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Measure the Heart Rate and Respiration Rate Under Nervous Situation

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Abstract

Clinical, physiological parameters are one of the most important fields in healthcare innovation. Many mobile applications ad devices are designed and programmed for this purpose. Each device or software is covering a part of monitoring or it designed for a specific purpose like monitoring cardiovascular while doing cardio training. In this research, we study the effect of being under nervous situation on the heart rate and respiration rate using PPG signal to come out with a possible solution for monitoring these parameters under such conditions. The results show that heart rate is highly affected when the subject is under nervous situation where the respiration rate is not highly affected.

Keywords: Heart Rate (HR), Respiration Rate (RR), PPG, nervous situation, cardiovascular

INTRODUCTION

Health care is very important factor for all people. Everyone interested by checking his/her health status by himself and frequently instead of going to the hospitals for checking up. Many devices are implemented for this reason. Some of them are portable and easy to use. With growing of technology, they start using smartphones with programmed applications to monitor and measure the health care parameters. Using an application on smart phones are much easier than a fixed device despite of its inaccuracy. Because it is easier for patients to use many applications on one device only instead of having many equipment each one of exact thing. One the other hand these applications can give an indication about the patient status even if it is not accurate 100%. The most popular applications are implemented for measuring:

- Heart rate
- Respiratory rate
- Blood Pressure (BP)
- Pulse Blood Pressure
- Oxygen saturation level

These parameters are called the physiological parameters of the body [1]. Photoplethysmography (PPG) signal is widely used for calculating the physiological parameters such as blood pressure (BP) where the changes in BP affecting the shape of PPG signal. Many parameters, effects on the shape of PPG such as subject movement, sensor that is used to collect the signal, location of collecting and changing in BP. HR can give an indication about the heart status. Blood pressure is the force of blood that travels through the arteries, which is another important physiological parameter that is used for health care monitoring. BP contains two values that should be measure which are the systolic blood pressure (SBP) where it is related to the highest contrast of the heart and the diastolic blood pressure (DBP) which is related to the low contrast of the heart. BP can be measured in both invasive and non-invasive way. The invasive measurement is more accurate, but it is harder to use for the patient because it needs to insert a needle directly into the artery. For that it is not used widely and mostly they are depending on non-invasive measurement. The non-invasive techniques are the Korotkoff and Oscillometry methods [2]. The accuracy readings of non-invasive are very good because they are confined to only one point at a time.

The real problem is how to monitor the cardiovascular parameters continuously. Many devices are implemented for this reason. Some of them are working on one parameter only, others are used in a clinical department like hospitals. The needs for portable device or mobile application that can monitor all parameters continuously and at home become very important. There are some applications that are working on this issue, but almost they are not accurate because they did not base on scientific researches. In this research we will study the effect of subjects when they are become under pressure on the cardiovascular parameters (HR and RR) to implement a program for monitoring these parameters.

The rest of this paper will be organized as follow: Sections two is a literature review about the selected physiological parameters and the previous work that is done in this area. Section three is the methodology that is used for this research. Section four is the results and discussion and finally, section five will be the conclusion.

LITERATURE REVIEW

The tissues in the human body are hidden under the skin, the thickness of the skin is different from one place to another. The soft skin allows the light to transmit throw it. The Photoplethysmogram (PPG) acquires the information that can be collected by dropping a light source on the tissue then collect the reflection using a receiver [3]. The PPG signal contains two components which are the AC and DC components. The important part is the AC component because it contains all the information about the heart where the DC component does not have any information and it is

negligible. Fig. 1 shows a typical PPG signal that is collected from the subjects.

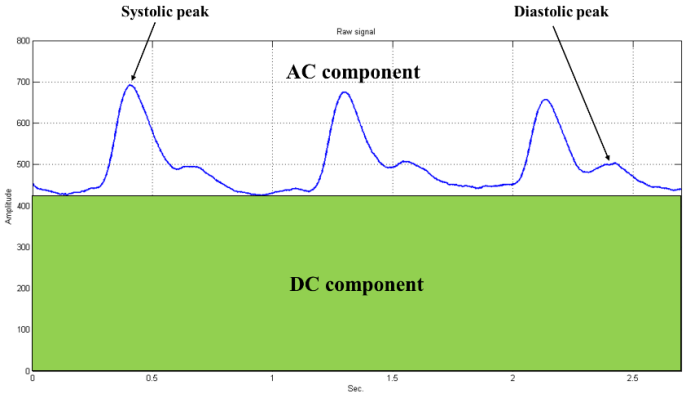

Figure 1. PPG signal with AC and DC components

PPG signal is used in various clinical cases such as monitoring the physiological parameters (heart rate, respiration rate, blood pressure and oxygen rate).

A. Heart Rate (HR)

One of the most important parameters of physiological characteristics is the heart rate. It is used in wide range of medical settings such as ambulatory patient monitoring and hospital based. The beat of heart is synchronous with the AC component of the PPG signal, for that it can be a good source for information of heart rate. PPG signal is the most popular signal that is used by the sophisticated algorithms to extract the heart rate information. This information including both time and frequency techniques [4]. Movement artifact makes a real problem for correct measuring by reducing the confidence in the rate parameter. Many algorithms have been investigated to improve the heart rate detection such as zero crossing and digital filtering where they used for separating respiratory and heart rate from PPG signal that is collected from ear [5]. Another device for heart rate and respiration have been described based on PPG where it used for monitoring the neonatal care unit and test the ECG and PPG signals [6]. By adjusting the offset of PPG signal, the heart rate shows that 1% false only for both negative and positive beats. To measure the changes in heart rate accuracy, two signals should collect from same place in different situation. In [6] a study hand is used to collect data first in rest and under movements. The two approaches that shows a significant improvement in both time and frequency domain are Fast Fourier Transform (FFT) and Weighted Movement Average (WMA). By applying new computer algorithms, the heart rate error reduced to 6 beats per minute compared to classical algorithms which is 11 bpm for FFT and 16 bpm for WMA [7]. A new technology is used to measure the heart rate by Bland and Altman [8]. The technology done by demonstration between radial piezoelectric and pulse oximetry and the radial artery [9].

B. Respiration Rate (RR)

The respiration rate is the physiological monitoring of the number of breathing intervals per minute. The respiration rate is used in many clinical instrumentations such as sleep study assessment, neonatal and critical care. It is possible to measure the breathing using PPG signals depending on the respiration variation. The PPG signal contains low frequency respiratory induced intensity variations (RIIV) which is well documented [10, 11]. By considering that contributions of the venous return to the heart that is included in RIIV which caused by changes in the sympathetic tone control and alternations in intra thoracic pressure of the blood vessels. Until now, the RIIV physiological mechanisms are not fully understood. During mainly thoracic breathing, lower respiratory rates observed higher tidal volumes with highest RIIV amplitude. In [10, 11], they tested the coherence and CO2 reference against thoracic impedance measurements and they investigate the complex phase relationship between pressure and RIIV. Many other research is done to understand the lower frequency components of PPG signal. Another study is done on the variations of the finger PPG signal to induce the respiratory [12]. This study is observed under arm BP cuff pressurize with high systolic blood pressure (SBP). The aim of this study was to give further evidence for autonomic nervous system involvement. Other researcher groups investigate various RIIV extraction algorithms [13]. They used pattern recognition of neural network algorithm to extract RIIV from the reflection PPG measurement mode. This technique gives good results with low error. To estimate the respiratory rate of the PPG signal, wavelet transform has automation facilitated [14]. Another study is done on breathing with changing in pulse timing characteristics. PTT is used to track arousals during obstructive in this study. The results of this study give as useful clinical non-invasive measurement of inspiratory [15]. The changes in PTT significantly induce the slow-paced breathing and deep inspiratory challenges in autonomic testing.

C. Related Work

Monitoring cardiovascular hypertension is one of the important fields in healthcare. Many studies are done in this field. Some of these studies are focused on one parameter only, some of them deals with more than one. PPG signal is used in many application of healthcare monitoring. Most of studies focuses on Blood Pressure, how to monitor the Cuffless BP or how to estimate the BP from PTT and PWV [16]. A group of researchers focus on monitoring the breathing rate only using smartphone applications [7]. Another researcher group is working on implementing social media on how to avoid becoming nervous depending on others experience [17]. There is a group of researchers who works on measuring heart rate depending on the changes in Diastolic blood pressure to reduce heart failure [18]. Monitoring heart rate is important and give an indication for many things but it is not enough to cover all clinical healthcare. Many other researches done in this field. Almost

they are focusing on one parameter only like heart rate or respiration rate using different methods or algorithms. The results are almost similar. Few of them study more than one parameter in same research but the limitation of these research is either using different types of signals or it is hard and expensive to implement. Some research is done for hospital case only, that means they cannot use it at home.

METHOD

A. Database Description

Eleven volunteering subjects (8 males and 3 females), with ages from 24 to 28 years, have been participated in this research. The PPG signal was continuously recorded from the left-hand finger in two cases one in normal situation and another in under nervous situation. Fig. 2 shows the location of data collection.

Figure 2. PPG signals detection point

The PPG signals was detected by a self-designed sensor composed of a photo detector and infrared light emitting diode (LED) with wave length of 900 nm. The PPG signals were measured for 90 seconds in the two situations separately and stored in two channels by an acquisition software developed by Matlab. All the collected PPG signals were recorded with sampling frequency of 500 Hz.

Table 1. Illustrate the database.

Subject No.	Age	Gender	Weight (Kg)	High (M)
S01	25	M	87	175
S02	25	M	72	165
S03	27	F	62	150
S04	30	F	51	155
S05	25	M	76	172
S06	24	M	67	178
S07	23	M	86	175
S08	23	M	93	168
S09	27	M	87	176
S10	25	F	78	157
S11	23	M	64	177

Fig. 3 shows typical 10 seconds sequence from recorded PPG signals where (a) represent the signal in normal case and figure (b) represent the PPG signal that is collected in under pressure case.

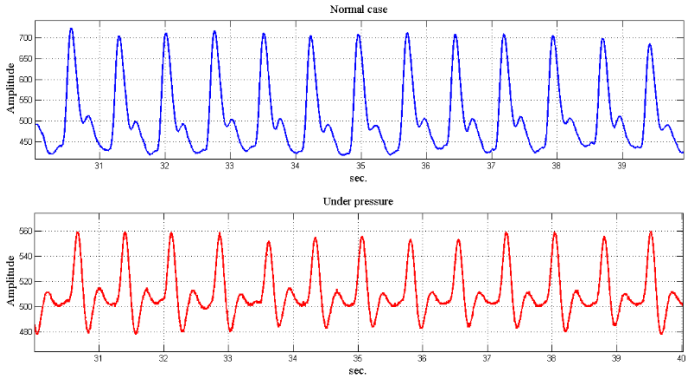

Figure 3. Typical 10 seconds PPG signal

B. PREPROCESSING

The collected signal is raw signal that contains all information that we did not need all of them and it contains noise that occurs either because of the sensor or subject movement during data acquisition. To eliminate these unwanted factors, few pre-processing steps are done. The first step is normalizing the signal using sampling frequency of 500 Hz. The second step is filtering the signal to remove the noise. FIR bandpass filter is used with 5^{th} order and frequency [0.001, 0.04]. cut-off frequencies are used. The cut-off frequency is determined by applying Shannon Nyquist formula. The third step is to remove the DC part from the signal by detrending it. Fig. 4 shows the filtered signal compare to the original signal both are detrended to make the comparison easier. The blue line represents the raw signal and the red represents the filtered signal. It can be noticed that the red one is more smooth and cleaner.

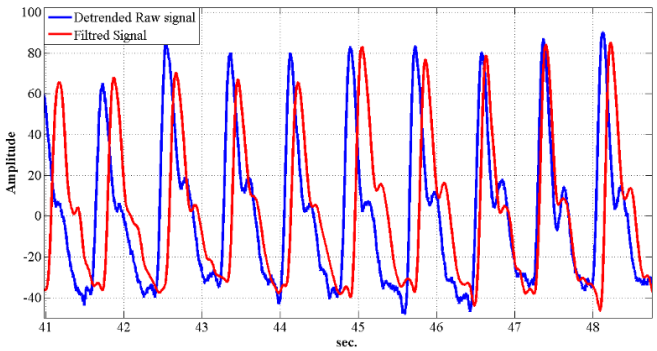

Figure 4. Raw and filtered PPG signal

RESULTS AND DISCUSSION

A. Calculating Heart Rate (HR)

The heart rate is the number of heart pulses per minute. Generally, the range of heart rate for normal people is between 40 to 120 pulses per minute. This section will be

divided into three steps which are demonstrating the heart rate for all subjects in normal case, then calculating the heart rate for all subjects under nervous and finally, comparing the results of the two cases to conclude the effect of pressure situation on heart rate. Fig. 5 shows the HR for one subject in normal case for 90 seconds.

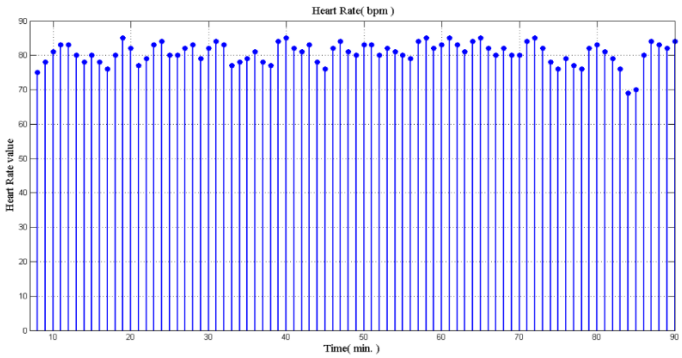

Figure 5. HR values for one subject

To calculate the HR for all subject, the mean is taken for HR values of each subject and stored. Form the figure it can be noticed that the HR values for all subjects are between 76 and 85 pulses per minute which is normal. Generally, most of human being's heart rate are increasing when they will be under pressure. But the increasing is different from one subject to another. Some peoples are reaching to the danger rate, some of them they can manage themselves and stay in normal range. The pressure itself also affect the heart rate. For example, the pressure on someone at exam hall is not like who is at hospital and waiting for danger surgery. Fig. 6 shows the comparison between the HR for the subjects in normal case and under nervous situation. Where it shows that some of the subjects are still in normal range where others are higher than normal range but very close to normal. This because of pressure that we used in testing because it is not easy to collect data from person who is under high real pressure. For this project, the case was before and after exam.

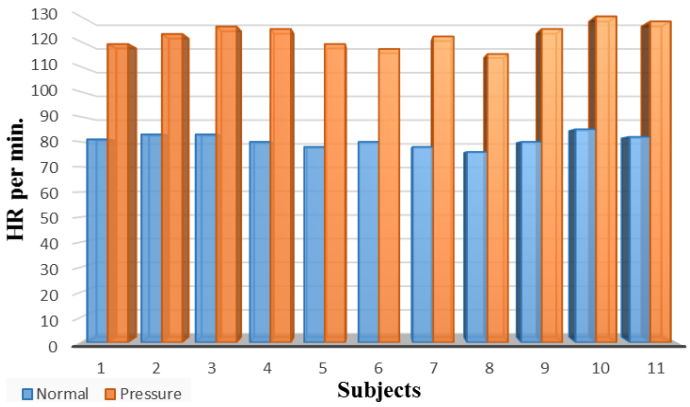

Figure 6. HR comparison between normal and under pressure cases

From the figure, it is easy to distinguish the effect of pressure on the heart rate. Almost all people suffering from increasing the heart rate when they will be under pressure. This experiment shows that even a normal daily pressure effect on heart rate. That leads to there is a need for monitoring this parameter to be sure about human's health. As mentioned before the range of increasing is different from one person to another, it depends on the person himself and it is also affected by the pressure of the situation.

B. Calculating Respiration Rate (RR)

The respiration rate is the number of breathing per minute. The average range of respiration for normal people in rest is between 3 to 20 breaths per minute. The number of breath per second depends on the age of the subject and other parameters. For example, the respiration of the children is higher than adults and it is very low in the senior citizens. The respiration rate is affected by many criteria such as exercising or running. In this research, we are focusing on nervous situation to determine how this is affecting on the respiration rate. The section will be divided into three steps as well, the first step is calculating the RR in normal case to approve that our algorithm is giving us correct results compare to standards readings. The second step is to calculate the RR for all subjects under nervous situation and finally comparing between the results to conclude the effect of pressure on the respiration. Calculating the respiration rate is not easy like HR, the respiration is more complicated. The way of calculating the RR is by applying polynomial AR model on the PPG signal to extract the polynomial parameters then start calculating the RR. After calculating the RR, the values are stored in an array for each subject. Fig. 7 shows the RR of one subject for 90 seconds.

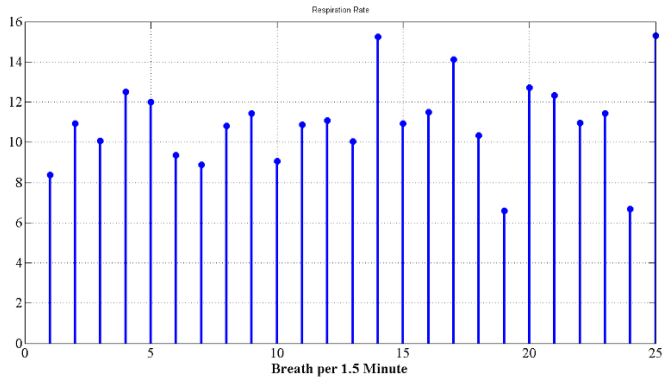

Figure 7. Respiration Rate (RR) for one subject

By calculating the number of breath, we can find it is equal to 25 breaths in 90 seconds, that means the RR is around 16 respirations per minute which is normal. The respiration rate is increasing in several situations for example when playing games or doing cardio training. The reason of increasing the respiration is that the brain needs more oxygen to continue working normally therefore, the person starts breathing faster to gain more oxygen. Fear or any troubles in

physiological indicators causes same things to need more oxygen to keep the body working normal. In this research we will test the effect of pressure on the respiration rate. Fig. 8 shows the comparison between the RR in normal case and under nervous situation where it can be noticed that there is an increasing in the values of respiration rate but this increasing is not too much comparing to the normal case. This because our pressure was not high enough and the small number of subjects. The other thing is that in both cases they still in normal range. That leads to the effect of pressure did not affecting on respiration, in other world it is not a danger parameter from this point of view. From literature, the respiration rate is highly affected by body movement like training and playing more than pressure.

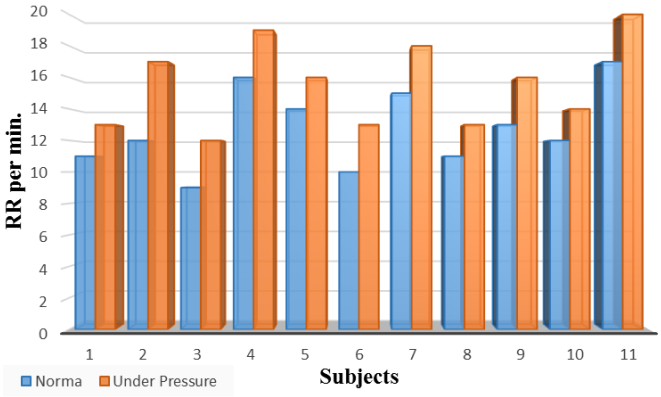

Figure 8. RR comparison between normal and under pressure

CONCLUSION

Generally, the technology is becoming more advance in every filed of life, this advancement reflected in the biomedical engineering, where it becomes more innovative. Monitoring the physiological clinical parameters becomes one of the most wanted from everyone. Many mobile applications and devices are designed and programmed for this purpose. Each device or software is covering a part of monitoring or it designed for specific purpose like monitoring cardiovascular while doing cardio training. The reason of start implementing these applications and devices is everyone needs to use them personally and because of the standards are very expensive or not cover all needs. For example, monitoring blood pressure continuously, it is impossible to monitor it using the cuff which is the standard that is used to measure the blood pressure.

For that Cuffless techniques appears.

In this research, we studied the effect of nervous situation on the HR and RR using PPG signal. The idea is to calculate the HR and RR for all subjects in two situations. first in normal case and second under nervous situation then comparing the results to determine the effects of pressure position on the human's physiological parameters. The results show that heart rate is highly affected by the pressure position. The respiration rate is affected also but not high.

REFERENCES

[1] M. Lansdown, 1957, A method of using induced waves to study pressure propagation in human arteries, [J]. Circ. Res, 1957, 5:594-601.

[2] Y. Zhang, 2004, Blood Pressure Devices, IEEE/EMBS International Summer School on Medical Devices and Biosensors (ISS-MD).

[3] M. Maguire and T. Ward, 2002, The Photoplethysmograph as an instrument for physiological measurement, Department of Electronic Engineering, NUI Maynooth.

[4] Yan Y. S., Poon C. C. and Zhang Y. T., 2005, Reduction of motion artifact in pulse oximetry by smoothed pseudo Wigner–Ville distribution, J. Neuroeng. Rehabil. 2 3.

[5] Nakajima K., Tamura T. and Miike H., 1996, Monitoring of heart and respiratory rates by photoplethysmography using a digital filtering technique, Med. Eng. Phys. 18 365–72.

[6] Johansson A. and Oberg P. A., 1999, Estimation of respiratory volumes from the photoplethysmographic signal, Part 1: experimental results Med. Biol. Eng. Comput. 37 42–7.

[7] Yanzhi Ren, Chen Wang, Jie Yang and Yingying Chen, 2015, Fine-grained Sleep Monitoring: Hearing Your Breathing with Smartphones, IEEE conference on computer communication INFOCOM.

[8] Bland M., 1995, An Introduction to Medical Statistics, 2nd edn (Oxford: Oxford University Press).

[9] Foo J. Y. and Lim C. S., 2006, Pulse transit time as an indirect marker for variations in cardiovascular related reactivity Technol, Health Care 14 97–108.

[10] Nilsson L., Goscinski T., Johansson A., Lindberg L. G. and Kalman S., 2006, Age and gender do not influence the ability to detect respiration by Photoplethysmography, J. Clin. Monit. Comput. 20 431–6.

[11] Nilsson L., Johansson A. and Kalman S., 2000, Monitoring of respiratory rate in postoperative care using a new photoplethysmographic technique, J. Clin. Monit. Comput. 16 309–15.

[12] Nitzan M., Faib I. and Friedman H., 2006, Respiration-induced changes in tissue blood volume distal to occluded artery, measured by Photoplethysmography, J. Biomed. Opt. 11 040506.

[13] Johansson A., 2003, Neural network for photoplethysmographic respiratory rate monitoring Med, Biol. Eng. Comput. 41 242–8.

[14] Leonard P. A., Douglas J. G., Grubb N. R., Clifton D., Addison P. S. and Watson J. N., 2006, A fully automated algorithm for the determination of respiratory rate from the Photoplethysmogram, J. Clin. Monit. Comput. 20 33–6.

[15] Pitson D. J., Sandell A., van den Hout R. and Stradling J. R., 1995, Use of pulse transit time as a measure of inspiratory effort in patients with obstructive sleep apnoea, Eur. Respir. J. 8 1669–74.

[16] Francesco Viola and William F. Walker, January 2005, A Spline-Based Algorithm for Continuous Time-Delay Estimation Using Sampled Data, IEEE transactions on ultrasonics, ferroelectrics, and frequency control, vol. 52, no. 1.

[17] Edhelmira Lima-Medina, Orlando Loques Cl´audio Mesquita, 2014, Minha Sa´ude a Healthcare Social Network for Patients with Cardiovascular Diseases, IEEE, 978-1-4799-4823.

[18] Jia-Li Ma, Yuan-Lian Cui, and Ming-Chui Dong, 2013, An Effective Low-Complexity Multi-Vital-Signs Compression Technique for Embedded-Link e-Home Healthcare, 35th Annual International Conference of the IEEE EMBS, Osaka, Japan.