Design of an Embedded Monitor System with a Low-Power Laser Projection for the Detection of a Patient’s Breath

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Abstract— Our design uses a low-power laser reflection mark to detect the chest fluctuation of a patient’s breath. If the breath rate is abnormal, a warning message is sent to the hospital by the embedded system.

I. INTRODUCTION

The traditional ways of monitoring the breath rate involve contact with the human body. For example, for Impedance Pneumography, one side of the electrode, which is placed on the skin of the chest, sends a high-frequency current and concurrently uses the other side of the receiving electrode to receive the current changes that take place during a breathing cycle. The earlier methods require some sort of tying up or other contact with the body. Thus there is a need to design a method of breath detection that avoids contact with the human body. Our design detects chest expansion and contraction in a way that is similar to the detection of a moving object by laser reflection [1-2]. There are three major methods used to detect a moving object. First, “temporal differencing”, which is used to find the difference between two continuous image data, obtains the changes in the volume of a moving object [3]. If the background variation is not great, this method works well. Second, “background subtraction” establishes the background of the images and then inputs one image after another in order to cancel the background and to obtain the moving object [4]. This method, which produces a complete outline of moving objects, is very sensitive to changes in the environment because the background is established from the very beginning. Third, “optical flow” calculates moving locations in time to discern each pixel in the image [5]. This method requires a large amount of computing, and its use in an embedded board seriously affects efficiency. In our previous design, we have already used the image processing method with “temporal differencing” whose use in the embedded board does not result in much of a burden [6].

II. OPERATION ENVIRONMENT OF THE SYSTEM

Fig. 1 shows the operation environment of our system. We use a low-power laser irradiating a patient’s chest with a smooth reflection surface and let the laser reflect this onto the wall. Then we use the Webcam to monitor the laser projection on the wall. For home healthcare our design sends images captured by the Webcam to the embedded board which through digital image processing determines whether the breath rate is normal. The LCD displays the real-time status of the breath rate on the embedded board. If no signs of breath are detected, a warning message is sent to the hospital by the network interface of the board.

III. USING THE TEMPORAL DIFFERENCING METHOD AND LASER REFLECTION METHOD TO DETECT MICRO-VIBRATION

The “temporal differencing” method uses two continuous images for subtraction to detect moving objects. It quickly adapts to changes in lighting or background. Although this method may detect moving objects which are already broken up, we learn if any moving object is detected.

Fig. 2 shows the temporal differencing method which reads the continuous image from the Webcam, then fetches the separated image and processes it at the gray level. It finds the subtraction of the continuous images, chooses the threshold value for the decision, uses a Gaussian filter to remove noise and then obtains the moving object.

When a patient breathes, the chest displacement is small. So we propose the laser reflection method to enlarge the displacement of the chest to detect the breath rate more easily. Fig. 3 shows the projection length of the moving object. X is the downward displacement of the chest which can be amplified by laser reflection onto a tilted wall. The magnification of the projection length is shown in Eq. (1).

\[
\frac{Y}{X} = 2 \times (\sin r \tan (\theta + r) + \cos r)
\]

By Eq. (1) we have the relationship between magnification and oblique angle of the wall which can easily provide a 10-times amplification if \(\theta \geq 20^\circ\) and \(\theta + r \geq 80^\circ\).
Our design integrates the embedded board with a Webcam. The sensor element of the Webcam is CMOS, which has 300 thousand pixels, and a focus from 20 mm to 10 m. The core of the embedded system is the operating system, and our design uses Linux and a C-code program to meet the efficiency requirements.

Fig. 4 shows the software user interface of our design whose indicators show the direction of the chest movements by the laser projecting point on the LCD display as “up” or “down”. It means the moving direction of the ribcage.

V. CONCLUSIONS

Our design uses a Webcam, the temporal differencing method, the low-power laser reflection method and an embedded board to monitor the patient’s breath without the inconvenience of any contact with the body. Laser projection can magnify the moving distance by more than 10 times. Our design therefore detects chest expansion and contraction more easily. The additional cost is small for monitoring a patient’s breath in home healthcare.

REFERENCES