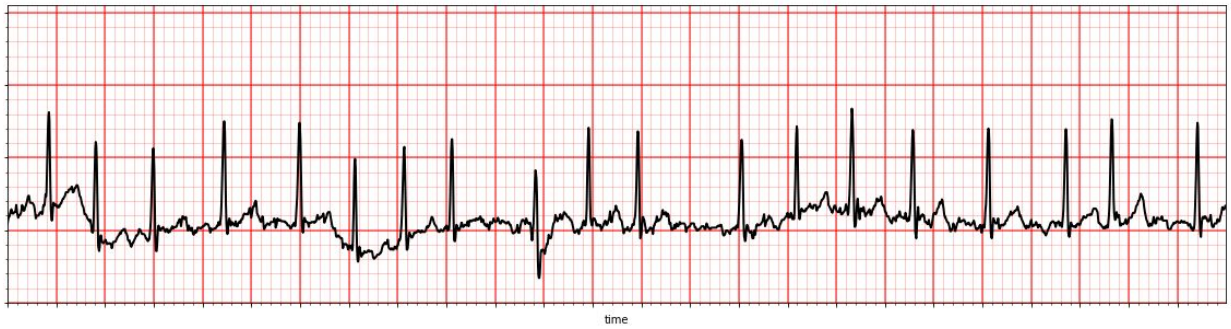
Detecting AFib using photoplethysmography data

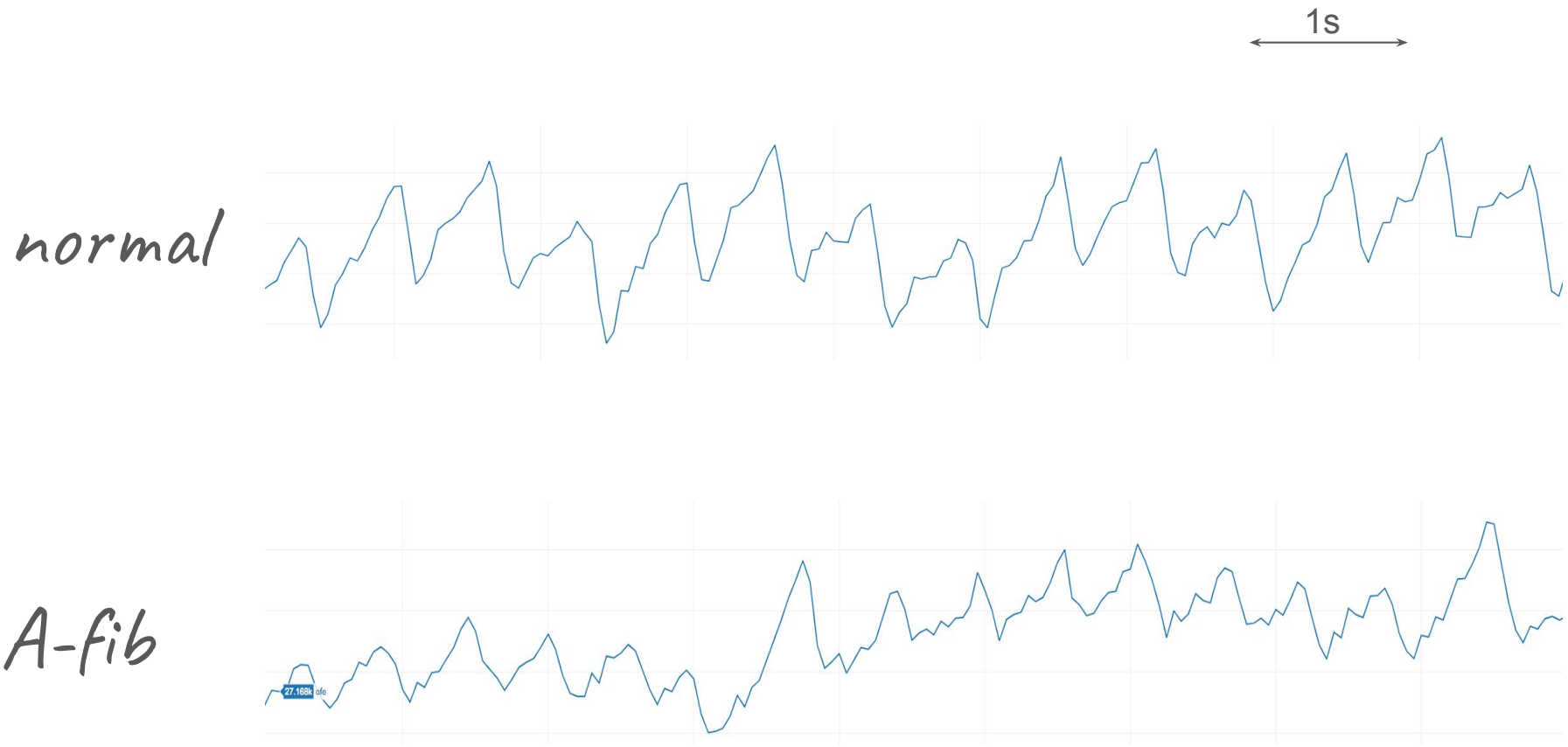
Electrocardiogram (ECG)

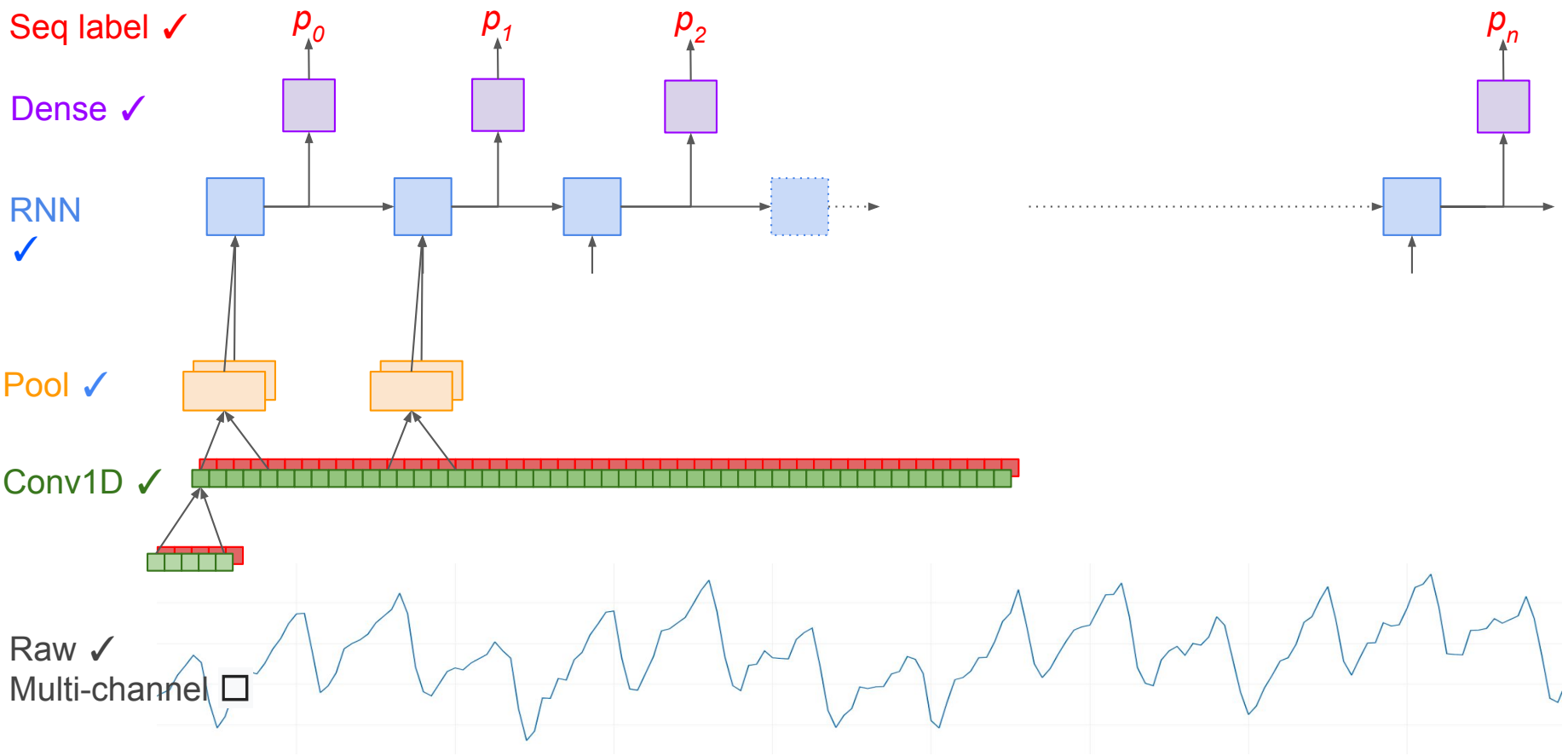
normal

A-fib

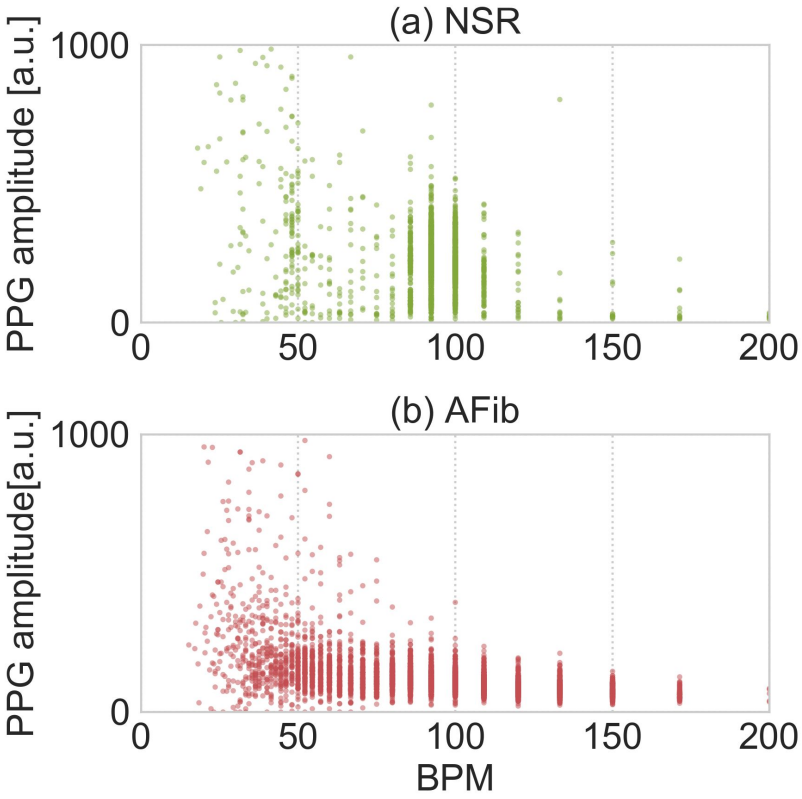


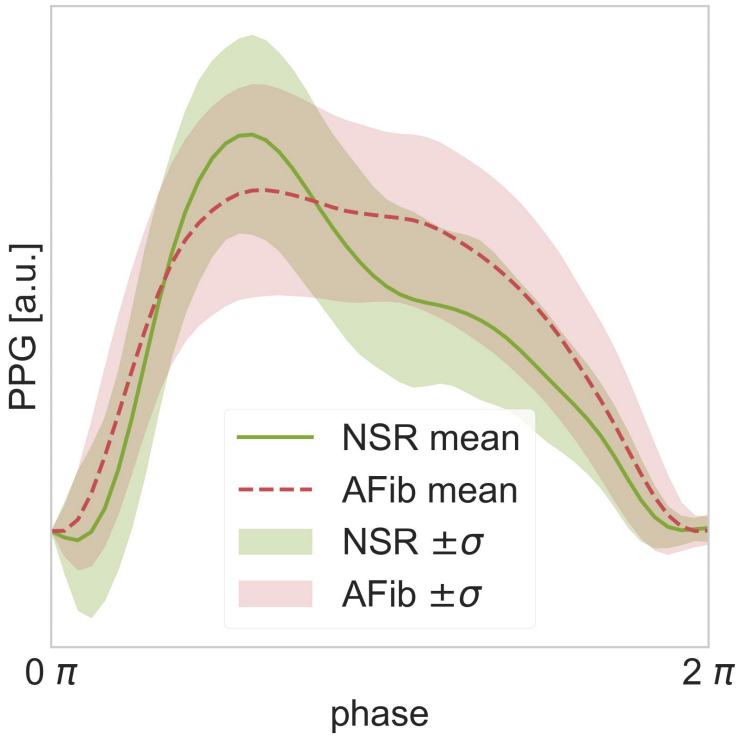
Photoplethysmogram (PPG)




Seq label ✓
Dense ✓
RNN
✓
Pool ✓
Conv1D ✓
Raw ✓
Multi-channel ☐
p_0
p_1
p_2
p_n

Waveform morphology





Convolutional-recurrent neural network architecture

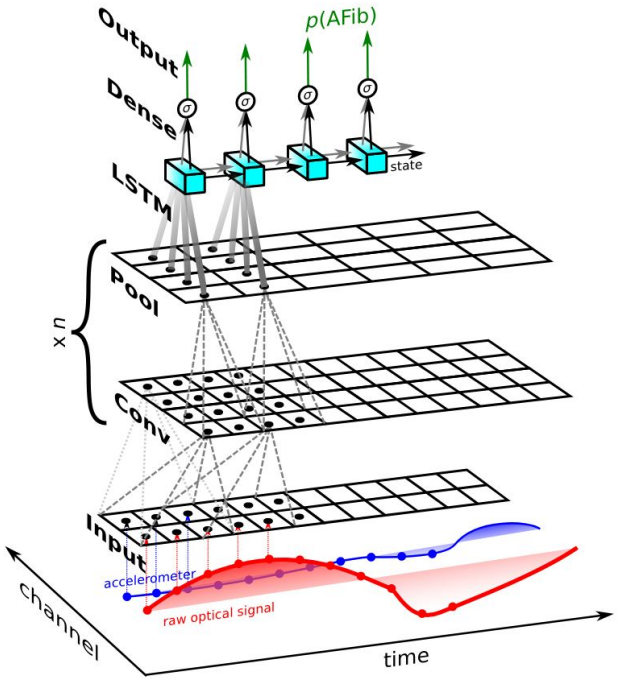
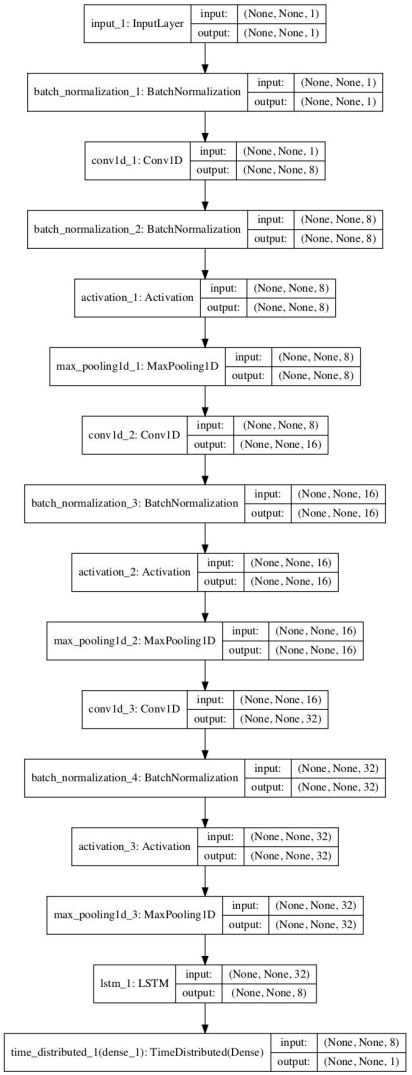
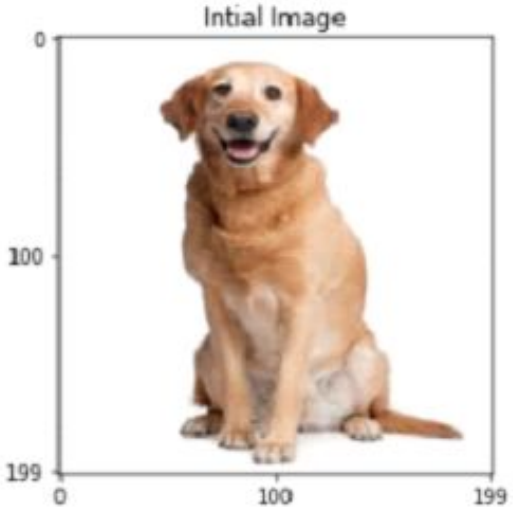


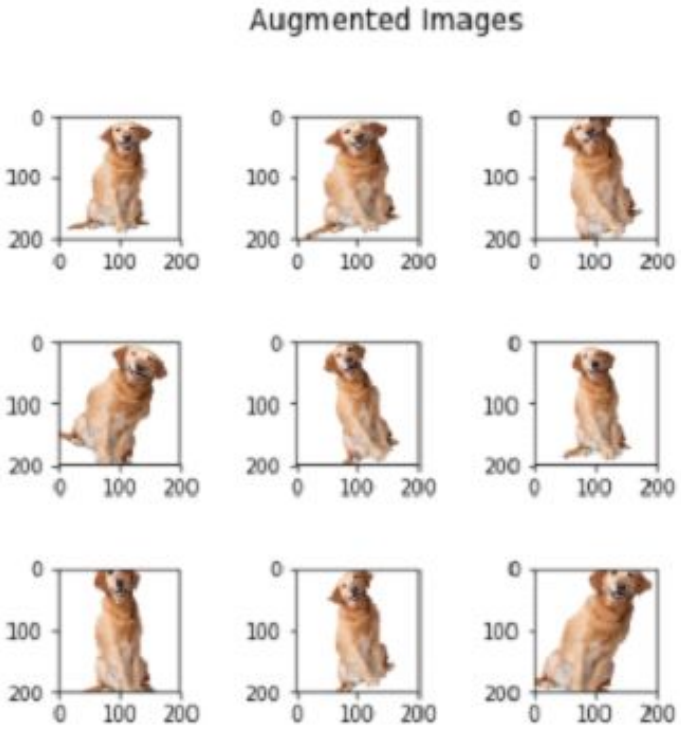
Figure 1: A convolutional-recurrent architecture for classification of raw time-series data. While the receptive field of each neuron in the convolutional (Conv) layers is well defined, the recurrent long short-term memory (LSTM) layer can learn variable-length correlations.

https://arxiv.org/abs/1807.10707

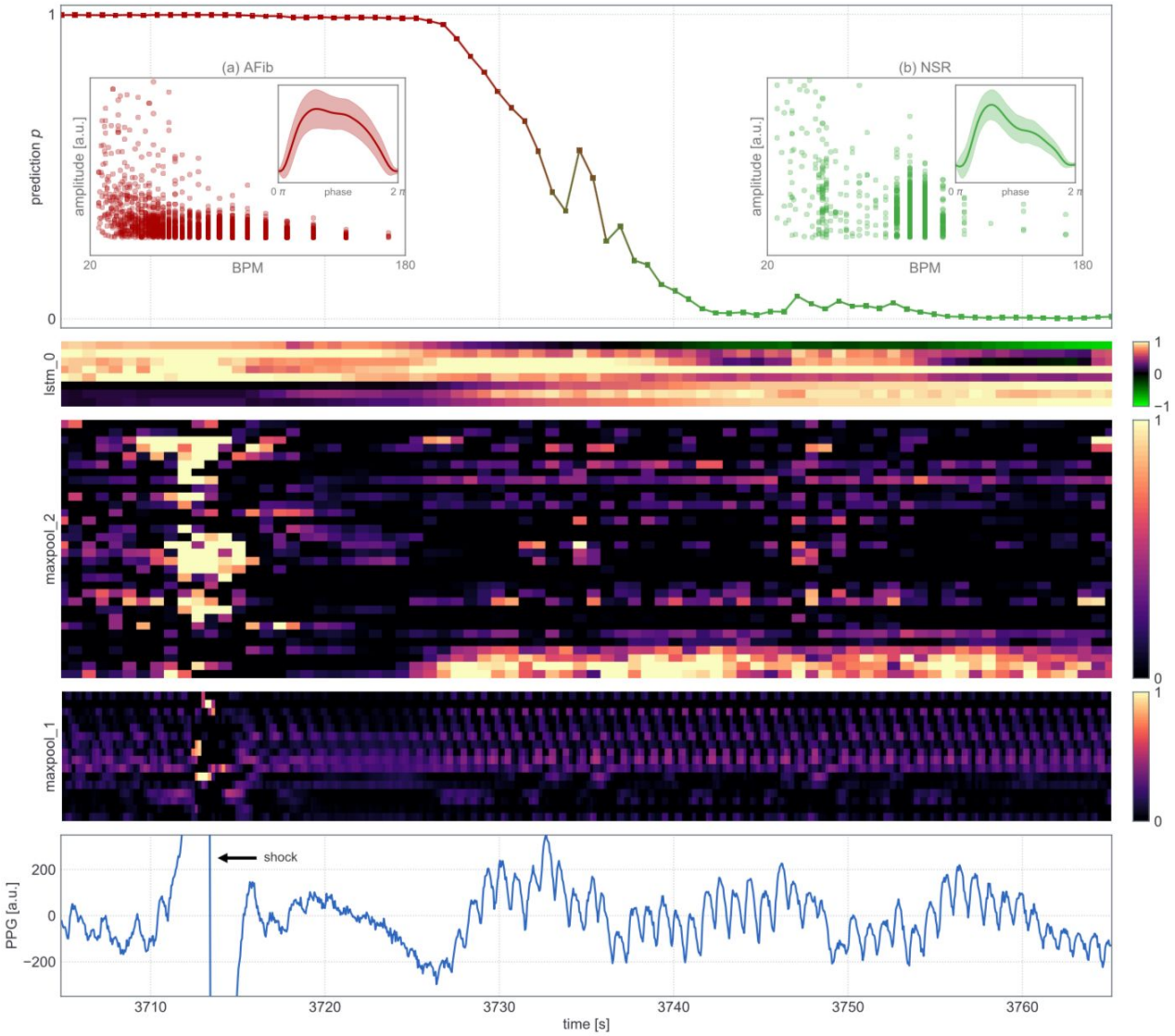

input_1: InputLayer
input: (None, None, 1)
output: (None, None, 1)
batch_normalization_1: BatchNormalization
input: (None, None, 1)
output: (None, None, 1)
conv1d_1: Conv1D
input: (None, None, 1)
output: (None, None, 8)
batch_normalization_2: BatchNormalization
input: (None, None, 8)
output: (None, None, 8)
activation_1: Activation
input: (None, None, 8)
output: (None, None, 8)
max_pooling1d_1: MaxPooling1D
input: (None, None, 8)
output: (None, None, 8)
conv1d_2: Conv1D
input: (None, None, 8)
output: (None, None, 16)
batch_normalization_3: BatchNormalization
input: (None, None, 16)
output: (None, None, 16)
activation_2: Activation
input: (None, None, 16)
output: (None, None, 16)
max_pooling1d_2: MaxPooling1D
input: (None, None, 16)
output: (None, None, 16)
conv1d_3: Conv1D
input: (None, None, 16)
output: (None, None, 32)
batch_normalization_4: BatchNormalization
input: (None, None, 32)
output: (None, None, 32)
activation_3: Activation
input: (None, None, 32)
output: (None, None, 32)
max_pooling1d_3: MaxPooling1D
input: (None, None, 32)
output: (None, None, 32)
lstm_1: LSTM
input: (None, None, 32)
output: (None, None, 8)
time_distributed_1(dense_1): TimeDistributed(Dense)
input: (None, None, 8)
output: (None, None, 1)

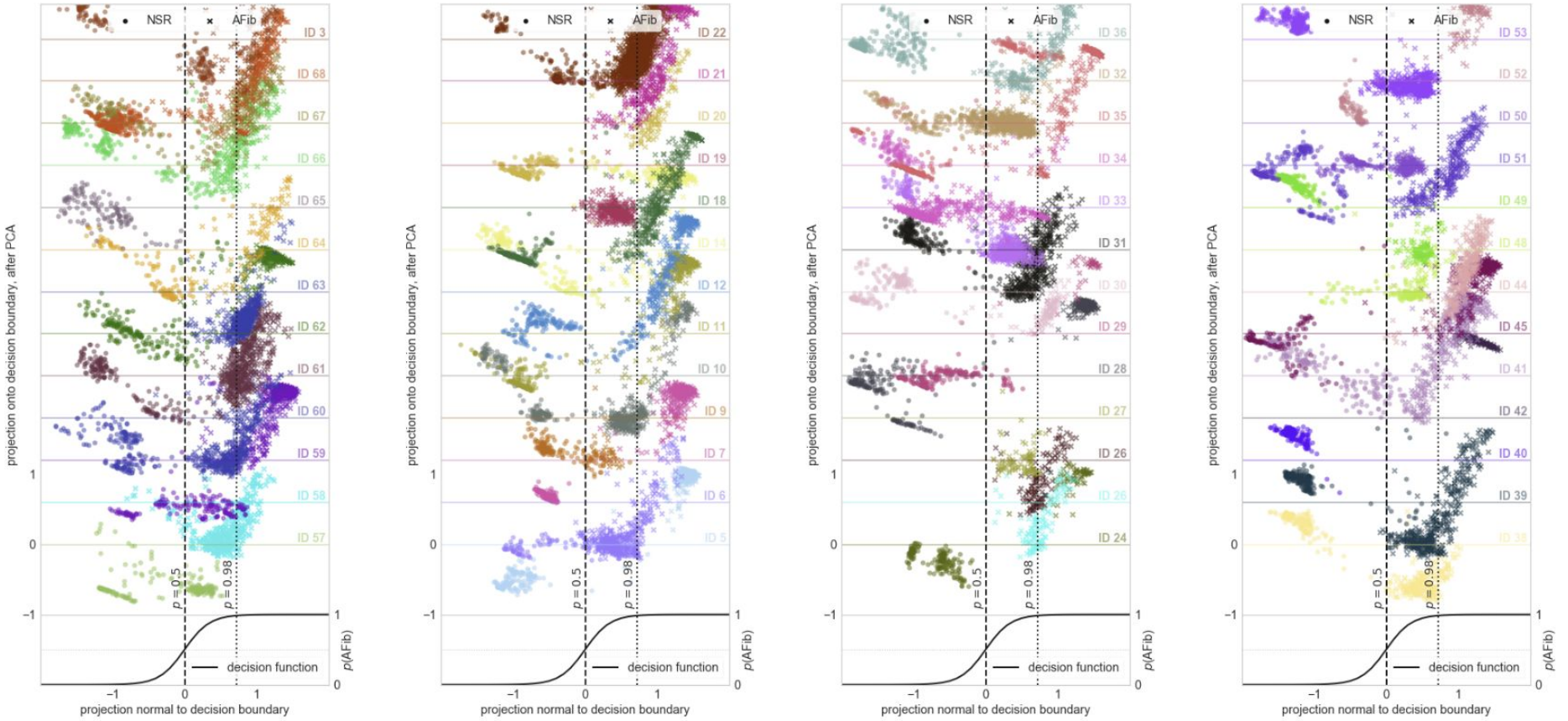
Data augmentation



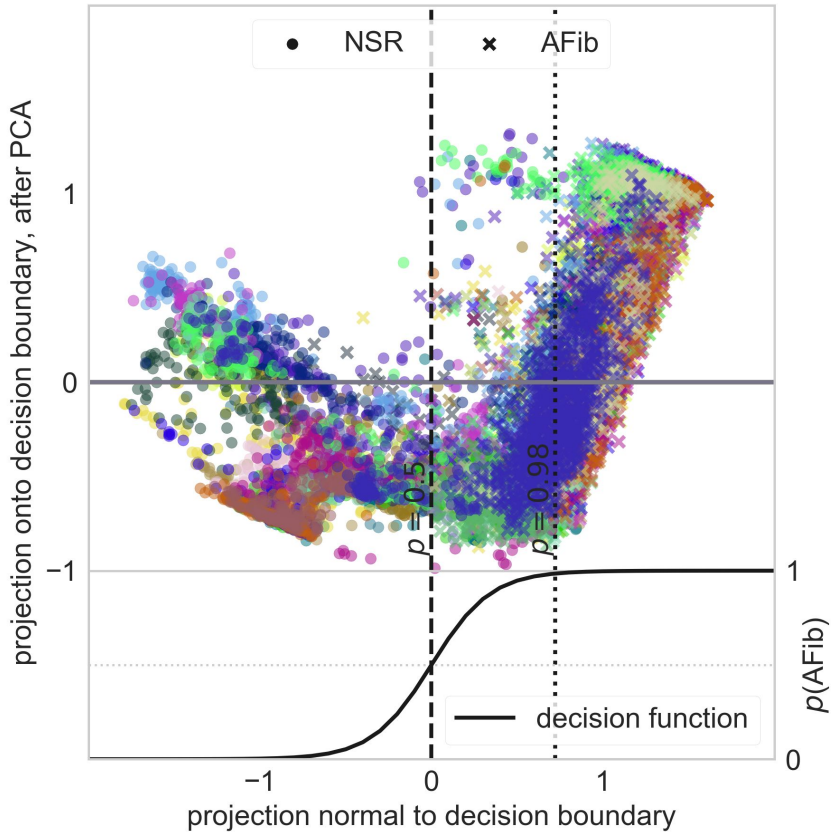


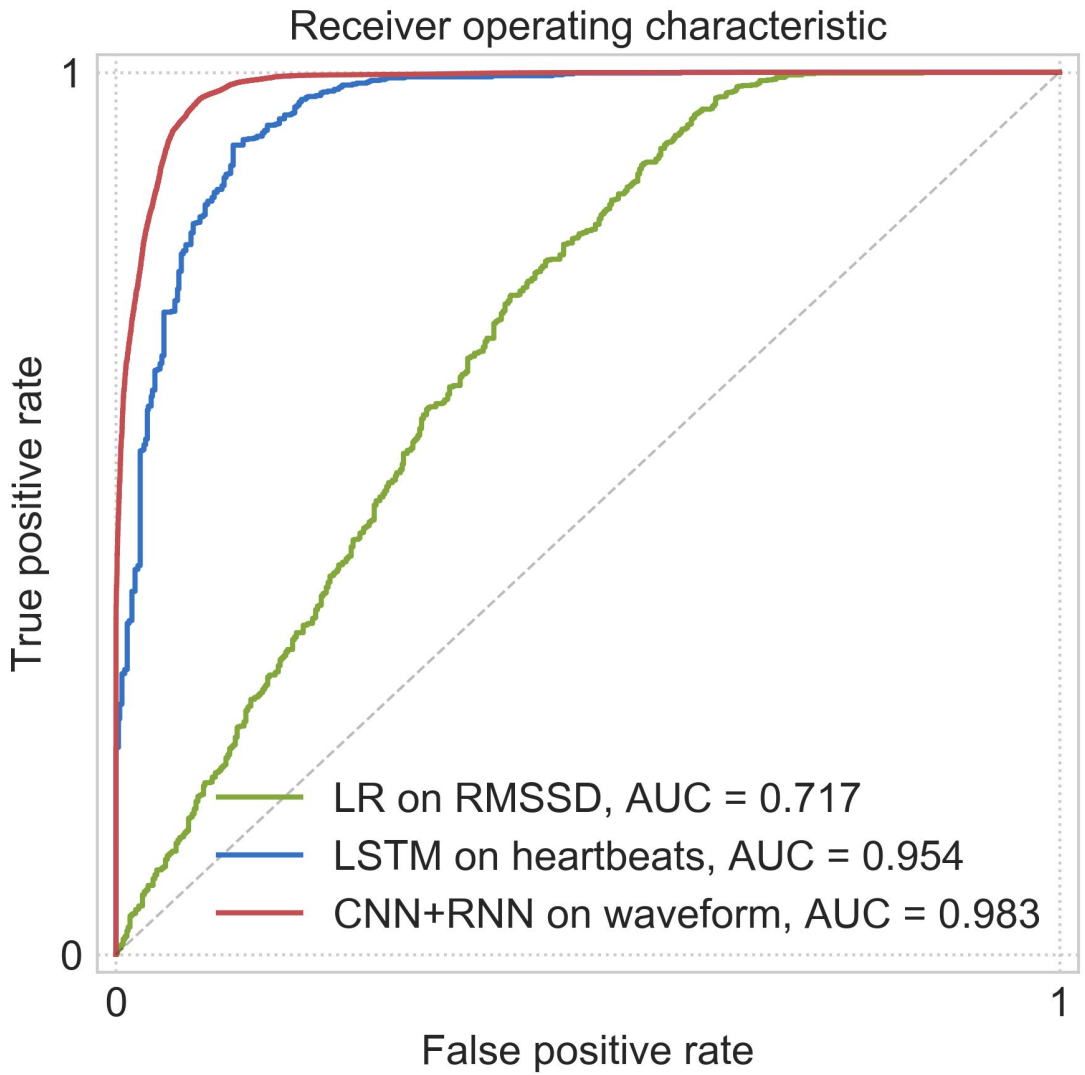
https://towardsdatascience.com/image-augmentation-14a0aafd0498


prediction p
1
0
(a) AFib
amplitude [a.u.]
0 π
phase
2 π
20
BPM
180
(b) NSR
amplitude [a.u.]
0 π
phase
2 π
20
BPM
180
lstm_0
1
0
−1
maxpool_2
1
0
maxpool_1
1
0
shock
PPG [a.u.]
200
0
−200
3710
3720
3730
3740
3750
3760
time [s]


NSR
AFib
ID 3
ID 68
ID 67
ID 66
ID 65
ID 64
ID 63
ID 62
ID 61
ID 60
ID 59
ID 58
ID 57
projection onto decision boundary, after PCA
p = 0.5
p = 0.98
decision function
p(AFib)
projection normal to decision boundary
NSR
AFib
ID 22
ID 21
ID 20
ID 19
ID 18
ID 12
ID 11
ID 10
ID 9
ID 7
ID 6
ID 5
projection onto decision boundary, after PCA
p = 0.5
p = 0.98
decision function
p(AFib)
projection normal to decision boundary
NSR
AFib
ID 36
ID 32
ID 35
ID 34
ID 33
ID 31
ID 30
ID 29
ID 28
ID 27
ID 26
ID 25
ID 24
projection onto decision boundary, after PCA
p = 0.5
p = 0.98
decision function
p(AFib)
projection normal to decision boundary
NSR
AFib
ID 53
ID 52
ID 50
ID 51
ID 49
ID 48
ID 44
ID 45
ID 41
ID 42
ID 40
ID 39
ID 38
projection onto decision boundary, after PCA
p = 0.5
p = 0.98
decision function
p(AFib)
projection normal to decision boundary

Heart rhythm embeddings from the LSTM layer





https://www.sciencedirect.com/science/article/pii/S2666501820300040

Thanks!

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