Detection of Myocardial Infarction using Pulse Plethysmograph Signals

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Objective:-

This paper targets detection of MI through a novel Pulse Plethysmograph (PuPG) signal analysis. PuPG signals are acquired through subject's index finger which are further preprocessed with low pass filter. Comprehensive feature analysis is performed to select three features having best discriminative properties. SVM classifier is applied to perform detection of MI and Normal subjects.

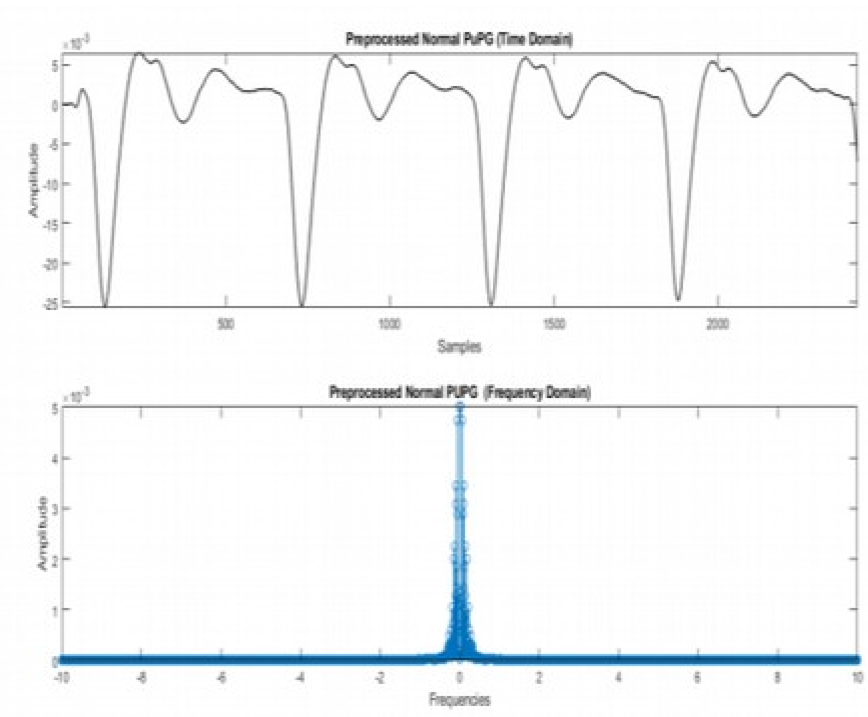

Figure 5: Time and frequency domain representation of PuPG of Normal person

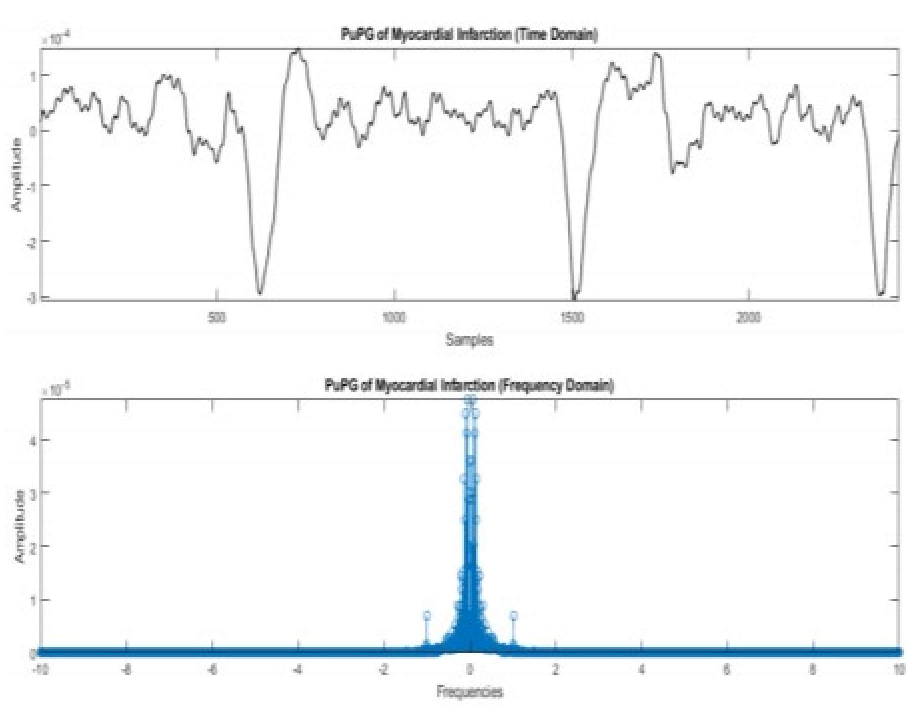

Figure 4: PuPG signal of MI subject with its Fourier Transform

TABLE II: DATASET DESCRIPTION

Classes	Male	Female	samples
Normal	36	36	72
MI	25	15	30
Total	120	-	-

Total 120 signals were collected from normal persons and MI patients from multiple hospitals were used to evaluate the performance.

Preprocessing:-

1. After data acquisition step the first step is to denoise the signals. For denoising of signals, we applied low pass filter of 35Hz on raw signals.
2. The signal in each lead is normalized to address the problem of amplitude scaling and eliminate the offset effect.

Feature Extraction:-

We employed statistical features (signal mean, standard deviation, and variance), frequency domain features(mean frequency) and time domain features (energy, total jitter, log energy, Spurious free dynamic range, Lyapunov exponent) for thorough feature analysis.

TABLE III. PERFORMANCE EVALUATION OVER COMBINATION OF MULTIPLE FEATURES

Mean	Standard deviation	Total Jitter	Energy	Lyapunov Exponent	SFDR	Mean frequency	Log Energy	Variance	Accuracy
●	●		●	●				●	78.4%
	●							●	67.6%
		●	●	●			●		71.6%
	●	●			●		●	●	79.4%
				●	●	●			**98.5%**
		●					●	●	68.6%
●				●	●	●			94.1%
	●	●	●			●	●		81.4%

Maximum average classification accuracy is achieved through mean frequency, Lyapunov exponent and Spurious free dynamic range features.

1. **Lyapunov Exponent (LE):-** The Lyapunov exponent is defined by the average growth rate λi of the initial distance. Lyapunov exponents are the functions of dynamic system.

$$\frac{\| \delta x_i(t) \|}{\| \delta x_i(0) \|} = 2^{\lambda_i t} (t \to \infty) or\ \lambda_i = \lim_{t \to \infty} \frac{1}{t} \log_2 \frac{\| \delta x_i(t) \|}{\| \delta x_i(0) \|}$$

2. **Mean frequency:-** Mean frequency is calculated using the periodic-mean frequency estimate.

$$M_i = \frac{f_s}{4\pi} \{\arg[\sum_{k=0}^{N/2-1} | X_i(k) |^2\ e^{j2\pi k/N}] \bmod 2\pi\}$$

3. **Spurious free dynamic range (SFDR):-** In SFDR is defined as the ratio of desired frequency component to the largest undesired frequency component at the output of DDFS. Its unit is decibel.

$$SFDR = 20 \log_{10} (\frac{A_p}{A_s})$$

In this study, MI and normal class of PuPG signals is distinguished through SVM with different kernels. SVM-linear (SVM-L), SVM-Quadratic (SVM-Q), SVM-Cubic (SVM-C) and SVM-Gaussian (SVM-G) were employed to test the classification performance.

Results:-

- Evaluation of classifier is performed through 10-fold cross validation. The performance of the model is in following table:

TABLE IV: PERFORMANCE EVALUATION OVER DIFFERENT CLASSIFIERS

Classifier	Acc.	Sen.	Spec.	Error
SVM-L	94.12	94.44	93.33	5.88
SVM-Q	97.35	100.00	91.00	2.65
SVM-C	97.79	100.00	92.50	2.21
SVM-G	**98.58**	**100.00**	**95.17**	**1.42**
KNN-M	94.95	100.00	82.83	5.05
KNN-C	94.51	100.00	81.33	5.49
KNN-W	96.96	100.00	89.67	3.04
DT	96.67	97.50	94.67	3.33

- Experimental analysis reveals that SVM-G achieved best performance in terms of accuracy (98.5%), sensitivity (100%) and specificity (95.1%).

Conclusion:-

Proposed method is reliable in terms of detecting MI. But more signals from MI subjects, in order to train classifier with more data and test robustness.