T.C.
KTO KARATAY UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROJECT PROGRESS REPORT

"ESTIMATION OF RESPIRATORY RATE
FROM PHOTOPLETHYSMOGRAM DATA USING
TIME-FREQUENCY SPECTRAL ESTIMATION"

Team Members: Abdullah TOPATAN
İ.Levent DURAN
Hakan ÖZCAN

CONTENTS:

a- Background :

The human respiratory system is a series of organs responsible for taking in oxygen and expelling carbon dioxide. Respiratory rate refers to the breaths taken per minute. It is important for many clinical uses including detecting sleep apnea, sudden infant death syndrome, and chronic obstructive pulmonary disease, and measurements of respiratory rate are indicated in many intensive care and operative settings [1]. Continuous and non-invasive monitoring of respiratory rate could be very beneficial in improving the safety of patient.

In humans, the average rate of breathing is dependent upon age. Newborns up to 6 weeks take 30 to 60 breaths per minute, while the average resting respiratory rate for adults is 12 to 20 breaths per minute. [2] Physical exertion also has an impact on respiratory rate and healthy adults can average 45 breaths per minute during strenuous exercise.[3]

b- Project Goal :

The aim of this project is to develop a mobile-based system estimating breaths that a person take per minute. A similar approach described in [4] will be used. The mobile phone will be placed on the person's upper chest lying at on the ground for recording acceleration changes using the built-in accelerometer of mobile device. Due to the movements of chest wall, each rise and fall will be counted as one cycle of respiration. The system will first filter the acceleration data and then analyze the patterns between the motion profile and breathing.

Another aim of this project is to develop an automated respiratory rate monitor that is economical, easy to use, easy to find, easy to update accurate and widely accessible.

This project will result in the development of an economical and easy reach method to enhance the medically ubiquitous accurate respiratory rate monitor and alarm system. The product developed by this project will answer that call and result in the improvement of patient monitoring and evaluation, which should lead to a decrease in medical errors and in morbidity and mortality.

c- Approach :

Accelerometers of new generation mobiles phones are reliable enough to contribute into the project. Mobility and easy usage fetaures are very important for the patients who has trouble with respiratory system.

There are several tecnique to measure the respiratory rate estimation. Using such as infrared sensors, doopler signal, accelerometer, ultra sound sensors, biosensors, sound and vibration sensors are used for respiratory estimation device. Most of them dependent different kind of device and some other procedures which is cause waste of time. They also expensive to buy and too big to carry. For these reason estimating respiratory rate on mobile phone is both logical and cheap and it can customize easily.

A mobile phone which has accolerometer can produce error signal acording to x,y,z axis. We will use z axis signal. Z axis signal is produced when the phone moving to gravity direction. It is not efficient to directly without filtering. There are some filtering calculation formulas. Guasian filter seems to be efficient for smoothing the signal which is coming from the accelerometer. After smoothing signal limits are determined according to patients age. Peaks are determined and counted for one minute. After this,value is evaluated and compared between critical value. If it is critical value first step alarm process will run after indicates the respiratory rate per minute on secreen.

Accelerometer output signal process block diagram

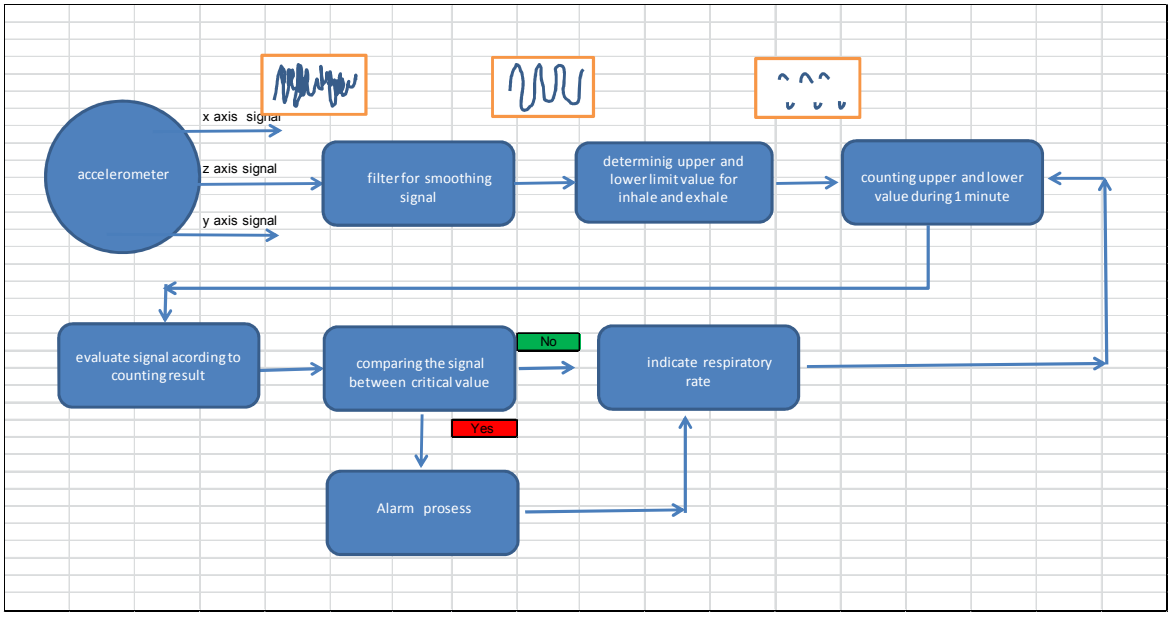

Figure:1 Overview of the system

Signal coming from the mobile phones accelerometer needs to be smooting. Gaussian filter is suitable for the project

The impulse response of the Gaussian filter is

$$h(t) = \frac{\exp\left(\frac{-t^2}{2\delta^2}\right)}{\sqrt{2\pi}\cdot\delta} \quad \text{where} \quad \delta = \frac{\sqrt{\ln(2)}}{2\pi BT}$$

Signal process will be shown below. Blue signal refers to signal coming from the mobile phone accelerometer . Red signal refers to output signal after the gaussian filter

Gaussian Filter signal process

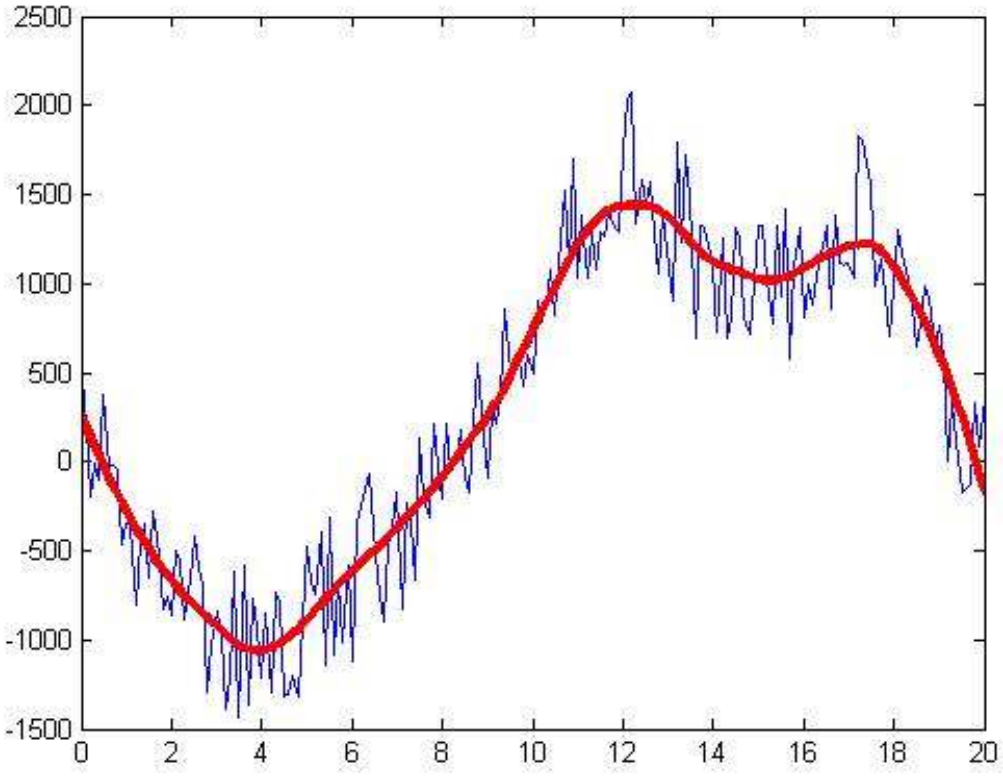

Figure 2 Gaussian filter

Peak Determination

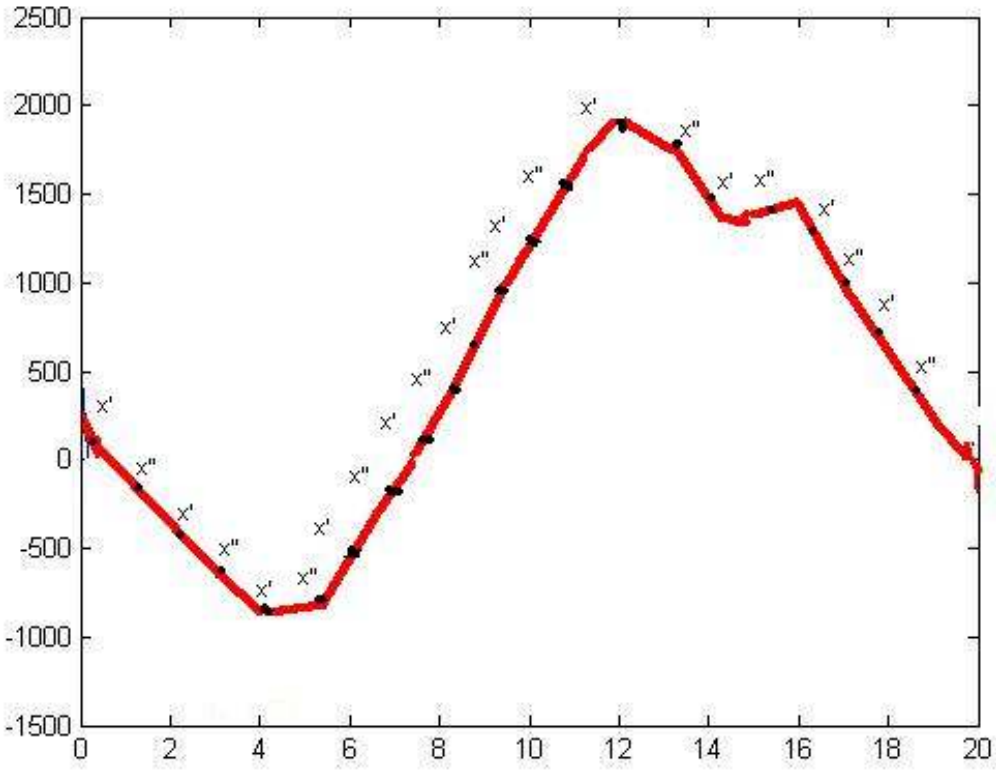

Figure 3 peak determination

Peak determination is the most important process in this project because chest movement while breathing is different according to people. Peak detection is the process of finding the locations and amplitudes of local maxima and minima in a signal that satisfies certain properties.

x' refers to first measurement x" refers to second measured.

* If first measurement value is smaller than second measurement value signal is rising

* If first measurement value is equal (or around) second measured value they can be peak if the first measurement value bigger than second measured value

* If first measurement value is bigger than second measurement value signal is falling

d- Progress :

Code was writen on eclipse both obtain accelerometer signal on mobile phone and making software user interface for android device. Accelerometer signal was taken from the mobile phone .This signal was monitorized in degree form. This trial software was installed on android phone. Trial software was worked succesfully so far.

User interface of software shown in figure 4.

e- Timetable (Gantt Chart):

S/N	TASK	ASSINGMENT TO	DUR	%	Weeks													
					1st	2nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th	14 th	15 th
1	Requirment Analysis	I.L.DURAN A.TOPATAN H.ÖZCAN	29	100	x	x	x	x	x										
2	preperig proposal	I.L.DURAN A.TOPATAN H.ÖZCAN	20	100			X	X	X										
3	Reading medical artical about respiratory system	I.L.DURAN A.TOPATAN H.ÖZCAN	35	100		X	X	X	X	X	X								
4	taking algorithms	I.L.DURAN A.TOPATAN H.ÖZCAN	20	100					X	X									
5	Resource signal filters and calculations	I.L.DURAN A.TOPATAN H.ÖZCAN	20	70					X	X	X	X							
6	Design	I.L.DURAN A.TOPATAN H.ÖZCAN	10	50								X	X	X	X				
7	Implementation	I.L.DURAN A.TOPATAN H.ÖZCAN												X	X	X	X		
8	Testing & Maintanance	I.L.DURAN A.TOPATAN H.ÖZCAN															X	X	X
9																			

f- Future Work :

Basic features was worked but peak dedection and other interface menus need to be done. Software will serve more then one patient so user interface should be customized with patient information.

After the project, respiratory rate result coming from the mobile phone can compare medical device which is design respiratory rate monitoring. We will understand smooting filter and determinating peaks upper and lower side correct or incorrect. If there is a incorrect result we will check all filter and signal processing calculation and algorithm.

g- Referance:

[1] K. H. Chon, S. Dash, “Estimation of Respiratory Rate From Photoplethysmogram Data Using Time-Frequency Spectral Estimation”, IEEE Transactions on Biomedical Engineering, vol. 56, no. 8, pp. 2054-2063, 2009.

[2] Younes M. Role of respiratory control mechanisms in the pathogenesis of obstructive sleep disorders.J Appl Physiol. 2008;105:1389–1405.

[3]Respiratory System: Facts, Function and Diseases
Kim Ann Zimmermann, LiveScience ContributorDate: 22 August 2012 Time: 05:40 PM ET

[4] V. Chandrasekaran, \Measuring Vital Signs Using Smart Phones", Master's Thesis, Univeristy
Of North Texas, December 2010.