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A non-invasive technique to analyse movements and cardiac vibrations with classification of respiration in infants

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Abstract: **Respiration is an important indicator of individuals health. As a part of patient care hospitals used to monitor respiration continuously. Existing respiration monitoring methods are of contacting types. This may become discomfort to patients especially to infants. In this work, a non contact method is developed to monitor respiration. The method consist of an ultrasound sensor followed by a in-phase and quadrature detection scheme that separately monitor respiratory movements ,non respiratory movements and cardiac vibration . Further it will classify the respiratory signal as normal respiration, respiration with artifacts and sleep apnea. This is done by detecting features of respiratory signal and comparing it with normal values. Feature extraction is done by the help of certain equations and using second order auto regressive model. The results shows that for normal respiration , it consist of a certain rhythm and energy. In case of sleep apnea energy is very low and lack of rhythm. In respiration with motion artifacts, the energy is too high and may not have a specific rhythm. We have to compare the features of given respiratory wave with abnormality to the features of normal wave. Then we can classify it as sleep apnea or respiration with motion artifacts. This non contacting method therefore useful to detect movements and cardiac vibrations without making discomfort to infants. Also, through this system early detection and taking treatment at correct time is possible.**

Key words- feature extraction, non contacting method, , second order autoregressive model, ultrasound sensor

1.INTRODUCTION

Physiological monitoring of respiration rhythm and heart rate during sleep are useful for diagnosing disorders like sleep apnea, sudden death syndrome and heart diseases. For this there are many contacting and non contacting techniques. Contacting methods may be impedence plethysmography , attaching sensors or any other methods. This may become discomfort to infants. Non contacting methods may useful to ensure comfortability of infants. This may include pressure mattresses, ultrasound waves, infrared waves, etc.... Ultrasound sensors are used in this work with a frequency range that is above human audible range and will not affect infants.

Monitoring of respiration rhythm may be altered by non respiratory movements. The purpose of this work is to separately monitor respiratory, non respiratory and cardiac vibrations. Thus we can receive signals free from noise. This noise free signal is again classified to normal respiration, respiration with artifacts and sleep apnea. By the help of a second order autoregressive model(AR) , it will extract features of respiratory signal. This is used to classify respiratory signals.

This work is mainly used to identify disorders like sleep apnea and reduce risk of serious heart diseases in future. sleep apnea is a disorder found in infants. Suspected patients stops breathing for a short period of time. It may last from 10 seconds to 1 minute or more during sleep time. Then infants suddenly starts breathing again. Infants having sleep apnea is at the risk of heart diseases, obesity and diabetis. Sleep apnea is treated by giving continous positive airway pressure(CPAP). Thus airway blockage can be reduced .

Sleep apnea may be of obstructive sleep apnea which is caused by blockage of airway , central apnea which is caused when brain is failed to signalling breath muscles and mixed apnea which is a combination of both.

Monitoring respiratory and non respiratory as separate channels makes required signal is of free from artifacts and noise. Thus respiratory signal alone can be used to detect respiratory disorders. This method can be used to analyse the cardiac vibrations .

2.LITERATURE SURVEY

Monitoring respiration rate and heart rate is essential for patient care. For this there are many contacting and non contacting methods.

Contacting methods include ,airflow method, acoustic methods, accelerometer ,etc.... In airflow method, respiration rate is measured by detecting airflow at nose. This is done by placing thermistors at nose. In acoustic methods, by the help of a sensor respiratory rate is measured. Movements are mainly detected by using accelerometers. Accelerometers are placed at wrist and chest wall of infants. All contacting methods were makes discomfort to patients, especially to infants. This may cause stress to infants and cause a change in respiration rate.

Non-contacting methods are videodata, radar, ultrasound sensors,etc... Videocamera is used to detect cerebral palsy in infants. It needs a motion tracking sensor. It is expensive by the use of computer based video analysis. Radar is another method which can be used even in infants. However the use of radar is expensive and becomes complex. Ultrasound sensors are less expensive method to detect respiration rate. In[3] ultrasound sensors are placed at two sides of bed. Vibration of mattress is measured and received wave is demodulated by an envelope detector. It requires more than one sensor and cannot detect cardiac vibrations and types of respiration. It fails when patient is out of bed.In [5] the sensor is placed under mattress. The shape of mattress affect amplitude of received signal. The sensor maintenance is difficult and its accuracy is low.

3. RESEARCH ELABORATIONS

3.1 BASIC SENSING SYSTEM

Below figure shows the basic sensing system

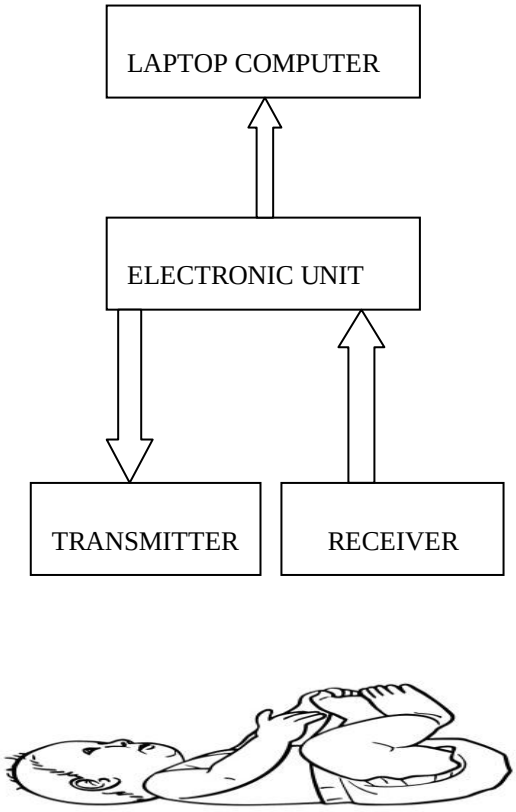

Figure 1: basic sensing system

Sensor unit consist of a transmitter and receiver. Sensor is placed 15-50 cm above body of infant. A 40KHz ultrasound wave is transmitted continuously. This frequency is used because of its excellent propagation and this range is above human audible range. Thus it will not affect infants. Reflected ultrasound wave is received and given to an electronic unit. The acquired data is analysed with the help of a laptop computer. While the body of infant moves, there cause a slight shift in phase of reflected signal, because of Doppler effect. This phase shift is detected in electronic unit.

3.2 FUNCTIONAL BLOCK DIAGRAM

This is based on an in-phase and quadrature detection scheme. There is a crystal oscillator operating at 4MHz . This 4MHz is divided into 160KHz and 40 KHz by passing through a dual biquinary divider. After amplification of 40KHz wave is used to drive transmitter. The dual “D”

flipflop process 160KHz. It produced in-phase(phase A) and quadrature phase(phase B) clocks. Received signal after amplification given to a comparator. This is used to convert the signals to logic levels "0" and "1". Output of comparator is given to inputs of phase A and phase B comparator simultaneously.

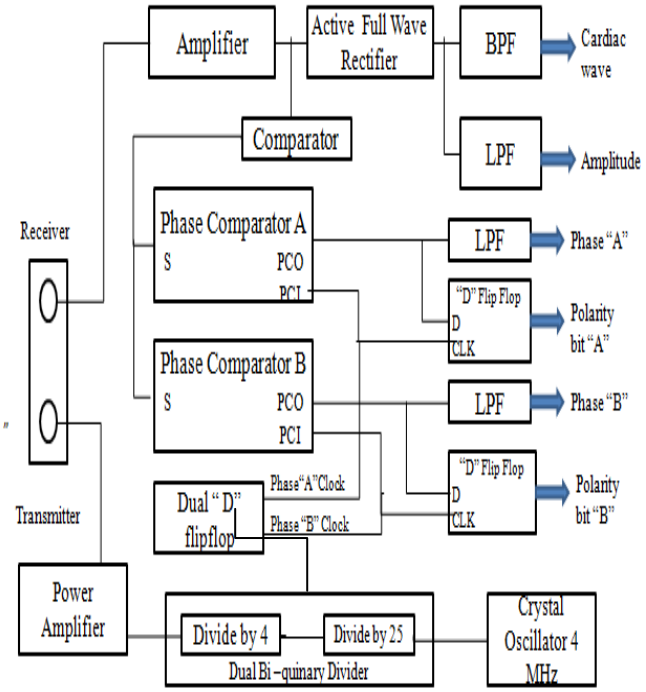

Fig 2: functional block diagram

The phase "A" comparator output PCO was connected to low pass filter to get phase A. Similarly phase "B" comparator was connected to low pass filter to get phase B. The PCO and PCI of each phase comparators was connected to "D" flip flops separately to produce polarity bits "A" and "B".Received signal is also given to a full wave rectifier and smoothened by a low pass filter. This gives the amplitude of received signal. Received signal while passing through a band pass filter will produce cardiac wave.

3.3 ALGORITHM

The flow chart consist of four inputs. Phase A and phase B, polarity bits A and polarity bit B. We have to check which phase is in linear region. Phase comparators used here has linearity range of 0.5 to 4.5v. if it is above linearity range ,the signal to noise ratio will be low. Thus linearity range must be considered to reduce noise. Since, the phase between outputs are fixed at difference of 90^0 , either one must be at useful region at a time.If phase "A" is in linear region it is used, otherwise phase "B" is used. Selected phase is accumulated and produce the respiratory output.

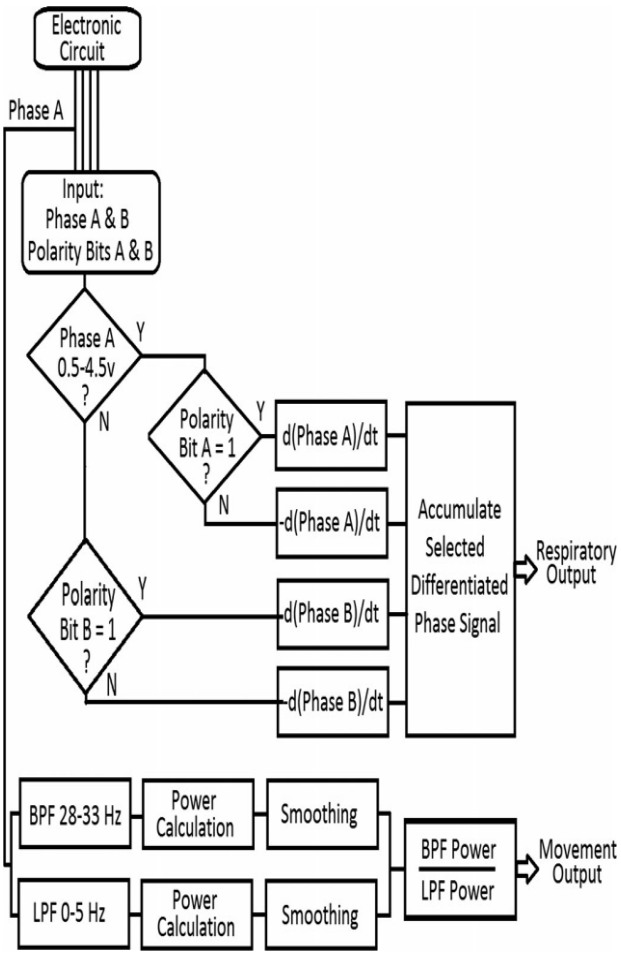

Fig 3: flow chart[1]

The respiratory signal is used to extract features with the help of certain equations. The four main features of respiratory signals are (a) Energy Index ,(b) Respiration Frequency,(c)Dominant Frequency, (d) Strength of Dominant Frequency.

3.4 FEATURE EXTRACTION

3.4.1 Energy Index(EI)

Energy contained in a signal f(t) is

$$\mathbf{E_f} = \int_{-\infty}^{+\infty} |f(t)|^2 \mathbf{dt} \qquad \mathbf{(1)}$$

This is total the total energy in a signal. If total energy is finite non zero value, it will be an energy signal. Aperiodic

signals are turn out to energy signals. Equation for Energy Index is

$$\mathbf{EI} = \frac{1}{N}\sum_{n=0}^{N-1} |\mathbf{x_n}|^2 \quad \mathbf{(2)}$$

3.4.2 Respiration Frequency(FZX)

Zero crossing is a point where sign of a function changes from positive to negative. Respiration frequency was determined from the number of times that signal crosses a baseline. It is also found by calculating square root of EI.

$$\boldsymbol{FZX} = \sqrt{\boldsymbol{EI}} \quad \mathbf{(3)}$$

3.4.3 Dominant Frequency (FAR)

For this, respiration signal is modelled as a second order autoregressive model.

$$\mathbf{X(n) = a_{1x(n-1)+}a_2x(n-2)+e(n)} \quad \mathbf{(4)}$$

where a_1 and a_2 are coefficients of autoregressive model

3.4.4 Strength of Dominant Frequency(STR)

$$\mathbf{STR} = \sqrt{\mathbf{a_1}^2+\mathbf{a_2}^2} \quad \mathbf{(5)}$$

This gives the power of dominant frequency. STR has a value of 0 and 1. If STR is close to 1, it will be a regular rhythm. Otherwise it will be a abnormal signal.

4. RESULTS AND DISCUSSIONS

4.1 RESULTS

This paper describe a non contacting sensor which used reflecting ultrasound to separately monitor respiratory, non respiratory and cardiac vibrations. High frequency part of reflected ultrasound wave represents the non respiratory movements. When body of infant moves , these artifacts produces large phase shift in reflected wave relating to the transmitted wave. Thus corresponds to high frequency signals. Avoiding motion artifacts we get the noise free respiratory signal. This respiratory signal is useful to detect respiratory disorders like sleep apnea. Also reflected wave passing through band pass filter (BPF) gives the cardiac vibrations.

Respiratory signal is used to extract the features for classification of respiration with the help of certain equations. These features are Energy Index, Respiration Frequency, Dominant Frequency and Strength of Dominant Frequency.Examining the output, we can see that the patient is affected by sleep apnea. Respiratory signal of patent is compared with normal wave to find the type of respiration . here we can see that patient's respiratory wave has no specific rhythm and respiration rate is below a critical level. Also the patient stops breathing for short period of time. Also the cardiac wave has low amplitude than normal cardiac wave. Thus the resultant respiration type is sleep apnea

4.2 DISCUSSIONS

This method uses a non contacting ultrasound sensor. According to body movement and respiration, reflected signal has a phase shift related to transmitted signal. Using an in-phase and quadrature detection scheme we can analyse respiratory,non respiratory and cardiac vibrations. Classification of respiratory signal is made by detecting features of respiratory signal. If respiration is normal, it is charecterised by certain rhythm and presence of some energy. Sleep apnea is characterised by lack of rhythm and energy. Motion artifacts has a sudden increase in amplitude or a sudden variation in rhythm of heart.

Sleep apnea is again as obstructive sleep apnea, that is something blockas the airway. Central apnea is next type in which brain fail to signall the muscles to breath. The third type is mixed sleep apnea which is a combination of both. Obstructive sleep apnea is common type. This can be treated by giving continous oxygen supply to lungs.

CONCLUSIONS

A non invasive technique for monitoring respiration and cardiac vibration is developed. This has high durability, because none of infant and infants body is directly applied to sensor. Thus it will not affect the sensing system. This is an

efficient way to detect sleep apnea. We get respiratory, non respiratory movements and cardiac vibrations from a single non contacting method. Also by using certain equations , we can easily classify types of respiration. The project becomes an efficient method to detect and cure sleep apnea at correct time. A sleep apnea infant is at high risk of heart attack, obesity and diabetis in future. This can be treated by reducing airway blockage. For this, a patient needs a continous oxygen supply. Uvulopalatopharyngoplasty is a surgery used to cure such diseases.

Thus the project is useful for detecting sleep apnea in real time applications. As a future scope we can modified this to find the type of sleep apnea.

REFERENCES

[1] **Gregory P. Heldt, and Raymond J. Ward** , (2016) "*Evaluation of Ultrasound-Based Sensor to Monitor Respiratory and Nonrespiratory Movement and Timing in Infants"* IEEE transactions on biomedical engineering, vol. 63, no. 3

[2] **G. Emeriaud**, (2006) *"Diaphragm electrical activity during expiration in mechanically ventilated infants," Pediatric Res.*, vol. 59, no. 5, pp. 705–710

[3] **K.Mukai,** (2009) *"A remote monitor of bed patient cardiac vibration, respiration, and movement,"* in *Proc. IEEE 31st Annu. Int. Conf. Eng. Med. Biol. Soc.*, pp. 5191–5194.

[4] **L. Adde**, (2010) "Early prediction of cerebral palsy by computer-based video analysis of general movements: A feasibility study," *Dev. Med. Child Neurol.*, vol. 52, no. 8, pp. 773–778

[5] **Y. Yamana**,(2011) *"A sensor for monitoring pulse rate, respiration rhythm, and body movement in bed,"* in *Proc. IEEE Conf. Eng. Med. Biol. Soc.*, pp. 5323–5326.

[6] **Farah AL-Khalidi, Reza Saatchi, Heather Elphick and Derek Burke ,(2011)** "*An Evaluation of Thermal Imaging Based Respiration Rate Monitoring in Children"* ,American Journal of Engineering and Applied Sciences 4 (4): 586-597, 2011 ISSN 1941-7020

[7] **William Daw1,*, Ruth Kingshott1, Reza Saatchi, Derek Burke, Alan Holloway, Jon Travis, Rob Evans, Anthony Jones, Ben Hughes and Heather Elphick1,(2016)**," *Medical Devices for Measuring Respiratory Rate in Children: a Review*", Journal *of Advances in Biomedical Engineering and Technology, 3,* 21-27

[8] **P. D. Geiger and L. H. Hudgins** ,*"Stand-off non-invasive acoustic baby monitor,"* U.S. Patent 6 150 941, Nov. 21, 2000.

[9] **P. Arlotto,** (2014)"*An ultrasonic contactless sensor for breathing monitoring,"*
Sensors, vol. 14, no. 8, pp. 15371–15386