Evaluation of the Signal Quality of Wrist-Based Photoplethysmography

NIKHILESH PRADHAN (CARLETON UNIVERSITY)

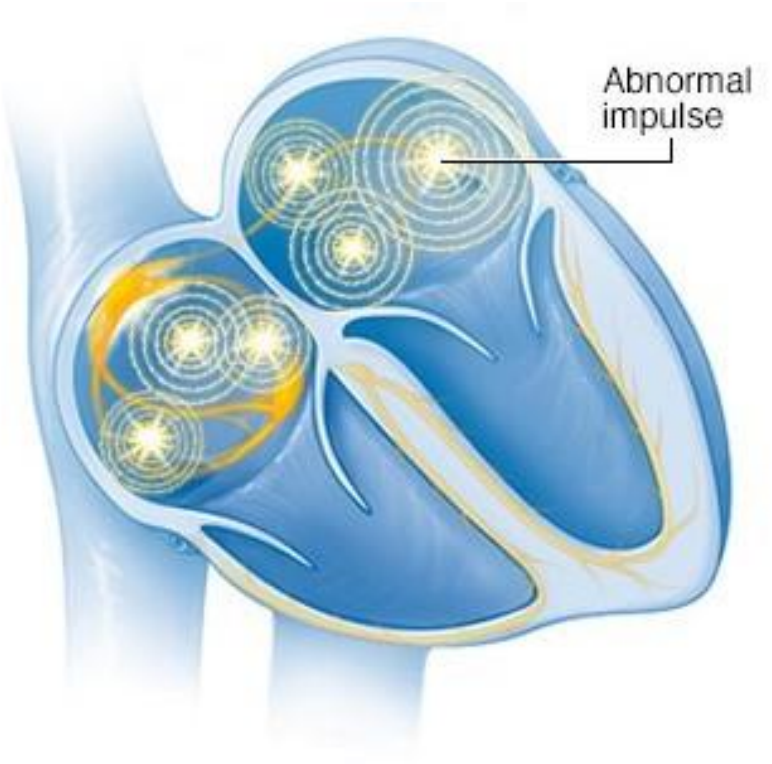
SUPERVISORS:

PROFESSOR ANDY ADLER (CARLETON UNIVERSITY)

PROFESSOR SREERAMAN RAJAN (CARLETON UNIVERSITY)

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

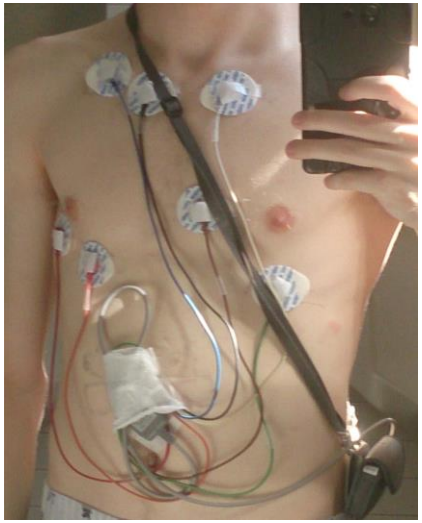


From:https://www.mayoclinic.org/-/media/kcms/gbs/patient-consumer/images/2014/07/07/14/43/mcdc11_heartforafib.ashx

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

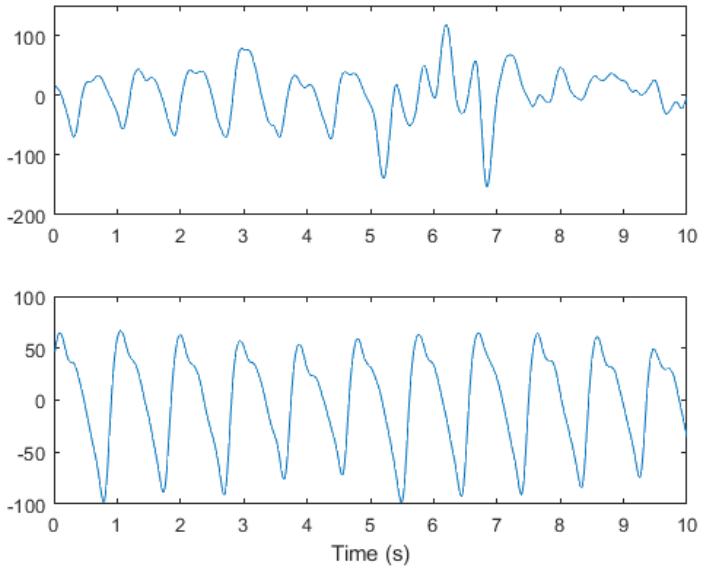
Publications

- 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

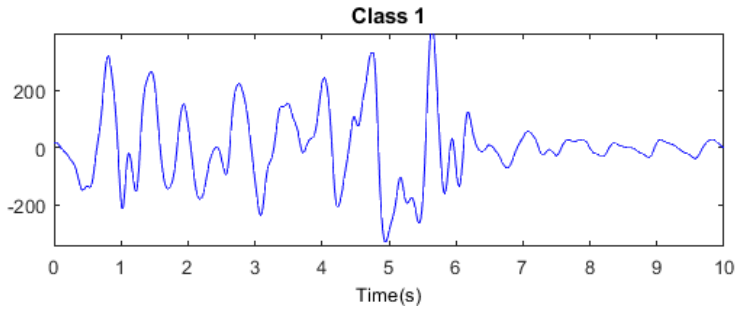
PPG Examples

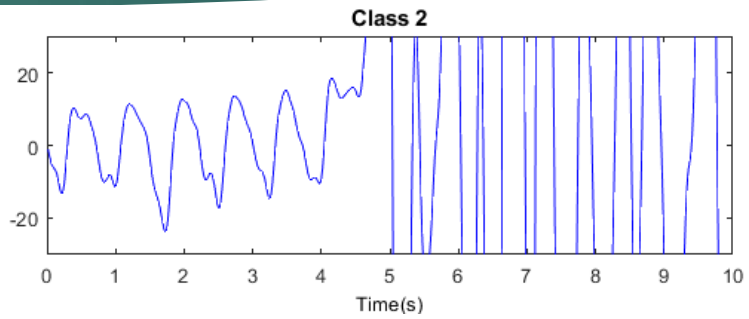


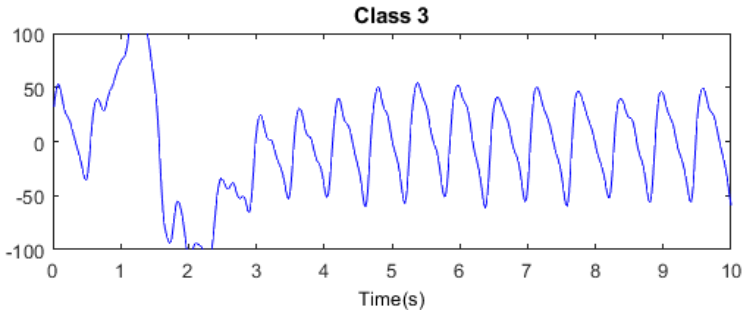
Empatica E4

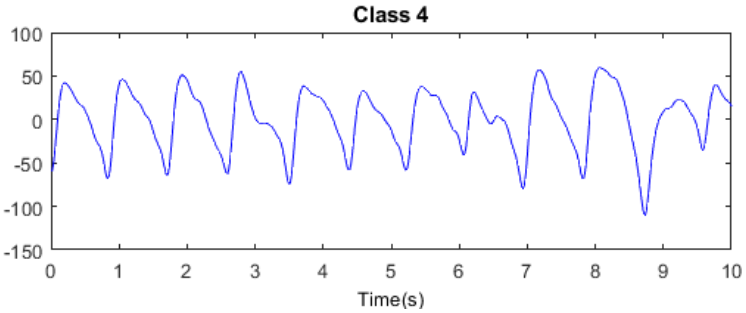
From:http://enhanced-safety-innovation.com/the-most-comfortable-and-accurate-bracelet-to-monitor-physiological-signals-in-real-time/

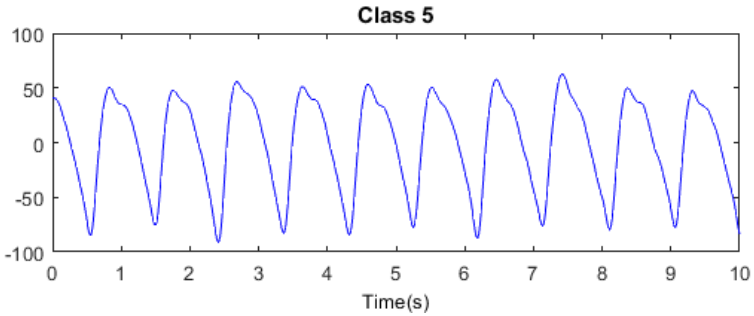
Signal Quality Classes







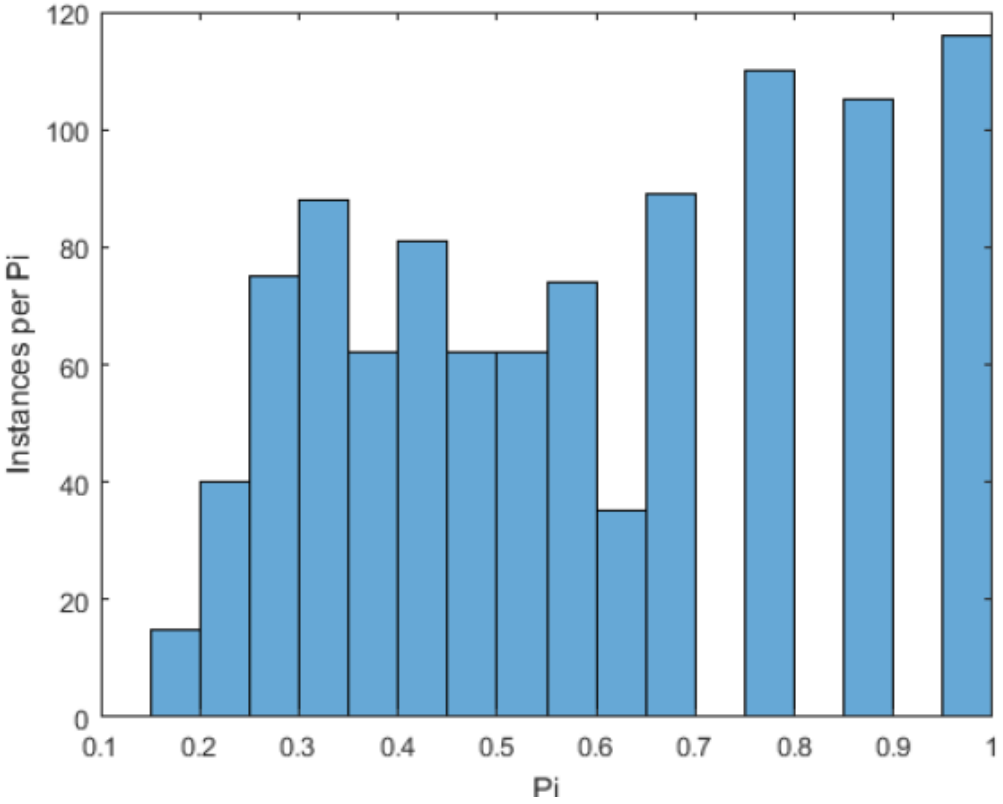




Gold Standard

- 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

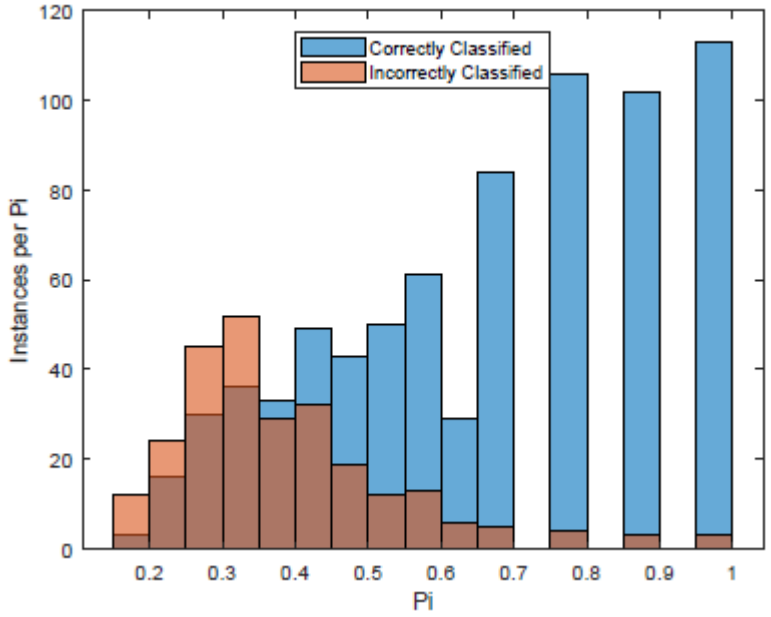
Selected Features:

- 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
k-Nearest Neighbour	42.9%
Multi-Class SVM	43.5%
Naive Bayes	63.6%
Decision Tree	66.9%
Random Forest	**74.5%**

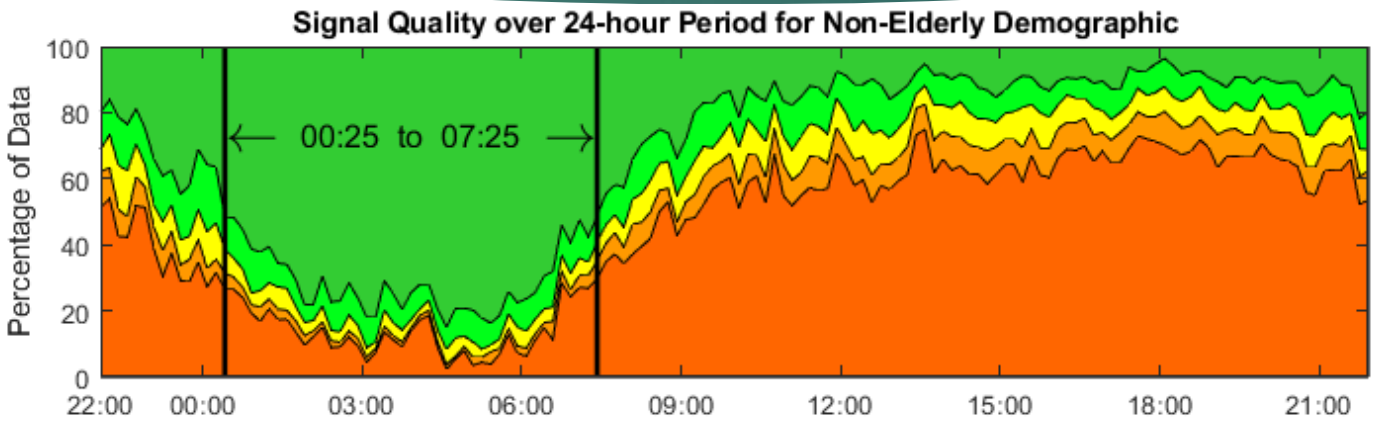
Results: Overall Signal Quality

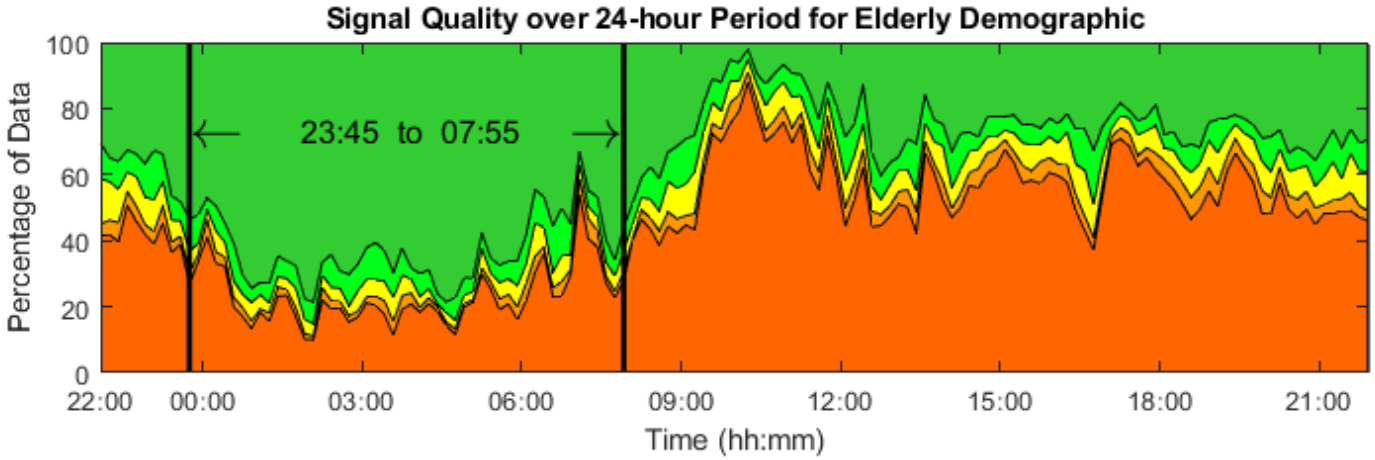
- Selected classifier applied to full dataset

	Signal Quality				
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Non-Elderly	44.4%	6.2%	7.2%	9.8%	32.5%
Elderly	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/fE997/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