Cardiac Tachyarrhythmia Detection by Poincaré Plot-based Image Analysis

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INTRODUCTION

Atrial tachyarrhythmia detection may be challenging due to the low amplitude of atrial signals, more susceptible to noise, and the presence of ventricular activity, of greatest amplitude. Computationally expensive methods for ventricular cancellation as well as good quality signals are required for their analysis[1].

We present an image-based 2-min ECG* classification method that relies only on RR intervals and does not depend on explicit thresholds and rhythm-dependent parameters definition.

*ECG: Electrocardiogram

WHY?

- Ventricular R peak detection is more robust against noise.
- Lower computational power required.
- Poincaré plot used in previous studies but based on the definition of parameters and thresholds describing particular patterns in the plot. → Some patterns either cannot be easily described by simple parameters or cannot be intuitively appreciated[2].

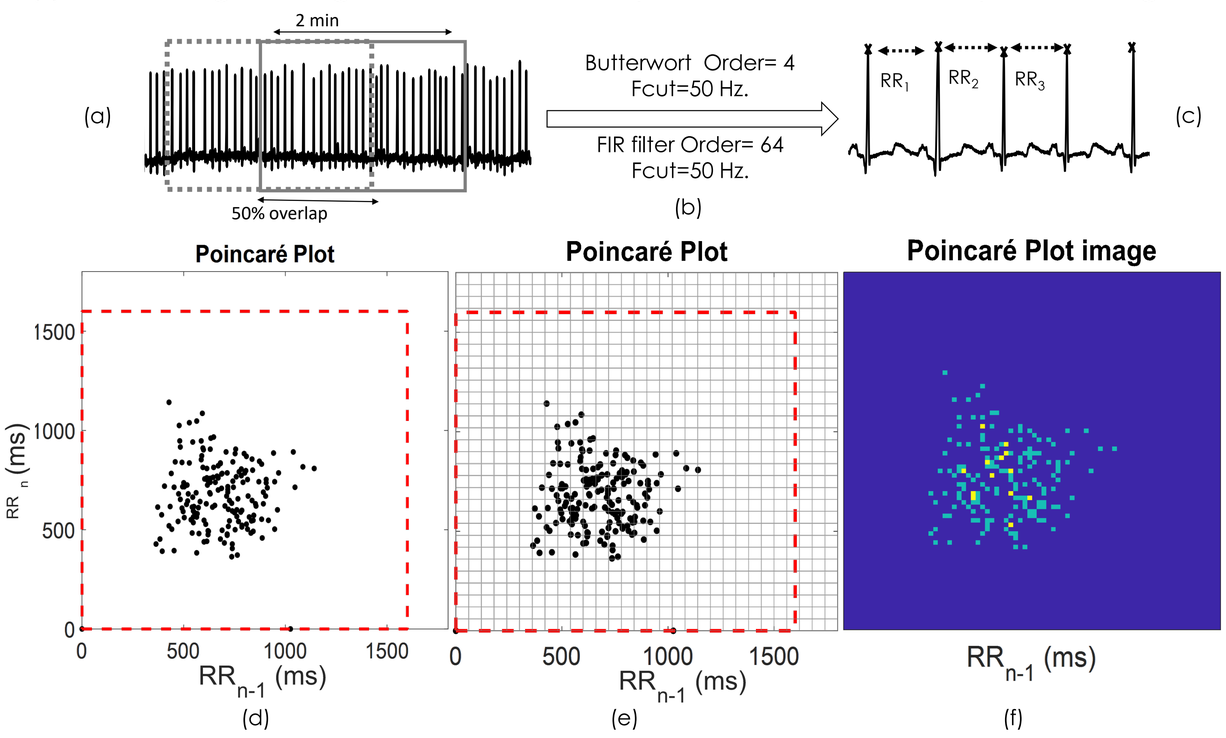
MATERIALS & METHODS

DATA: PHYSIONET databases	N° recordings	Duration	Rhythms included*
MIT-BIH arrhythmia database	48	30 minutes	NSR, AF, AB
MIT-BIH Atrial fibrillation database	26	10 hours	AF
Long-term atrial fibrillation database	84	24 hours	NSR, AF , AB

*NSR: Normal sinus rhythm. AF: Atrial fibrillation. AB: Atrial bigeminy.

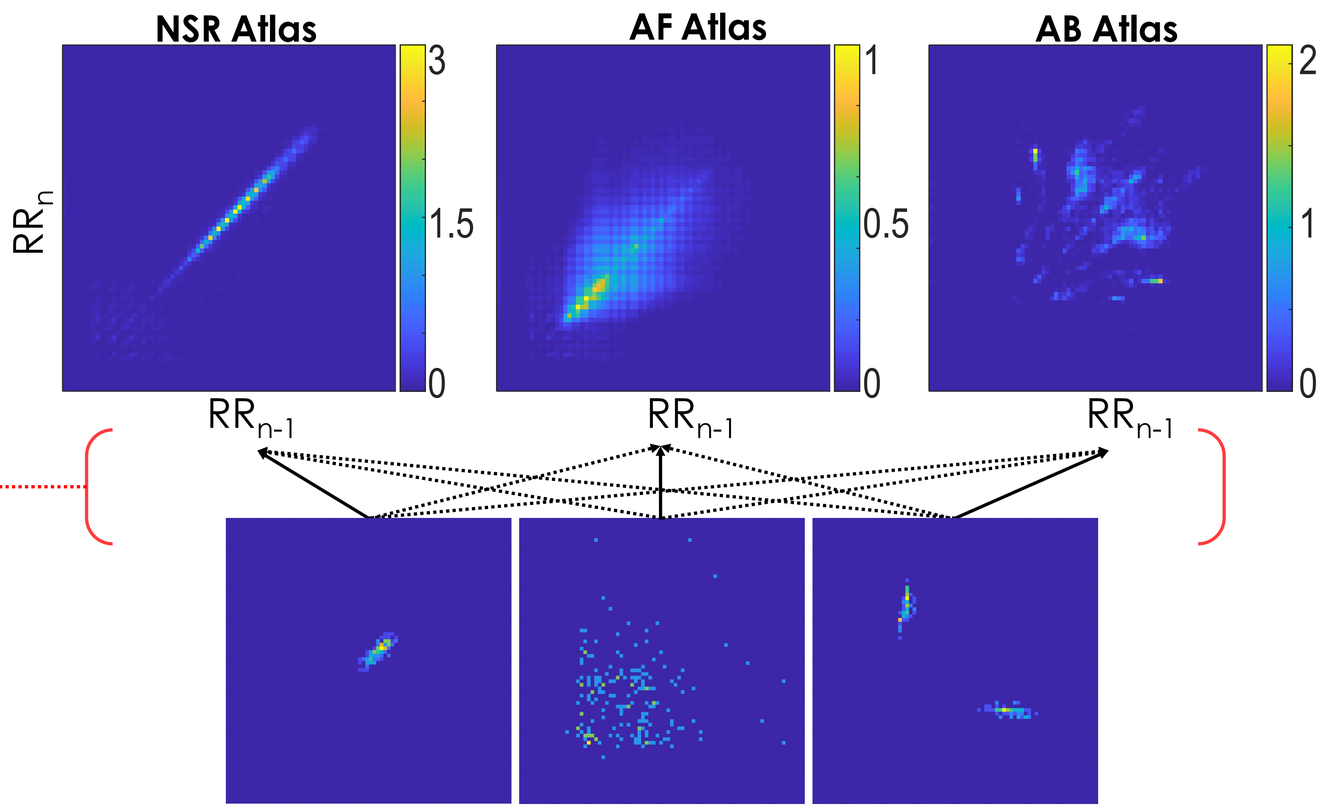
1. IMAGE GENERATION

(a)2-minute sliding window 50% overlap.
(b) Eliminate electromyographic, baseline wander and power-line noise.
(c)Pan Tompkins' algorithm to detect R peaks. RR intervals computed.
(d,e) Transformation to 2D histogram, bin size 20 ms and Range 0-1600 ms.
(f) Final Image: Images labelled as a rhythm if >50% of its samples belonged to it



2. ATLAS GENERATION

One atlas for each rhythm of study was created. Each atlas was computed as the average of the 80% of the images belonging to a specific rhythm.

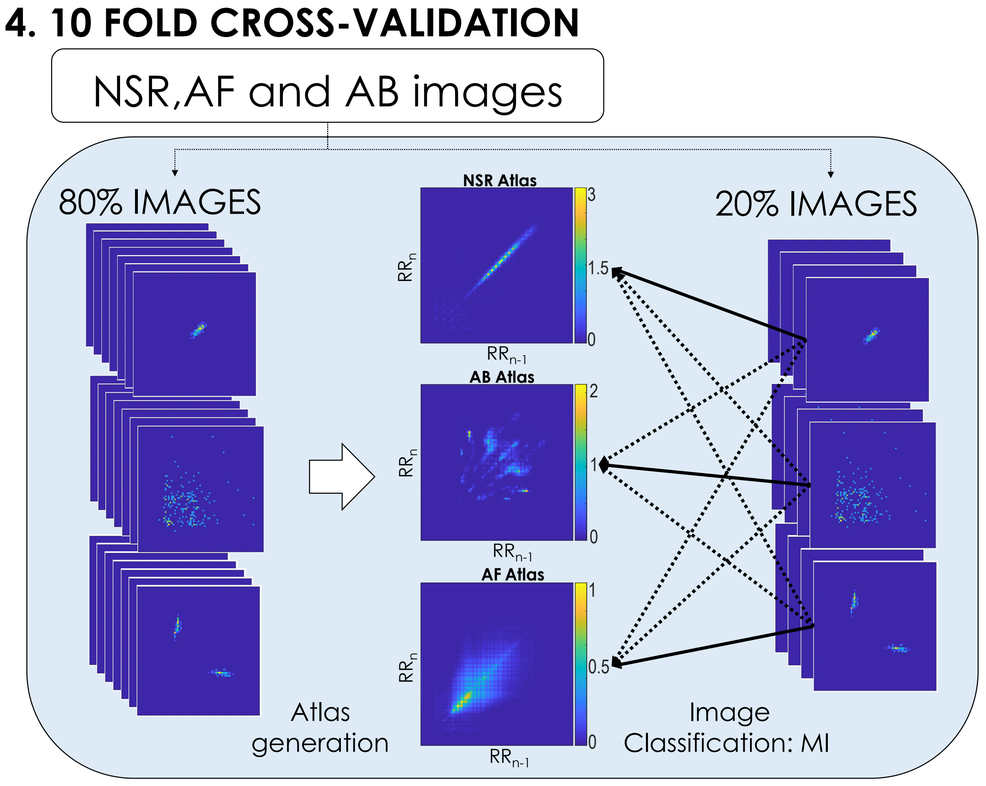


Example images of different rhythms that would be classified using mutual information. (a) NSR, (b) AF, (c) AB.

3. IMAGE CLASSIFICATION: MUTUAL INFORMATION

Mutual information (MI) was computed between each image (of the remaining 20%) and each of the three atlases. The highest MI value an image attained with each of the atlases, indicated the rhythm it should be categorized in.

4. 10 FOLD CROSS-VALIDATION

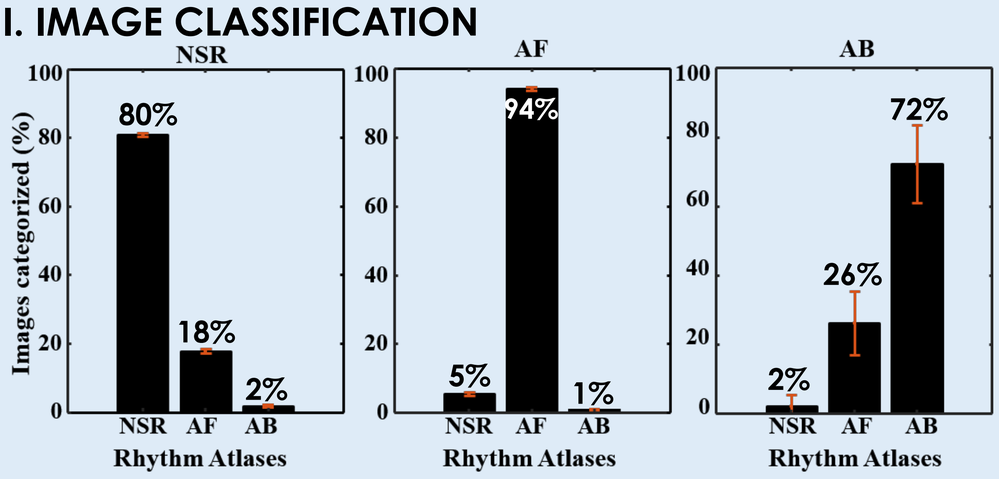


RESULTS

I. IMAGES GENERATED

Rhythms	Total Images	Patients
Normal Sinus Rhythm (NSR)	27955	59
Atrial Fibrillation (AF)	33637	85
Atrial Bigeminy (AB)	76	6

II. IMAGE CLASSIFICATION



Bar plot of the classification. Each plot represent how the images labelled as a certain rhythm have been classified.

CONCLUSION

The former study presents a novel approach for rhythm classification using Poincaré plots without the need of explicitly compute rhythm-specific indexes and thresholds.

Converting plots into images and creating atlases enables to capture the implicit representation of ventricular characteristic patterns during different cardiac rhythms.

Acknowledgements

This project is framed inside MY-ATRIA consortium. MY-ATRIA project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No.766082

References

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