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KTO KARATAY UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROJECT FINAL REPORT

"ESTIMATION OF RESPIRATORY RATE
USING MOBILE PHONE ACCELEROMETER"

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1-) ABSTRACT:

Being aware of normal respiratory rate is very importent and vital as an abnormally low or high breath per minute can be indicative of many health problems.This project especially important for patients who trouble with tachypnea,bradypnnea,apnea, asthma ect.It is used smartphones accelerometer in android operating system cellphone. 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. This project provide a easy,cheap and fast measurement opportunity to the patients. Respiratory rate measurement is also done in diffirent method using green channel of fingers video image which is cently contact to camera lens. Fingers video data is imported to matlab and observed the changes the values. Fingers color changes related with not only heart rate but also respiratory rate . Gaussian filter and peak detection process is run in matlab code. Matlab create a plot about fingers video. This plot is near with android cellphones plot.

CONTENTS:

2-) INTRODUCTION :

a. PROBLEM STATEMENT :

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 [3]. 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. [4] Physical exertion also has an impact on respiratory rate and healthy adults can average 45 breaths per minute during strenuous exercise.[5]

b. PROJECT SIGNIFICANCE:

The aim of this project is to develop a mobile-based system estimating breaths that a person take per minute.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.

3-) RELATED WORK:

There are several tecnique to measure the respiratory rate estimation. A similar approach described in [6] will be used using such as infrared sensors, doopler signal, accelerometer, ultra sound sensors, biosensors, sound and vibration sensors are used for respiratory estimation device. There are also use another complex method using optical sensors and lenses.[2] 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.

4-) METHOD :

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.

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.

Figure 1 : Overwiev of system is shown below. Source of signal is mobilephones accelerometer. Signal goes to filter for smooting after that it goes peak dedection and peaks are counted. Signal plot and counter data is shown in phones screen. There are optional alarm process for alarming upper and down value determining before acording to persond age .

a. ACCELEROMETER OUTPUT SİGNAL PROCESS BLOCK DİAGRAM

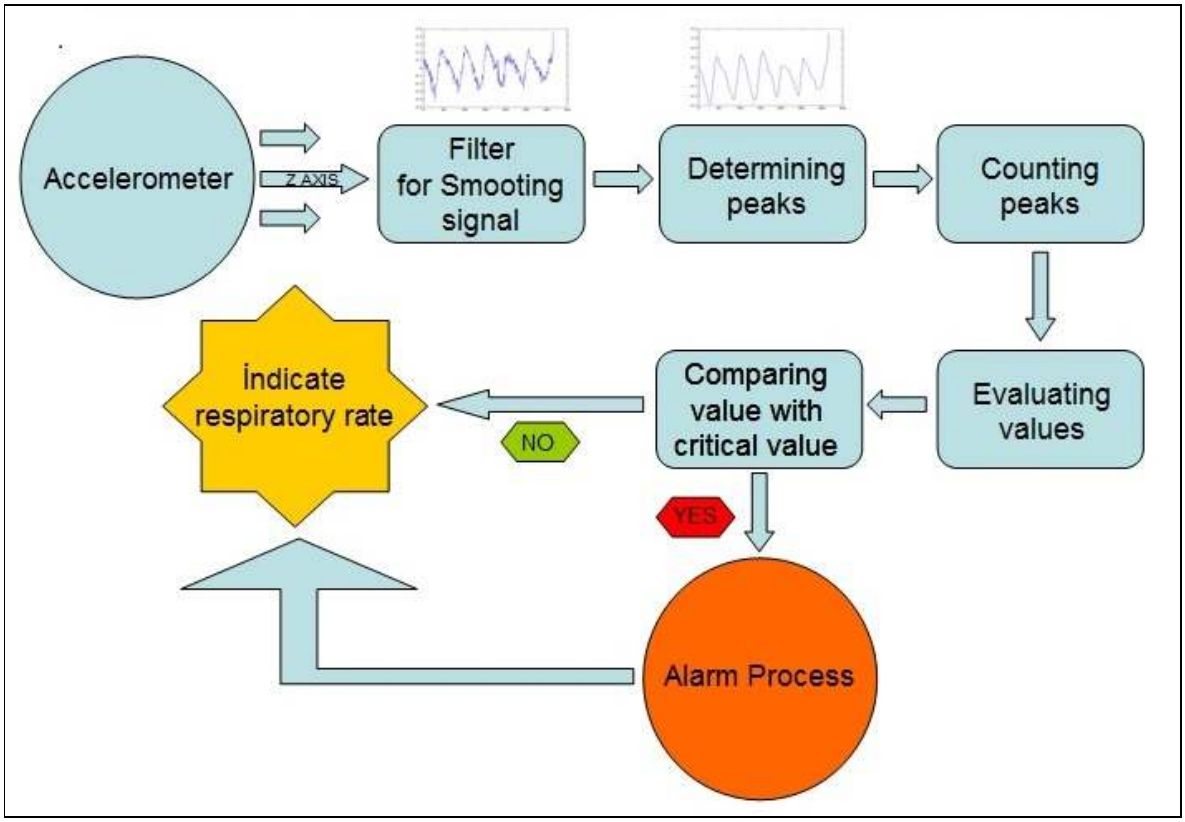


Figure:1 Overview of the system

b. SIGNAL PROCESS :

Signal coming from the mobile phones accelerometer needs to be smooting. Signal coming from the accelerometer is have high frequency component. This is kind of parasite . We want to determine real signal changing acording to chest movement. Gaussian filter is suitable for the project because this filter both eliminates high frequency and save main signal related with chest movement.

The impulse response of the Gaussian filter is

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

Where $'\delta'$ is related to 3-dB bandwidth-symbol time product (B*Ts) of the Gaussian filter as given by:

$$\delta = \frac{\sqrt{\ln(2)}}{2\pi BT}$$

Where B is bantwidth Ts is Symbol time

c. GAUSSIAN FILTER SIGNAL PROCESS:

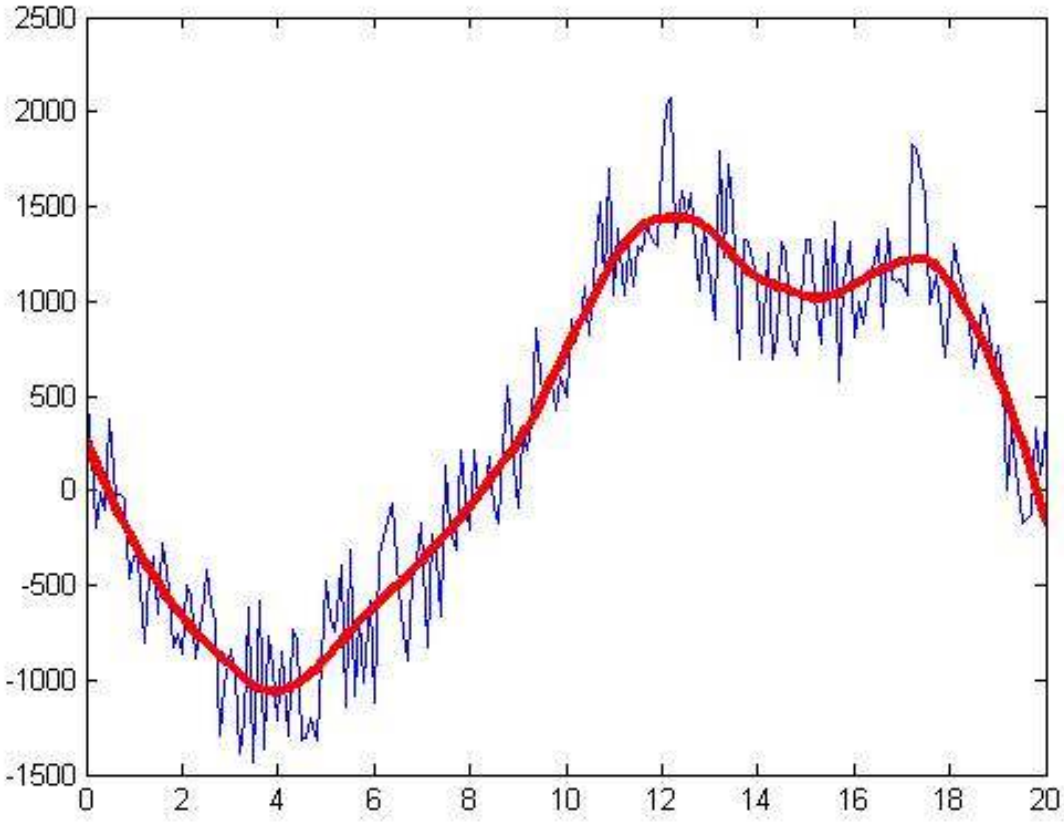


Figure 2 Gaussian filter

Figure 2 depicts gaussian filter outputs. Signal coming from accelerometer is blue one. This signal has high frequency component. Red one is Gaussian filter output. Its value is kind of avarege of left and right side. Gaussian filter calculation is more complex accordig to this. This average value related not only the left and right side value but also the time function effect

d. PEAK DETERMINATION:

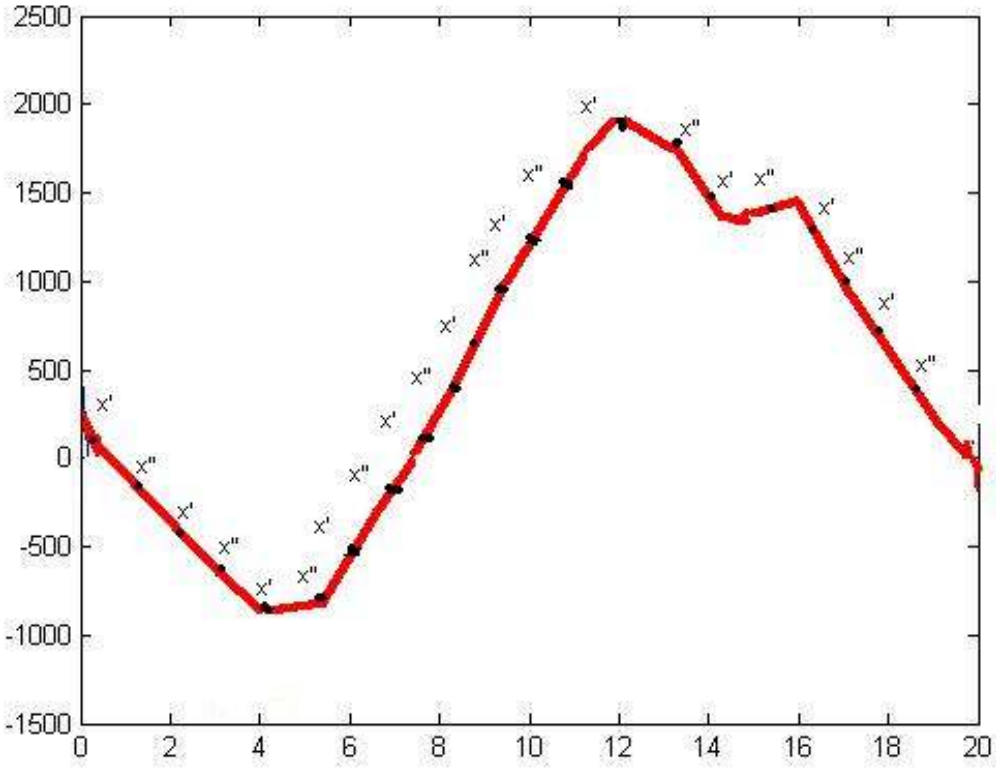


Figure 3 peak determination

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

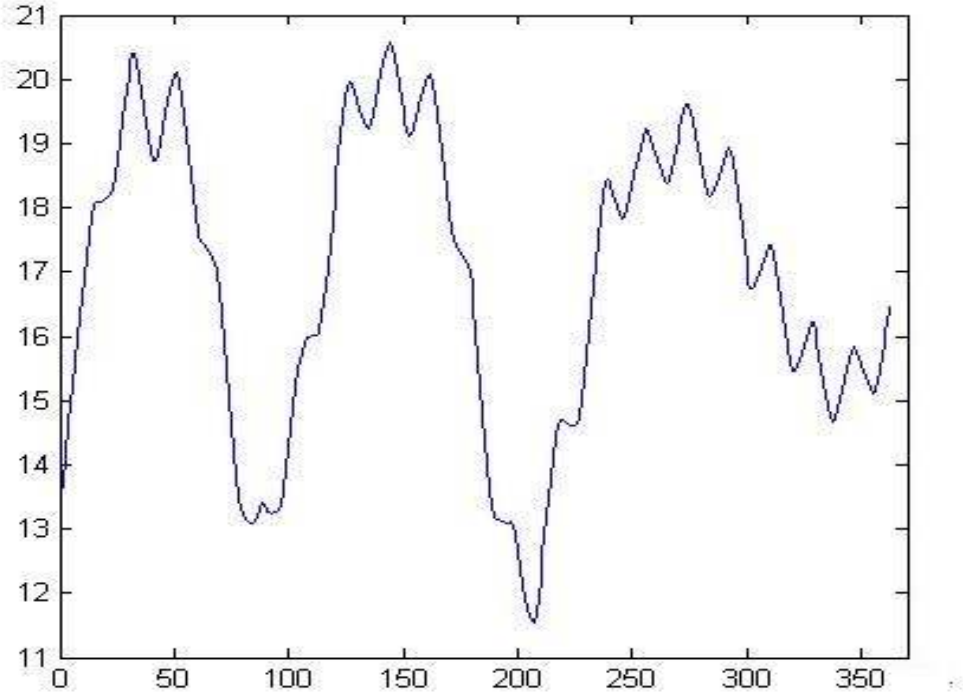
* If first measurement value is bigger than second measurement value signal is falling

e. ALTERNATIVE MEASUREMENT WITH FINGER VİDEO:

Respiratory rate can be estimate from the finger video. This method is used only alternative way to measure respiratory rate. When we taking oxigen blode carry more oxigen simultaneously. It can be observe outside of the skin by video camera. green channel is more convinient to observe colour changes. Videos recoded directly cently touch on camera lens. Video lenght is 20 second. Video signal process by using matlab.

Gaussian filter is also aplied on the finger video because video signal have parasite. filter is used to eliminate these

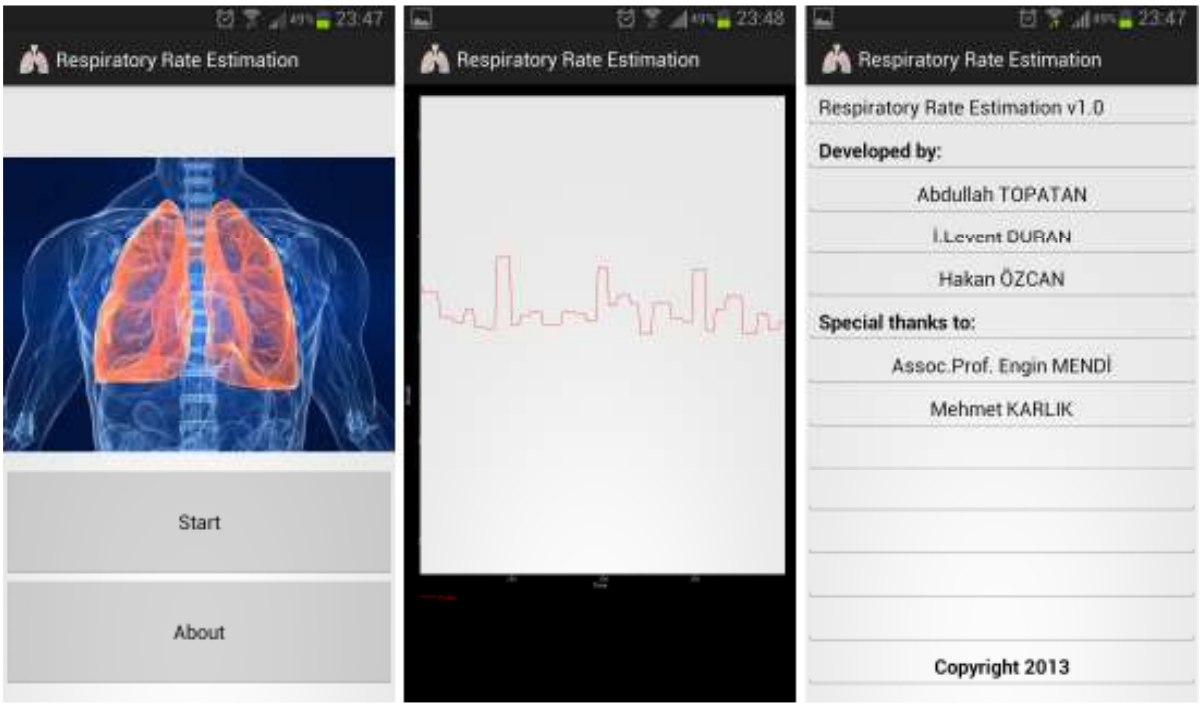
f. OUTPUT OF MATLAB WORK:



Respiratory_Rate = 23.9091 heart_rate = 72.7757 Figure 3

Figure 3 depicts matlab work outputs. Finger video coming from video camera is converted to signal versus time on matlab. We study green channel of video signal. This signal has high frequency component. Gaussian filter is applied for eliminating hight frequency parasite.

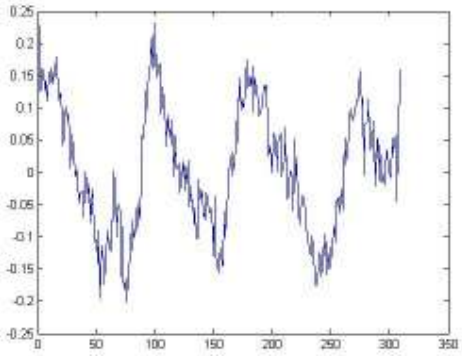
g. SECREEN IMAGE ON ANDROID DEVICE:



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.

h. SAMPLE PLOTS OF ACCELEROMETER DATA

Before Smooting



After Smooting

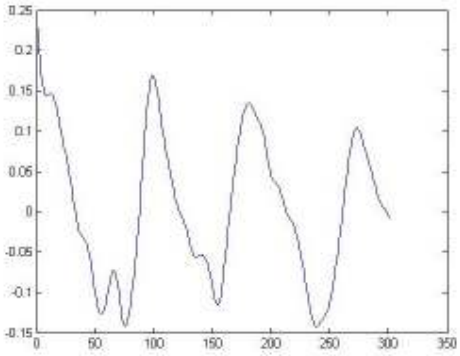
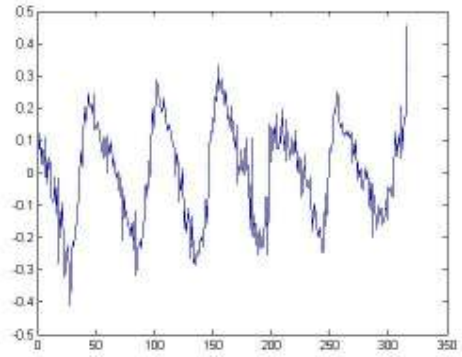


Figure 4a : 43 male lying down position (no effort)

Before Smooting



After Smooting

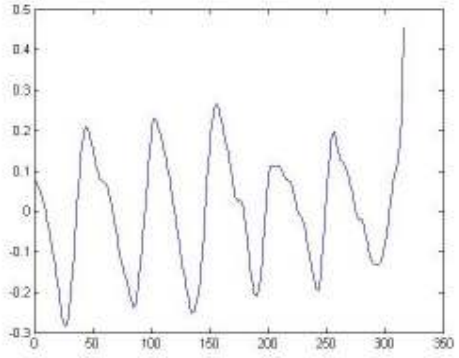
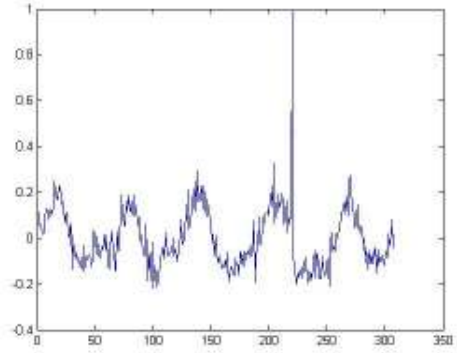


Figure 4b : 43 male lying down position (after effort)

Before Smooting



After Smooting

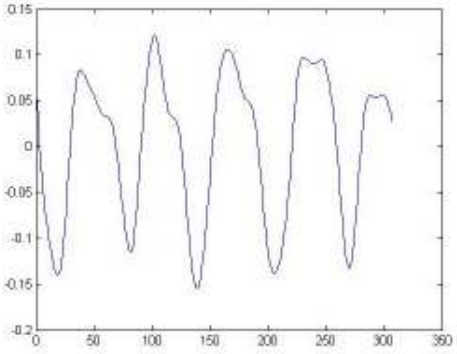


Figure 4c: 43 male standing up position (no effort)

these plots above belongs to 43 years old healty male person. Measure is done during 20 second. Three diffirent measurement is done of each person. These are measure in standing position , measure in lying down position and finally after 30 second excirsize measurement in lying position

5-) RESULTS / FINDINGS / TESTS :

Important features was worked on android cell phone such as peak dedection and smooting process. Interface menus can be done according to requirement. Software will serve more then one patient so user interface should be customized with patient information.

The other work relaterd with project was in matlab. Accelerometer data is taken from the cellphones and writen in txt file. Data writen in txt was import to matlab. Smooting and drawing plot are done in matlab. Measurements are done both normal condition and after 30 second excirsize condition to be sure that method is true. We obtained realistic and reliable result for measurement in liying position. But in standing position accelerometer data is not perfect to measure because of parasites are sometimes of time almost bigger than the real value. Some times it is not posible to determine 100% real value low frequency data from the whole data comig from the accelerometer.

S/N	PERSON		TESTS								
	AGE	GENDER	LYING	REAL	ERROR	EFFORT	REAL	ERROR	STANDING	REAL	ERROR
1	12	F	21	21	0	27	27	0	21	21	0
2	31	F	18	18	0	27	27	0	19	18	5,55%
3	42	F	21	21	0	24	24	0	21	21	0
4	57	F	27	27	0	33	33	0	28	27	3,70%
5	35	M	21	21	0	27	27	0	20	21	5%
6	24	M	27	27	0	30	30	0	27	27	0
7	41	M	15	15	0	18	18	0	17	15	13,30%
8	45	M	30	30	0	42	42	0	30	30	0
9	43	M	12	12	0	21	21	0	13	12	8,33%
10	47	M	15	15	0	21	21	0	15	15	0

Figure 5 : Result of Tests

Fifure 5 depicts 10 persons who are diffirent age and gender test results in lying down, standing position and after excirsize lying position matlab results respectively real measurement.

6-) SYSTEM CONFIGURATION:

Smooting filter and Peak Detection software for PC will be implemented in:
• Eclipse java indigo SR1 Wın64 on a Microsoft Windows PC.
• Using java syntax.
Smooting filter and Peak Detection Software for Mobile will be implemented in:
• Eclipse java indigo SR1 Wın64 on Android Phone on a Microsoft Windows PC.
• ANDROID SDK R16 Wındows
• Using Android Phone for testing, debugging.
• Matlab 2011 64 bit is used enother signal processing

7-) SUMMARY :

Being aware of normal respiratory rate is very important and vital as an abnormally high or low breath per minute can be indicative of many health problems.[1] it is posible to measure respiratory rate using smartphones accelerometer in android operating system cellphone. This project provide a easy,cheap and fast measurement opportunity to the patients. Results are 100% true in lying down position in every condition , gender and age respectively the real measurement Respiratory rate measurement is also done in diffirent method using green channel of fingers video image which is cently contact to camera lens. Fingers video data is imported to matlab and observed the changes the values. Fingers color changes related with not only heart rate but also respiratory rate [2]. Gaussian filter and peak detection process is run in matlab code. Matlab create a plot about fingers video. Most of time resuls are not near to real value because of some disturbance such as finger swinging ,level of daylight , cellphone shaking . This method can be perfectionnement using external strong green light.

8-) REFERANCES:

[1] Cystic Fibrosis hey B. Browning, M.D.; Gilbert E. D'Alonzo "Importance of Respiratory Rate as an Indicator of Respiratory Dysfunction in Patients with", DO., F.C.C.P; and Martinj Tobin, M.D., F.C.C.P

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[3] 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.

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

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