

Pattern recognition in ECG time series

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INTRODUCTION

Introduction

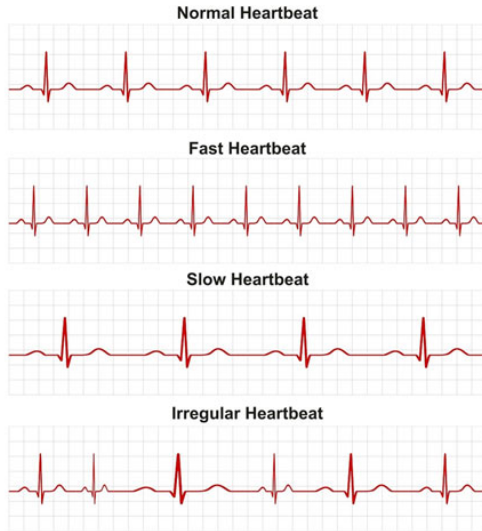


Figura 1: Heart arrhythmias.

Introduction

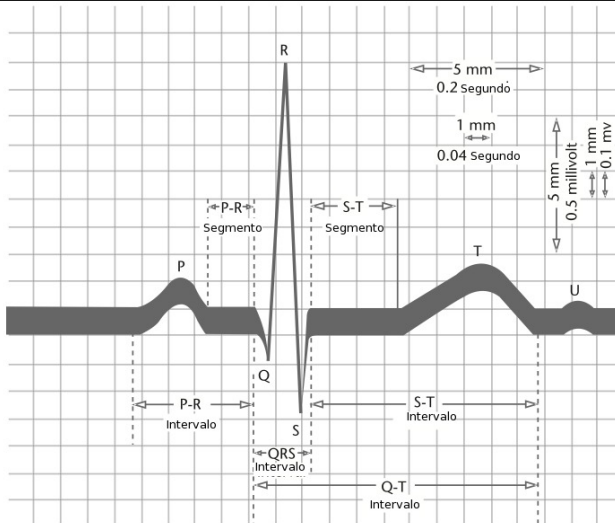


Figura 2: Features of a signal ECG (CLIFFORD et al., 2006).

Introduction

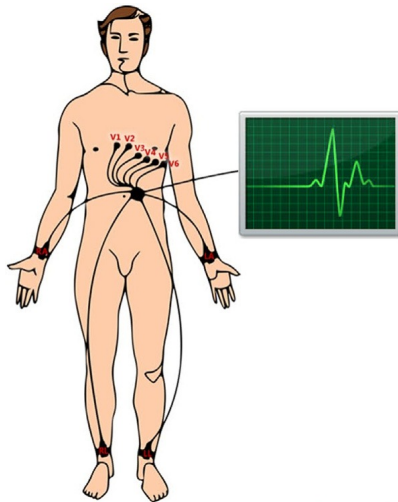


Figura 3: Typical 10 electrodes (leads) configuration (LUZ et al., 2016).

Introduction

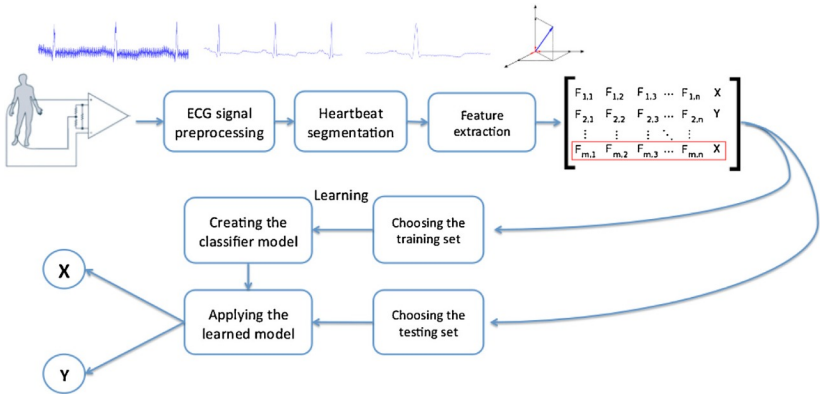


Figura 4: A diagram of the arrhythmia classification system (LUZ et al., 2016).

Introduction

- Automatic ECG classification systems has two main paradigms: *intra-patient* and *inter-patient*.
 - *Intra-patient* a subject's heartbeat is used both for building the classification system and for testing.
 - **Inter-patient* used a separate set of subjects for building the classification system, and another for testing.
- *The best paradigm to simulate a real scenario.

DATABASE

Database

MIT-BIH

- MIT-BH Arrhythmia Database (MOODY; MARK, 1990);
- Developed by MIT and Boston's Beth Israel Hospital;
- 48 annotated records (signals) obtained from 47 subjects between 1975-1979;
- Each record has 30 minutes selected from recorded 24 hours;
- Sample of 360Hz in 2 channels (V and II);
- Four records include paced beats.

Database

MIT-BIH and AAMI Labels

Tabela 1: Mapping between MIT-BIH and AAMI* labels

MIT-BIH class	AAMI class	Number of events
Normal beat (N or .)	Normal (N)	90125
Left bundle branch block beat (L)		
Right bundle branch block beat (R)		
Atrial escape beat (e)		
Nodal (junctional) escape beat (j)		
Atrial premature beat (A)	Supraventricular ectopic beat (S)	2781
Aberrated atrial premature beat (a)		
Nodal (junctional) premature beat (J)		
Supraventricular premature beat (S)		
Premature ventricular contraction (V)	Ventricular ectopic beat (V)	7009
Ventricular escape beat (E)		
Fusion of ventricular and normal beat (F)	Fusion beat (F)	803
Paced beat (P or /)	Unknown beat (Q)	15
Fusion of paced and normal beat (f)		
Unclassified beat (U)		
Unknown beat (Q)		
TOTAL		100733

*Association for the Advancement of Medical Instrumentation.

Database

Inter-patient paradigm

Dataset	Recordings
DS1 (Training)	101, 106, 108, 109, 112, 114, 115, 116, 118, 119, 122, 124, 201, 203, 205, 207, 208, 209, 215, 220, 223, and 230.
DS2 (Testing)	100, 103, 105, 111, 113, 117, 121, 123, 200, 202, 210, 212, 213, 214, 219, 221, 222, 228, 231, 232, 233, and 234.

Tabela 2: Distribution of the MIT-BIH recordings between training and testing proposed by (CHAZAL; O'DWYER; REILLY, 2004)

*AAMI recommends deleting four records with paced beats (102,104,107,217).

PROPOSED METHODOLOGY

Proposed Methodology

- MIT-BIH database and Inter-patient paradigm
- Preprocessing (Filtering)
- Segmentation (QRS Complex detection)
- Feature Extraction
- Classification

Proposed Methodology

- Preprocessing (Filtering):
 - Discret Wavelet Transform (DWT)
 - Scipy filters (Savitzky-Golay, medfilt, wiener, etc.)
- Segmentation (QRS Complex detection):
 - Normalization (0-1)
 - Extract T waves from R-peak signal annotation file
 - Arrhythmia type from annotation file
 - Length of each heartbeat: 300 samples
- Feature Extraction:
 - Discret Wavelet transform (DWT)
- Classification:
 - SVM and neural network

METHODS

Methods

How does Wavelet Transform work?

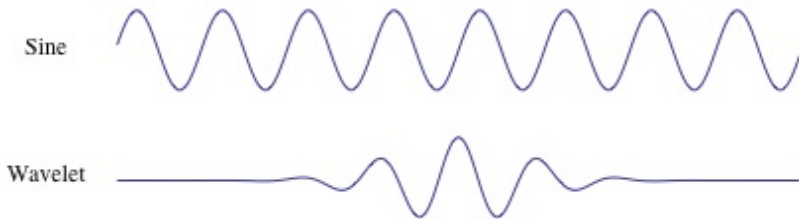


Figura 5: The difference between a sine-wave (Fourier) and a Wavelet (WT). The sine-wave is infinitely long and the Wavelet is localized in time (TASPINAR, 2018).

Wavelet \rightarrow small wave.

Methods

Wavelet Transform families

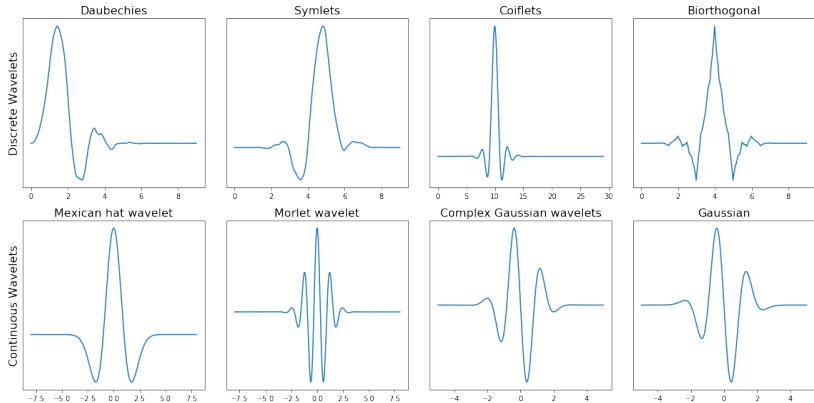


Figure 6: Some discrete wavelets families (DWT) and continuous wavelets (CWT) families. The Pywavelets library contains 14 mother Wavelets (families of Wavelets).

Each of them has different subcategories and differs from number of coefficients (vanishing moments) and level of decomposition.

Methods

Wavelet Transform families

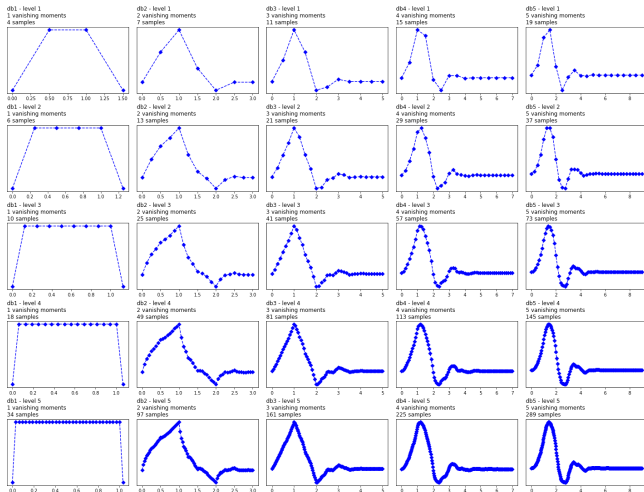


Figure 7: The Daubechies family of wavelets for several different orders of vanishing moments and several levels of decomposition.

Methods

Wavelet Transform Denoise

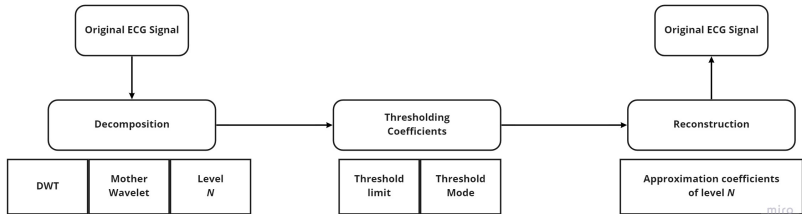


Figure 8: Noise Removal using WT Threshold method.

Methods

Wavelet Transform Denoise

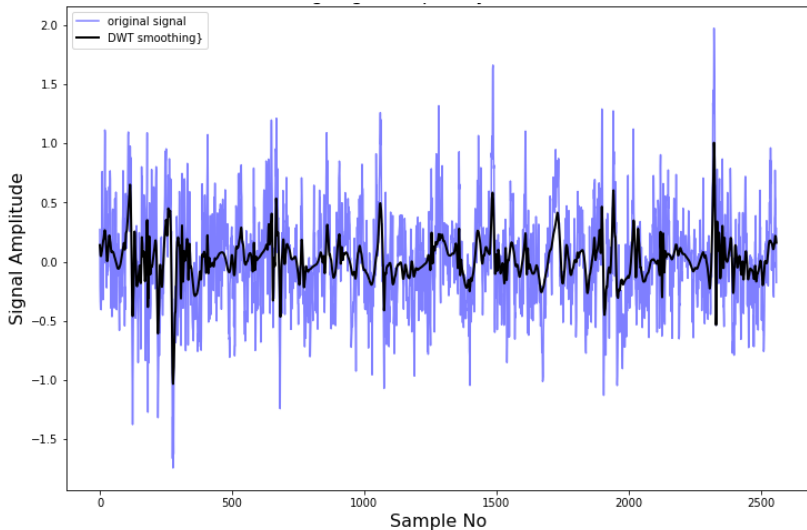


Figure 9: A high frequency signal and its DWT smoothed version.

Methods

Wavelet Transform Feature Selection

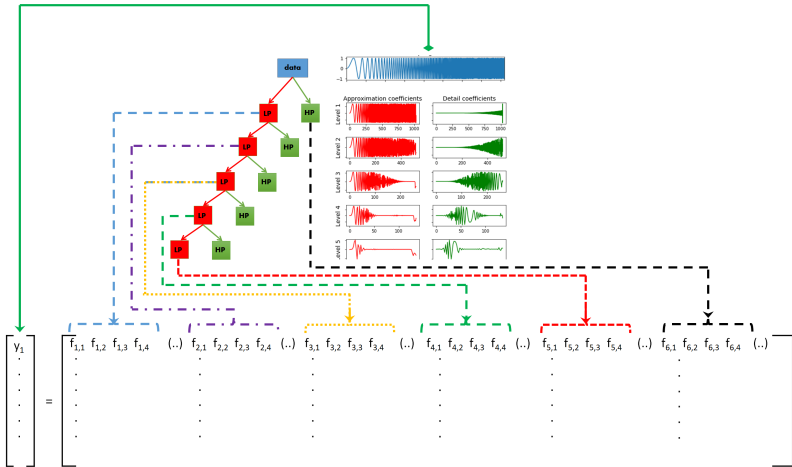


Figure 10: DWT can deconstruct signal in frequency sub-bands. And out of each sub-band it can generate features that can be used as input for a classifier.

Methods

What kind of features can be generated for each of the sub-bands?

Depend on the type of signal and the application!!!

Coefficient values	Entropy values
Statistical features	Variance
Standard deviation	Mean
Median	25th percentile value
75th percentile value	Root Mean Square value
Mean of the derivative	Zero crossing rate
Mean crossing rate	

Methods

Support Vector Machine (SVM)

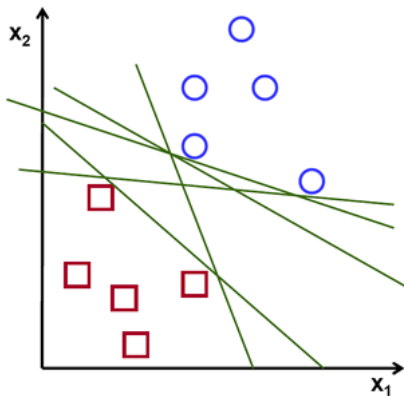


Figura 11: Hyperplanes in an N-dimensional space (N - the number of features)

Methods

Support Vector Machine (SVM)

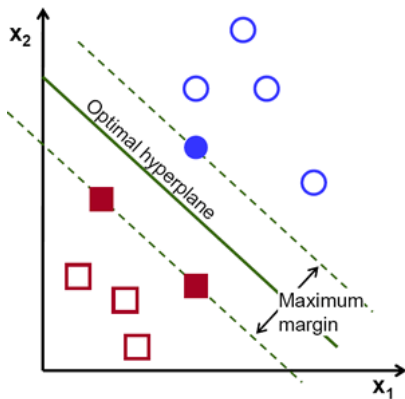


Figura 12: Hyperplanes and Support Vectors

Methods

Support Vector Machine (SVM)

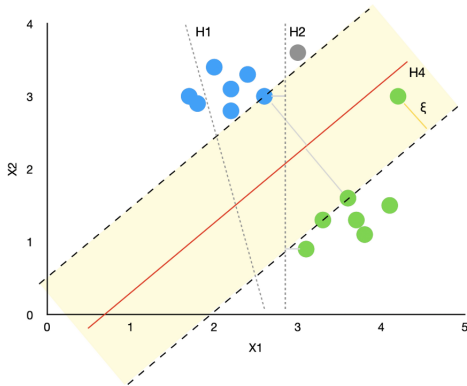


Figura 13: Soft-margin that allows for some points to be misclassified using a value ξ . It controls by regularization hypermeter **C**

Methods

Support Vector Machine (SVM)

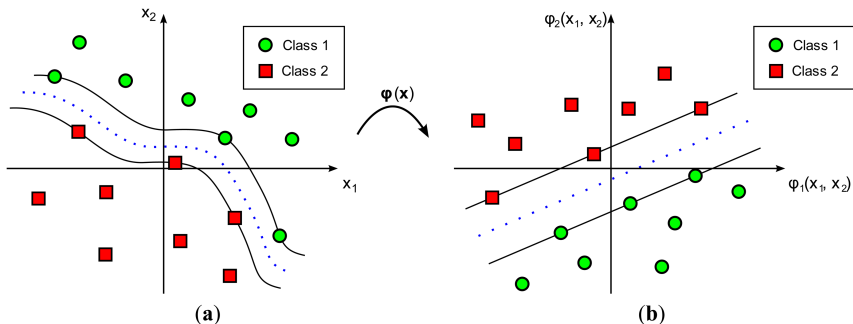


Figure 14: Non-linear SVM dimension transformation using kernel trick

Methods

Artificial Neural Networks

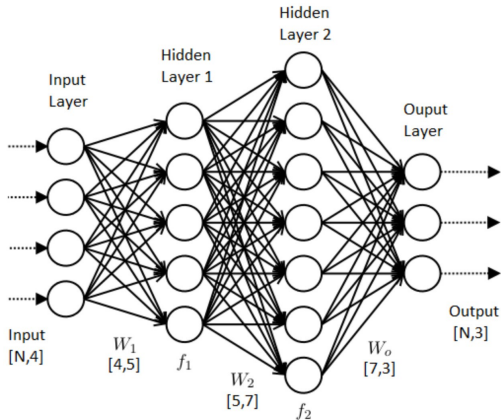


Figure 15: Artificial Neural Network

REFERENCES

References



CHAZAL, P. D.; O'DWYER, M.; REILLY, R. B. Automatic classification of heartbeats using ecg morphology and heartbeat interval features. *IEEE transactions on biomedical engineering*, IEEE, v. 51, n. 7, p. 1196–1206, 2004.



CLIFFORD, G. D. et al. *Advanced methods and tools for ECG data analysis*. [S.l.]: Artech house Boston, 2006.



LUZ, E. J. d. S. et al. Ecg-based heartbeat classification for arrhythmia detection: A survey. *Computer methods and programs in biomedicine*, Elsevier, v. 127, p. 144–164, 2016.



MOODY, G. B.; MARK, R. G. The mit-bih arrhythmia database on cd-rom and software for use with it. In: IEEE. [1990] *Proceedings Computers in Cardiology*. [S.l.], 1990. p. 185–188.



TASPINAR, A. *A guide for using the Wavelet Transform in Machine Learning*. [S.l.], 2018. Disponível em: <https://ataspinar.com/2018/12/21/a-guide-for-using-the-wavelet-transform-in-machine-learning/>.

"That's all Folks!"