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THERMALIMAGEPROCESSINGFORHUMAN RESPIRATION RATEMONITORING SYSTEM

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ABSTRACT:- *Respiration rate is an important indicator of an individual's health. It is the average number of times air is inhaled and exhaled per minute. A real-time thermal imaging based respiration rate monitoring method used to find the rate of respiration. It is not only measuring the respiration rate at the temperature changes under the tip of the nose it is also measures the respiration related to skin surface temperature. Facial tracking was used to monitor the motion of the head. The Robust algorithm used to remotely monitor breathing rate by using thermal imaging. The tip of the nose is detected and then, a region just under it was selected and detected inner corner of the eyes. A region of interest was created under the tip of the nose and the pixel values within it were averaged to produce a single feature for each image. The pixel values in this region between successive images were processed to determine respiration rate. The filtered signal was widowed with the Kaiser window and its magnitude, frequency spectrum was obtained. With the range of frequencies obtained the type of diseases are detected.*

INTRODUCTION

The processing of a two dimensional picture by a digital computer is called digital image. In a broader context, it implies digital processing of any two dimensional data. A digital image is an array of real or complex numbers represented by a finite number of bits. Given an image in the form of a transparency, slide, photograph or an X-ray is first digitized and stored as a matrix of binary digits in computer memory. This digitized image can then be processed and/or displayed on a high-resolution television monitor. This digitized image can then be processed and/or displayed on a high-resolution television monitor. For display, the image is stored in a rapid-access buffer memory, which refreshes the monitor at a rate of 25 frames per second to produce a visually continuous display.

With the development of technology, electronic circuits are shrinking and resulting in miniature circuits. As circuits will continue to shrink, it will need basic but very effective changes to manage its reliability constraint. Electronic component converts or change energy from one form to another. Some of the input energy is dissipated at the atomic level as the operatingand chip perform its function. This energy results as rise in case temperature of the semiconductor device. Electronic components by their nature produce heat as a result of the operation. This generated heat can lead to premature failure, degraded life or reduced reliability of devices or component itself, if not controlled within the limits. The general rule is, for an approximately 1°C rise in the case temperature above about 100°C, the chip failure rate getsincreased by about 5%. Due to this physical relationship, the design goal is to bind the component temperature to a maximum of about 100°C to 120°C for power semiconductors and about 90°C for microprocessors. Specifically, in case of BJT as temperature increases, leakage current increases significantly. Depending on the design of the circuit, this rise in leakage current increases the current flow through the transistor and thus the power dissipation as resultant.

In Power MOSFETs, rise in temperature typically increase their on-resistance. As this generated heat not only depends upon the operating conditions, but also on the component selected for specific work. This leads to the need of thermal analysis of specific electronic component. Electronic component manufacturers provide thermal characteristics in datasheet in the form of maximum and minimum operating temperatures and thermal resistances for various conditions. But these thresholds are captured for specific operating condition and strictly derived with specific procedures. Whereas, these conditions have the mere possibility to be followed in practice by the designers due to need of application or design. For this reason, it is important to monitor the thermal behavior of electronic components as per the way it is used in the specific application within a device or circuit. Following the tedious calculus can only navigate to the nearest possible condition, but some extra assumptions have to be made to attest the reliability of components and device. To avoid this, in-circuit, thermalanalysis of electronic components has to be done to assure the reliability and other related phenomenon of components. There are various methods which were adopted previously but have limited impact. Some of old methods use Thermistors, liquid crystals which are limited due to area covered, complexity and uncertainty involved. As the heat generated by any specific component will always be same if the component has the same task to do.This means its thermal behavior will almost be constant depending upon its use within the circuitry or device. So, taking advantage of this condition, it is possible to map the thermal behavior of specific component using thermal imaging techniques Infrared radiations are radiated from every object which is above absolute zero temperature because of the movement of atoms and molecules. The intensity of these IR radiations is directly proportional to the object's temperature. This means, more the temperature of an object more will be the IR radiations emitted from an object. The wavelength spectrum of infrared radiation is 0.78 to 1000µm (micrometers). This is longer than the wavelength of visible light yet shorter that radio waves. Because of this, these IR radiations are invisible to human eyes and need special setup. The wavelengths of infrared radiation are classified from the near infrared to the far infrared. The intensity of the emitted energy from an object varies with temperature and radiation wavelength. The emitted radiation lies completely within IR wavelengths when the object is colder than about 500 °C

An important physiological process and an important discriminatory indicator of urgency for medical attention is respiration [1-2]. Respiration rate is the average number of times air is inhaled and exhaled per minute. It needs accurate measurement in sleep related studies and disorders, neonatal care, critically ill patients and the diagnosis and management of respiratory diseases [3–5]. It produces numerous detectable signs, e.g. chest and abdomen movements and variations in infrared emission from the skin surface centred on the tip of the nose [6]. Existing respiration rate monitors are generally contact based [7], i.e. they need to be attached to the subject's body, thus causing discomfort during recording [8], which in turn may alter respiration rate. The attached monitor can also become dislodged and body movements can interfere with their readings.

There were a number of studies to develop non-contact respiration rate monitors based on technologies such as video imaging, ultrasound and radar detection and air flow measurement [9–17]. Video monitoring tracks chest and abdominal movements. It however suffers from illumination variations and is not practical in low light intensity environments [14]. Ultrasound and radar-based respiration rate monitors are highly sensitive to movements. Thermal imaging as a technology for long term respiration rate monitoring, has recently become more realistic as thermal imaging devices have significantly improved in their scanning speed, sensitivity and portability, while their cost has reduced [18]. They can accurately measure facial skin surface temperature changes under the tip of the nose as air is inhaled and exhaled and these are in turn processed to indicate respiration rate.

The facial tracking method reported in [25] filtered the thermal images, segmented the subject's face from the image background and located the two warmest points on the face that corresponded to the inner corners of the eyes. Once these two points were located, the coolest facial region beneath them was located. This corresponded to the tip of the nose. A circle was then placed over this region and the pixel values within it were averaged to produce a point on the respiration signal. The method however did not operate in real-time due to high computational intensity.
Martinez *et al.* [26] detected the eyes and nostrils in thermal images by considering the image segments that had intensities similar to those of the skin temperature and extracted their features using the Haar wavelets. The method was computationally intensive.
In [27], a region beneath the tip of the nose was chosen as a respiration region of interest (ROI) and was tracked using the method described in [28]. The left and right boundaries of the nose were detected by obtaining the horizontal gradients of the grid, while the locations of the nostrils were identified by examining the vertical and horizontal projection profiles of the nose.

A coalitional tracking was also reported in [30]. The coalitional tracking reported in [31] was based on a pre-selection of a template, thus requiring a user intervention. A solution to template pre-selection that could deal with the issues highlighted in [29–31] was reported in [32]. It however was constrained by several issues,e.g. computational intensity, need for selecting a suitable threshold, requirement for face to be stationary at the start and detection of an involuntary eye blink.
In thermal imaging, infrared radiation emitted from an object is dependent on its surface temperature and emissivity. Emissivity measures the amount of infrared radiation from an object as compared with a black body at the same temperature. For the human skin at 32 °C, the emissivity is about 0.98 [34]. The infrared spectrum has a wavelength ranging between 750 nm and 1 mm (400 THz–300 GHz) range. Thermal imaging is unaffected by illumination and is a safe technology [35].

In this study, a real-time thermal imaging-based respiration rate monitoring that detected facial skin surface temperature changes under the nose tip was developed and its performance was evaluated. The tracking method in this study reduces the restrictions on the subject during the recording as compared with the earlier studies thus providing a significant advance on non-contact real time respiration rate monitoring.

By using fuzzy logic, with the average respiration rate frequencies obtained the different type of diseases was detected. In the following sections, the methodology, results and conclusions of the study are explained.

LITERATURE REVIEW

2.1 Introduction

Literature survey is done in order to know the previously available techniques and their significance and limitations. It also includes the various supporting papers for the proposed technique and their advantages. Some of the previously available techniques in the image proposing are discussed for the proposed method to remove the shadows in the satellite images using image processing techniques.

2.2 Corner Detection in Infrared Images for Real-Time Noncontact Respiration Rate Monitoring

In this Approach thermal imaging based noncontact respiration rate monitoring approach is developed. The approach identified and tracked the face region in the image. The two corners where the eyes and nose meet were detected by selecting the two highest temperature regions within the face. From these sites, the nose and the nostril were identified. A respiration region of interest (ROI) was specified under the nostril. The skin surface temperature in this region is affected most by respiration. The selected ROI in each recorded thermal image was represented by a single feature. A respiration signal was produced from the plot of the feature across the series of recorded images. Respiration rate was determined by using the frequency of the highest peak in the frequency spectrum. The approach was evaluated on 5 adult subjects. It was shown that it could track the face, determine the ROI and respiration successfully in real-time, even when there were some head movements.

2.3 Evaluation of Thermal Imaging Based Respiration Rate Monitoring

An important indicator of an individual's health is respiration rate. It is the average number of times air is inhaled and exhaled per minute. Existing respiration monitoring methods require an instrument to be attached to the patient's body during the recording. This is a discomfort to the patient and the instrument can be dislodged from its position. In this study a novel noncontact, thermal imaging based respiration rate measurement method is developed and evaluated. Facial thermal videos of 16 children (age: Median = 6.5 years, minimum = 6 months, maximum = 17 years) were processed in the study. The recordings were carried out while the children rested comfortably on a bed. The children's respiration rates were also simultaneously measured using a number of conventional contact based methods. Results: This allowed comparisons with the thermal imaging method to be carried out. The image capture rate was 50 frames per second and the duration of a thermal video recording was 2 min per child. The thermal images were filtered and segmented to identify the nasal region. An algorithm was developed to automatically track the identified nasal area. This region was partitioned into eight equal concentric segments. The pixel values within each segment were averaged to produce a single thermal feature for that segment of the image. A respiration signal was obtained by plotting each segment's feature against time. Conclusion: Respiration rate values were automatically calculated by determining the number of oscillations in the respiration signals per minute. A close correlation (coefficient = 0.994) was observed between the respiration rates measured using the thermal imaging method and those obtained using the most effective conventional contact based respiration method.

2.4 Breathing Analysis Using Thermal Imaging

The paper is devoted to the study of facial region temperature changes using a simple thermal imaging camera and to the comparison of their time evolution with the pectoral area motion recorded by the MS Kinect depth sensor. The goal of this research is to propose the use of video records as alternative diagnostics of breathing disorders allowing their analysis in the home environment as well. The METHODS proposed include (i) specific image processing algorithms for detecting facial parts with periodic temperature changes; (ii) computational intelligence tools for analysing the associated videosequences; and (iii) digital filters and spectral estimation tools for processing the depth matrices. Machine learning applied to thermal imaging camera calibration allowed the recognition of its digital information with an accuracy close to 100% for the classification of individual temperature values. The proposed detection of breathing features was used for monitoring of physical activities by the home exercise bike.

METHODOLOGIES

RECRUITMENT

An assesssiment of facial features detection method was carried out on set of thermal images from different person in a college. A further evaluation in determining respiration rate was carried out against two contact-based respiration rate monitoring methods.

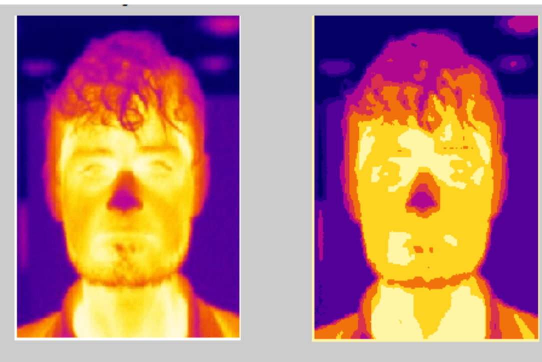
EXPERIMENTAL SETUP

Matlab (matrix laboratory) is a numerical computing environment and fourth-generation programming language. Developed by Math Works, Matlab allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran. Although Matlab is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems. In 2004, Matlab had around one million users across industry and academia. Matlab users come from various backgrounds of engineering, science, and economics. Matlab is widely used in academic and research institutions as well as industrial enterprises.

Matlab was first adopted by researchers and practitioners in control engineering, Little's specialty, but quickly spread to many other domains. It is now also used in education, in particular the teaching of linear algebra and numerical analysis, and is popular amongst scientists involved in image processing. The Matlab application is built around the Matlab language. The simplest way to execute Matlab code is to type it in the Command Window, which is one of the elements of the Matlab Desktop. When code is entered in the Command Window, Matlab can be used as an interactive mathematical shell. Sequences of commands can be saved in a text file, typically using the Matlab Editor, as a script or encapsulated into a function, extending the commands available.

RESULTS AND DISCUSSION

In this section, the study's results for Segmenting the images to localise face and find the determine location in the face to the images to localise face and find the determine location in the face to generating the respiration signal are presented. First we use to convert rgb to gray scale image because Conversion of a color image into a grayscale image inclusive of salient features is a complicated process. The respiration rate values obtained using thermal. imaging are compared against the values obtained using the two contact respiration rate monitors.



a b

Fig.1 morph image convertion
a original image
b converted image Fig. 1 morph image conversio

IMAGE PROCESSING TASKS

The converted grayscale image may lose contrasts, sharpness, shadow, and structure of the color image. To preserve contrasts, sharpness, shadow, and structure of the color image a new algorithm has proposed. To convert the color image into grayscale image the new algorithm performs RGB approximation, reduction, and addition of chrominance and luminance. The grayscale images generated using the algorithm in the experiment confirms that the algorithm has preserved the salient features of the color image such as contrasts, sharpness, shadow, and image structure. Then we continuing processing the image and remove the noise coefficient data by using Gaussian filter. A Gaussian filter is a linear filter. It's usually used to blur the image or to reduce noise. If you use two of them and subtract, you can use them for "unsharp masking" (edge detection). The Gaussian filter alone will blur edges and reduce contrast.then we proceed filtering process by using median filter. The Median filter is a non-linear filter that is most commonly used as a simple way to reduce noise in an image. It's claim to fame (over Gaussian for noise reduction) is that it removes noise while keeping edges relatively sharp. Briefly, this involved manually segmenting the image to produce the ground-truth by experimenting with different segmentation thresholds and visually observing the outcome against the subject in the image. The ground-truth was compared against the segmented images obtained using the inter-variance, moment and entropy.

c d

Fig.2 using fussy algorithm
c original image
d Search area to locate the inner corners of the eyes in three subjects

This was performed by determining the total number of pixels (Ptg) in the ground-truth that had a binary value of 1 and then ANDing these pixels with the segmented image using each of the three techniques. The total number of pixels (Ptm) in the resulting image that were 1 was determined. The closeness of each segmentation to the ground-truth was determined by the following equation

Percentage closeness = Ptm Ptg × 100

The inter-variance method was used in this study as it was closest to the ground-truth. The algorithm's computational requirement was sufficiently low for real-time operation.

2.4 Detecting the inner corners of the eyes

To detect the inner corners of the eyes, a search region and an approach to analyse it were needed. These are explained in the next sections.

2.4.1 Determining the search region:

In the horizontal profile (Hp(x)), a region existed between the detected sides that contained information about the location of the inner corners of the eyes (Fig. 1*b*).

This region exhibited largest abrupt changes, mainly because the inner corners of the eyes have highest segmented facial temperature. This temperature difference was further enhanced by the method in which the pixel values within each cell were replaced by their maximum. The local top and bottom minima on the horizontal profile, where these changes occurred were marked as top (x_{tf}) and bottom (x_{bf}) feature areas, respectively. Since this information did not specify the vertical coordinates of the inner corners of the eyes, a search area was created spanning from the left y_{lt} to the right y_{rt} boundaries. Thus, the feature search area F_{sa} was over a region that was contained within (x_{tf} , y_{lt}) to x_{bf} , y_{rt}.

2.4.2 Search region analysis approach:

According to the anthropometry of the face, the separation between the inner corners of the two eyes (i.e. the distance between the two medial inter-canthals, *B*) is approximately one-fifth of the breadth of the head (*H)* [39, 40]. Therefore, a search template of size 3(H /5) was created. The search was initiated from the left-top corner of the selected region, moving forward by a pixel at a time to the end of the right side and then returning the left, a pixel below the previous row. The template that contained two peaks, separated by about H/5, indicated the location of the inner corners of the eyes. When the face was fully visible in the image, the template contained two peaks with similar magnitudes separated by about H/5. For images that full face was not visible, the side of the eye nearest to the camera had a larger peak.

2.5 Detection of the tip of the nose

The tip of the nose was located by the vertical projection of the region enclosed by the identified inner corners of the eyes and the bottom boundary of the face. As the tip of the nose is the coolest facial point under the eyes, it corresponded to the lowest point in this vertical projection.

2.5.1 Generation of respiration signal

Once the tip of the noise was detected, a circle with radius 5 pixels was placed under it and pixel values within it were averaged to produce a point on the respiration signal.

This process was repeated for the successive images and every 20 consecutive points of the respiration signal were filtered using a fourth-order Butterworth filter that had a cut off frequency of 2 Hz. The respiration signal was continuously displayed in real-time to aid monitoring of the data recording. After each 1024 points, the filtered signal was windowed with the Kaiser window (flatness value = 0.5, this value was chosen as it suitably tapered the signal edges without significantly altering its shape) and its magnitude frequency spectrum was obtained. The frequency corresponding to the largest peak in the spectrum was multiplied by 60 to obtain respiration rate in cycles per minute.

FUZZY LOGIC

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets[42][46]. The representation and processing depend on the selected fuzzy technique and on the problem to be solved[43]. Fuzzy image processing has three main stages, image fuzzification, modification of membership values, and, if necessary, image defuzzification[44][45]. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques[46][49]. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values[46][50]. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on, [45][50]. Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware[47][51]. Edges characterize boundaries and Edge detection is one of the most difficult tasks in image processing hence it is a problem of fundamental importance image processing[46][48]. Edges in images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality[42]. Edge detection of an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image[47]. Digital image processing allows one to enhance image features of interest while attenuating detail irrelevant to a given application, and then extract useful information about the scene from the enhanced image[42][46].

CONCLUSION

A real-time thermal imaging based noncontact respiration rate monitoring method was developed. Its ability to segment the face from the image background was tested. The thermal imaging respiration rate monitoring was evaluated by comparing it against the contact respiration rate monitoring methods that used thoracic and abdominal bands. The respiration rate values obtained using the three methods were very close. In the remaining three subjects that had very large head movements that led to a significant proportion of the face to move out of camera's field of view, the respiration rates from the thermal imaging method was not accurate. The existing method works well in scenarios that head movements are not so large to cause the face to move out of camera's field of view and find advance diseases with help of respiration rate system.

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