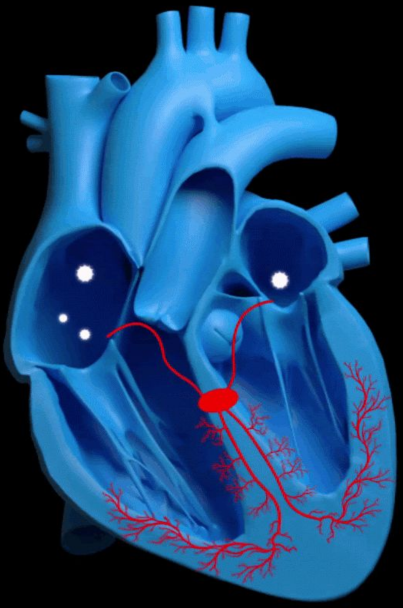
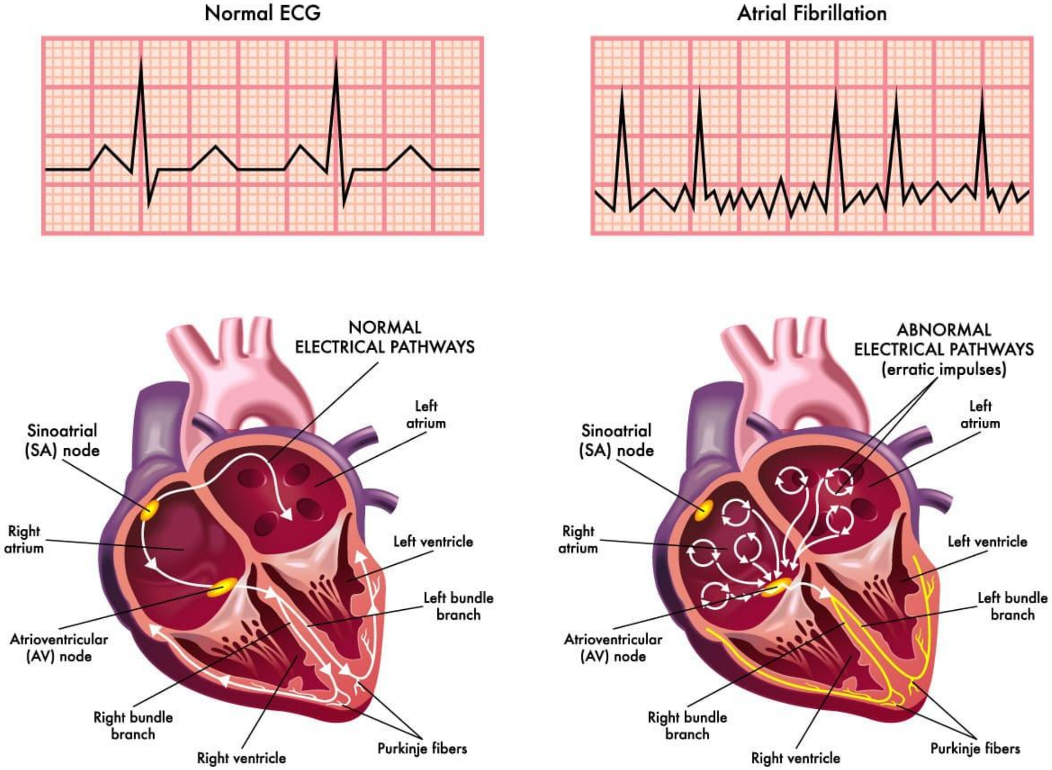
Atrial Fibrillation detection



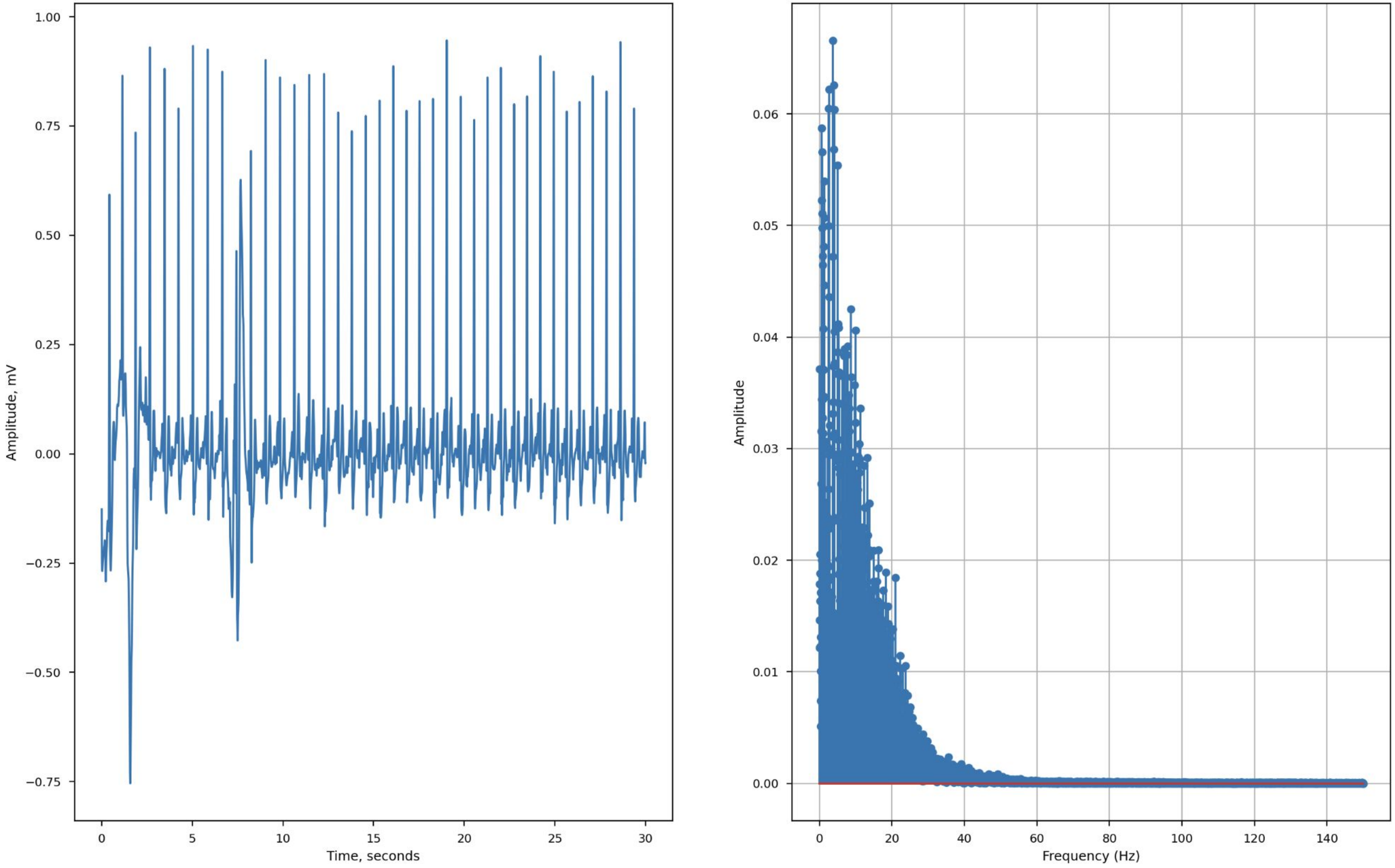
Bohdan Hlovatskyi
Signal Processing Course Project


Normal ECG
Atrial Fibrillation
NORMAL
ELECTRICAL PATHWAYS
Sinoatrial
(SA) node
Left
atrium
Right
atrium
Left ventricle
Left bundle
branch
Atrioventricular
(AV) node
Right bundle
branch
Right ventricle
Purkinje fibers
ABNORMAL
ELECTRICAL PATHWAYS
(erratic impulses)
Sinoatrial
(SA) node
Left
atrium
Right
atrium
Left ventricle
Left bundle
branch
Atrioventricular
(AV) node
Right bundle
branch
Right ventricle
Purkinje fibers

Data

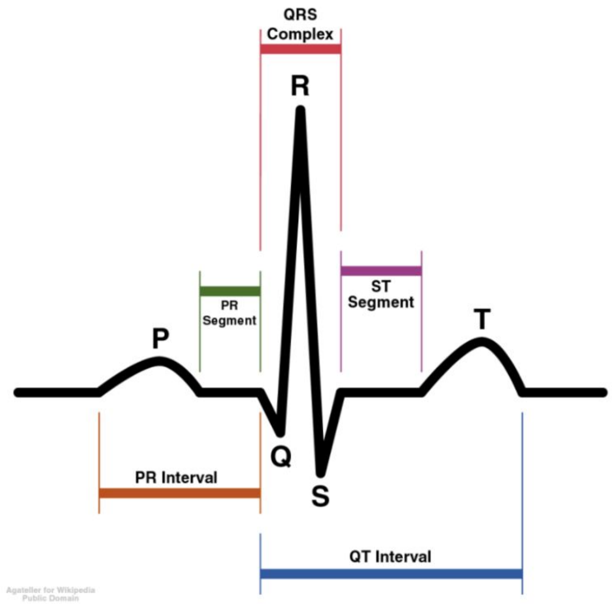
- AF Classification from a Short Single Lead ECG Recording: The PhysioNet/Computing in Cardiology Challenge 2017
- The training set contains 8,528 single lead ECG recordings lasting from 9 s to just over 60 s
- ECG recordings were sampled as 300 Hz and they have been bandpass filtered by the AliveCor device

Type	# recording	Time length (s)				
		Mean	SD	Max	Median	Min
Normal	5154	31.9	10.0	61.0	30	9.0
AF	771	31.6	12.5	60	30	10.0
Other rhythm	2557	34.1	11.8	60.9	30	9.1
Noisy	46	27.1	9.0	60	30	10.2
Total	**8528**	**32.5**	**10.9**	**61.0**	**30**	**9.0**



Amplitude, mV
Time, seconds
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
0
5
10
15
20
25
30
Amplitude
Frequency (Hz)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140

Preliminaries



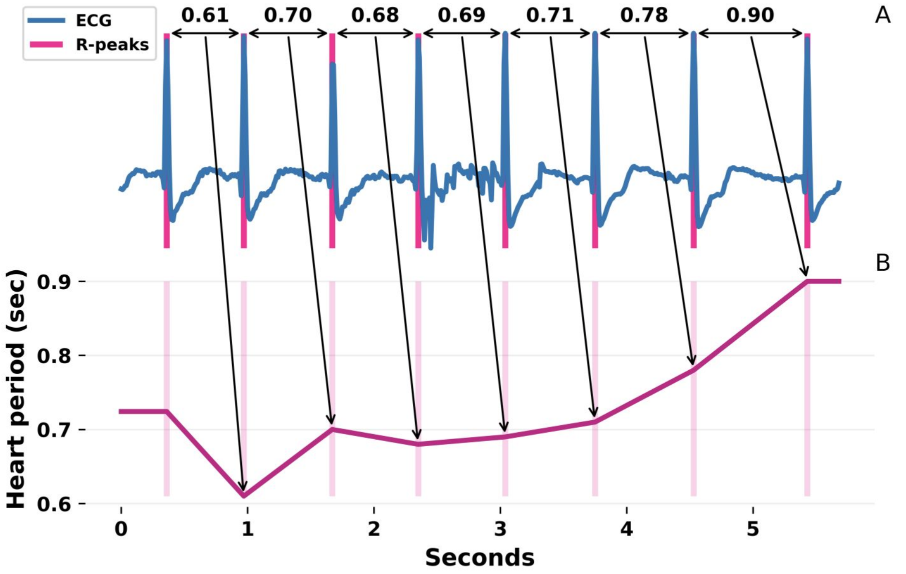
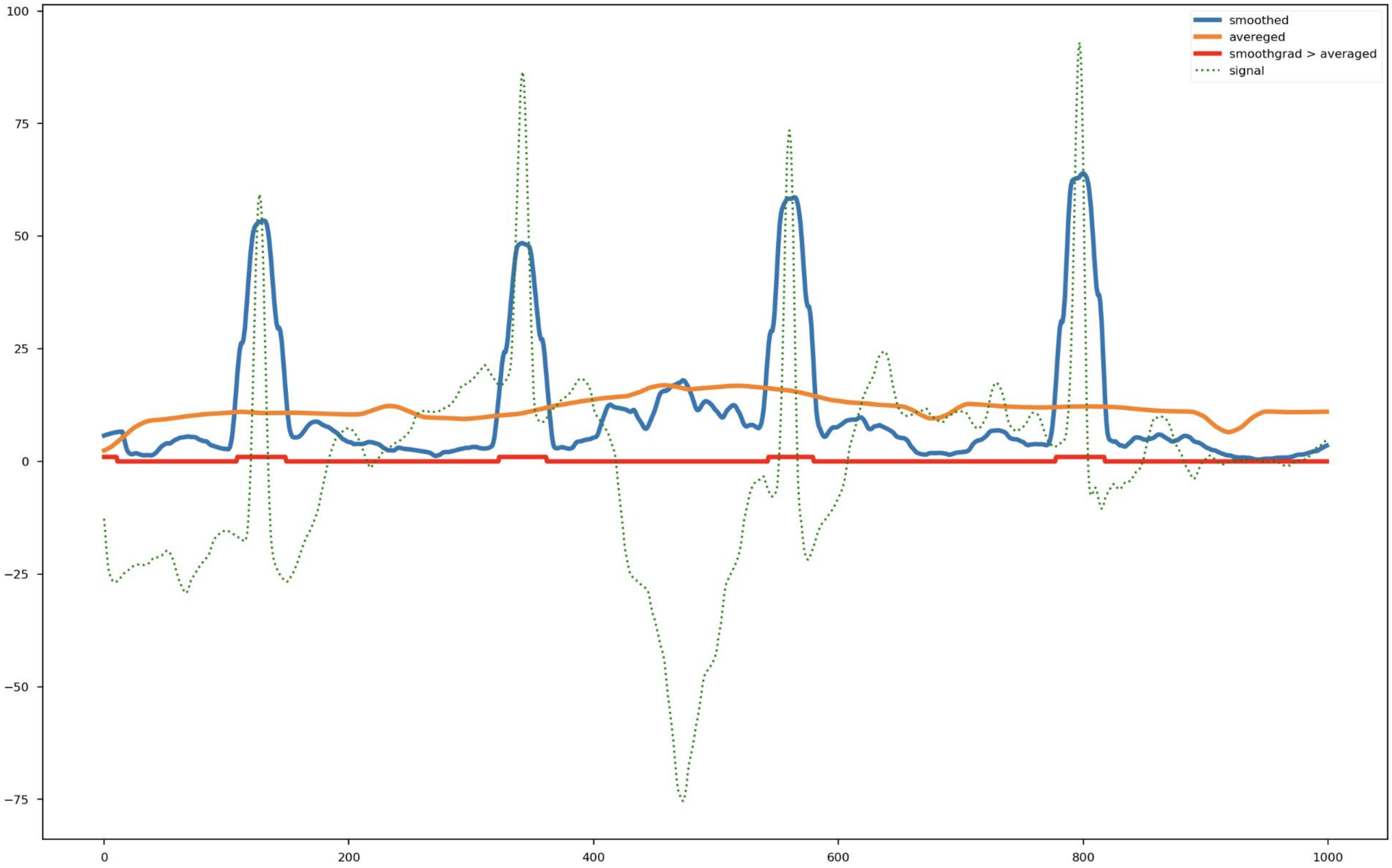
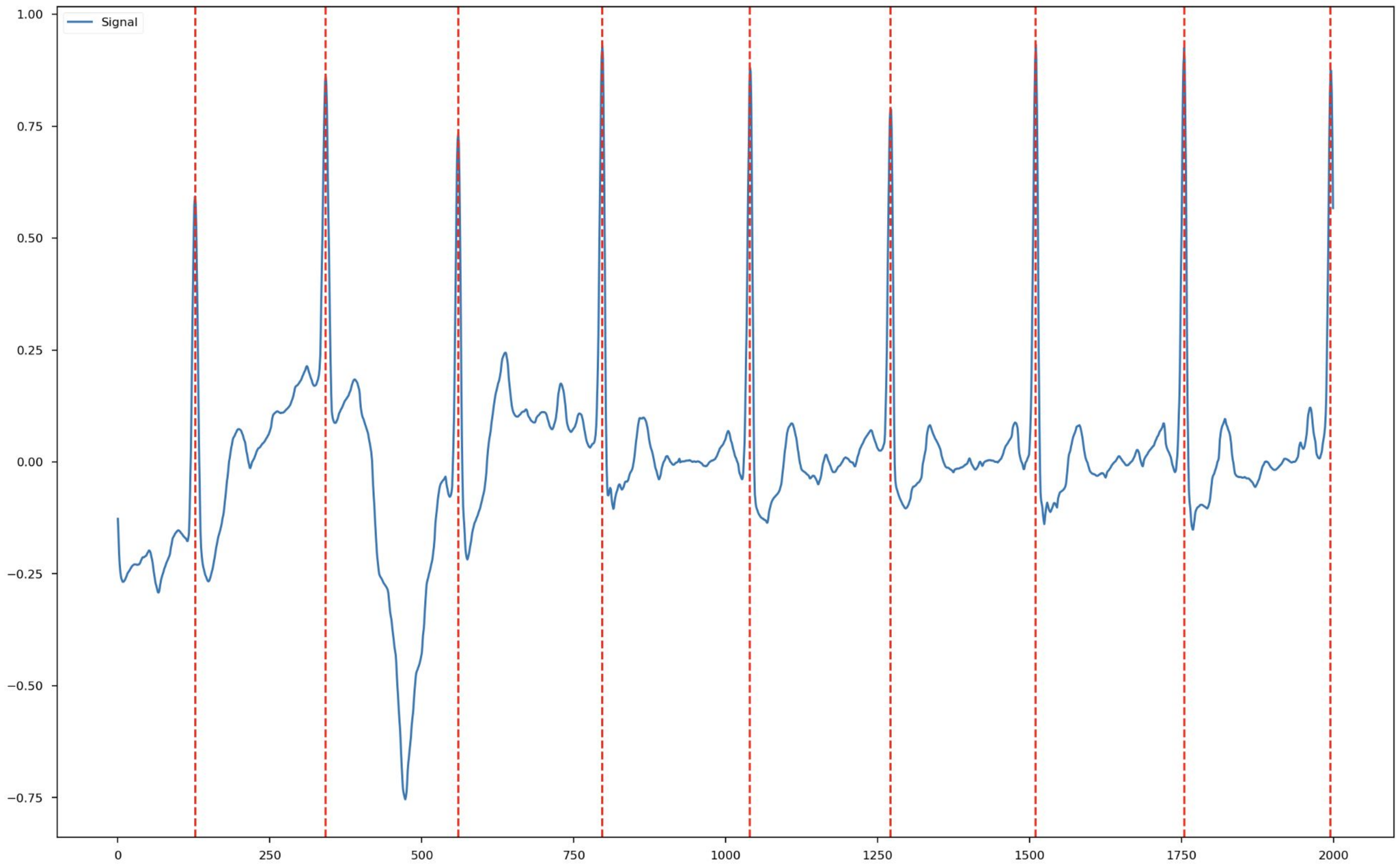


Figure 1: Extraction of heart period (panel B) based on R-peaks in an ECG (panel A). Note that this is conceptually identical to the extraction of heart period based on systolic peaks in PPG.

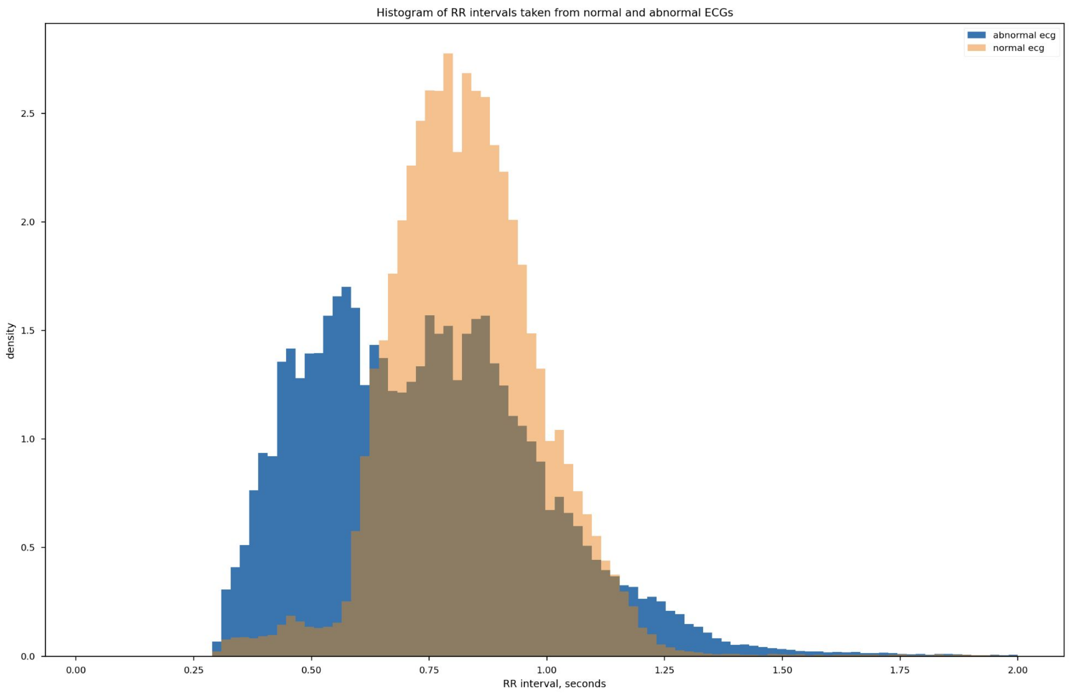


smoothed
avereged
smoothgrad > averaged
signal
100
75
50
25
0
−25
−50
−75
0
200
400
600
800
1000



Signal
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
0
250
500
750
1000
1250
1500
1750
2000

KS Test

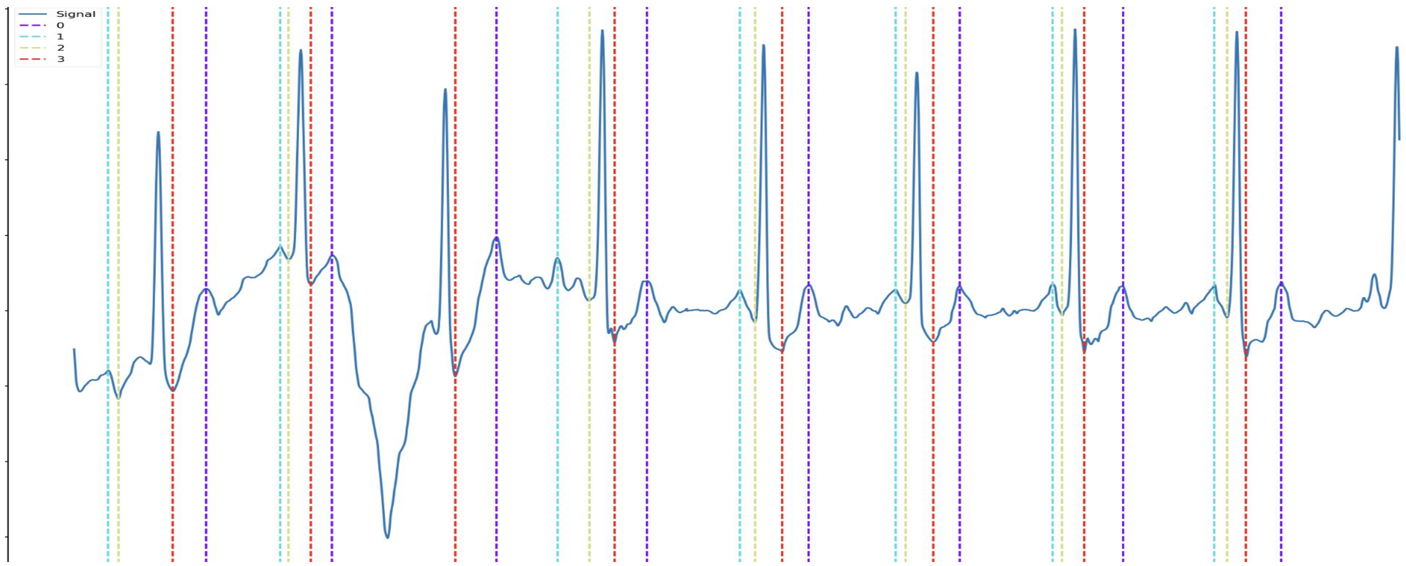


$$D_{n,m} = \sup_x |F_{1,n}(x) - F_{2,m}(x)|,$$

where $F_{1,n}$, $F_{2,m}$ are the empirical distribution functions of the first and the second sample respectively

Machine Learning

- Logistic regression on raw ECG
- Logistic regression with hand-crafted features
- XGBoost with hand-crafted features



Logistic regression (baseline)

Classification Report:

	precision	recall	f1-score	support
0	0.60	0.63	0.61	1049
1	0.36	0.33	0.35	657
accuracy			0.52	1706
macro avg	0.48	0.48	0.48	1706
weighted avg	0.51	0.52	0.51	1706

Logistic regression (add. feat.)

Classification Report:

	precision	recall	f1-score	support
0	0.63	0.76	0.69	1011
1	0.51	0.35	0.42	693
accuracy			0.60	1704
macro avg	0.57	0.56	0.56	1704
weighted avg	0.58	0.60	0.58	1704

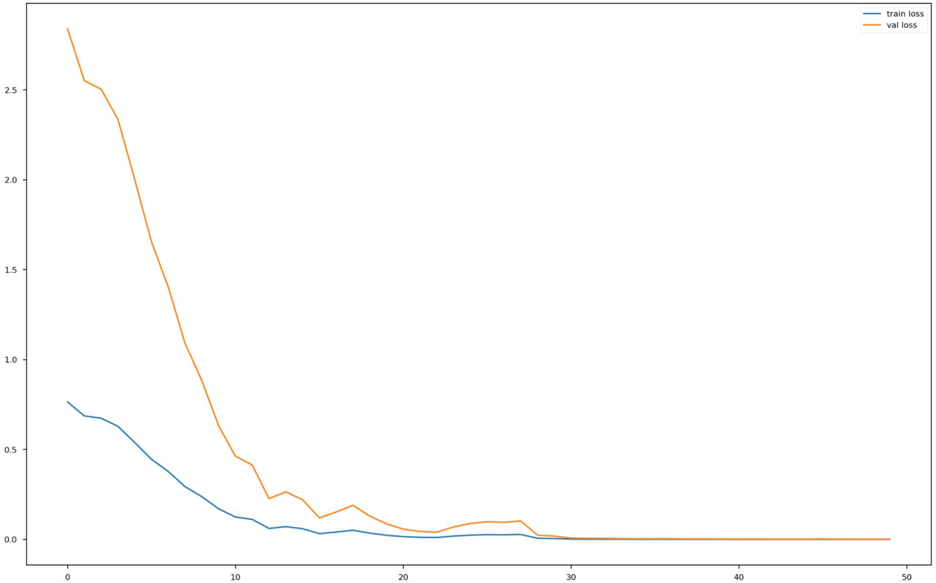
XGBoost (add. feat.)

Classification Report:

	precision	recall	f1-score	support
0	0.71	0.92	0.80	1011
1	0.80	0.45	0.58	693
accuracy			0.73	1704
macro avg	0.76	0.69	0.69	1704
weighted avg	0.75	0.73	0.71	1704

CNNLSTM

```
ECGLSTM(
  (conv1): Conv1d(1, 3, kernel_size=(3,), stride=(3,))
  (conv2): Conv1d(3, 9, kernel_size=(3,), stride=(2,))
  (bn1): BatchNorm1d(9, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (conv3): Conv1d(9, 9, kernel_size=(3,), stride=(2,))
  (conv4): Conv1d(9, 27, kernel_size=(3,), stride=(2,))
  (conv5): Conv1d(27, 27, kernel_size=(3,), stride=(2,))
  (conv6): Conv1d(27, 81, kernel_size=(3,), stride=(2,))
  (bn2): BatchNorm1d(81, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (lstm): LSTM(81, 256, num_layers=2, batch_first=True, bidirectional=True)
  (fc1): Linear(in_features=1024, out_features=256, bias=True)
  (bn3): BatchNorm1d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (fc2): Linear(in_features=256, out_features=2, bias=True)
  (dropout): Dropout(p=0.3, inplace=False)
)
```

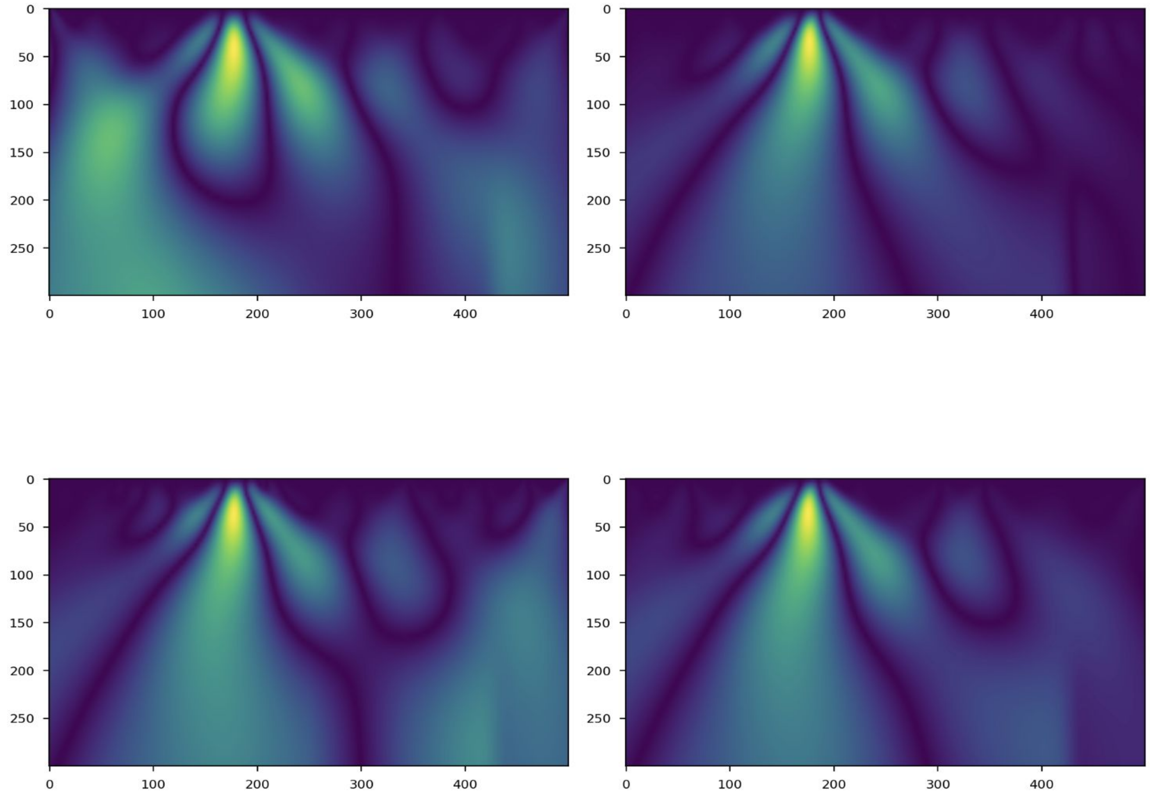


Classification Report:

	precision	recall	f1-score	support
0	0.80	0.84	0.82	1049
1	0.72	0.67	0.69	657
accuracy			0.77	1706
macro avg	0.76	0.75	0.75	1706
weighted avg	0.77	0.77	0.77	1706

Method	**F1 Result**
KS Test	**0.6**
Logistic Regression	0.48
Logistic Regression with add. feat.	0.56
XGBoost	**0.69**
CNNLSTM	**0.75**

DWT



Conclusion

Atrial fibrillation is one of the most common types of heart arrhythmia. It is dangerous as it **increases the risk of a stroke**. Approximately five percent of the population is diagnosed with heart arrhythmia. Several approaches to Atrial Fibrillation detection were implemented and discussed. They were compared on a dataset provided by **PhysioNet in Cardiology Challenge 2017**. While methods with hand-crafted features give good performance, they require a lot of domain knowledge. Deep learning approaches showed to be superior in terms of accuracy
.