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Healthcare Decision-Making with a Reliable and Efficient ECG-Based Biometric System

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Presentation Outline

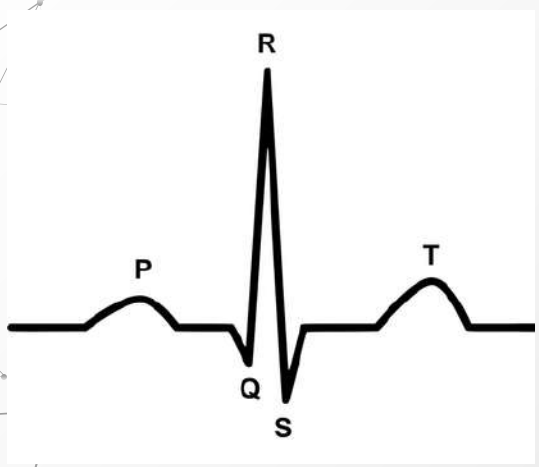
1

Introduction

What is biometrics?

Biometrics are unique physical or behavioral characteristics that can be used to identify an individual. The term "biometrics" comes from the Greek words "bios," meaning life, and "metron," meaning measure.

- Heart is the most important part of the human body.
- It is also an uninterrupted data source.



Schematic diagram of normal sinus rhythm for a human heart as seen on ECG

- **P-Wave:** Its frequency spans from 10 to 15 Hz, while its duration varies between 0.06 and 0.12 seconds.
- **QRS-Complex:** Its amplitude varies between 0.5 and 1 mV, and its duration spans from 80 to 120 ms.
- **ST-Segment:** Can be anywhere from 0.1 to 0.5 millivolts in amplitude, and it can last anywhere from 120 to 180 ms.

2

Motivation

- The increasing demand for accurate identification in healthcare is one of the main motivations for this study.

- ECG-based biometrics could be used to improve patient safety by preventing unauthorized access to medical records or by verifying the identity of patients before administering medication.

- ECG signals are a promising modality for biometric identification because they are continuously available. This means patients could be identified without interrupting their care or wearing a special device.

3

State of the Art

Authors	Year	Databases	Approach	Results
Azam et al.	2020	Private	Extraction of features using Discrete Wavelet Transform (DWT) + MLP	96.40%
Yuniarti et al.	2022	MIT-BIH Arrhythmia	Extraction of QRS waveform features + 1D-CNN	92.00% (F1-Score)
Li et al.	2020	Five public datasets	Two CNNs are trained for feature extraction and Classification, respectively	94.30% (Average)
Zehir et al.	2023	MIT-BIH Arrhythmia	Extraction of frequency domain features + SVM	97.00%

- Despite its medical nature, ECG biometrics has not yet been integrated into healthcare systems.
- Not all methods take medical conditions into consideration.

4

Proposed Method

PTB Diagnostic ECG Database

- The database contains 549 records from 290 subjects.
- Each record includes 15 simultaneously measured signals.
- Each signal is digitized at 1000 samples per second, with 16 bit resolution over a range of ± 16.384 mV.
- The signals, came from 209 males and 81 women, both healthy and diseased, ranging in age from 17 to 89.

Pre-processing

1 Filtering

- A 4th-order Butterworth bandpass filter was used to filter the ECG signal.
- The frequency range of the passband is [1 Hz - 40 Hz].

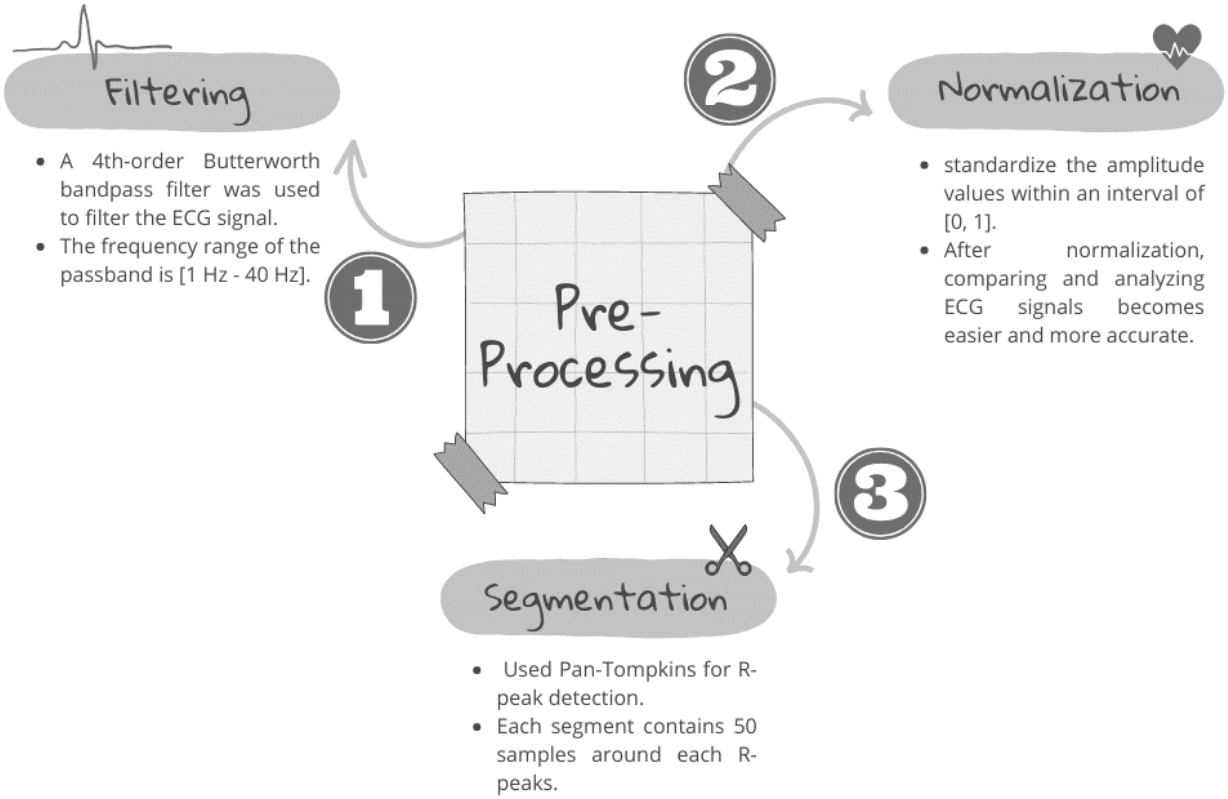
2 Normalization

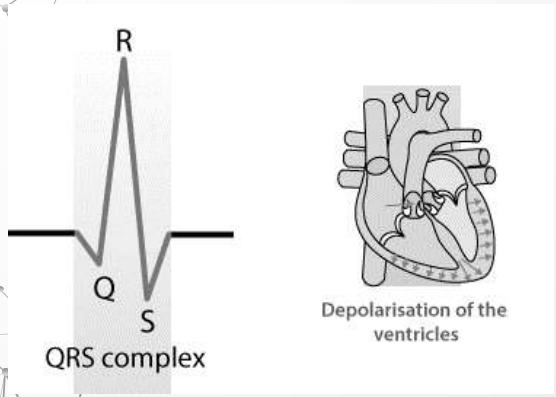
- Standardize the amplitude values within an interval of [0, 1].
- After normalization, comparing and analyzing ECG signals becomes easier and more accurate.

3 Segmentation

- Used Pan-Tompkins for R-peak detection.
- Each segment contains 50 samples around each R-peaks.

Pre-processing





QRS complex is the main spike seen in the ECG.

- Around 9500 QRS complexes were obtained for the 48 healthy subjects.
- More than 68,000 QRS complexes were obtained when using 282 subjects.

Deep Learning Model

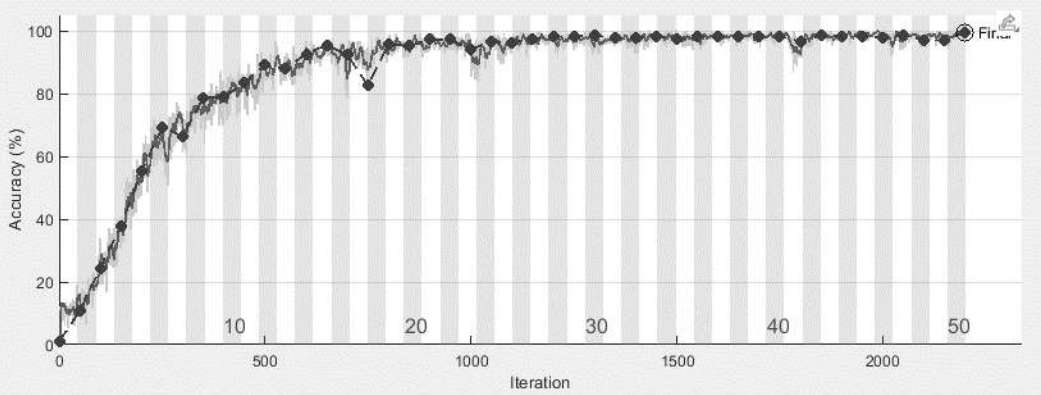
#	Layer
1	Sequence input with 1 dimension
2	Gated recurrent unit cell with 100 hidden units
3	20% dropout
4	Gated recurrent unit cell with 100 hidden units
5	Fully connected layer
6	Softmax
7	Classification output (cross-entropy)

5

Experiments and Results

Experiments

- PTB Diagnostic ECG Database.
- Single Lead Only.
- Classification of QRS Complexes.
- Accuracy as metric.



Training progress of our system on the healthy subjects, showing training accuracy alongside validation accuracy

Epochs: 50
Mini-batch size: 150
Learning rate: 0.001
Optimizer: ADAM

Results

Authors	Database used	Accuracy achieved
Zhang et al.	ECG-ID MIT-BIH	92.53% 91.31%
Lee et al.	CU-ECG	98.48%
Zihlmann	ECG-ID MIT-BIH	90.70% 91.15%
Hamza et al.	PTB	95.40%
Jyotishi et al.	PTB MIT-BIH	97.30% 96.81%
Our method	PTB: 48 Healthy Subjects PTB	99.47% 97.60%

- Superior accuracy compared to state-of-the-art models.
- Significant implications for decision-making processes in healthcare.
- Enhance the efficiency and accuracy of medical processes.
- Critical in time-sensitive medical scenarios.

6

Conclusion

- We proposed an approach based on ECG biometrics.
- Our approach obtains better results on the PTB Diagnostic ECG Database.
- Only use QRS complexes.
- For future works, hardware implementation.

THANK YOU FOR YOUR ATTENTION!