The multimodal medical data preprocessing and classification framework

Final project for Foundations of Data Science course

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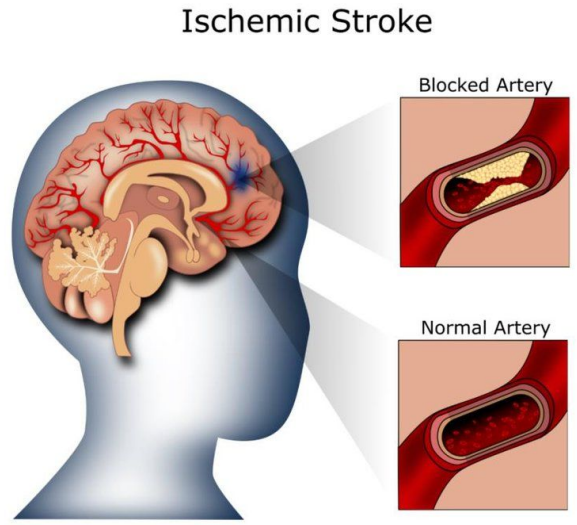
Problem statement

Ischemic stroke is the most socially significant disease of the nervous system

- third cause of death in the developed countries
- often connected and complicated by atrial fibrillation (AF).
- no sufficiently accurate method for atrial fibrillation detection



AF is asymptomatic, especially on early stages

⇩

Prophylactic therapy is not prescribed

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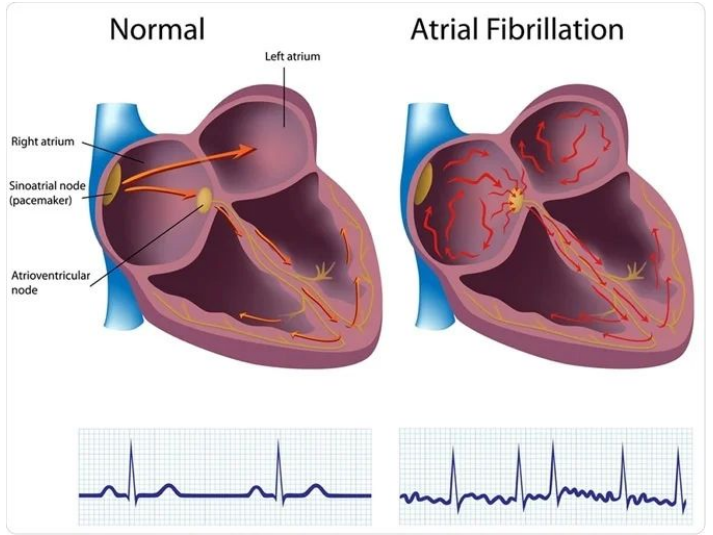
Disease immediately manifests itself as ischemic stroke



In some cases, the first attack of the obvious AF is complicated by the development of a stroke.

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Problem statement

Problem: patient's data is studied and stored separately. There is no standard workflow with multi-modal datasets.

A combination of several modalities may profit in terms of more accurate disease predictions.

Aim:

- to create the first framework that can use all insights from data extracted from the text descriptions of medical records (EHR) and from the time-series recordings of the electrocardiograms in twelve leads (ECG)

- to provide a visualisation tool to simplify the recommendation process for an expert

ECG Data

ECG data

Provided for the PhysioNet/Computing in Cardiology Challenge 2020

China 12-Lead ECG Challenge Database

- 3,453 (male: 1,843; female: 1,610)
- 12-lead ECG recordings
- lasting from 6 seconds to 60 seconds.
- sampled at 500 Hz

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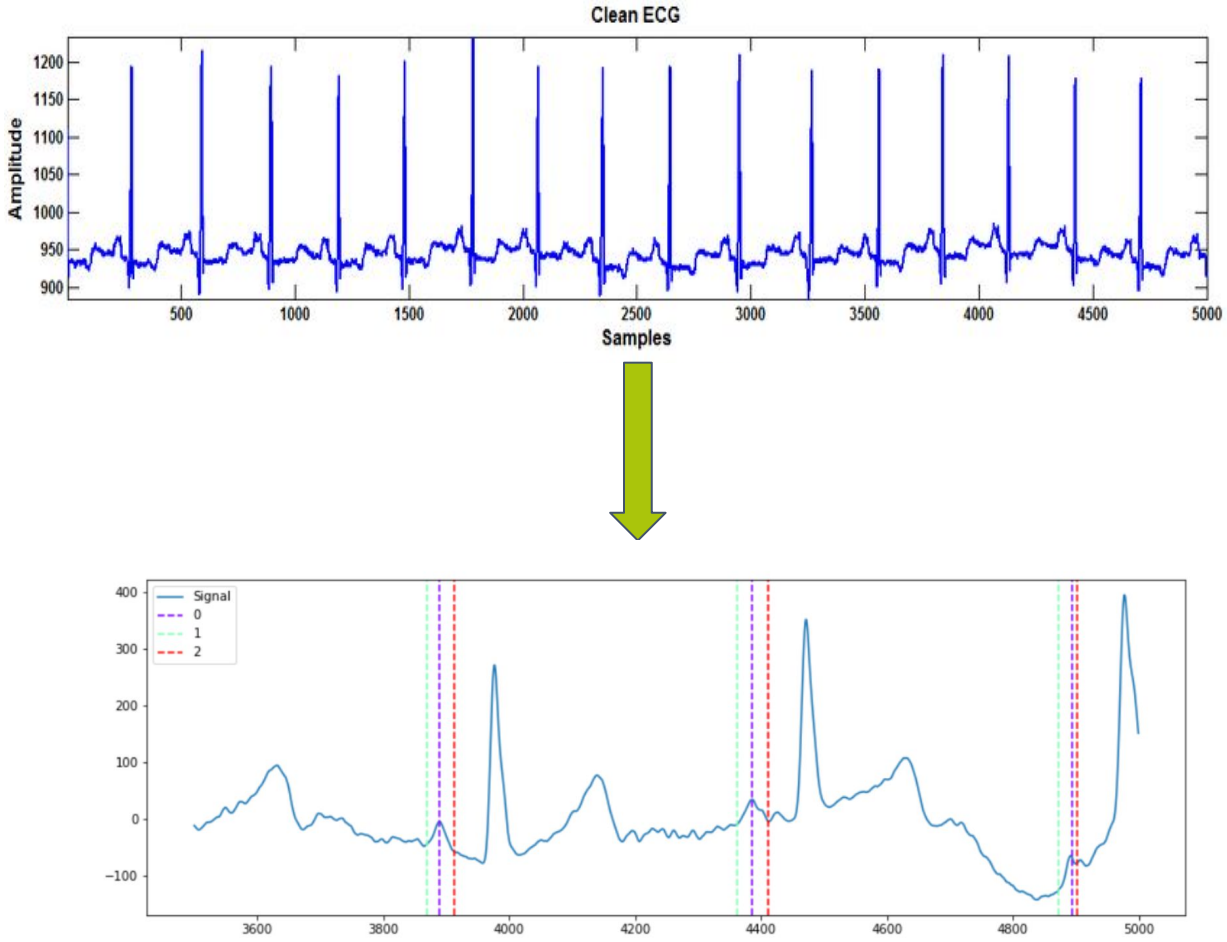
ECG Signal Segmentation



- P wave are represent atria conduction
- Segmentation of ECG is a separate hard challenge
- In our project for segmentation we use Neurokit python package

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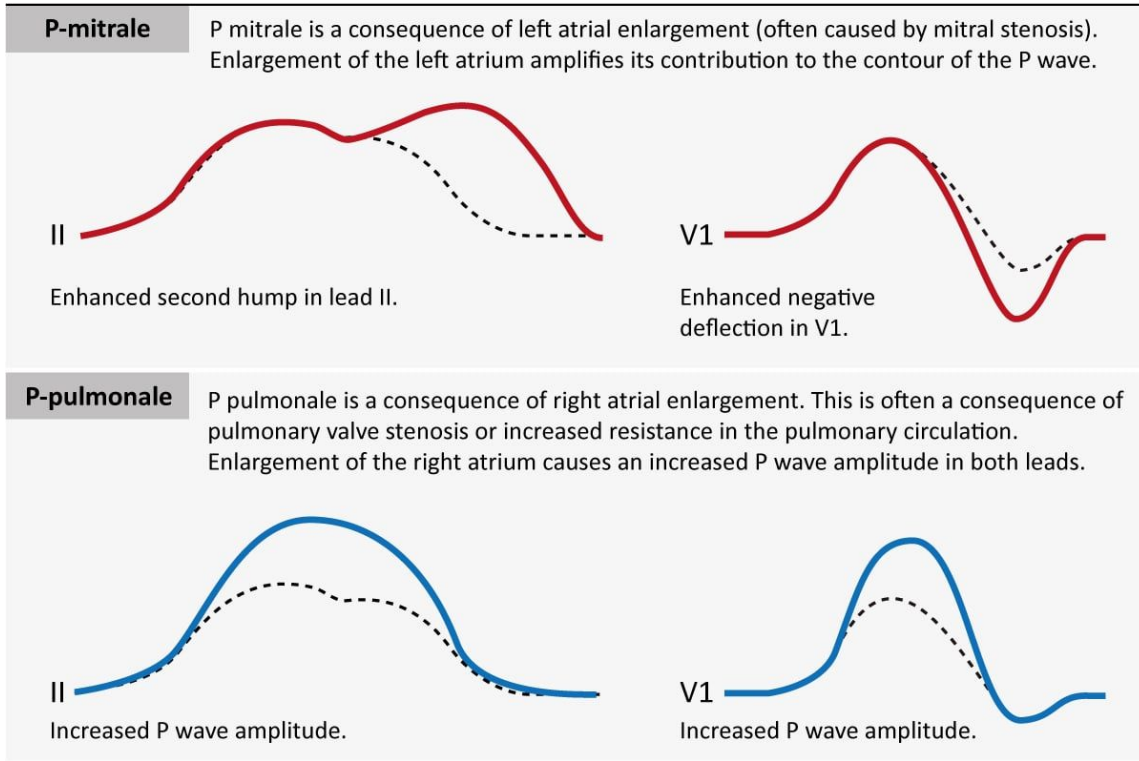
ECG feature generation

- Duration of P wave
- Maximum of P wave duration (within all leads)
- Difference between minimum and maximum duration of P wave in each lead
- Biphase P wave in leads II, III, aVF
- P wave amplitude
- Time from P wave peak start till its absolute maximum value in leads V1 и II
- Area under P wave curve
- Index area under P wave curve/Duration
- PQ interval duration
- Terminal index: production of amplitude on duration of negative phase of P wave in V1 lead



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EHR Textual Data

Main challenges:

- No state of the art datasets medical textual data in Russian
- No trained models for medical data in Russian
- Only statistical approaches exist for evaluation

Our dataset:

- 164 000 EHR
- Noisy with many typos and errors
- Some keys are broken

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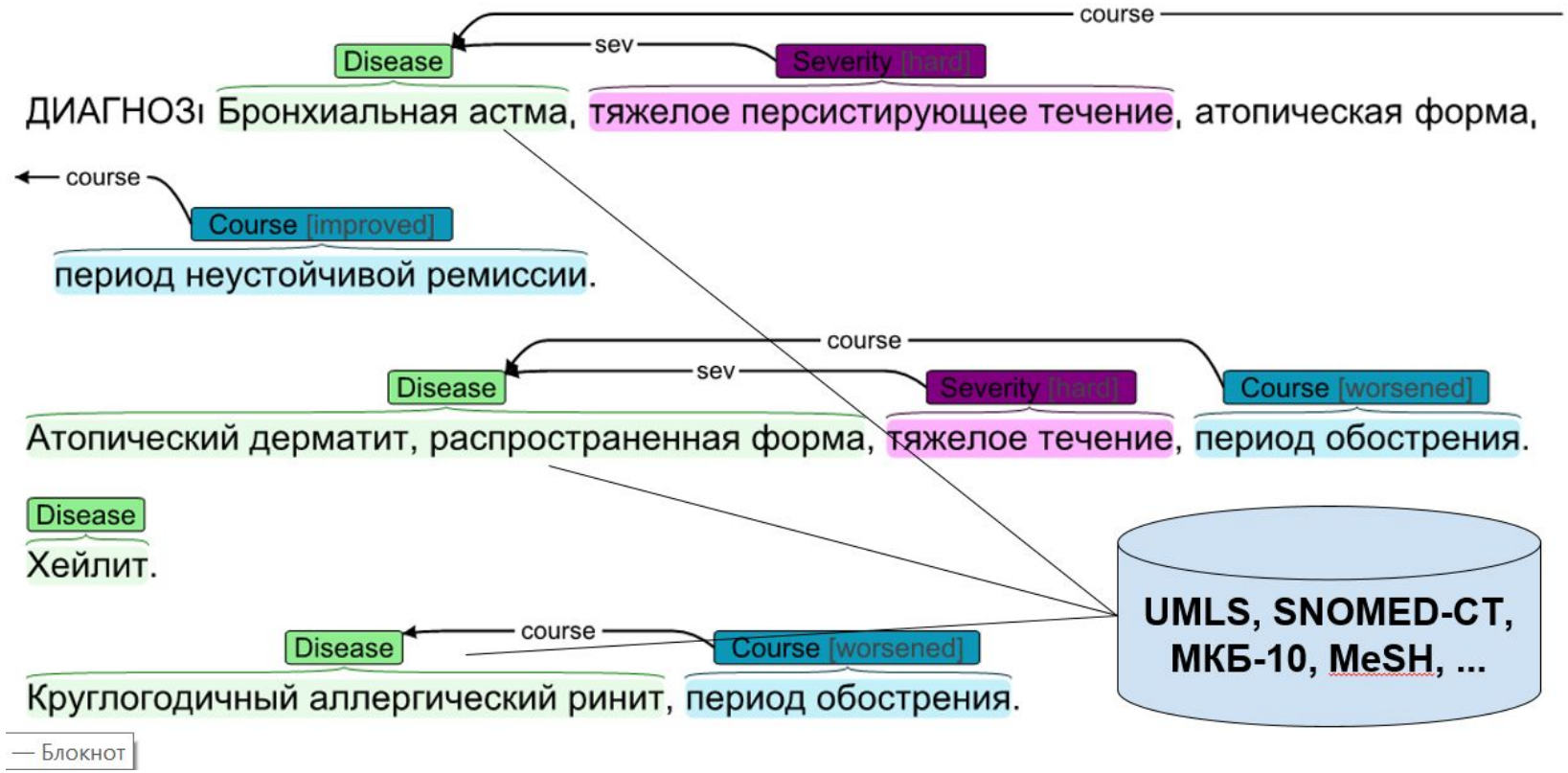
EHR Diagnosis Sample



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Text Feature Extraction

Pipeline:

- Restoring keys
- Restoring broken htmls
- Rules for some common typos

Approaches:

- Yargy parser
- BERT based models for Russian

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Text Feature Extraction Quality Comparison

Attribute To extract	Rules F1	Bert Models F1(avg)
Hypertension	0.98	0.96
PAD	0.94	0.67
Diabetes	0.98	0.90
CAD	0.99	0.88

Tested on:

- Dataset labeled by expert (750 fully annotated EHR)

Reasons:

- BERT based models were trained on non medical data
- Not enough samples in the training corpus

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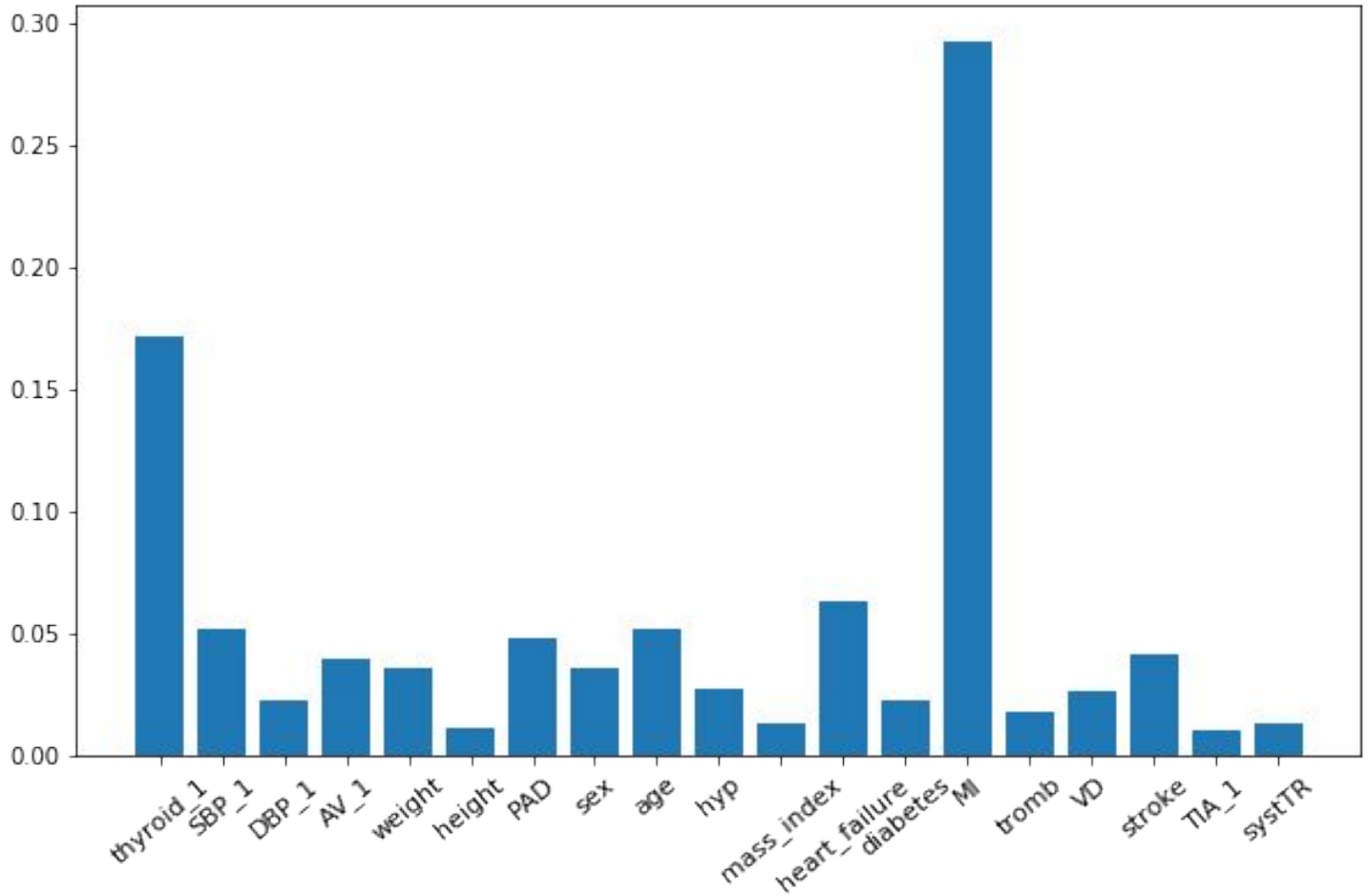
Results
Text Feature Importance



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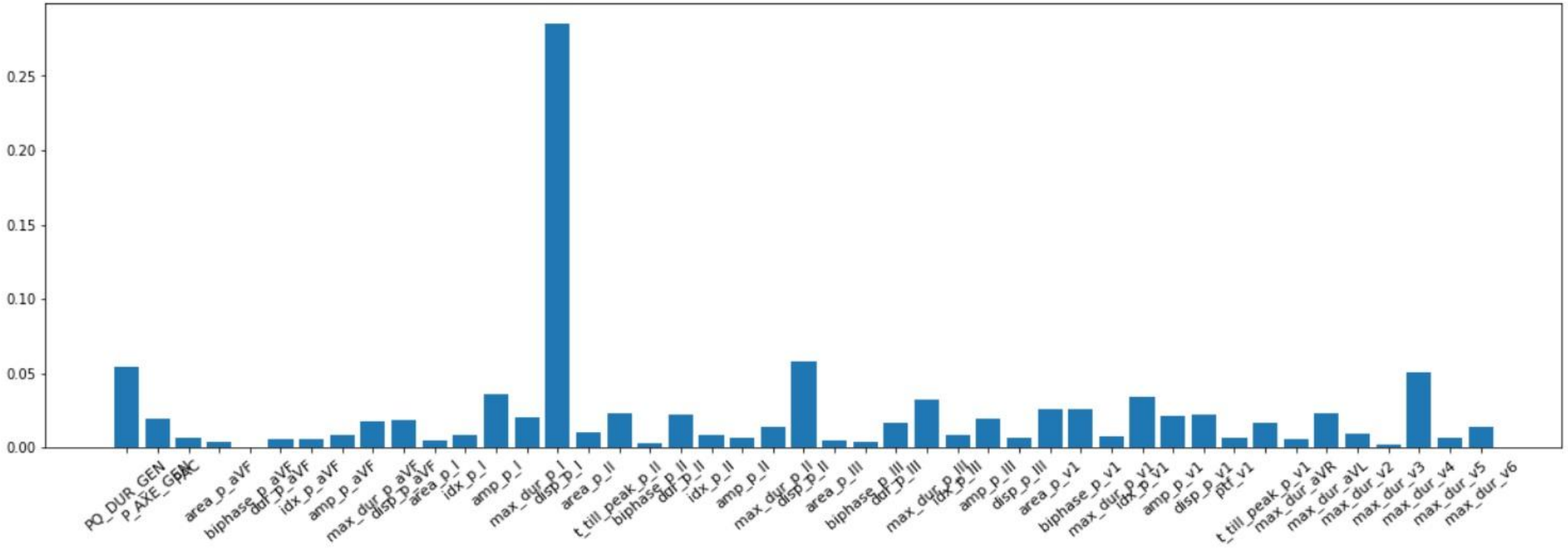
Results
ECG Feature Importance



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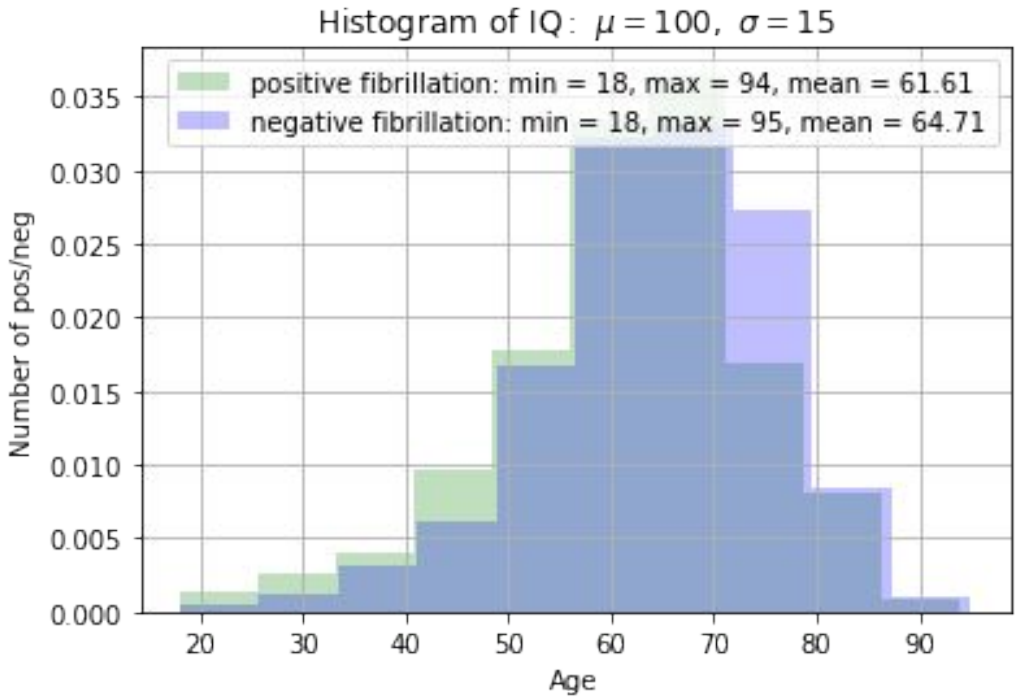
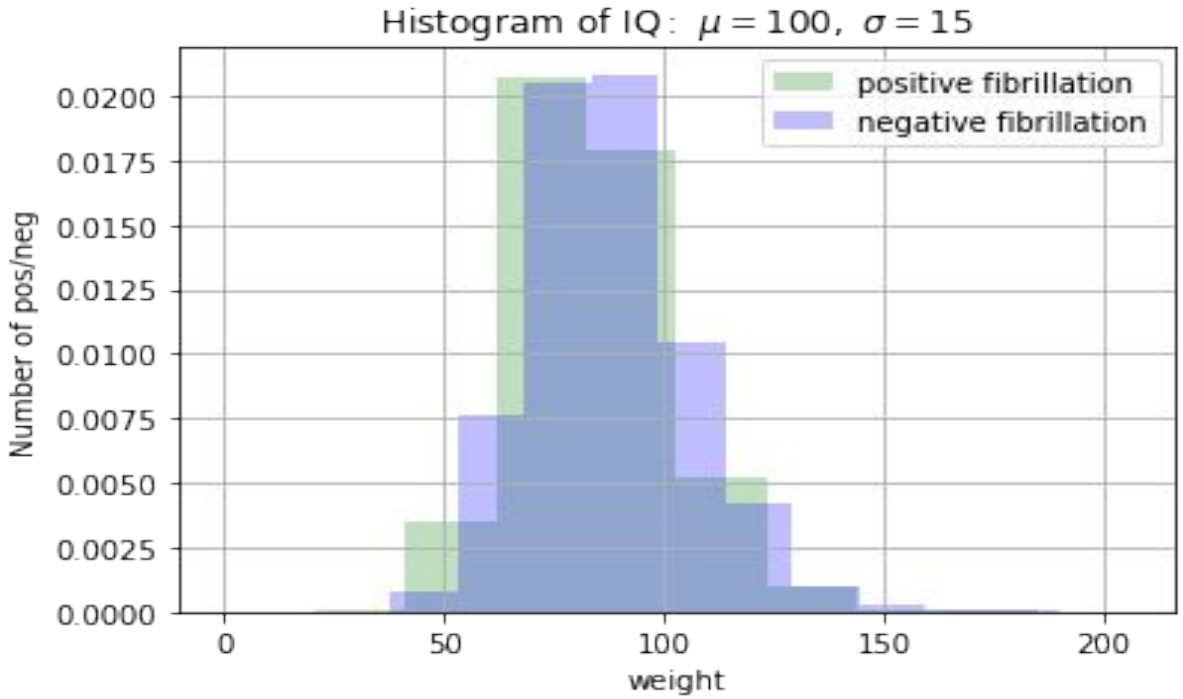
Correlation Analysis for Age and Weight





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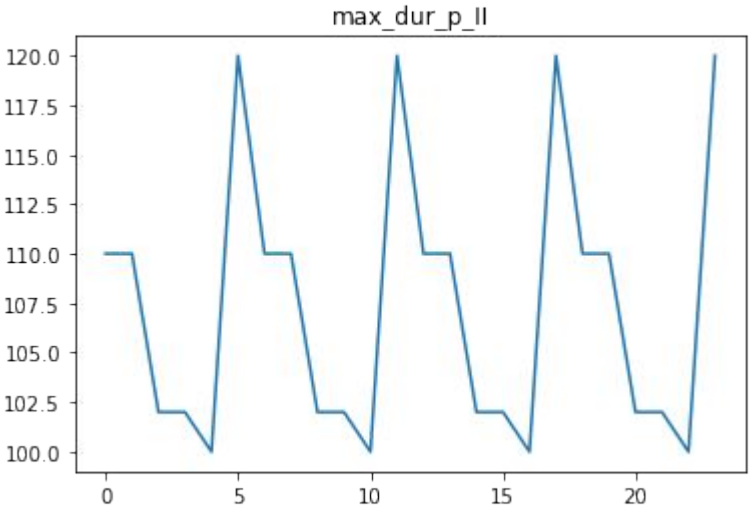
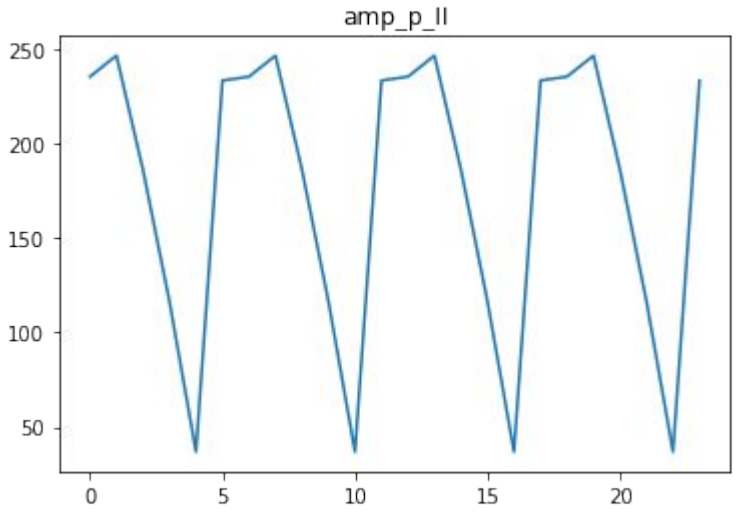
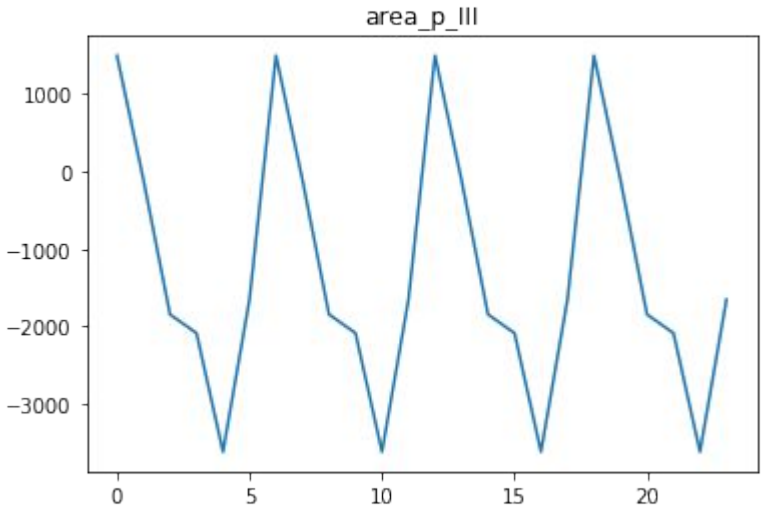
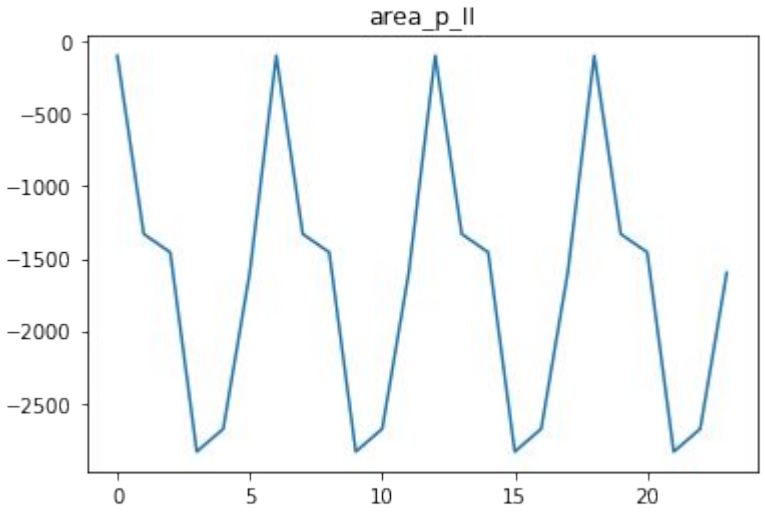
Time Dynamics









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Tools Implemented

1. ECG feature generation
2. Text feature generation
3. Visualization and data analysis
4. SQL tool for data storage

thx.

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