Real-Time Image Based Homecare Service System

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Abstract: - In this paper, a monitor system for homecare service is developed, which can recognize expression of the patient and track the location of the patient. A single camera and image processing technique is utilized to develop the system and the following tasks are achieved. 1. When the patient lies on the sickbed, we can measure the position and height of the patient's body and provide the data to the second subproject to adjust the sickbed such that the patient can be much comfortable. 2. When the patient leaves the sickbed, we can track the location of the patient and detect if there is any accident happened. 3. According to the recognized gesture of the patient, we can understand what he (or she) wants or whether he (or she) needs some help. Then we can know the requirement or feeling of the patient. 4. The system can also recognize the expression of the patient. If the system detects pain expression, there will be alarm sound to notice nurses. This paper is provied an automation system for taking care of those who suffered for illness with an real-time monitoring and tracking system. The purposes are to make less the burden of the staffs whose job is to take care of the patients, and to give the patients the feeling of being unrestrained.

Key-Words: - gesture, expression, recognition, real time, eye detection.

1 Introduction

Nowadays, there are so many people who have suffered from whether it is a physically or mentally impairment and disability. Some serious illnesses make people even unable to take care of themselves. Therefore, the homecare system takes an important role in the dependency of the body and mind of humanity.

In order to apply this caring system to the hospital or homecare to be able to reach the automation, and also for the time being able to decrease the burden for nurse or staff who take care of the patients, by using the CCD video camera to monitor the patients conditions is one of a good solution. The using of CCD in video processing, image processing, analyzing, and its making out following the technology development has shown many achievements but most of the usages are built on different purposes. This paper is provied an automation system for homecare of those who suffered for illness, direct speaking is not to let the patient to move from the sickbed and offering the watcher an immediate monitoring and tracking. The purposes are to make less the burden of the staffs whose job is to take care of the patients, and to give the patients the feeling of being unrestrained, to keep the respect of humanity rights, and at the same time to enjoy a better quality of live.

These last few years, the detecting, the measuring, and the identifying of the human face needs to be taken seriously. Since, the human's facial expressions usually reflect their feelings and their thoughts. The most important technology is to determine someone's emotional expression by the capture face image, e.g. eyes, eyebrows and mouth. The measurement of eyes is divided into two methods. The first method is using the infrared rays to increase the rate of identifying and simplify the intensity of complexness. When the infrared rays are beamed to human's face, the pupil of the eye which taken the infrared rays would result a different phenomenon of reflection. This method could easily determine and track down a precise position of the eye [1], [2]. However, we also know that human's eyes can not see the infrared rays, which forces us to use a special well-designed infrared rays video camera that could let our retina to detect the reflected infrared rays. That means it increases our expenses in equipments as well. The other hand, the infrared rays themselves have already possessed some amount of power, a human-made infrared rays will even more be provided with even a higher specified power, and this power is big enough to harm our retinas which makes us to give up this method.

Another method is using the most basic image processing to deal with the problem. [3] By using the Principal Component Analysis (PCA) and Active Appearance Models (AAM) we could detect and measure the position of eye but this method sure will take some amount of time of training. [4] bring up with the idea of using the block area as deformable template to find out the block area of the eye. [5] transfer RGB into YC_bC_r makes the observer to be able to see that around the eye there are a very high value of C_b and a very small value of C_r. By using this two characters would strengthen tracking the area of the eye.

[6] is a method that have the best result for various emotional expressions determination, when there are many changes of emotional expression of patient. The idea is that using action units as the base of identifying by the captured one's part of face image, like eye, eyebrows, mouth and the characteristics of lines. The captured image could convert all of these characteristics into parameters using the neural network. The weakness of this method is that we need a long time to deal with, unable to achieve real time processing and need to the training time when a problem appeared.

In this paper, a monitor system for homecare is developed, which can recognize expression of the patient and track the location of the patient. A single camera and image processing technique is utilized to develop the system and the following tasks are achieved. 1. When the patient lies on the sickbed, we can measure the position and height of the patient's body and provide the data to the second subproject to adjust the sickbed such that the patient can be much comfortable. 2. When the patient leaves the sickbed, we can track the location of the patient and detect if there is any accident happened. The purposes are to decrease the needs of human power and to share the responsibilities of taking care of the patients, hoping that this monitoring system could become more efficient and having a more accurate using.

The paper is organized as follows: Section 2 presents the system of our proposed homecare service system. The simulation result and some discussion for the proposed system is described in Section 3. Finally a conclusion is drawn in the final section.

2 The System of Homecare Service

The four subsystems are included in the homecare service system. There are the height of body measuring, the location of patient tracking, hand sign identification and identify emotional expression.

2.1 The Height of Body Measuring

A start position of a person is given that when a person was stand on a fixed position or lay down on the sickbed. The system measures the body height immediately with adjust the measuring result by the height of the sickbed and the location of the bed plank. A complicated background could affect the appearance of a noise. The mean filter and twice erosion are used to solve this problem. First, the system build a background information as I_{back}, the capture image I_{now}. We apply the subtracting function to I_{now} and I_{back}, then get the position of a person, as shown in equation(1). one of the Th_R、Th_G and Th_B is becoming the threshold value of R、G and B. In this paper, we take $Th_R = Th_G = Th_B = 25$ for $I^R_{now}(x,y)$, $I^G_{now}(x,y)$ and $I^B_{now}(x,y)$.

$$I_b(x,y) = \begin{cases} 0, \ if \quad I^R_{now}(x,y) - I^R_{back}(x,y) < Th_R \ and \\ \quad I^G_{now}(x,y) - I^G_{back}(x,y) < Th_G \ and \\ \quad I^B_{now}(x,y) - I^B_{back}(x,y) < Th_B \\ 1, \ otherwise \end{cases} \quad (1)$$

Using the morphology of the erosion and dilation to eliminate the noise and reduce the light effect of an image. The mask is used for the image operation, the mask shown in Fig.1, as one of the pixel of P1、P2、P3、P4、P6、P7、P8 or P9 as the background, set P5 as a background, on the other it is moving object. By the result of erosion, the complete appearance of a person is gotten. By image scanning, we get the quantity of pixel position of a height of a body, which makes us be able to calculate the body height of a patient by using each pixel stands for the actual size of an object.

P1	P2	P3
P4	P5	P6
P7	P8	P9

Figure 1. The mask of 3×3 block

2.2 The Location of Patient Tracking

In order to determine the location of patient, we set the uniform that was worn by the patient by easiest color which is a light green.

From the captured image that was captured by the video camera, and sent to a computer. This picture then seen as an RGB color of an image, which means that each pixel has its three bits that construct for the image color. But the RGB image is easy to be interfered by the light, for example, by having the same color with the light change could interfere the value of RGB. In order to get the exact scope value of a patient, this system of RGB must be set so that it's not easy to be interfered with the HSI color presentation. HSI means that each pixel could present a Hue, Saturation and Intensity. The range of Hue is $0^\circ \sim 360^\circ$, the range of Saturation is 0 ~ 1, and the range of Intensity is 0 ~ 255. The conversion formulas are shown below on equation(2), (3), and (4).

$$H = \begin{cases} \theta, & if\ B \le G \\ 360-\theta, & if\ B > G \end{cases} \quad (2)$$

where

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}\left[(R-G)+(R-B)\right]}{\left[(R-G)^2+(R-B)(G-B)\right]^{\frac{1}{2}}} \right\}$$

$$S = 1 - \frac{3}{(R+G+B)}\left[\min(R,G,B)\right] \quad (3)$$

$$I = \frac{1}{3}(R+G+B) \quad (4)$$

Due to the experiment measurement, the patient's uniform color area is $100^\circ \sim 150^\circ$, where $G-B>10$ and $G-R>10$. If the tracking object fit with three conditions, the patient is determined. In order to detect and measure whether the patient who is under the sickbed have an incident or not, like getting fell down and unconscious. A new method for the background [5] is used, the formula shown below

$$I_{REF}(s,t+1) = \gamma(s,t)I_{REF}(s,t) + (1-\gamma(s,t))I(s,t+1) \quad (5)$$

where,

$$\gamma(s,t) = \begin{cases} 0 & motionless\ and\ I_{REF}(s,t)\ not\ exists \\ 0.5 & motionless\ and\ I_{REF}(s,t) not exists \\ 1 & motion \end{cases}$$

If the patient fell unconscious, as a result of a continuous renewing background. The system can detect the incident might happen which next will tell the health staffs by send an alarm.

2.3 Hand Sign Identification

We use the method of skin color to detect and measure the hand sign. First, the capture image transfers the RGB color space into NCC (Normalized Color Coordinates) color. Since the model of RGB color presentation is very sensitive with the variation of light. The NCC coordinates can also decrease the dependency of color and luminance. The transform equations are shown below

$$r = \frac{R}{R+G+B} \quad (6)$$

$$g = \frac{G}{R+G+B} \quad (7)$$

Equation(6) is the normalization for the red color, it decrease the dependency of red color to luminance. The equation (7) is the normalization for the green color to decrease the dependency of green color to luminance. Next is the definition of an area of skin color, shown in Fig. 2, with the vertical axis *g*, and the horizontal axis *r*. We could see that the units area of skin color is approximately gather at the point of $0.2 < g < 0.4$, $0.2 < r < 0.6$.

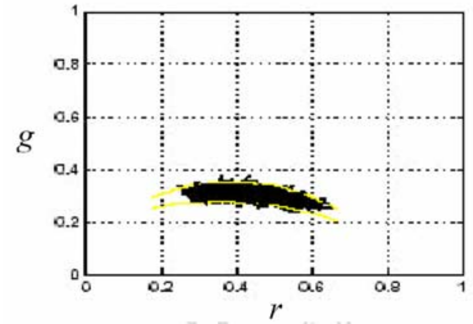


Figure 2. skin color area

By using the second quadratics formula, we could get the upper part $F_1(r)$ and the lower part $F_2(r)$

$$F_1(r) = -1.376r^2 + 1.0743r + 0.1452 \quad (8)$$

$$F_2(r) = -0.776r^2 + 0.5601r + 0.1766 \quad (9)$$

As we know that the white color (r = 0.33 and g = 0.33) is also in the range of the area so that we join it into the terms of the lower area of addition and subtraction.

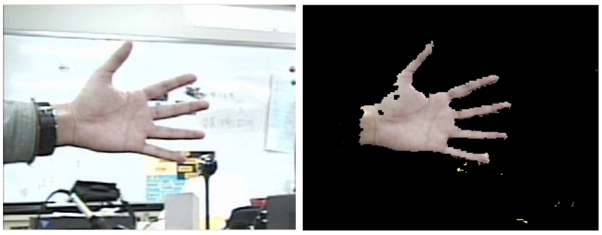
$$w = (r-0.33)^2 + (g-0.33)^2 > 0.0004 \quad (10)$$

Combining above equations, we could get the area for the skin color, shown in equation(11), when S = 1 means that the content that it determine is having the color of skin.

$$S = \begin{cases} 1 & if\,(g < F_1(r)\ \&\ g > F_2(r)\ \&\ w > 0.0004) \\ 0 & otherwise \end{cases}$$

(11)

Fig.3 shows the detecting and measuring of skin color.



(a) (b)

Figure 3. detecting and measuring the skin color (a)captured image (b)detected and measured skin color

The morphology method is used to eliminate the noise and to patch the image of hand. Then, the image transfer to binary image, give the white color for the hand's part, and black color for others. Next, the Sobel operation is used to obtain the rough sketch of the edge of hand. The calculation is shown below on equation (12) and (13),

$$G_x(i,j) = (C(i-1,j+1) + 2\times C(i,j+1) + C(i+1,j+1)) - (C(i-1,j-1) + 2\times C(i,j-1) + C(i+1,j-1)) \quad (12)$$

$$G_y(i,j) = (C(i+1,j-1) + 2\times C(i+1,j) + C(i+1,j+1)) - (C(i-1,j-1) + 2\times C(i-1,j) + C(i-1,j+1)) \quad (13)$$

Having both above formulas, $C(i,j)$ behave as the image position having the i column and j row of pixels value. If the value of $G_x(i,j)$ is higher than the threshold value (500) then the direction of edge is set to be a horizontal edge, or else it is a vertical edge. The same principal goes for the $G_y(i,j)$, If the value of $G_y(i,j)$ is higher than the threshold value (500) then the direction of edge is set to be a vertical edge, or else it is a horizontal edge. By combining both vertical and horizontal edges of signal, we could immediately get the rough sketch of hand, shown in Fig.4.

Figure 4. Measuring the hand edges

By using the edge images, the median position of hand and the distance of each edges of hand are calculated, the farthest median position is gotten. For example we take the point as θ_w, following this point, we could differ hand's parts into two parts, namely finger part area and non-finger part area, where the finger part area is $\theta_w - 90^\circ < \theta < \theta_w + 90^\circ$, shown in Fig.5.

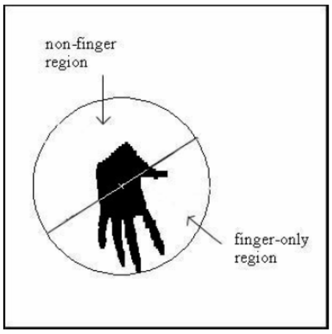


Fig.5 Finger detection

Considering the median point of hand as the center of circle, the radius starts from 0 increasing, when the circular scanning of hand edges is on progress, it records the points and the positions that it read. When the circular size is more than the area of hand, it stops scanning.

From radius of 0 – 360 degree, there would be edges of hand, where each one of the peak values stand for one finger, and from the last circular scanning, we get the number of peak values, and afterwards we'll be able to identify the signal of hand successfully. [7]

2.3 Identify Emotional Expression

The Y, C_b, Cr presentation image is used to identify the emotional expression of the patient. Since, there is a very high value of C_b and a very low value of Cr around the eye and the color of eye are different greatly with the color of skin. Eye map is obtained by Y by using the equation (15).

$$EyeMap = \frac{Y(x,y) \oplus g(x,y)}{Y(x,y) \otimes g(x,y) + 1} \quad (15)$$

The symbol $\oplus$ and $\otimes$ present the dilation and the erosion operation for the grey level image.

After the face image getting, the eye and eyebrows are determined by the eyes are the upper part of face, and following the above mentioned method. In order to decrease the computational complexity for the image processing, this system only identify the painful emotional expression of the patient. This is the important emotional expression that a hospital needs to consider. When a person shows a painful expression, he sure bends his eyebrows and there would be a great number of wrinkles occurred around the brows. The idea for emotion expression identification based on these wrinkles around the brows. The system find out the area of brows which are colored in white are eyebrows. By knowing this, we could easily get the area of brows. As well know, the Sobel vertical operation is used for the measured edge to get the result that there is no phenomenon of eye. However, when there is a painful expression of face there would be great changes of wrinkles in the eye edges.

3 Simulation Result and Discussion

Fig. 6 shown the proposed homecare system. The height of body is measured very accurately. In the hand sign identifying, this system not only can determine the exact signal but also able to overcome two troublesome problems, the size of palm and the direction of palm. This system can detect the changes of direction and the size of the palm with the principal of skin color.

The emotional expression determination is analyzed by the characteristics of face. Since, the character of eye is detected and exacted the position. By many experiments this could affect the measuring the image of eye are very important. There are three main causes is due to the system will failure. The first is that because of the light effect which could affect the skin color to lapse, and cause the face part to be incompletely detected, results the measuring of the eye to be a failure. The second, when a person's fringe of hair grew longer and accidentally covered the eye, this way could also make the eye measurement failed. The third, according to the mathematical formula that we performed before, when the patient wore a glasses, and it might because of the edge of the glasses that possible to make a loss during the detecting and measuring the eye.

Figure 6. The proposed homecare system

4 Conclusion

In this paper, we proposed a system for homecare system. This system provided two achievements, first is that for the patient: determining and tracking the location and position of the patient, then detect if there is an incident happened during the health care like being unconscious, and also to let this system to be able to warn the health staffs. The second is that for the changes of emotional expression: when this system detects any painful expression of faces, the system will also give a warning to the health staffs to solve the matter. In the future, we could increase the kinds of emotional expression identification. However, that would also increase the time to deal with and the time to calculate the mathematical operation. This is what should be overcome in the next day.

References:

[1] Z. Zhu, K. Fujimura, Q. Ji, "Real-time eye detection and tracking under various light conditions," in: ACM SIGCHI symposium on eye tracking research and applications, New Orleans, LA, USA, 2002.

[2] C. H. Morimoto, D. Koons, A. Amir, and M. Flickner, "Pupil detection and tracking using multiple light sources," Image and Vis. Comput. 18 (2002) 331-335.

[3] F. De la Torre, C. Garcia Rubio, and E. Martinez. "Subspace eye tracking for driver warning," Proc. of ICIP, 3:329-332, 2003.

[4] J. Deng and F. Lai, "Region-based template deformation and masking for eye-feature extraction and description," *Pattern Recognition*, 30(3):403-419, 1997.

[5] R. L. Hsu, A. M. Mohamed, and K. J. Anil, "Face Detection in Color Images," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 24, no. 5,

2002.
[6] Y. L. Tian, T. Kanade, and J. F. Cohn, "Recognizing Action Units for Facial Expression Analysis," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol.23, no.2, 2001.
[7] E. J. Holden and R. Owens "Recognizing Moving Hand Shapes," Proceedings of the 12th International Conference on Image Analysis and Processing, 2003.