



# HEARTMATE: AUTOMATED INTEGRATED ANOMALY ANALYSIS FOR EFFECTIVE REMOTE CARDIAC HEALTH MANAGEMENT

Arijit Ukil<sup>1</sup>, Soma Bandyopadhyay<sup>1</sup>, Chetanya Puri<sup>1</sup>, Rituraj Singh<sup>1</sup>, Arpan Pal<sup>1</sup>, Ayan Mukherjee<sup>2</sup>

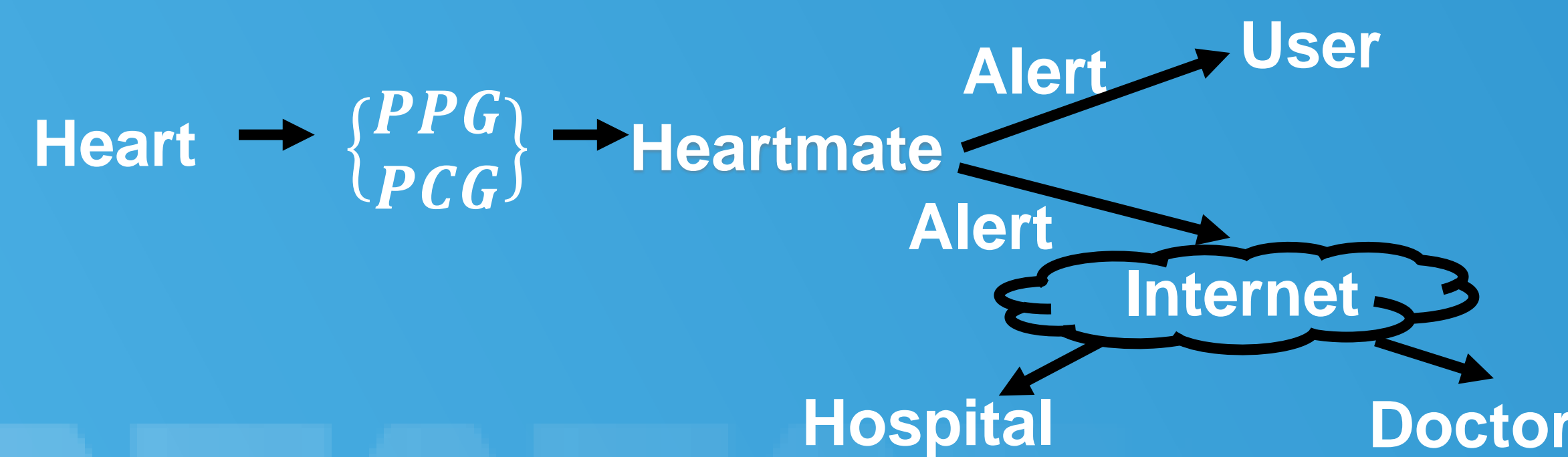
<sup>1</sup>TCS Research and Innovation

<sup>1</sup>Tata Consultancy Services, Kolkata, <sup>2</sup>Indian Institute of Technology, Kharagpur, India

<sup>1</sup>{arijit.ukil, soma.bandyopadhyay, chetanya.puri, singh.rituraj, arpan.pal }@tcs.com

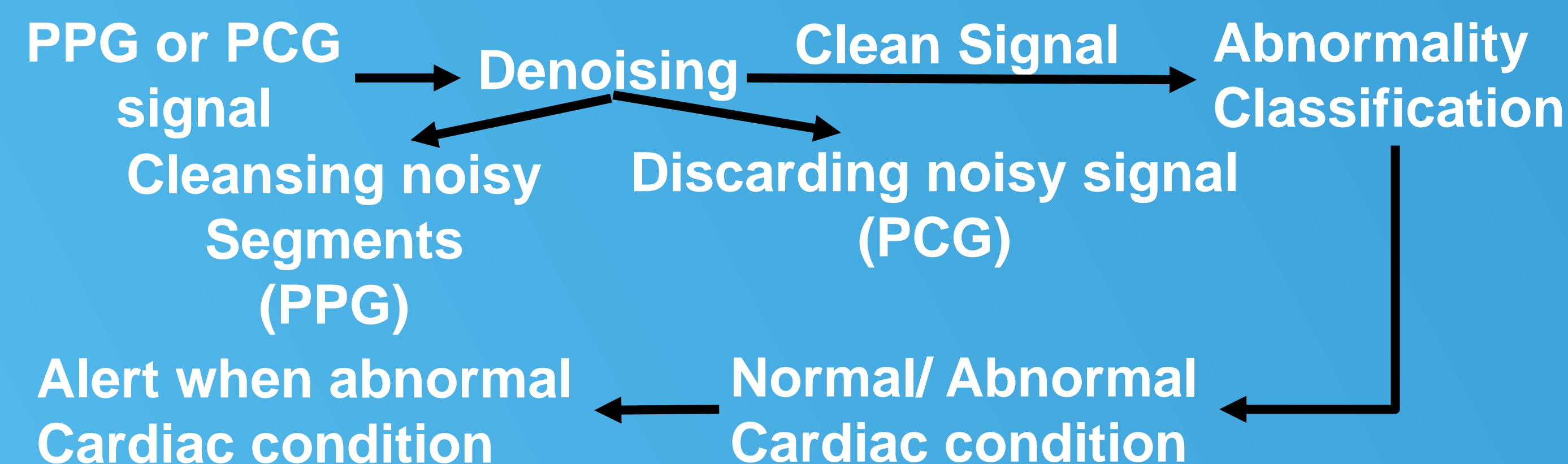
<sup>2</sup>ayanmukherjee.email@gmail.com

- ❑ Heartmate generates necessary alerts from unusual cardiac events.
- ❑ Denoising to discard noisy/corrupted signals.
- ❑ Cardiac arrhythmia using PPG and Cardiac abnormality using PCG.
- ❑ Low or no manual intervention.
- ❑ Mono-signal based morphological trend analysis considering individual cardiac characteristics



## DENOISING PCG/ PPG SIGNAL

- ❑ Band pass filtering between 0.7 – 5 Hz.
- ❑ Cardiac cycle segmentation [1-2]
- ❑ Envelope estimation.
- ❑ Template matching using dissimilarity (measure DTW based).

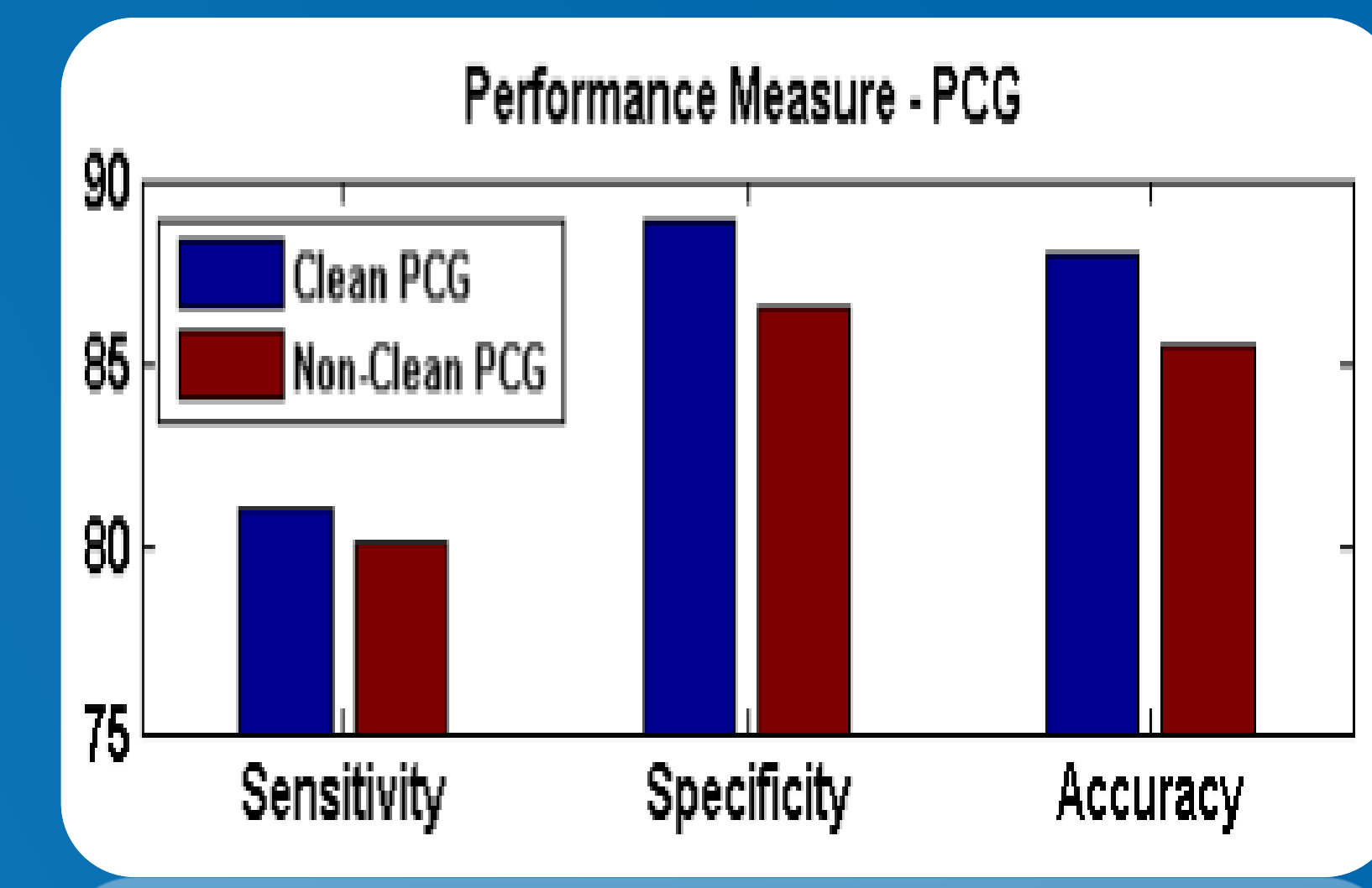
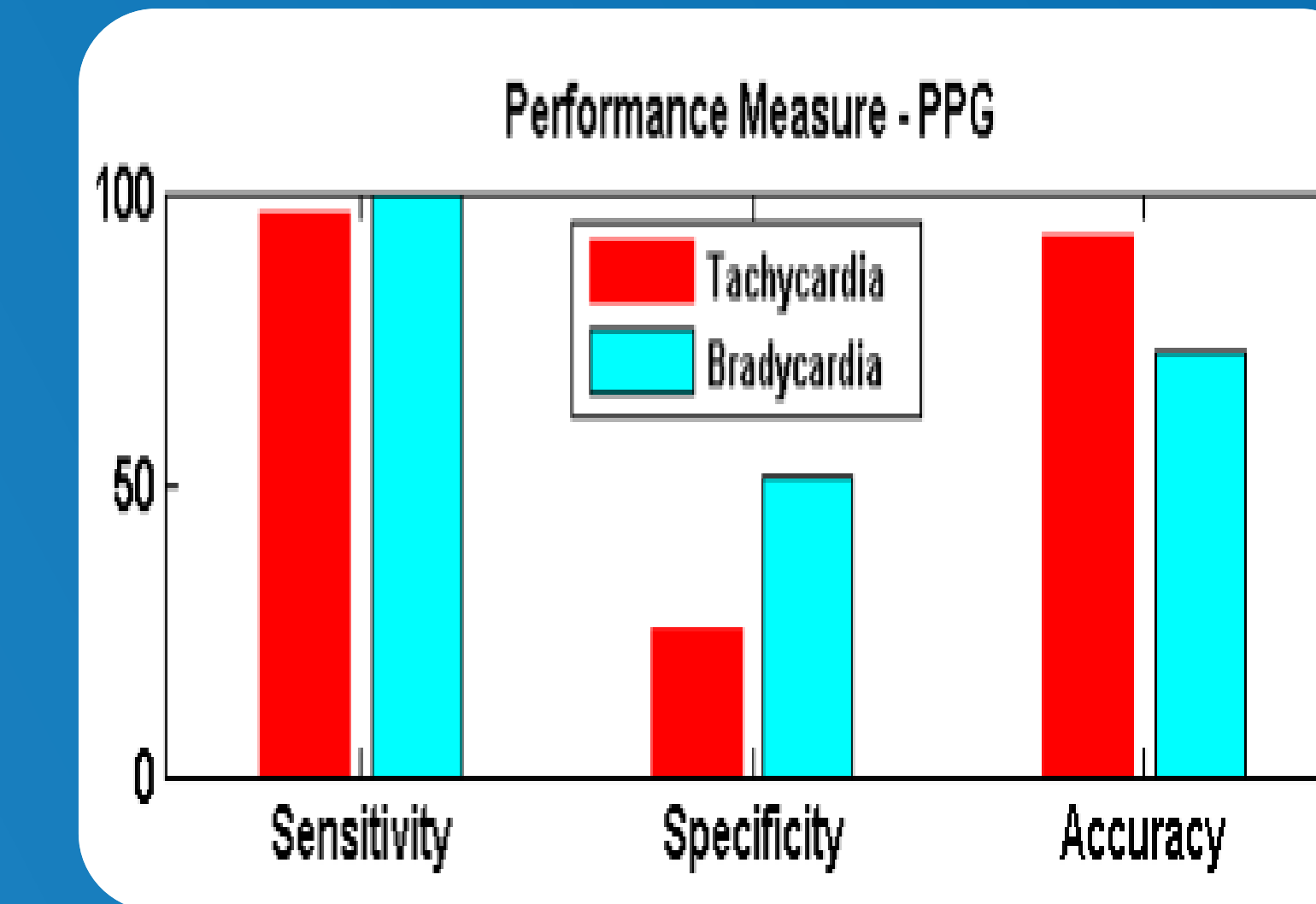


## ABNORMALITY DETECTION FROM PCG SIGNAL

- ❑ Supervised learning on balanced normal abnormal class.
- ❑ Feature Selection: We first select total 54 features from temporal, spectral and wavelet domains
- ❑ mRMR [4] based feature selection.
- ❑ Training: Support Vector Machine (SVM) classifier with non-linear radial basis function kernel
- ❑ Abnormality detection on the clean physiological signal.

## ABNORMALITY DETECTION FROM PPG SIGNAL

- ❑ Detects primarily cardiac arrhythmias like extreme bradycardia, extreme tachycardia.
- ❑ It is a three step process and follows our earlier proposed Heart-Trend algorithm [3].
  - ❑ Used Heart rate variability based feature
  - ❑ Closeness Prediction through k-Means
  - ❑ Classification: k-nearest neighbor (kNN) method for three class classification: *normal, bradycardia and tachycardia.*
- ❑ The denoising and abnormality detection methods for ABP are same as followed in PPG.



## TAKEAWAY

- Corruption hampers detection of cardiac events.
- Proper denoising improves detection accuracy of cardiac events.
- Cardiac Anomaly detection with minimization of false negatives (≈ least number of undetected conditions)

## REFERENCES

[1] W. Zong, T. Heldt, G.B. Moody, R.G. Mark, "An Open-source Algorithm to Detect Onset of Arterial Blood Pressure Pulses," IEEE Computers in Cardiology, pp. 259 - 262, 2003.  
 [2] D. B. Springer, L. Tarassenko and G. D. Clifford, "Logistic Regression-HSMM-Based Heart Sound Segmentation," IEEE Transactions on Biomedical Engineering, pp. 822-832, 2016.  
 [3] A. Ukil, S. Bandyopadhyay, C. Puri, and A. Pal, "Heart-trend: an affordable heart condition monitoring system exploiting morphological pattern," ICASSP, pp. 6260- 6264, 2016.  
 [4] H. Peng, F. Long, and C. Ding, "Feature selection based on mutual information: Criteria of max-dependency, max-relevance, and min-redundancy," IEEE TPAML, pp.1226–1238, 2005.