Digitization of ECG

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Introduction

- An electrocardiogram (ECG) is a medical test that records and analyses the electrical activity of the heart.[4]
- ECGs are used to identify and assess cardiovascular diseases (CVDs).

Digitally Recorded ECG
: ECG which is collected digitally from the ECG Machine.

Digitized ECG
: Paper ECG converted into Digital ECG.

- Problem While Fetching ECG: Variations in Geometry, Pixel intensity, overall picture quality might decrease.

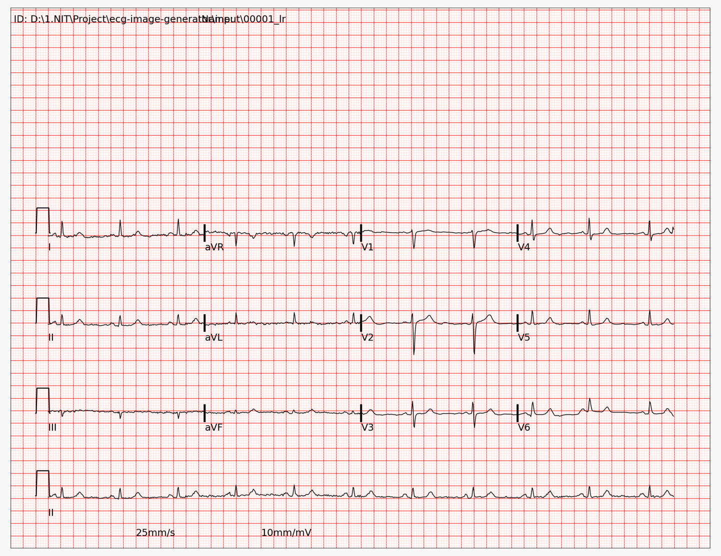

Figure 1. Digitally Recorded ECG [4]

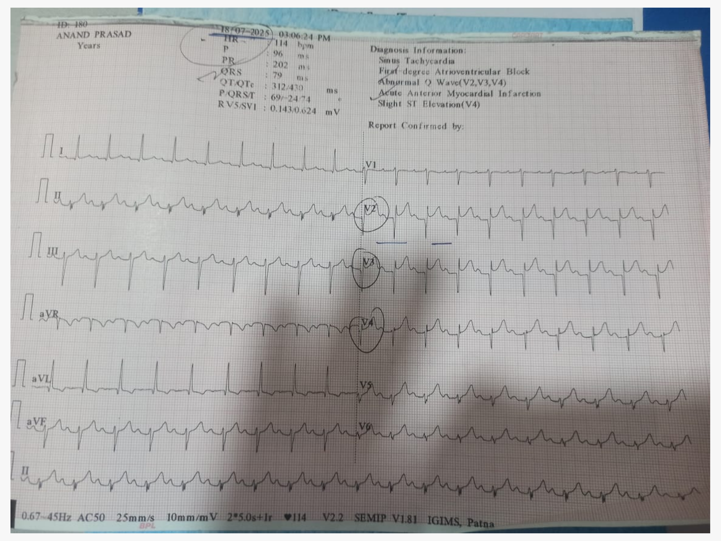

Figure 2. ECG

PTB-XL, a large publicly available ECG dataset

- The dataset comprises 21,837 clinical 12-lead ECG records of 10 seconds length from 18,885 patients.
- Patient demographics include 52% male and 48% female, with ages ranging from 0 to 95 years.
- The raw ECG waveform data was annotated by up to two cardiologists.
- Each record can have multiple "ECG statements" assigned to it, making it a multi-label dataset.
- The data is provided at two sampling frequencies: the original 500 Hz and a downsampled 100 Hz.

Table 1. Distribution of Class of PTB-XL [4]

#Records	Superclass	Description
9528	NORM	Normal ECG
5486	MI	Myocardial Infarction
5250	STTC	ST/T Change
4907	CD	Conduction Disturbance
2655	HYP	Hypertrophy

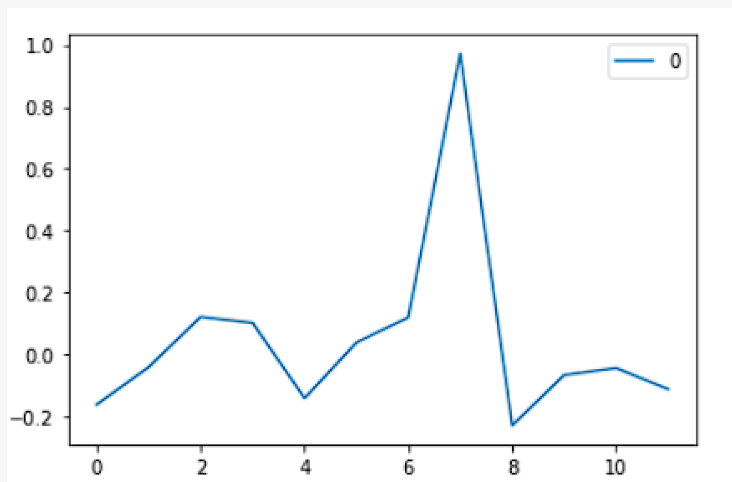

Figure 3. LEAD II of ECG [4]

ECG-ImageK-it

A toolkit for synthesis, analysis, and digitization of electrocardiogram images

1. **Synthetic Image Generation**
2. **Digitization**

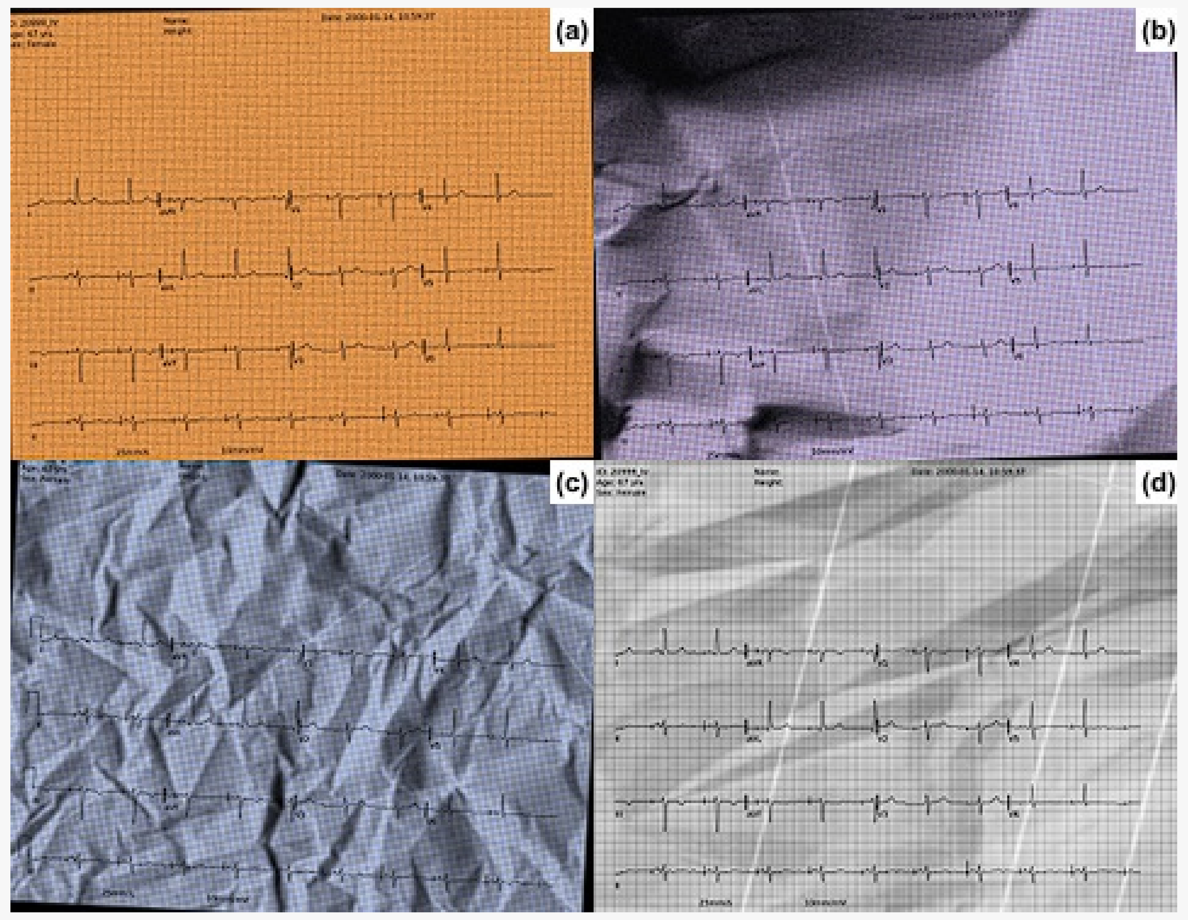

Figure 4. Four example images of signal 20999. (a) rotated by one degree, (b) rotated by two degrees with wrinkles and shadows, (c) rotated by three degrees with wrinkles and shadows, (d) not rotated with wrinkles and shadows.

Architecture

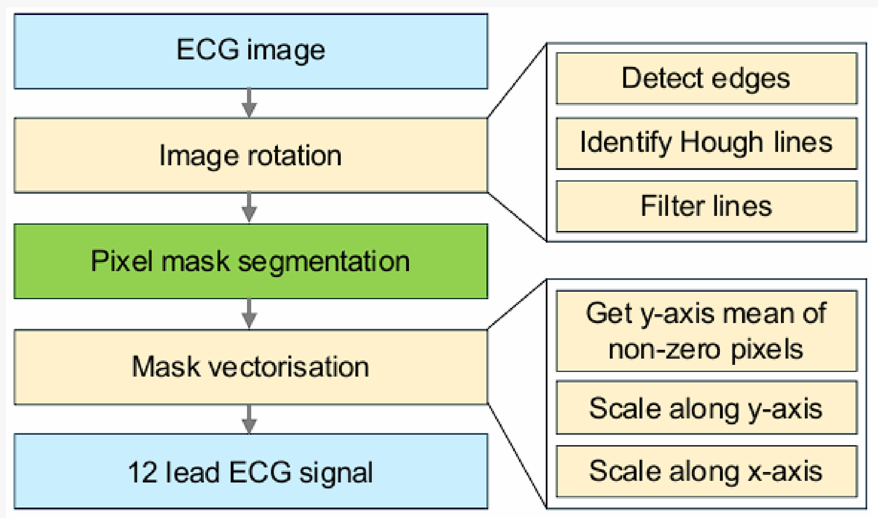

Figure 5. A schematic diagram of our model architecture. Blue: Data, Yellow: Rule-based engineering, Green: Deep learning. [3]

- Rotation. We used the HoughLines() method from the opencv (cv2) Python package.
- Segmentation. We used nnU-Net[1], nnU-Net automatically configures the image processing and network architecture based on the data, using three types of parameters[3].
- To create mask we use the one provided by ecg-image-kit. (dense mask)[2]

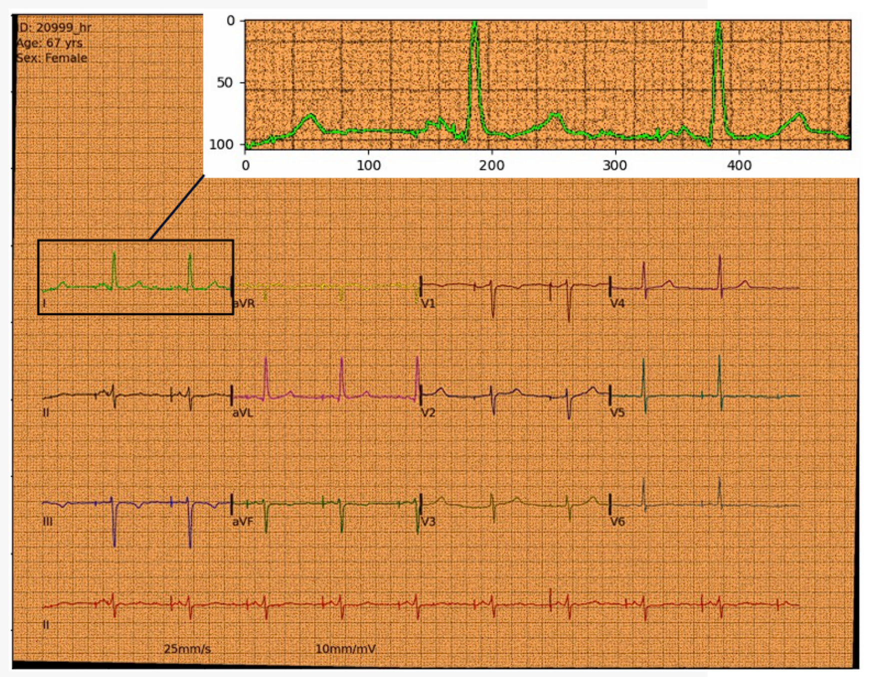

Figure 6. Example of predicted masks for signal [3]

- Vectorisation. In order to convert the mask, which is a matrix of pixel values, into a signal[3].

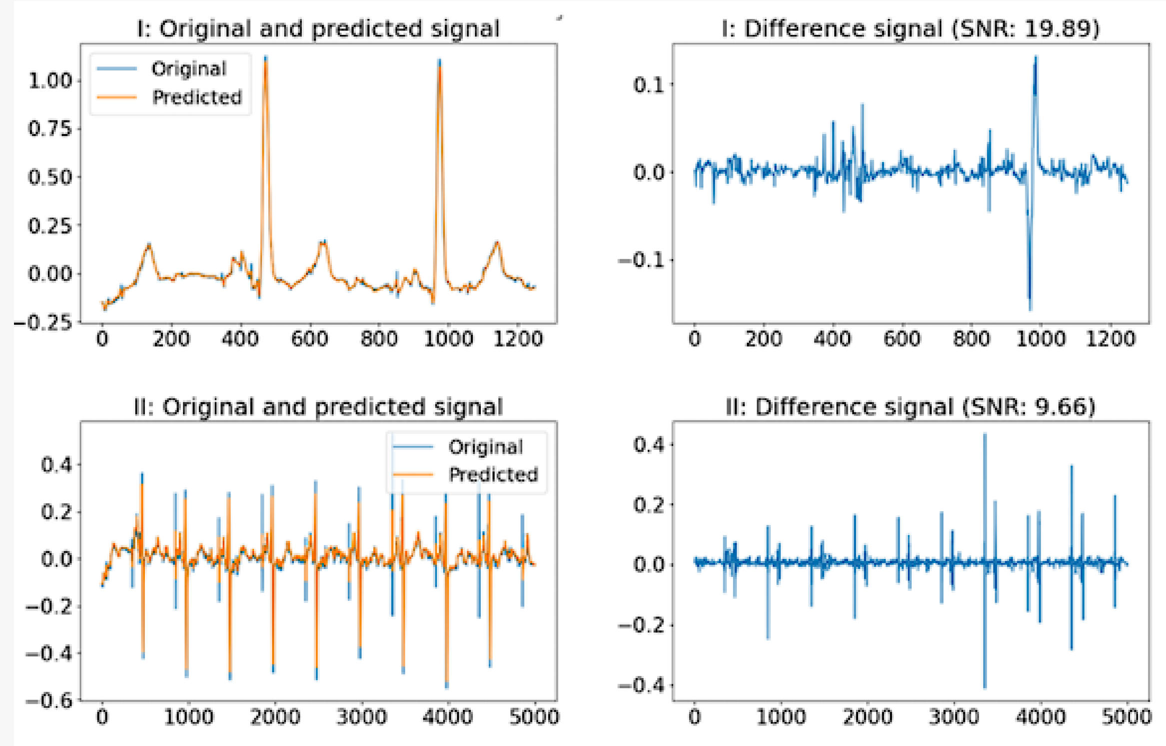

Figure 7. Vectorisation example for signal 20999. Left: original and predicted signal. Right: signal difference. [3]

Results

- The metric used in the the digitisation task was the signal-to-noise ratio (SNR)

$$\mathrm{SNR} = 10 \cdot \log_{10} \frac{\sum_i y_i^2}{\sum_i (\hat{y}_i - y_i)^2}. \tag{1}$$

- In the rotation step, we achieved a correct rotation prediction on over 99.7

Table 2. Results

Train Images	Augmentation	Mask	SNR
20k	Headers, calibration, wrinkles, rotation, cropping	ecg-image-kit	12.15

References

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[3] Felix Krones, Ben Walker, Terry Lyons, and Adam Mahdi.
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