International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

A Review Paper On Non – Contrast Respiration System

Pawandeep Kaur[1], Harpreet Kaur[2]

[1, 2]Guru Kashi University, Sardulgarh Road, Talwandi Sabo, Bathinda (151302)

Abstract: ***Studied the noncontact respiration monitoring system combining image processing and data analysis. Various contact measurement methods have been developed for estimating the breathing rate of a subject. Moreover, highly automated, non-contact monitoring of breathing function may have a significant impact on certain biomedical applications. In this paper the different problems are studied and these problems are implemented with the help of non-contrast respiration system to get maximum accuracy on the data.***

Keywords: breathing rate, respiration, ECG and LED etc

1. Introduction

Monitoring of breathing function has applications among others in polygraph, sleep studies, sport training, early detection of sudden infant death syndrome in neonates, and patient monitoring.

Various contact measurement methods have been developed for estimating the breathing rate of a subject. George B. Moody, et al. developed a contact modality in which numerous Electrocardiogram (ECG) electrodes and sensors are attached to the subject [1]. The principle of operation is based on the fact that the heart rate is typically modulated by breathing, a phenomenon known as sinus arrhythmia [2]. Therefore, a signal corresponding to the heart function contains breath information, which is filtered out using band-pass filters.

As an improvement over the ECG method, the BioMatt method [3] was developed in Finland by a group of researchers who were studying sleep disorders. BioMatt performs measurements of vital signs, such as breathing and cardiac activity without electrodes. Initially, BioMatt could not distinguish motion that was due to breathing versus cardiac activity or body movement. Later, Larson developed a signal processing technique to separate out the components of the BioMatt signal [4].

Photo plethy smography (PPG) is a variant method of the ECG, developed to measure blood volume changes in living tissues by absorption or scattering of near-infrared radiation. This modality consists of an infrared Light Emitting Diode (LED) and a photodiode which can be clamped to the ear lobes, thumbs, or toes. It is advantageous in that it is portable, compact, and needs very little maintenance. The measurement of blood volume changes by PPG depends on stronger absorption of near-infrared light by blood when compared to other superficial tissues [5]. The amount of backscattered light corresponds to the variation of the blood volume. As in ECG, the breath waveform is separated from the cardiac signal through various methods that have been developed [6], [7]. However, using heart function as a basis for acquiring the breathing waveform is unreliable since sinus arrhythmia is not present in all individuals. Control of cardiac activity by breathing depends on the age and medications administered to subjects.

Other contact modalities are capable of measuring directly the breathing signal. An example of such modality is the abdominal strain gauge transducer [8] that is strapped around the subject's chest and measures the change in thoracic or abdominal circumference while breathing. Another example is a thermistor measuring nasal air temperature variation as an indication of breathing [9].

The disadvantage of all the aforementioned technologies is that they require close contact with the subject, which in certain cases may be quite uncomfortable and awkward (e.g., abdominal transducer). A contact-free but active technology called Radar Vital Signs Monitor (RVSM) [10] was developed in 1996 to monitor the performance of Olympic athletes. The RVSM detects breathing-induced movement of the chest based on the Doppler phenomenon. It measures breath at distances of up to 15 feet behind an 8 inch hollow concrete or wooden wall. A Radar Flashlight [11] was built to make use of this capability in assisting law enforcement personnel to detect individuals hidden behind walls. In 2000, RVSM was used in non-contact polygraphy [12]. The disadvantage of this technique is that motion artifacts corrupt breath signals and specialized frequency filters need to be used to separate them.

In 2000, infrared imaging proved its potential in deception detection when thermal image analysis was used by Pavlidis et al. to detect facial patterns of stress at a distance [13]. A little later Pavlidis et al. used infrared imaging to compute periorbital perfusion as a replacement of the corresponding polygraph channel that uses finger contact sensing [14], [15]. The proposed use of infrared imaging for computing breathing function may also replace the corresponding polygraph channel that uses abdominal transducer. Incremental replacement of contact channels with non-contact ones may prove very effective in the field of polygraphy, where it is essential that subjects feel as comfortable as possible during examination.

Moreover, highly automated, non-contact monitoring of breathing function may have a significant impact on certain biomedical applications. For example, in sleep studies this new methodology will enable monitoring of sleep apnea with minimal or no wiring of the subject, potentially at his\her home and not in the lab. This will not only improve the subject's comfort but also facilitate much more sustained monitoring than is currently feasible.

The use of infrared imaging for measuring breathing function is based on the fact that the exhaled air has temperature higher than the typical background of indoor environments. This creates a discriminating thermal signature that can be captured through an infrared imaging sensor. The phenomenon is quasi-periodic and can be quantified using either statistics or calculus. From the statistical point of view one can model the breathing cycles as multi-Normal distributions – one with "cold" temperatures corresponding to inhalation and one with "hot" temperatures corresponding to exhalation. From the Calculus point of view one can model the quasi-periodicity of breathing through Fourier analysis.
In the present article, we describe a statistically based methodology for quantifying breathing rate on infrared imaging data. Alternative methodologies, like Fourier analysis, can be used but are not addressed in our present work. Our goal is to open a new line of research by demonstrating the feasibility of monitoring breathing function in a highly automated and non-contact fashion.

2. Breathing Function

Respiration in a man involves three well defined stages [16]. The first stage called breathing comprises of inspiration, which is the process of taking oxygenated air into the lungs and expiration, which is discharging out air rich in carbon dioxide. The second stage involves the transport of the oxygen to the cells of the body using the heart and the vascular system. The third stage is called cellular respiration where oxygen is used in the process of generating energy for physiological activities.

In our study, we are interested in monitoring breathing using infrared imaging. The breathing cycle consists of inspiration, expiration, and post-expiratory pause. During quiet breathing, inspiration begins due to negative pressure created inside the chest cavity by the contraction of the diaphragm. Expiration is a passive process where the air flow occurs due to the elastic recoil property of the lungs. The post-expiratory pause is caused when there is equalization of the pressures inside the lungs and the atmosphere.

Breathing cycle is defined as the time interval between the beginning of inspiration and the end of post-expiratory pause. During quiet breathing, the breathing rate may vary from 12-20 breaths/min and after physical activity, 30-40 breaths/min in healthy individuals. Figures 1(a) and 1(b) show typical duration of the three phases during quiet breathing and after physical activity respectively.

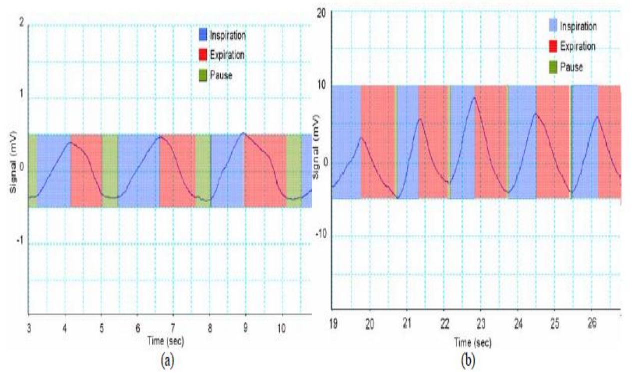

Figure 1: Output from a piezo-respiratory belt transducer showing the three breathing phases during (a) quiet breathing and (b) after exercise.

During quiet breathing, the duration of post-expiratory pause is comparable to that of inspiration and expiration. After a person undergoes physical exertion, the post-expiratory duration reduces considerably and in some cases, this phase may even cease to exist.

3. Tracking the Region of Interest(ROI)

We define as the Region of Interest (ROI) *R* the region in the background, where there is possible presence of respiratory airflow. It is in this small image region that our statistical algorithm is applied. The ROI is characterized by its size, shape, and position. Over time the size and shape of ROI remain the same but its position changes to cope with the subject's motion (tracking).

For simplicity, *R* was chosen to be a rectangular region. Typically, subjects are breathing through the nasal cavity, which results in a downward airflow profile. Breathing through the mouth is less prevalent and results in horizontal airflow profile. In our data set we observed downward airflow profiles (Figure 2(a)) in eight (8) video clips and horizontal profile (Figure 2(b)) in one (1) video clip. Hence, we chose a rectangular region *R* arranged in a longitudinal fashion to closely match the prevalent downward profile of airflow.

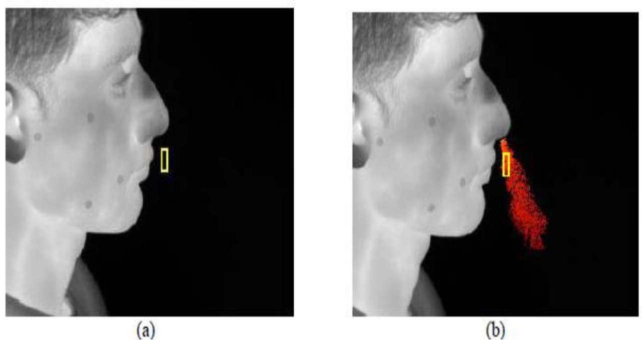

Figure 2: Visualization of breath during (a) non-expiration and (b) expiration. The ROI is anchored just under the subject's nose tip.

4. Contact Based Respiration Monitoring

Contact respiration rate monitoring instruments are usually based on measuring one of the following parameters:

respiratory sounds, respiratory airflow, respiratory related chest or abdominal movements, respiratory CO2 emission and oximetry probe SpO2. Respiration rate can also be derived from the electrocardiogram (ECG)

5. Chest and Abdominal Movement Detection

Chest and abdominal wall movements can best be measured by either mercury strain gauges or impedance methods. Respiratory inductance plethysmography is a non-invasive technique whereby two bands measure the respiration rate, the thoracic band which is placed around the rib cage and the abdominal band which is placed over the abdomen at the level of the umbilicus. The bands are made from an extendible/deformable conducting material, either a very fine wire or thin foil such that the conductivity can be maintained during the stretching process (2,5). The principle of the strain gauge sensor is based on increase in the resistance of a conductor when the area of the conductor is increased during the respiration process. Normally the inspiratory thoracic and abdominal expansion is almost synchronous. However, if the upper airway is partially obstructed, there may be a change in the phase angle and timing of the movements of the thorax and abdomen (6). The movements become asynchronous, ie the thorax moves inwards, and the abdomen outwards. During expiration this pattern is then reversed. Thoraco-abdominal asynchrony is a normal finding in infants in whom chest wall compliance is greater (7) and is exacerbated by respiratory disease or respiratory muscle weakness (8).

6. Literature Survey

This includes the literature of different authors related to the work:

Ta-Chi,Chiang et.al. [2016] have studied the noncontact respiration monitoring system combining image processing and data analysis. They implement the infrared thermal camera to obtain the gray scale to and split it into two parts, namely: face and nose. Firstly, the face is extracted from the image and nose is located from it. Secondly, we captured respiratory signal from the nose part of the image. Finally, the respiratory signal is divided into the (inhale) and (exhale) behavioristics. The data from inhale and exhale behavioristic were recorded and the analysist was done to the respiratory behavior.[1]

Alkali, Abd et.al. [2016] have studied the algorithm detected the tip of the nose and then, a region just under it was selected. The pixel values in this region in successive images were processed to determine respiration rate. The segmentation method, used as part of the facial tracking, was evaluated on 55,000 thermal images recorded from 14 subjects with different extent of head movements. It separated the face from image background in all images. However, in 11.7% of the images, a section of the neck was also included, but this did not cause an error in determining respiration rate.[2]

Karthik Mohan Rao1 et.al. [2015] have studied seven types of Respiration Rate monitors with different sensors. Respiration Rate monitor using Ultrasonic Sensor and Respiration Rate monitor using facial tracking method are the non-contact respiration rate monitoring system. Respiration Rate measurement based on Impedance Pneumography and Respiration Rate measurement are based on the Thoracic Expansion measurement include the sensor that are placed on the thorax. Respiration Rate monitor with MEMS based Capacitive Pressure Sensor, Respiration Rate monitor with temperature sensor, Respiration Rate meter–a low–cost design approach uses sensors that are mounted within the oxygen mask. Thus the Respiratory Rate Monitors discussed in this paper provide optimal result to detect changes in the severity of chronic illnesses. [3]

Farah AL-Khalidi et.al. [2015] have studied the shape and sizes of the region of interest (ROI) are investigated. The ROI represents the facial affected area most affected by exhaled air temperature changes. This area is the tip of the nose and the upper lip for the nose breathing and the mouth area for the mouth breathing. Segmenting the ROI was considered an important task in monitoring respiration by thermal imaging. Further work is in progress to enhance the algorithm so that it can cope with very large head movements. [4]

Farah AL-Khalidi et. al. [2015] have studied Respiratory rate is a vital physiological measurement used in the immediate assessment of unwell children. Convenient electronic devices exist for measurement of pulse, blood pressure, oxygen saturation and temperature. Although devices which measure respiratory rate exist, none has entered everyday clinical practice. An accurate device which has no physical contact with the child is important to ensure readings are not affected by distress. A thermal imaging camera to monitor respiratory rate in children was evaluated. Facial thermal images of 20 children (age: median=6.5 years, range 6 months-17 years) were included in the study. Recordings were performed while the children slept comfortably on a bed for duration of two minutes. Values obtained using the thermal imaging cameras were compared with those obtained from standard methods: nasal thermistor, respiratory impedance plethysmography and transcutaneous CO2.[5]

Farah Q Al-Khalidi et.al. [2011]: has introduced review of respiration monitoring approaches (both contact and noncontact) is provided. Concerns related to the patient's recording comfort, recording hygiene, and the accuracy of respiration rate monitoring have resulted in the development of a number of noncontact respiration monitoring approaches. A description of thermal imaging based and vision based noncontact respiration monitoring approaches we are currently developing is provided. [6]

R. Murthy et.al. [2005] have studied an advanced statistical algorithm based on multi-Normal data representation, the method of moments, and the Jeffreys divergence measure to address the problem. In experimental tests, they were able to compute correctly the breathing waveforms in eight (8) infrared video clips of three (3) subjects at distances ranging from 6-8 feet. The results were compared with ground-truth data collected concomitantly with a traditional contact sensor. The experiments demonstrated the promise of this modality, which may find applications among others in the next generation contact-free polygraph and in sleep studies. [7]

7. Problem Definition

A problem with airflow measurement is that some patients may not feel comfortable with the sensor. The collector can also affect respiratory activity by increasing dead space. The existing method worked well when the subject breathed through the nose (not mouth) and the mouth remained closed. An open mouth became the warmest facial region, causing the method to fail with some images, because the algorithm works only when the mouth is closed. Therefore, this problem (opened mouth) was dealt by only looking for the warmest region on the upper part of the ellipse thus excluding the mouth region.

Another problem with using a rectangular shape for the ROI is that the rectangular area always fills outside the boundary of the images in which the nose appeared to be too close to the edge.

8. Conclusion & Future Scope

In this paper I have conclude an improvement over the ECG method. In this review paper I have faced different problems that problems are airflow measurement is that some patients may not feel comfortable with the sensor. The collector can also affect respiratory activity by increasing dead space. In the future work these problems are resolved with the help of different methods with ROI algorithms.

References

[1] Ta-Chi,Chiang et.al. “The Non-Contact Respiratory Monitoring System Using Thermal Image Processing” 3rd International Conference on Green Technology and Sustainable Development , 2016
[2] Alkali, Abd et.al. “Thermal Image Processing for Real-Time Noncontact Respiration Rate Monitoring” Sheffield Hallam University Research Archive (SHURA) at 2016.
[3] Karthik Mohan Rao et.al. “A Review On Different Technical Specifications Of Respiratory Rate Monitors” IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 , Volume: 04 Issue: 04 | Apr-2015.
[4] Farah AL-Khalidi et. al. “ Respiratory Rate Measurement in Children Using a
[5] Thermal Imaging Camera” International Journal of Scientific & Engineering Research, Volume 6, Issue 4, April-2015
[6] Farah Q Al-Khalidi et. al. “Respiration Rate Monitoring Methods: A Review” John Wiley & Sons, Inc.,2011
[7] R. Murthy et.al. “Non-Contact Monitoring Of Breathing Function Using Infrared Imaging” Department of Computer Science University of Houston , April 09, 2005.
[8] Hamed Monkaresi, Rafael A. Calvo, and Hong Yan, “A Machine Learning Approach to Improve Contactless Heart Rate Monitoring Using a Webcam”, IEEE Journal of Biomedical and Health Informatics, .vol.17, No.9, pp.187-199
[9] Lee Seng Yeong, Ang, Li-Minn, Kah Phooi Seng, “Efficient connected component labelling using multiple-bank memory storage”, Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference, vol.9, pp.75-79, 9-11 July 2010.
[10] D.A. Socolinsky and A. Selinger, “A comparative analysis of face recognition performance with visible and thermal infrared imagery”. In Proceedings of 16th International Conference on Pattern Recognition, vol.4, pp. 217–222, Quebec, Canada, 2002.
[11] Fida’ Al-Obaisi, Ja’far Alqatawna, Hossam Faris, Ali Rodan, Omar Al Kadi, “Pattern Recognition of Thermal Images for Monitoring of Breathing Function”, International Journal of Control and Automation, Vol. 8, No. 6 (2015), pp. 381-392.
[12] Carina Barbosa Pereira, Xinchi Yu, Michael Czaplik, Rolf Rossaint, Vladimir Blazek, Steffen Leonhardt, “Remote monitoring of breathing dynamics using infrared thermography”, biomedical optics express 4382, 2015 Optical Society of America, published Oct 16, 2015.
[13] Zhou, Y., Tsiamyrtzis, P., Lindner, P., Timofeyev, I. and Pavlidis, I.: 'Spatiotemporal smoothing as a basis for facial tissue tracking in thermal imaging', IEEE Transaction on Biomedical Engineering, 2013, 60, (5), pp. 1280-1289.
[14] Edelman, G.J., Hoveling, R.J., Roos, M., van Leeuwen, T.G., and Aalders, M.C.: 'Infrared imaging of the crime scene: possibilities and pitfalls', J. Forensic Sci., 2013, 58, (5), pp.1156-1162.
[15] Murthy, J.N., van Jaarsveld, J., Fei, J., Pavlidis, I., Harrykissoon, R.I., Lucke, J.F., Faiz, S. and Castriotta, R.J.: 'Thermal infraed imaging: a novel method to monitor airflow during polysomnography', Sleep, 2009, 32, (11), pp. 1521-1527.
[16] Mostafa, E., Farag, A., Shalaby, A., Ali, A., Gault, T. and Mahmoud, A.: 'Long term facial parts tracking in thermal imaging for uncooperative emotion recognition', IEEEXplore, 2013,