

Heart Rate Measuring Using Mobile Phone's Camera

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Abstract

Nowadays there are many ways to measure the heart rate. They vary from taking pulse manually to using special devices such as pulsometers, and so on. One more way of the heart rate measuring is using mobile phone's on-board camera. Such approach allows user of a mobile phone to find out his/her heart rate without having to buy special devices like pulsometers. Furthermore, heart rate measuring using mobile phone's camera does not require any special skills, like taking pulse manually does. The requirement for the heart rate measuring using mobile phone's camera is just a phone with an on-board camera equipped with a flash (the quality of the camera does not matter) and a special application installed.

For the user of such an application measuring heart rate using mobile phone's camera is very simple. All that the user needs to do is just run the application, place a finger over the camera lens and somehow tell the application that he/she is ready for the measurement (for example, by pressing a button). After that, the camera flash is turned on and the application starts to capture frames from the camera (usually, for about 10 seconds) and then analyzes them to calculate user's heart rate. The crucial idea of this approach is the following: as the heart beats, it pushes the blood to every part of the body and to the fingers particularly, so it changes the color and opacity of the skin. These changes can be detected by analyzing the average red component of the frames, taken from the camera. Graph of the average red component values will contain "sharp" local maximums, in which the values of the signal derivative are quickly changing from large positive to large negative. Such a maximum is called a peak, it corresponds to a single heart beat. The heart rate can be counted according to the number of such peaks.

In practice it is not trivial to detect peaks of the signal, because the retrieved signal is too noisy due to movements of the finger among the camera lens and changing of the surrounding light level. In the thesis [1] the author filters a signal using a moving average filter to remove rough peaks from it. After that the entire signal is split into windows of fixed length. For each window a signal is compared to the sinusoidal pattern for determination of the peaks occurring at the equal intervals of the time. The heart rate is calculated as multiplication of the peaks count and ratio of 60 seconds to the length of the window. In the paper [2] authors propose to normalize the signal using smooth differentiation. After that it become simple to get the number of the peaks. This value divided by the running time of the video gives the estimation for the heart beat rate.

In practice it turns out, that such approaches are not quite applicable. The height of the rough peaks is comparable to the height of the needed peaks. Because of it filtration reduces not only the amplitude of the noise, but also the amplitude of the entire signal. To cope with these issues we developed a new algorithm of the heart rate measuring.

The main idea of the proposed algorithm is to find out the average distance between adjacent peaks. The algorithm contains the following steps:

- 1) Signal differentiation. This step is needed, because the surrounding light level can change during capturing of the frames, and that provokes the signal baseline to rise up or fall down. After the differentiation the signal's average become close to zero despite the surrounding light level variability.
- 2) Making of the sets, that contain n highest peaks of the signal. The value of n is considered from 3 to m , where m depends on the length of the measurement (for example, for the 10

seconds measurement length m equals 20).

- 3) Variance calculation. Peaks in each set from the previous step are sorted by the time of their appearance in the signal. Then variance of the distances between adjacent peaks is calculated for every set of the peaks.
- 4) Choosing appropriate set. In this step the set with the minimum variance value is chosen.
- 5) Heart rate calculation. In chosen on the previous step set the expected value of the distances between adjacent peaks is counted. This value is considered as the distance between the heart beats. Knowing the average distance between two heart beats, one can easily calculate user's pulse in beats per minute.

This algorithm of the heart rate measuring was successfully implemented in Pulse Detector application available for Symbian platform from Nokia Store: <http://store.oivi.com/content/314173>.

Index Terms: mHealth, Pulse detection, Mobile phone, Camera.

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