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Non-Intrusive Distress Signal Detection using Image Processing

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***Abstract* – Intrusive systems have the ability to achieve desired results of distressing using various methods like heart beat measurement, temperature sensing, humidity sensing, blood pressure measurements etc. but these systems have a major drawback of being intrusive. However, an efficient non-intrusive system which could replace the above mentioned systems can be developed with the help of image processing. Real time incorporation of the same can also be possible with the help of open source software's and assisting hardware. Not only will the system overcome the drawbacks of intrusiveness but also an impulsive real time system can be implemented.**

***Keywords* – Human Eye, Signaling, Distressing.**

I. Introduction

Distress signals play an important role in modern human life which is completely dependent on the technologies available worldwide. Before the invention of the same, there were convenient yet effective ways of distressing a panic situation but it had several limitations like distance of communication, compatibility of systems, not so developed communication means etc. to overcome all these in a simple and cost effective manner, modern image processing methods are being used in addition to standard distress signaling techniques.

A person at other end may not be able to respond to the distress signal as he may not know what signal is the person at this end is trying to give. Hence, a universal system needs to be incorporated in order to achieve the desired result. Conventional intrusive methods do yield the required output but these cannot be used in mobile places or systems wherein hardware /system interference is not required like a person who wants to distress his condition of being held at gunpoint in a car or a person who is not capable of moving his limbs in a hospital. Hence at such times, non-intrusive systems are vital and are a smart method of distressing the particular authority.

II. Methodology

The flowchart of the overall working of the system is as shown in figure (1). As the basic approach is using image processing, a camera source is required to acquire the images from the source. Since the system is real time application based, video camera with an acquiring capacity of 30-40 images/frames per second is used. An image/frame is an array of pixels arranged in a logical order (rows and columns). These pixels are the building elements of an image which have various gray levels depending on the representation of the same in digital form. For e.g. an 8 bit pixel will have 2^8 =256 levels or shades of colour (black and white). The extreme level 255 will correspond to white and level 0 will be represent black. In case of colour pixel, it comprises of 3 planes R,G,B which correspond to red, green and blue colour values respectively. Real time images are taken continuously from a camera mounted on the dashboard of the car or in the patients room. Face is extracted using Haar like features and real time face detection [2]. Eye region is extracted from the detected face using theory of approximations and rounding off of face regions. Though approximate, the efficiency of drawing out eyes from an extracted face is reached is up to 98.7% followed by correct distressing too. A high definition video camera could output the efficiency to 100% by reducing unwanted blurring or corruption of extracted images.

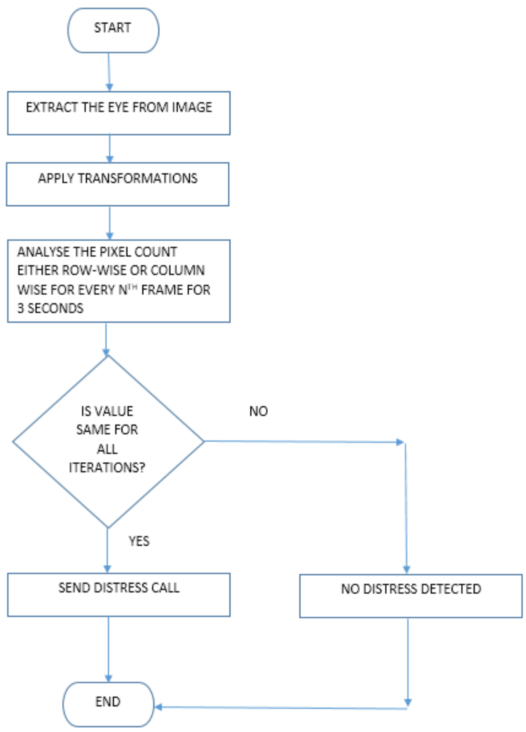

Fig.1. Flowchart for the algorithm

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There could be various combinations using eye movement to signal distress. Here we have used the closed eye method. The frames captured by video camera is cropped to get eyes which is the region of interest. The flow of distress signal using eyes is as shown in figure (2). The algorithm also focuses on various transformations in the extracted images as it is quite essential for it to be efficient during all conditions be it during the night or during the day too. Transformations not only enhance the image quality but also makes it easier for computer vision to differentiate between slight or extreme variations in the gray levels of the extracted image. The transformation to be applied is a stepwise process and its flow is shown in figure. (c).

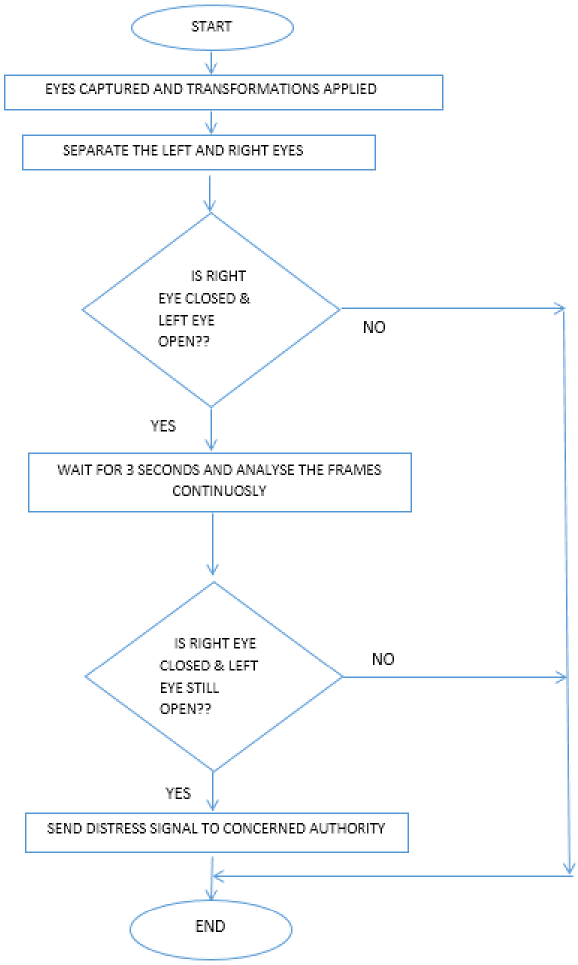

Fig.2. Identification of distress signal flow.

The very first transformation applied after gray level conversion is histogram equalization. A histogram is a plot of pixel intensities to the no of pixels. This needs to be equalized to enhance the black portions of the image if in case the image is taken under low light conditions. The next operation performed is bit plane slicing. Since most of the image information is present in the MSB plane of the gray level, we have extracted the MSB plane of the acquired image. The image is now ready for mathematical assessment.

$$F(x,y) = \sum_{i=0}^{N} \sum_{j=0}^{M} I(i,j) \quad (1)$$

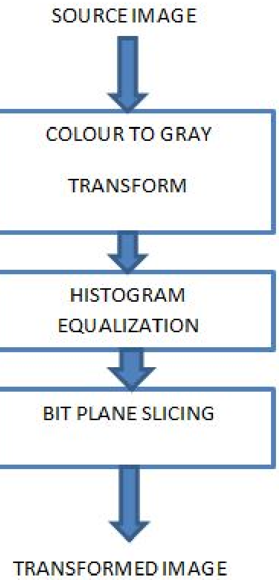

Fig.3. Transformation sequence

As the image consists of a finite no of rows and columns which are the no of pixels arranged in an order similar to a grid like structure, let the image be represented by equation 1. Where I(i,j) represents the intensity value of i^{th} row and j^{th} column pixel and F(x,y) represents the image of NxM resolution where N is the width and M is the height of the image. The image represented by equation 1 is split into two halves which would be represented by equation 2 and 3.

$$F1(x,y) = \sum_{i=0}^{N/2} \sum_{j=0}^{M} I(i,j) \quad (2)$$

$$F2(x,y) = \sum_{i=\left(\frac{N}{2}\right)+1}^{N} \sum_{j=0}^{M} I(i,j) \quad (3)$$

Equation 2.represents the upper half of the image while equation 3.represents the lower half of the image. As the characteristics of both the images would be different for closed eye and will be approximately same for an open eye in an ideal case. So matching the properties of the image would be one of the methods to determine the state of an eye. The properties include the mean, standard deviation or even the variance of upper and lower halves.

Fig.4. Original image

Fig.5. Histogram equalized image

Fig.6. Bit plane Sliced image(MSB)

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By calculating the total no of black or white pixels in both the sections of the original image and approximating the comparison, it is found that the no of pixels of either black or white intensities are approximately same for both the halves of the image if it is an open eye and they do not match for a closed eye or neither are they close enough with the values of each other. The equation of intensity count of the upper and the lower half is given by equations 4 and 5 respectively.

$$Black1 = \sum_{i=0}^{N/2} \sum_{j=0}^{M} O(i,j) \quad (4)$$

$$Black2 = \sum_{i=\left(\frac{N}{2}\right)+1}^{N} \sum_{j=0}^{M} O(i,j) \quad (5)$$

The no of black intensity pixels can be found by traversing the images and comparing each pixel with black intensity pixel and correspondingly incrementing the count value; the same logic is applied to the second half of the image represented by equation 3.

Fig.7. A normal open human eye

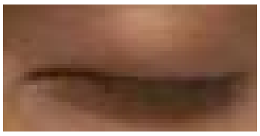

Fig.8. A closed human eye

Figure (7). shows a 30x60 image sample of an open human eye considering an illuminated source in front of it. Visibly, the image appears to be symmetrical about both the axes if the origin is considered to be the Centre of the image however it is not so in case of a closed eye which is shown in Figure (8). The image may not appear to be symmetric along horizontal axis as the distribution of same valued pixels is not approximately uniform throughout.

Fig.9. Image of an open eye split into two halves

Figure (9) shows two RGB to gray converted, histogram equalized and then bit sliced images of the original image shown in figure (4). Figure (10) shows similarly transformed image of a closed eye, and it can be very well justified that the distribution of intensities are not symmetric about the horizontal axis.

Fig.10. Image of a closed eye split into two halves

III. Results

Sample images of resolution 30x60 were taken from the video captured from the camera mounted (both closed and open eyes) and the test was carried out using MATLAB. It was observed that the mathematical modeling works for both the cases and true results were obtained for both the cases. The EXCEL graphs of the samples are as shown in figure (11) and figure (12).

It can be seen that the count of black pixels lie below 300 for a n open eye and the value drastically varies for above 300 for a closed human eye thus providing the threshold of 300. This depends on the lighting conditions too. The above results are validated for average lighting conditions.

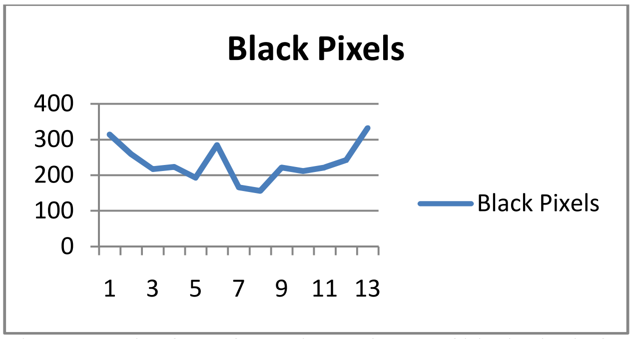

Fig11. Result of no of samples to the no of black pixels for an closed eye

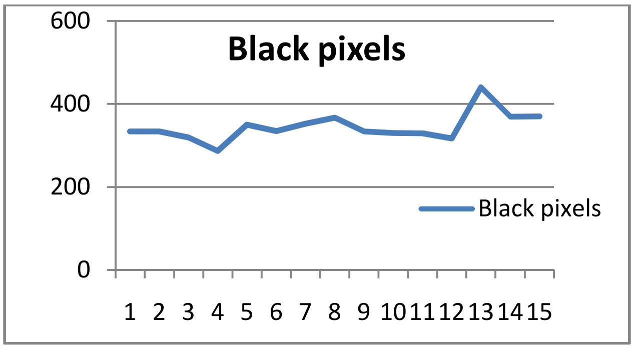

Fig.12. Result of no of samples to the no of black pixels for an open eye.

Figure (13) shows real time distress signal recognition by tracking eyes. The system efficiently detects the state of human eye (whether open or closed). Also, the pattern of distressing using eyes (right eye closed for 3 seconds while the left remains open) is detected 92% correctly. With the mentioned results, if the system is made compact and on-chip, a well-developed system can incorporate additional alarming circuits and advanced methodologies.

Table 1 shows the efficiency along with false detection rate of the system that we have designed for distressing.

Table 1: Statistical Analysis of data

Parameter	True Detection	False Detection	Efficiency
No of Samples	78	5	95.1%
Distress Samples	73	5	82.9%

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Fig.13. Results of real time distress signal detection..

IV. Summary and Future Work

The state of a human eye can be very well detected with less time and analyzed using the same image and comparing it with the split image without comparing it with a reference model.

Future work may include advances in precise and efficient detection of fatigue and drowsiness of eye.

A product can be developed and an on-chip system can be implemented in mobile/remote places. The same can be implemented on mobile platforms using advanced C and Java programming languages.

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