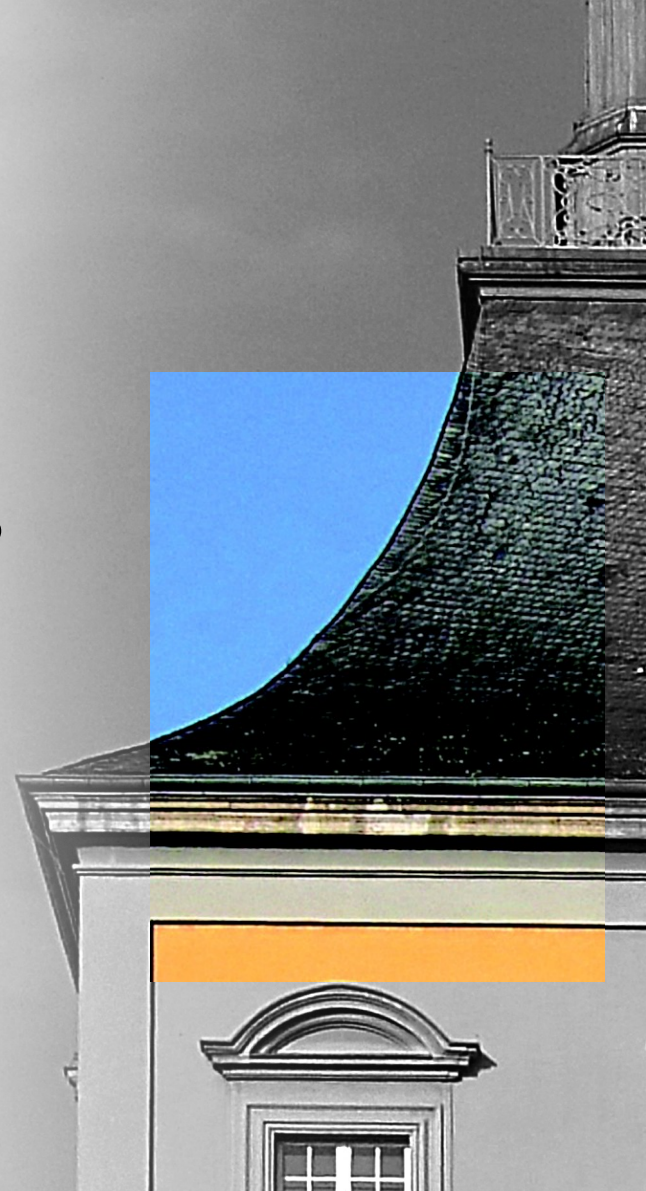
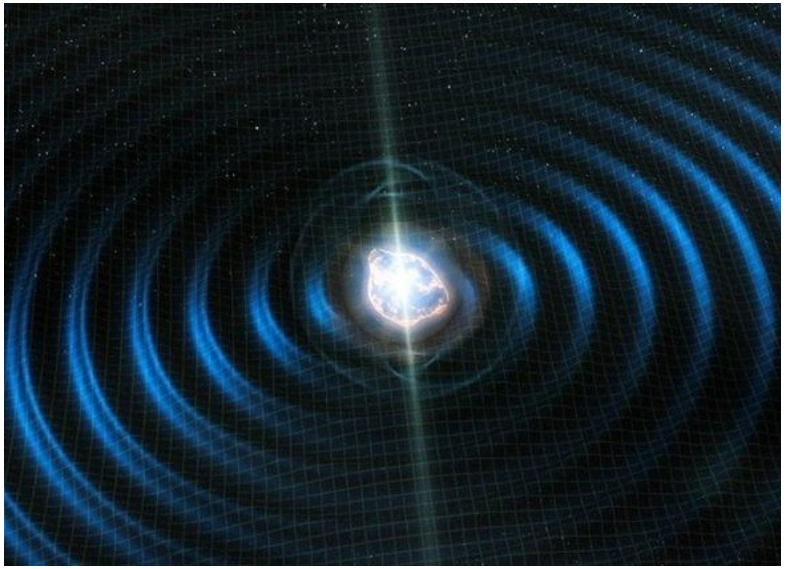


The G2Net-Challenge

- Rapidly spinning neutron stars
  → continuous gravitational waves
- LIGO interferometers at Hanford and Livingston

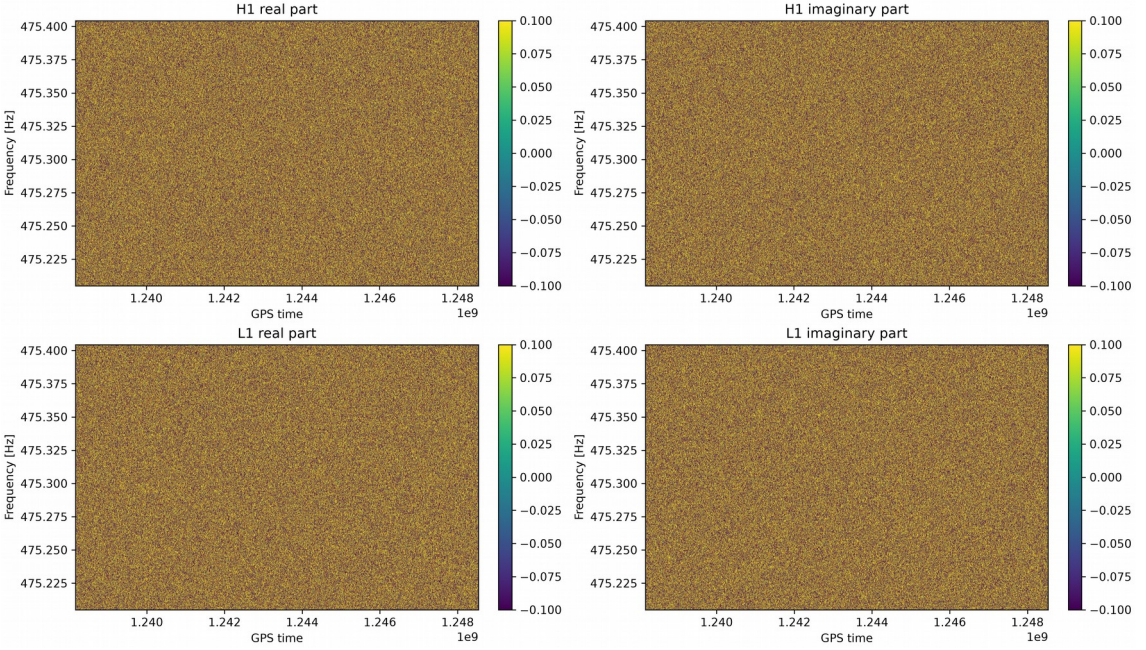


https://earthsky.org/space/gravitational-waves-single-neutron-stars-planck-einsteinhome/

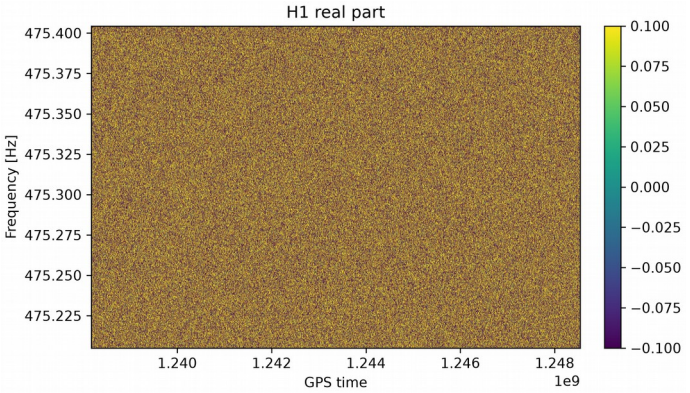
https://mpcomagnetics.com/blog/laser-interferometer-gravitational-wave-observatory-ligo-first-time/

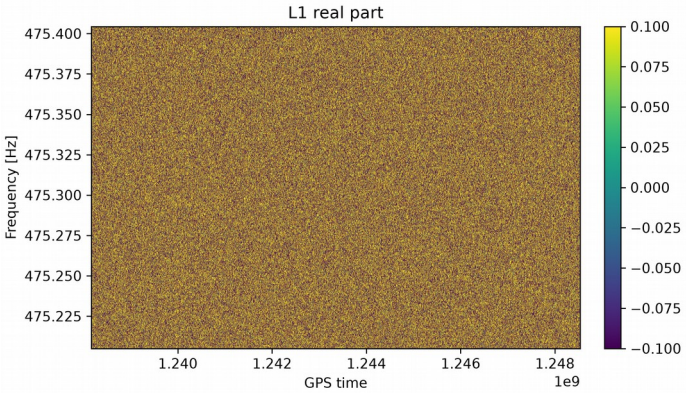
Dataset

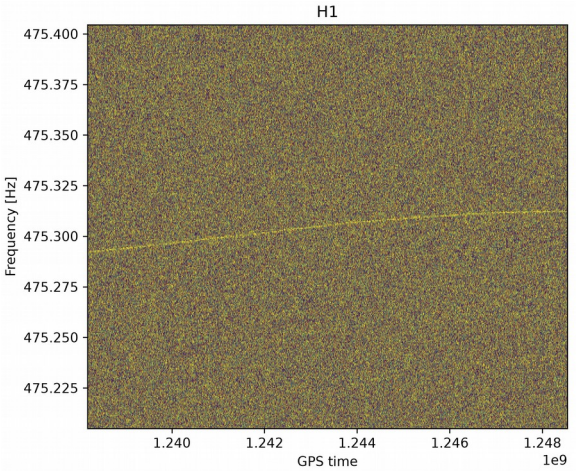
- Short-time Fourier Transforms (SFTs)
  - 360 frequency bins
  - ~4500 timesteps
- Labels:
  - 0 = background (200)
  - 1 = signal (400)
  - -1 = unclassified (3)

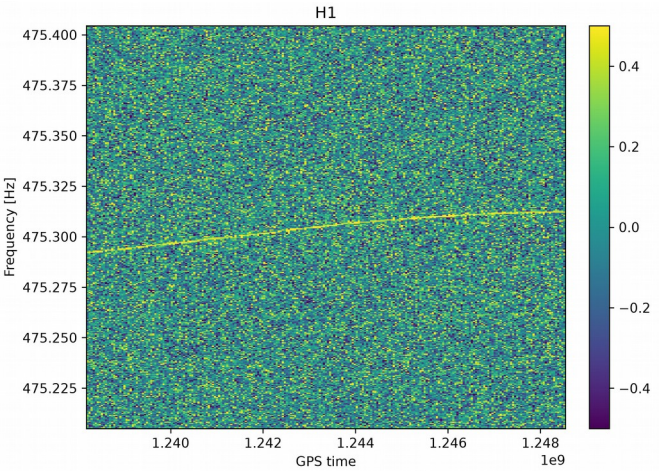


Preprocessing





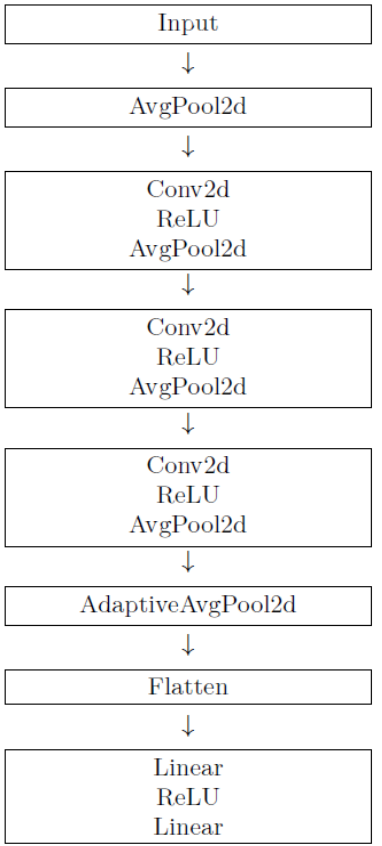




- Modulus
- Average Pooling
- Truncating / Padding

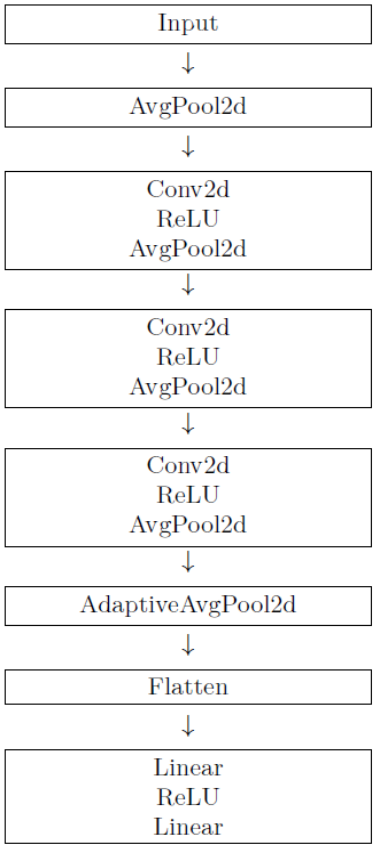
First Approach: CNN

- Input: $N \times 2 \times 360 \times 4500$
- Average pooling: kernel size (1,20), stride (1,20)
- Convolution: kernel size 3, padding 1
- Intermediate average pooling: kernel size 3
- Adaptive average pooling → (45,25)
- Channels: 2 → 16 → 32 → 64
- Linear: 45*25*64 → 128 → 1



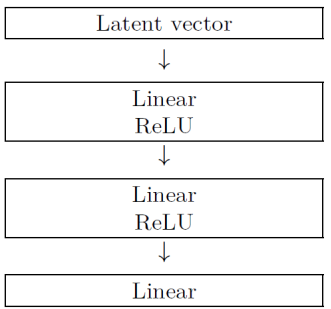
First Approach: CNN

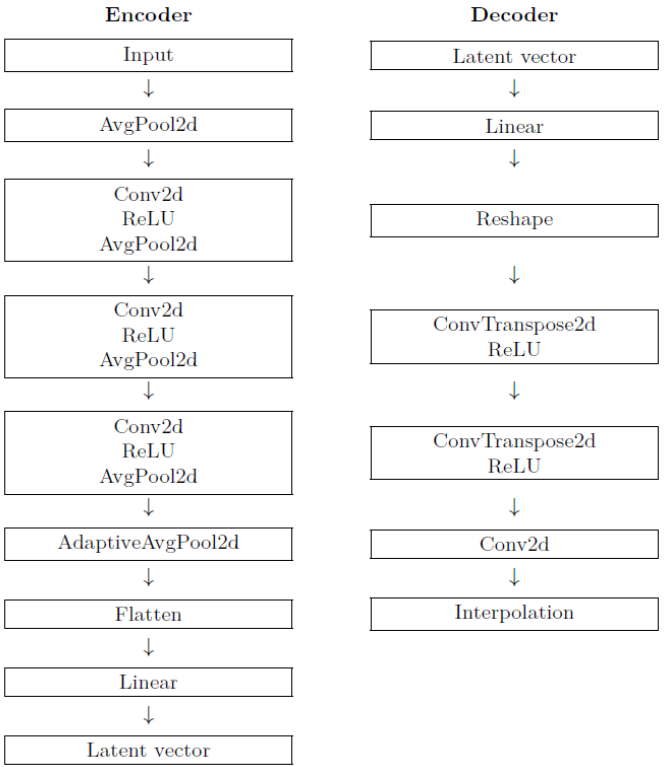
- Training:
  - BCEWithLogitsLoss
  - Adam Optimizer
  - 11-15 epochs
  - Batch size: 10



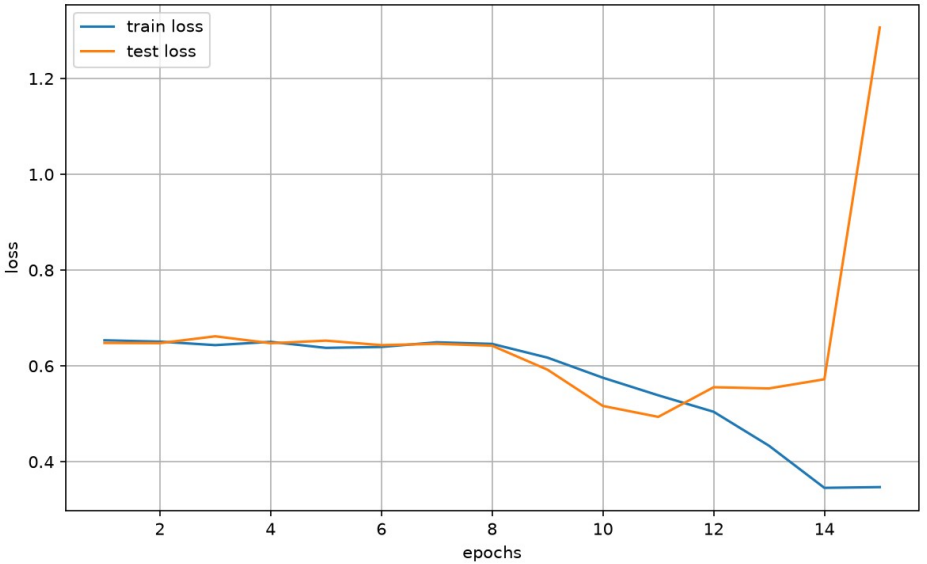
Second Apporach: Autoencoder

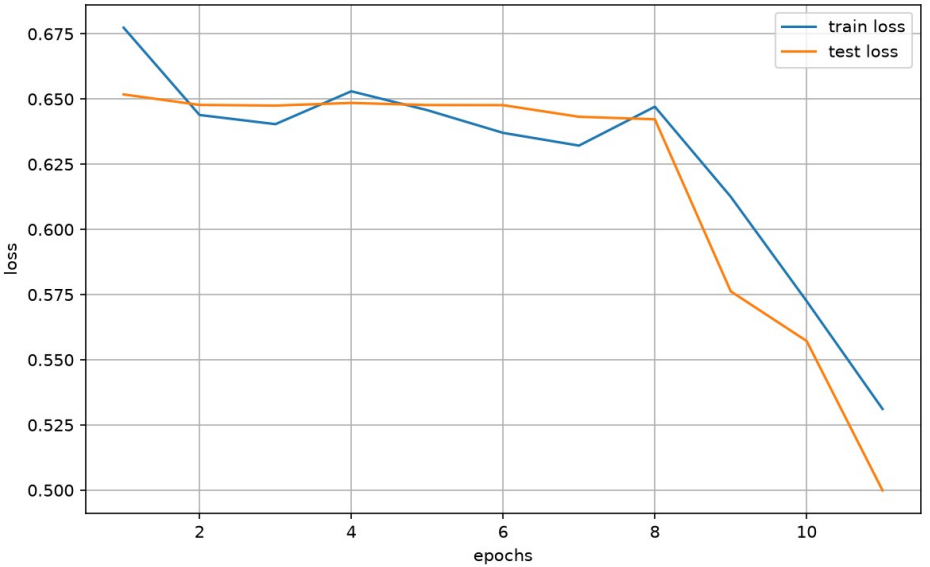
- Convolutional Encoder
- Decoder with transposed convolutional layers
- Training with MSE Loss
- MLP Classifier:



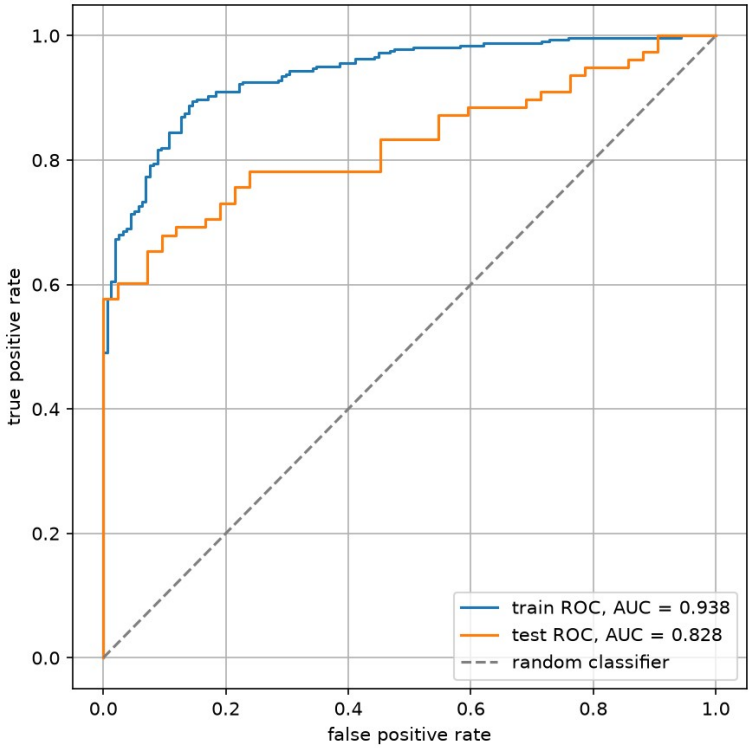


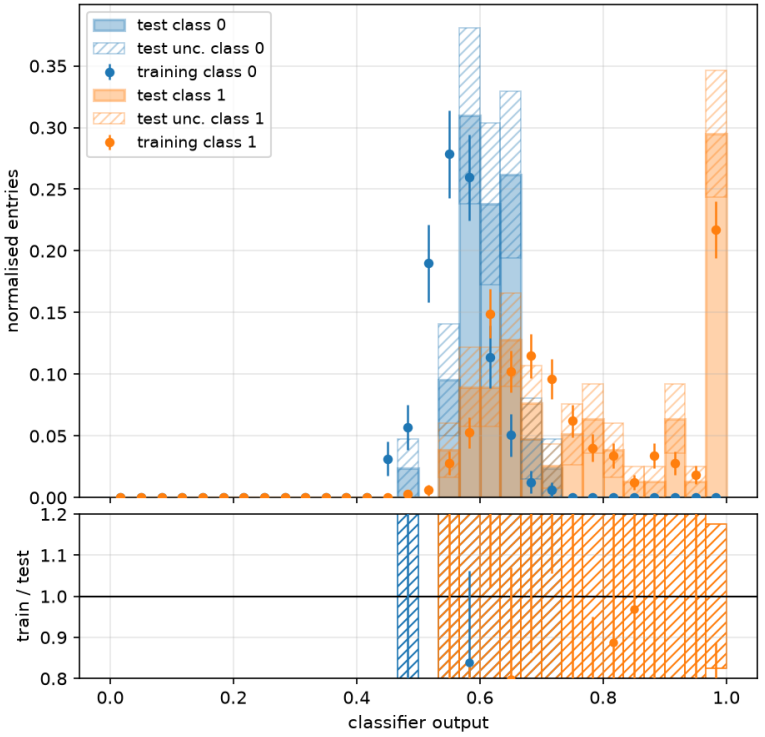
Results - CNN


train loss
test loss
loss
epochs
1.2
1.0
0.8
0.6
0.4
2
4
6
8
10
12
14

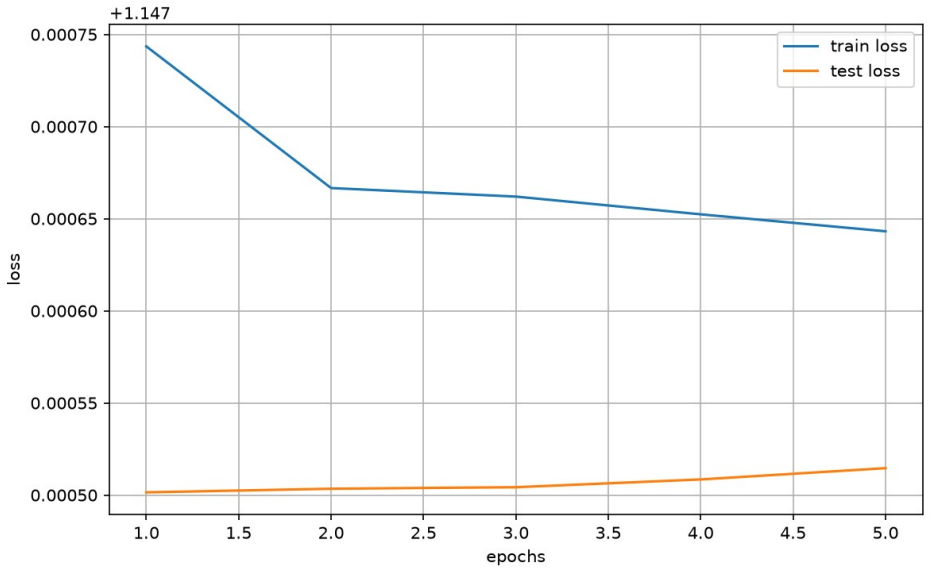

train loss
test loss
loss
epochs
0.675
0.650
0.625
0.600
0.575
0.550
0.525
0.500
2
4
6
8
10

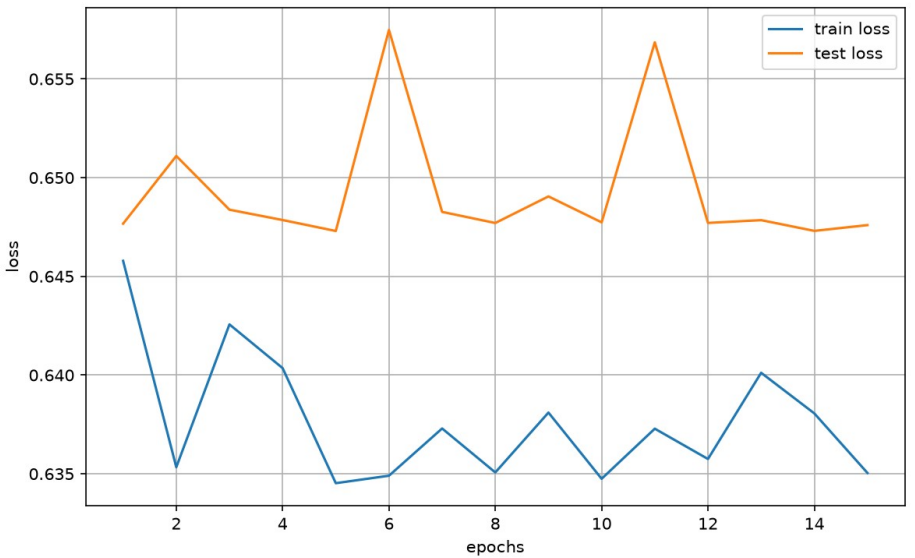
Results - CNN


true positive rate
false positive rate
train ROC, AUC = 0.938
test ROC, AUC = 0.828
random classifier

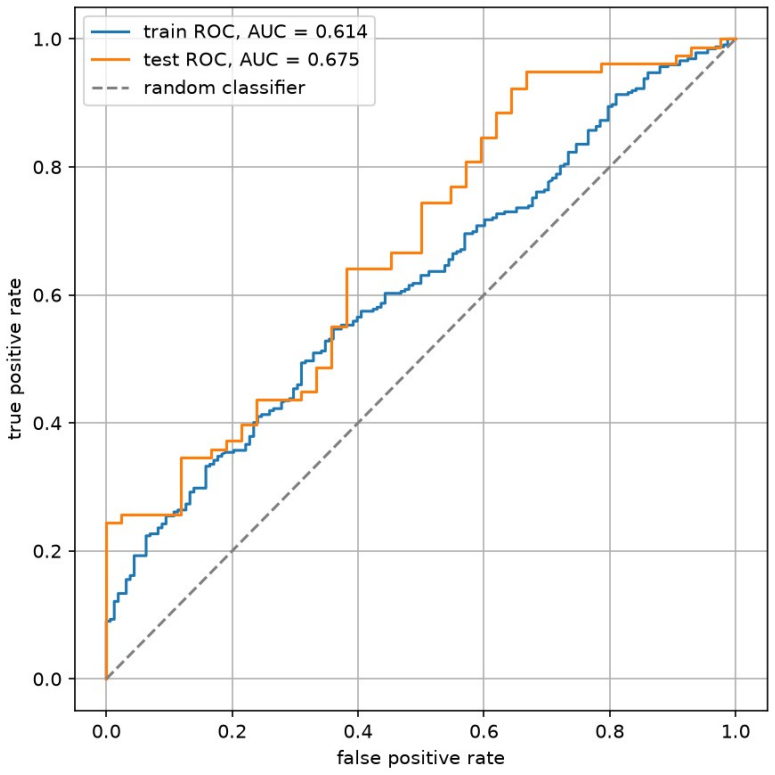

test class 0
test unc. class 0
training class 0
test class 1
test unc. class 1
training class 1
normalised entries
train / test
classifier output

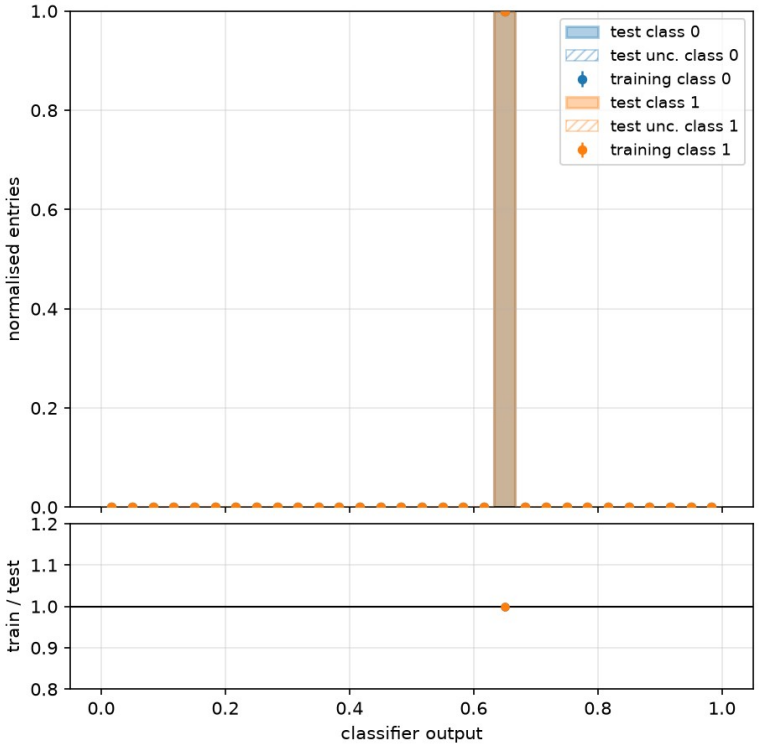
Results - Autoencoder





Results - Autoencoder





Thank you for your attention!