**SMART INDIA HACKATHON-2019: SOFTWARE EDITION**

## IMPACT 3/3

**Technology Bucket:** Healthcare & Biomedical devices **Category:** Software

**Organisation name:** Samsung R&D **Problem code:** SS1

**Problem Statement:** Real-time estimation of Heart Rate from facial images under different lighting conditions using Smartphone Camera Smart phone application that measures heartrate using on-board cameras in real-time and non-invasively offers several advantages and have multiple use cases. Detecting heart rate using only camera has an added advantage because in such case the users do not require any skills or compliance, but has to just capture image/video. During exercise, it is often desired that the user can measure their heart rate without any extra accessory. Wearing a wearable during exercise can be uncomfortable to certain users. Catering to the phenomenon of people using camera as the most popular smartphone feature we can address this problem. This work will predominantly focus on estimating Heart Rate in real-time from facial images captured using smartphone camera.

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## Idea/Approach Details

### IDEA/SOLUTION:

Heart Rate (HR) is one of the most important physiological parameters and a vital indicator of people's physiological state. Monitoring of HR often involves high costs and complex application of sensors and sensor based complex systems. Research progressing during last decade focuses more on non-contact-based systems which are simple, low-cost and comfortable to use. Still most of the non-contact-based systems are fit for lab environments in offline situation but needs to progress considerably before they can be applied in real time applications. Our proposed approach is to present a real time HR monitoring method using a simple smartphone camera. The heart rate is obtained through facial skin colour variation caused by blood circulation. Three different signal processing methods such as Fast Fourier Transform (FFT), Independent Component Analysis (ICA) and Principal Component Analysis (PCA) have been applied on the colour channels in video recordings and the blood volume pulse (BVP) is extracted from the facial regions. HR is subsequently quantified and compared to corresponding reference measurements. Linear regression method is applied to get best accuracy from it. This technology has significant potential for advancing personal health care and telemedicine. Further improvements of the proposed algorithm considering

environmental illumination and movement can be very useful in many real time applications such as athlete, elderly and driver monitoring.

## TECHNOLOGY STACK:

We first start with image pre-processing. Pre-processing is the most important part in any algorithm. Having structured data, helps in shooting high accuracy. Since, our main frame from the image is the face, Haar classifier is applied to eliminate the false positives, i.e., unwanted background. We average the green pixels obtained from the camera frame. The oxygenated haemoglobin absorbs light differentially. The pixels are taken from forehead too, which gives us the fluctuations. To measure the fluctuations on a hue range, we convert RGB to HSV pixels. Each hue corresponds to different colour. Therefore, we choose the appropriate effective absorption frequency. Our algorithm uses Haar cascade based detection function to detect the face and eyes from each frame captured by the camera. Using MATLAB software, we draw rectangular boxes around forehead, eyes and face. This is all as simple as object detection, where we detect eyes, forehead and face using Haar like feature-based cascade, which is a Machine Learning approach, where a cascade function is trained from positive and negative images, which is used to detect objects in a frame. The present algorithms gets 60% accuracy in detecting the above mentioned parameters, our algorithm uses segmentation and hence high accuracy is guaranteed.

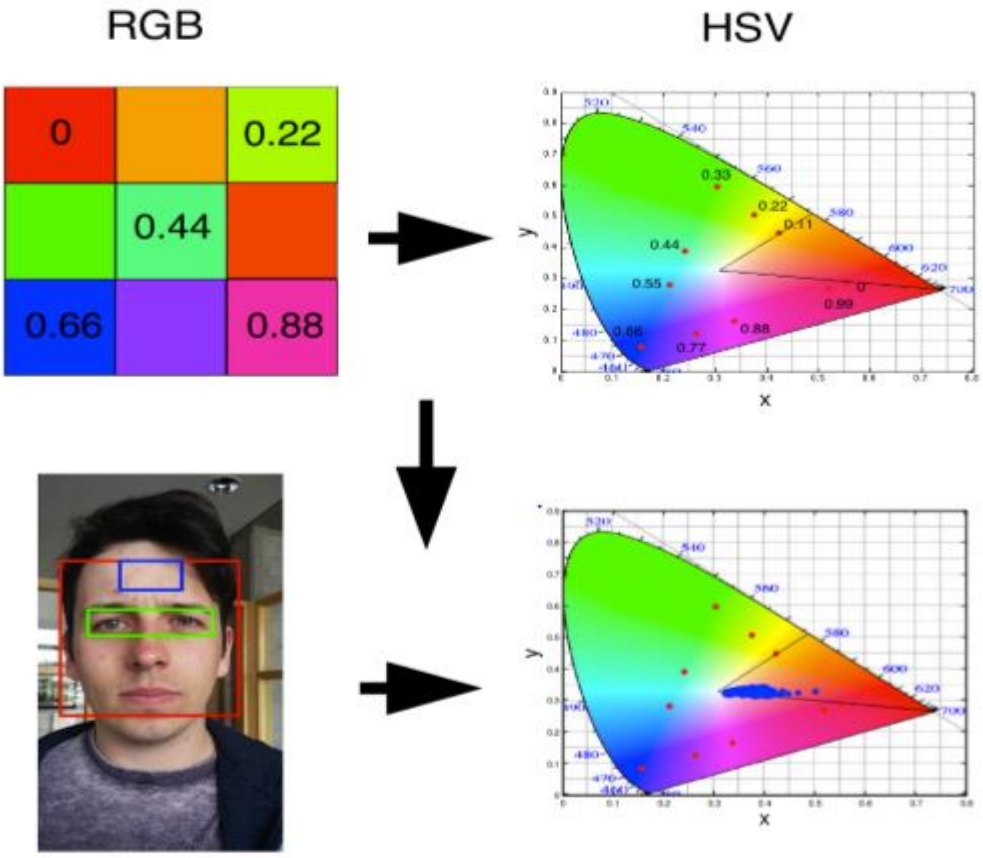


**Fig. Layout of operation using Matlab. (Source: IEEE Xplore)**

For subsequent processing, we use ICA based Joint Approximately Diagonalization of Eigen matrices algorithm. The output of this algorithm we obtain is simply a matrix. One of the matix column obtained is the HR signal. To find out the correct HR signal, we first find the cardiovascular pulse frequency and power spectrum. The spectra with maximum peal across all spectra are calculated. The frequency of the spectrum is considered as frequency of heart beats. Noise reduction techniques are used to attain utmost frequency since slight variations obtained as results with +/- BPMs gives a large gap of accuracy, compared with BPMs obtained from Heart rate sensor.

For cross-validation, we use simple Machine Learning technique for making algorithm more effective. We use Linear Regression and KNN classifier. These are used to estimate HR from these computed values. The errors obtained from these to estimate HR and actual HR rate is compared and minimized to its lowest. Every parameter is graphically visualised for better understanding of the algorithm. The whole algorithm is developed in Matlab software and Matlab C Coder is used to convert to standard code which can be used in Android Studio to develop it into a complete Android app. This app can be installed and used anytime, anywhere to estimate heart rate from our normal phone camera.

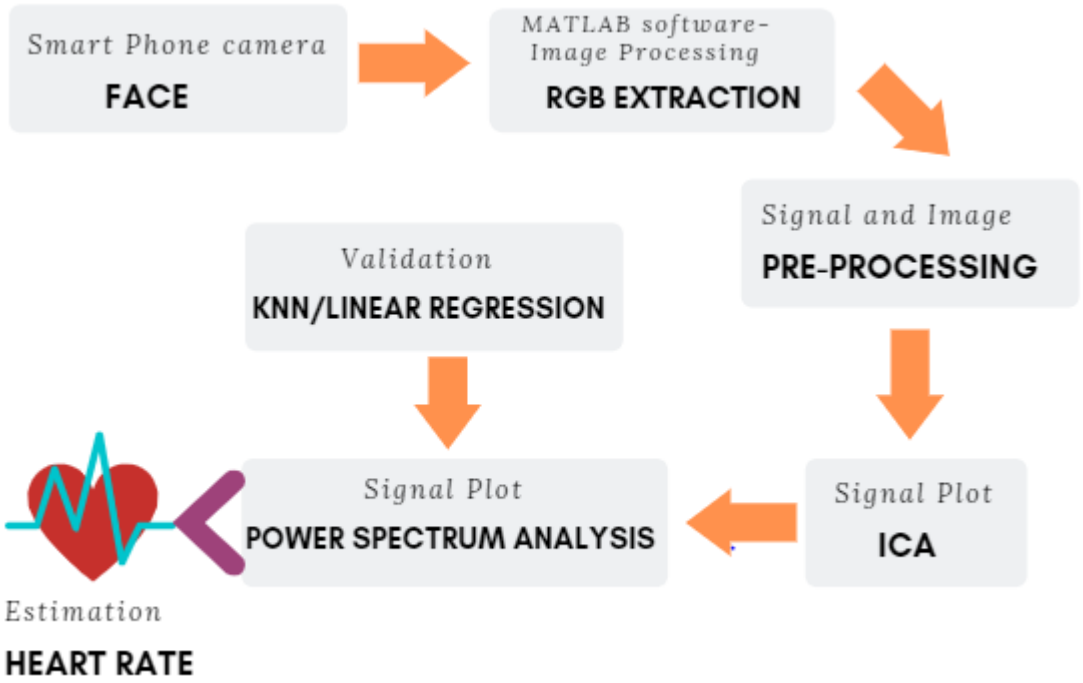


**Fig. Algorithm Flow Chart**

## USE CASE:

- This non-contact technology is promising for medical care and others indoor applications due to widespread availability of camera specially webcams.
- Although our solution, only addresses the recovery of the cardiac Heart Rate, many other important physiological parameters such as, RR, HRV and arterial blood oxygen saturation can potentially be estimated using the proposed technique.

- Creating a real-time, multiparameter physiological measurement platform with higher resolution of video based on this technology in driving situation will be the subject of future work.
- This algorithm can be used for surveillance purpose in a heavy crowd, where heart rate of the culprit is estimated as one of the parameters, since their HR will be high due to tension.

## DEPENDENCIES:

The whole algorithm right from developing to being converted to Android Studio standard form is done in Matlab, having several toolboxes such as Image processing and Computer Vision toolbox, Signal processing toolbox and Machine Learning toolbox. These toolboxes are used to compute the algorithm. Matlab C coder is used to convert the algorithm to standard Android Studio supported form. A simple mobile camera can be used to test the working of algorithm.