



Evaluation of the Signal Quality of Wrist-Based Photoplethysmography

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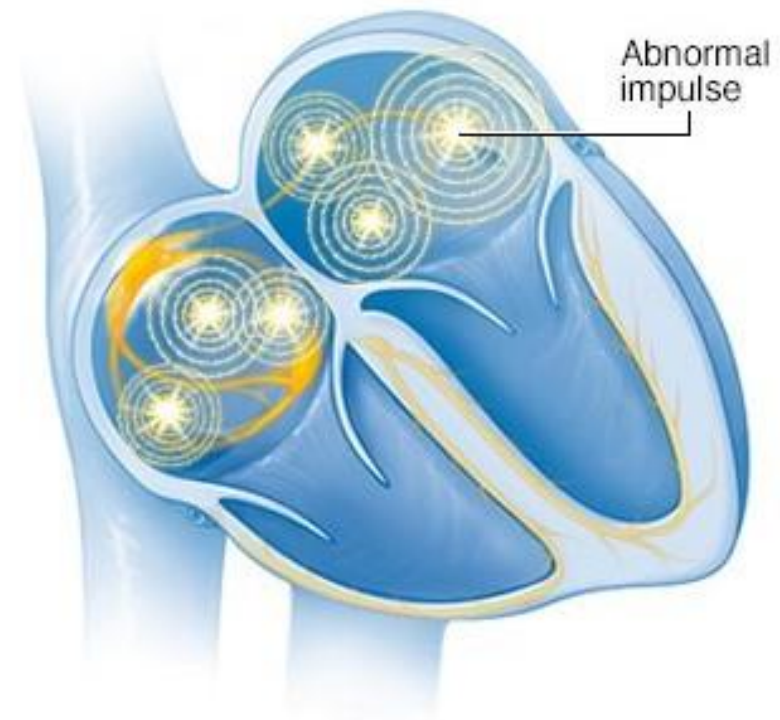
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Background: Atrial Fibrillation (AF)

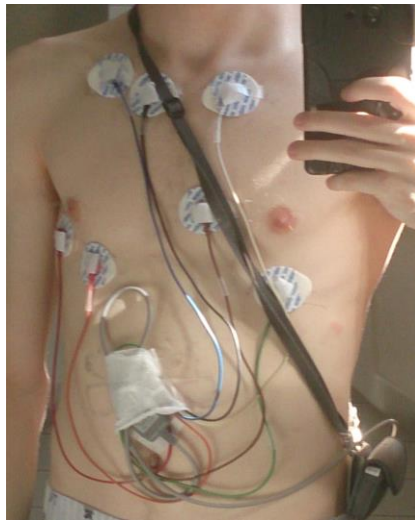
- ▶ Paroxysmal AF is episodic
- ▶ Silent AF presents severe risk of stroke
- ▶ 20-30% of strokes occur due to AF, increasing number due to paroxysmal AF



Motivation

- ▶ Wearable device for early detection and prevention of cardiac diseases

ECG Holter Monitor



PPG Wristband



Previous work

- ▶ AF detection in controlled conditions
- ▶ PPG signal quality with simulated periodic artefacts

Objectives

- ▶ To evaluate wrist-based PPG for use in long-term ambulatory monitoring
- ▶ To develop an algorithm for classifying the signal quality of wrist-based PPG
- ▶ To analyze the reliability and consistency of visual assessment as a gold standard for PPG signal quality

Publications

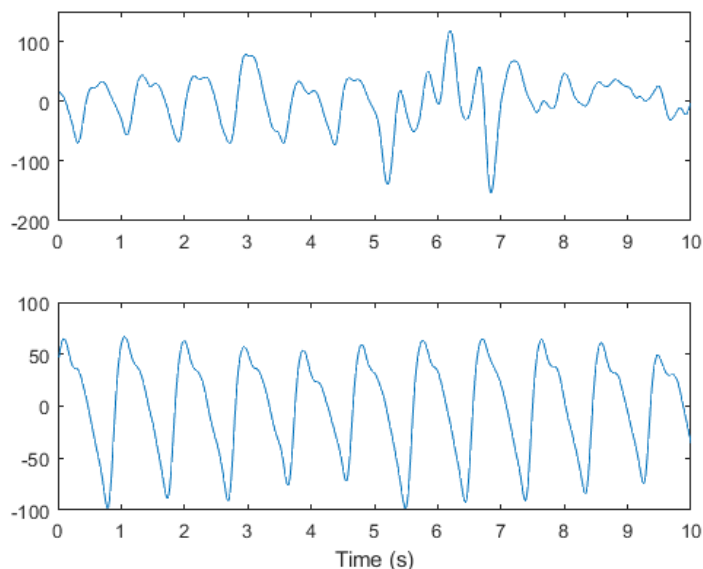
- ▶ Comparative ECG and PPG signal quality, presented at ISC 2016
- ▶ Algorithm for discrimination between extreme quality cases, presented at MeMeA 2017



Data Collection and Devices

- ▶ GE Seer Light Extend Holter (ECG), Empatica E4 (PPG + Accelerometer)
- ▶ Methodology: 24-hour monitoring with 26 participants: 10 elderly, 16 non-elderly

PPG Examples

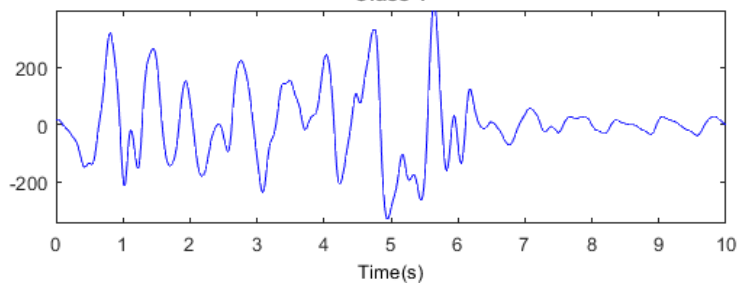
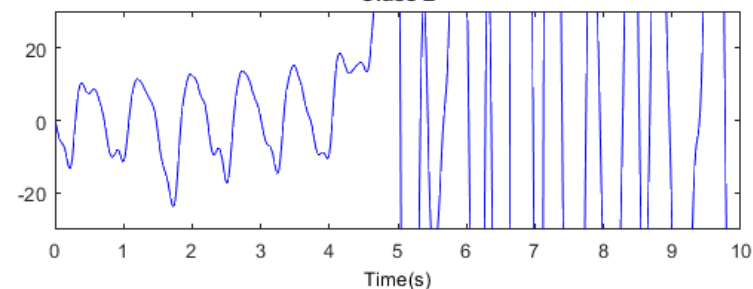
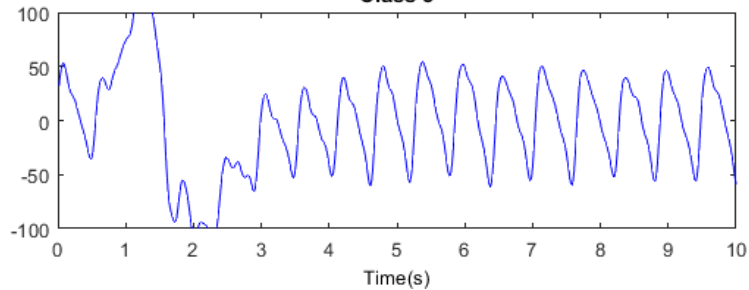
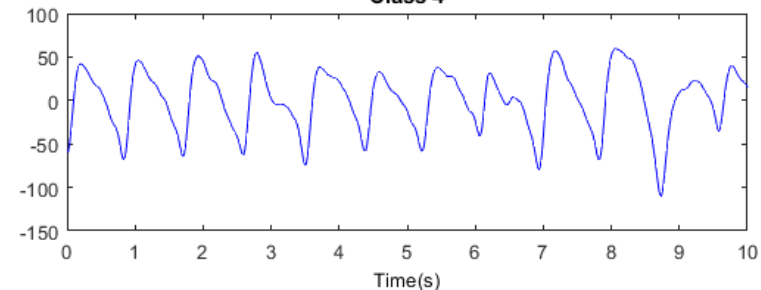
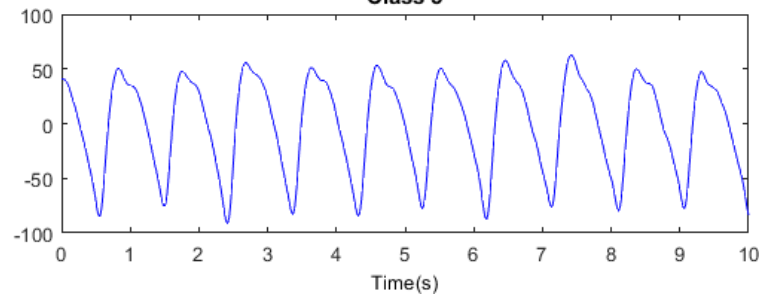


Empatica E4



From: <http://enhanced-safety-innovation.com/the-most-comfortable-and-accurate-bracelet-to-monitor-physiological-signals-in-real-time/>

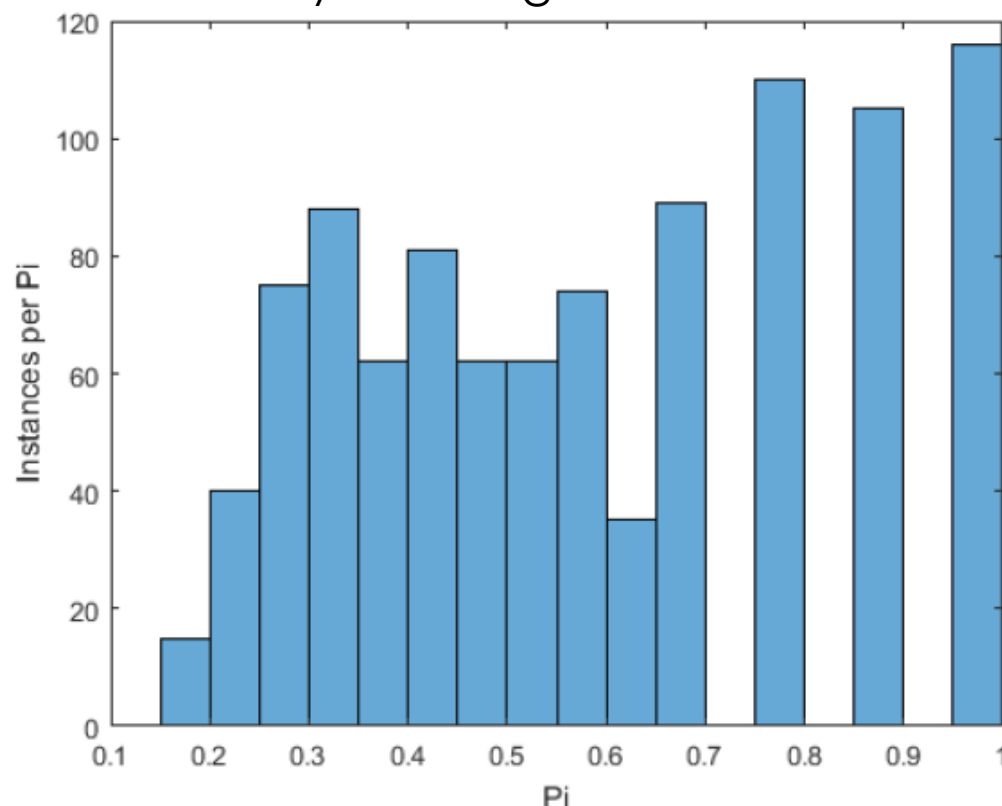
Signal Quality Classes

Class 1**Class 2****Class 3****Class 4****Class 5**

Gold Standard

- ▶ Gold standard based on visual assessment
- ▶ Quality assessment performed by 17 raters to assess subjectivity
- ▶ Fleiss' kappa of 0.4605, indicating moderate agreement

Number of PPG Segments
by Rater Agreement



Feature Selection

- ▶ Wrapper method used for feature selection
- ▶ Greedy step-wise forwards approach
- ▶ 9 of the 71 features were selected

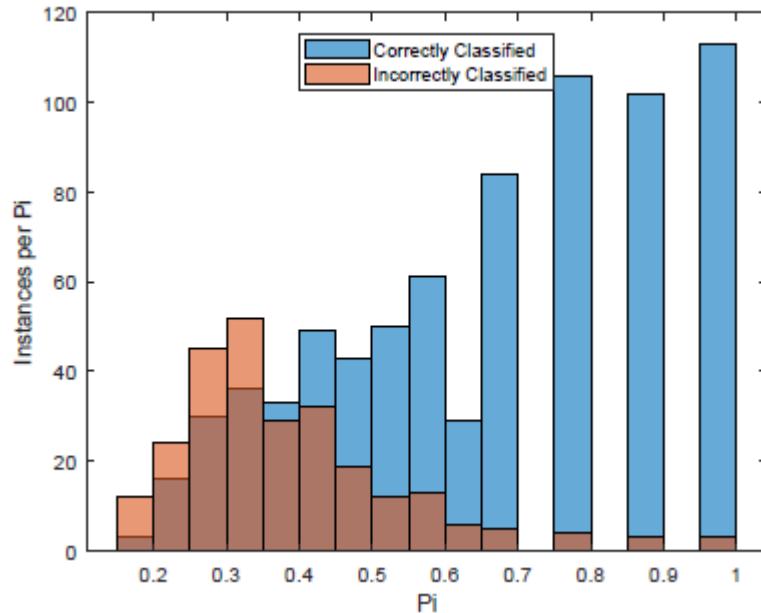
Selected Features:

- BillauerPeaks
- ZeroCrossings
- medianN
- medianR
- stdevE
- medianACC
- stdevACC
- ACPeakVals1
- ACPeakVals2

Classification Results

- ▶ Classifiers evaluated using modified 13-fold cross-validation

Classifier Performance vs.
Rater Agreement



Classifier Type vs.
Classification Accuracy

Classifier	Accuracy
<i>k</i> -Nearest Neighbour	42.9%
Multi-Class SVM	43.5%
Naive Bayes	63.6%
Decision Tree	66.9%
Random Forest	74.5%

Results: Overall Signal Quality

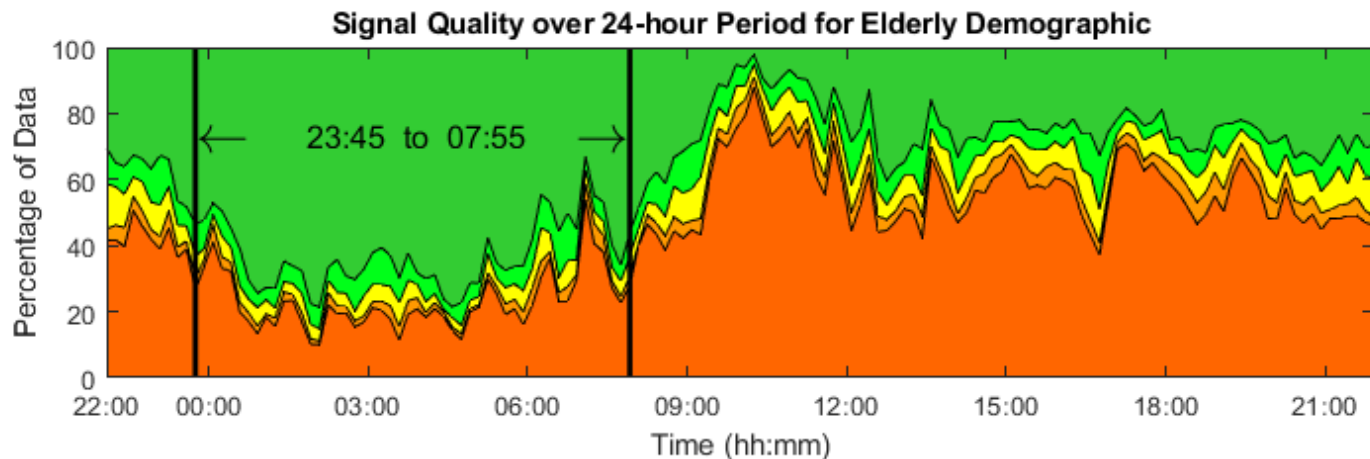
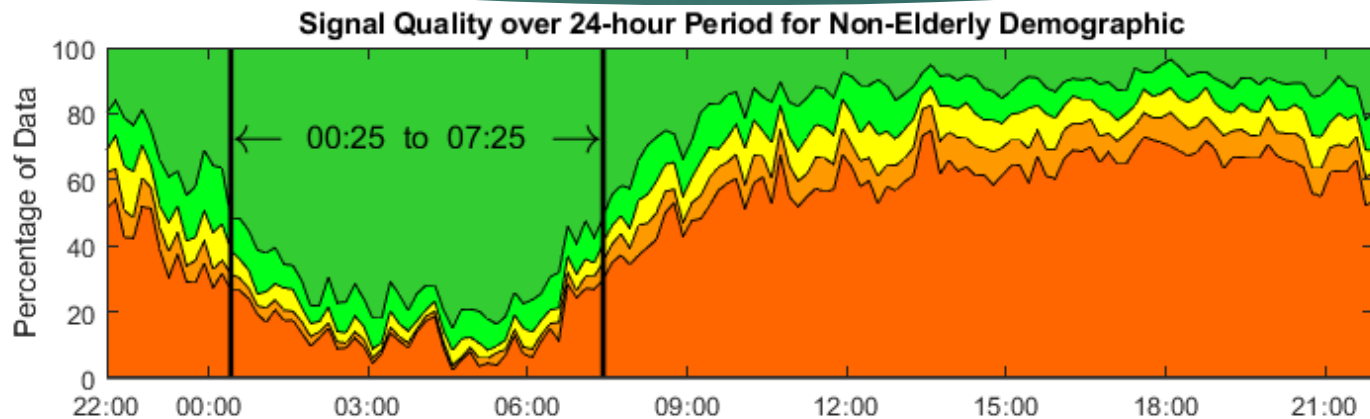
- ▶ Selected classifier applied to full dataset

Signal Quality

	Class 1	Class 2	Class 3	Class 4	Class 5
<i>Non-Elderly</i>	44.4%	6.2%	7.2%	9.8%	32.5%
<i>Elderly</i>	43.9%	3.9%	6.4%	7.3%	38.6%
Overall	44.2%	5.3%	6.9%	8.9%	34.8%

Table: Percentage of Data by Signal Quality Classification

Results: 24-hour Signal Quality



Future Work

- ▶ Atrial fibrillation detection
- ▶ Activity monitoring
- ▶ Individual results for 24-hour signal quality
- ▶ De-noising classes 3 and 4



From: <https://static-content.empatica.com/1E997/img/e4/>

Conclusion

- ▶ Developed classification algorithm with 74.5% accuracy
- ▶ Evaluated signal quality over 24-hour period
- ▶ Wrist-based may be suitable for night monitoring



Thank You

