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Pulse Rate Monitor At Pinna

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Abstract: **The pulse sensor designed in this work, is in the form of a wearable clip, and it is within a circular die that measures less than 1.2cm in diameter. Sensor is backed by a software algorithm, which tracks the peak of pulse signals with 95% accuracy. Pulse rate values from this sensor shows a difference of 1 or 2 beats per minute (BPM), on comparison with chosen commercial devices.**

Keywords: PPG (PhotoPlethysmoGraph), pulse rate, BPM, Pinna

I. INTRODUCTION

Pulse rate values are always an indication of the working state of the heart. Athletes normally have lower pulse rates than less active people [1]. The pulse is a result of pumping action in the heart[2], and higher pulse rates indicate faster pumping of blood which would lead to increased risks of cardiovascular diseases. Normal resting pulse rate values are to be in the range of 60-100, measured in units of BPM. Pulse rate measurements are usually made from Blood Pressure (BP) measuring devices and other optical methods in various pulse oximeter devices that are available in market. These devices use different technologies to track and report the pulse rate values. When the placement of pulse sensor tracks the capillary flow of blood as in finger tips (ChoiceMMed device), RED or IR LED's are the preferred light sources [3]. At the wrist, the arteries are much thicker than at fingertip, and then GREEN LED can be used [4], as in Intex FitRist Pulz.

Key point to note in this work, is the reason behind the choice of commercial devices as the references. The description to the choice can be split into two parts:-

1) Hardware components used and
2) Type of pulse tracking concept.

Novelty of design: The sensor designed and developed acquires the pulse signals from the pinna (the part of the ear that projects like a little wing from the head). Peak detection happens with the uniquely designed algorithm that adapts according to the nature of signal variation. Reported pulse rate values are at an error less than 1% in 95% of the cases.

II. IMPLEMENTATION:

This particular arrangement, shown in Figure 1 drew IR light at 920 nm, it was received at the other end by a three-pin IR Receiver (AX 1838)[5]. Data was filtered and processed by AtMEGA 328 Microcontroller, which is also programmed to calculate the pulse rate.

Figure 1: Circuit to measure pulse rate

The peaks of the raw values were more prominently seen at the output of this circuit, after filtering, as seen in Figure 2. It resembled the output from commercial sensor (ChoiceMMed Device).

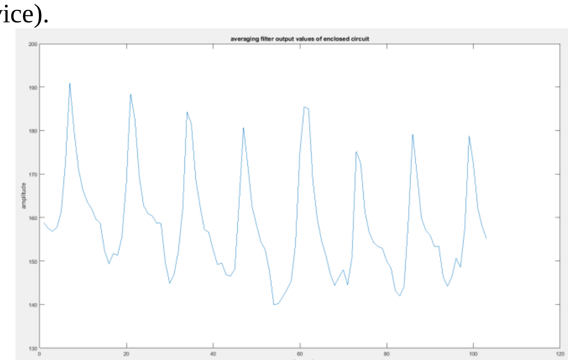

Figure 2: Output of sensor

The sensor built to measure pulse rate, was evaluated for its performance using two devices that were as far apart as possible, in terms of the technology they are using, to track pulse signals. The devices were:
1) ChoiceMMed Oxymeter device and
2) Intex FitRist Pulz Fitness band.

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ChoiceMMed being an approved medical grade device was a baseline for studying the variations in the pulse rate values that we get from the developed sensor [6]. The tests were done under two conditions:

1) Subjects sitting in relaxed positions
2) Subjects walking briskly for a minute wearing the device.

In each of these conditions, pulse rate variations were monitored for a minute [7]. Intex FitRist is more of a fitness device than a medical diagnosis quality one.

While the photo detector is most sensitive to the wavelength of light used by the LED; it can still detect an unwanted wavelength of light if it is bright enough. The unwanted light might come from the lights used within a room or even come from the natural light outdoors[8]. Response from the sensor, when it was just kept open to ambient light is seen in Figure 3

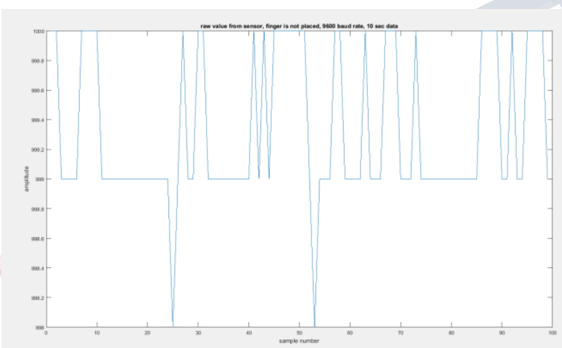

Figure 3: Response of sensor to ambient light

To make sure the response from IR Receiver is not affected by ambient light of the experiment environment, sensor was placed inside a 3D printed clip; the Figure 4 shows the normalized (mapping raw values from 900 to 1000 to 1023) response in this case.

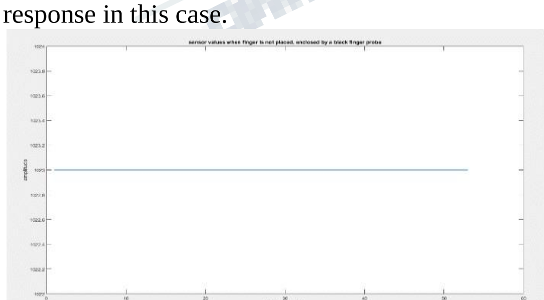

Figure 4: Normalized response of sensor to ambient light

III. ALGORITHM

The algorithm used in this work is:
Step 1: Read the raw value from sensor

Step 2: Apply Averaging Filter on raw data

Step 3: Keep the number of samples to be averaged as 50 (based on experimentation)

Step 4: Record averaged values for 10 seconds

Step 5: Set the maximum threshold as 800, in terms of amplitude

Step 6: Plot the sequence of filtered data, in form of square pulse waveform.

Step 7: Track values which remain constant at threshold level for more than 6 sample numbers, these are the pulse peaks

Step 8: Number of peaks * 6 is the pulse rate in bpm (beats per minute)

IV. RESULTS

Threshold method depicted in software algorithm (III), gives the peak detection method developed in the work. Figure 5 shows the output for threshold method of peak detection. Thresholded pulses representative of PPG peaks are having more width as depicted.

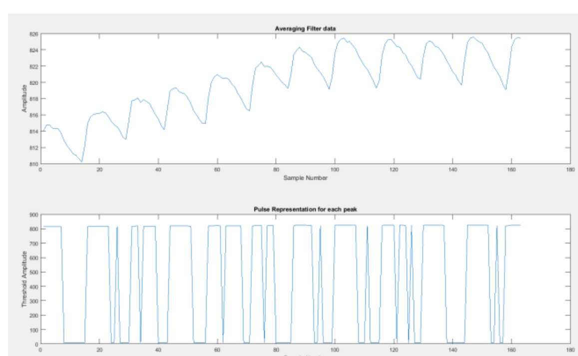

Figure 5: Threshold code output

Table 1 reports the pulse rate values obtained from sensor, for ten users, in comparison to commercial devices:

Table 1: Reported pulse rate values

Subject	Pulse Rate measured using		
	Device developed in this work	ChoiceMMed Device	Intex FitRist Pulz Device
1	93	94	93
2	90	90	90
3	73	74	72
4	86	87	86
5	79	80	78
6	70	70	70
7	80	82	82
8	87	88	87
9	98	100	98
10	78	79	78

V. CONCLUSION

IR transmitter and receiver reduced the cost of sensor construction. The entire circuit operates at 3.3V and draws 0.4mA. Smaller size of sensor made it easier to house it in a clip, making it a wearable device for pulse rate monitoring at pinna.

Pulse Rate values reported from the sensor had an error of less than 1% in majority of the measurements taken. The sensor was calibrated to accommodate the noise introduced due to movement artifacts and yet report the pulse rate values with 95% accuracy.

VI. ACKNOWLEDGEMENT

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