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Drowsiness Detection Using Eye Blink

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Abstract*: Proposed Drowsiness Detection System is based on Blink Detection method which is based on calculating the distance between two arcs of eye using connected 'labeling method'. Proposed method is robust enough against different users, noise, and eye shape changes with highest accuracy. It uses a Haar based cascade classifier for eye tracking. The presented method is non intrusive and hence provides a comfortable user interaction. This paper presents a labeling method for eye tracking and blink detection in the video frames obtained from low resolution consumer grade web cameras.*

Keywords*: Blinking ,eye arc ,Haar cascade ,labeling, PERCLOS, Face detection, Real-time system.*

1. Introduction

Different methods have been developed for eye tracking and blink detection. The eye tracking methods includes use of, feature based models, template matching, appearance based models, statistical models, clustering algorithms etc. The eye blink detection methods includes the use of intensity vertical projection, SIFT feature tracking, template matching, skin color copies, Gabor filter responses etc. But most of these methods need special hardware settings and their performance is not reliable when used in real world situations under uncontrolled lighting conditions and normal resolutions. Therefore, this paper presents a new method for eye tracking and blink detection using consumer grade cameras. The accessible method is very much user friendly and does not require any specialized hardware. It performs well in uncontrolled lighting conditions under standard resolutions of an USB web camera.

2. Developed Method

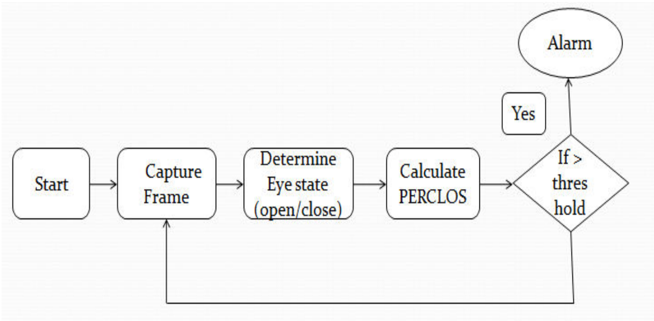

Figure 1. Software Block Diagram

In the current work we study the detection and classification of eyes in three stages
i. Face detection and eye localization
ii. Eye detection
iii. Eye state classification

3. Working Principle

The primary purpose of the Drowsy User Detector is to develop a system that can reduce the drowsiness. The system may be programmed to provide an instant warning signal when drowsiness is detected with high certainty, or, alternatively, to present a verbal secondary task via recorded voice as a second-stage probe of driver status in situations of possible drowsiness. The IR transmitter is used to transmit the infrared rays in our eye. The IR receiver is used to receive the reflected ultraviolet rays of eye. If the eye is closed means the output of IR receiver is high otherwise the IR receiver output is low. This to know the eye is closing or opening location. This output is give to logic circuit to indicate the alarm. Here one eye blink sensor is fixed in vehicle where if anybody looses conscious and agree through alarm. The proposed system is used to avoid drowsiness.[2]This paper involves avoiding laziness of employee or user to unconsciousness through Eye blink. Here one eye blink sensor is fixed in system where if user lose his consciousness, then it alerts the user through buzzer.

4. Face and Eye Detection

Primarily Haar classifiers have been used for Face and Eye detection. A rectangular Haar like feature can be defined as the difference of the sum of pixels of areas inside the rectangle, which can be at any position and scale within the original image. Each Haar like feature consists of two or three connected black and white rectangles. The Haar wavelets are a natural set basis functions which encode differences in average strengths in different regions. The value of a Haar-like feature is the difference between the sums of the pixel gray level values within the black and white rectangular regions:

"f(x)=Sum black rectangle (pixel gray level) - Sumwhite rectangle (pixel gray level)"

The advantage of using Haar like features over raw pixel values is that it can reduce/increase the in-class/out-of-class variability, which makes the classification easy.

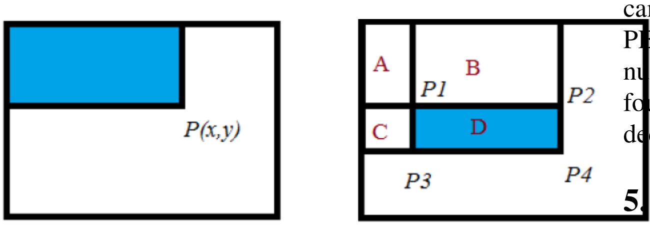

Figure 2. Integral image representation

From Figure 2, Integral image at location of x, y contains the sum of the pixel values above and left of x, y, inclusive:

$$P(x,y) = \sum_{x'<x, y'<y} i(x',y')$$

$$P_1 = A, P_2 = A + B, P_3 = A + C, P_4 = A + B + C + D$$

$$P_1 + P_4 - P_2 - P_3 = A + A + B + C + D - A - B - A - C =$$

The calculation of Haar like features is made fast by the use of integral image symbol[5]. The number of Haar like features in an image is too large. In a sub image of size 24x24 the number of features contained is 180,000. The Haar like features are evaluated in a cascaded manner .Weak classifiers reject the region where the chance of finding face is less[8]. More time is spent on the promising regions in the image .The features used in each stage and their threshold is selected in training phase. Training is done with AdaBoost algorithm. In training phase the classifier is trained with a
number of positive and negative samples to get a cascaded classifier[10]. It consists of cascaded stages of weak classifiers. The optimum set of cascaded features and corresponding thresholds are gained from the AdaBoost algorithm.

5. Application Of Haar classifier in face detection

The frames gained from camera are of resolution 640x480. First Haar cascade for detection of face is used. The cascaded stages are applied on the image in every scale and at every location. Once the face is detected a region of interest (ROI) is selected from the face region, based on face geometry. Now in this ROI Haar cascade for closed eyes is applied if it detects a closed eye a counter increments and camera fetches next frame and it is processed[11] If closed eye is not detected Haar classifier for open eyes are checked. After it is complete it takes the next frame from camera and processes it. In each minute the PERCLOS value is considered as the ratio between number of closed eyes detected and amount of eyes found. From the threshold of PERCLOS, fatigue level decision is taken, and can be used to alarm the user.

5. Face tracking

Searching for face in every frame in every scale rises the computational complexity. The real-time performance of the algorithm can be better if we use the temporal information[2]. If the position and size of face is known accurately in a frame, then we can select a Region of Interest around that position where we can find the face in following frames. The computational complexity is less since the search region is reduced.

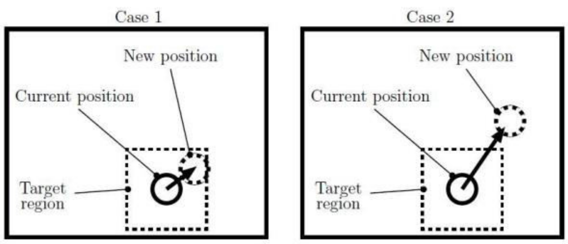

Figure 3. Tracking in Video

Figure 3. shows two cases in tracking, if the position of face is accurately known in one frame, the location of the face can be predicted in subsequent fames. This reduces the computational complexity. But in the second case the motion of face is fast so the location of face will be outside the selected ROI. By tracking face with a prediction method avoid this problem. In tracking, the ROI is selected around the predicted position of face in the subsequent frame thereby reducing the tracking failure[9]. There are several

methods available for object tracking mean shift tracking, optical tracking and Kalman filter based tracking. The first two methods relies image intensity values in following frames. The performance of mean shift tracking and optical tracking is poor because of the changing light conditions. We have selected Kalman filter based estimate since the prediction method depends on the measurement of face location from Haar based face detector only.

6. Haar Cascade for Eye Detection

Two separate classifiers for open eye and closed eye are used in this method. The classifier for open and close are trained with a databank and positive and negative images are given for training[3]. The ROI selection is done and the detection of eye is performed in the localized region. The flow chart of the Haar based eye detection is shown here. The number of open and closed eyes over one minute windows are calculated and PERCLOS values are found.

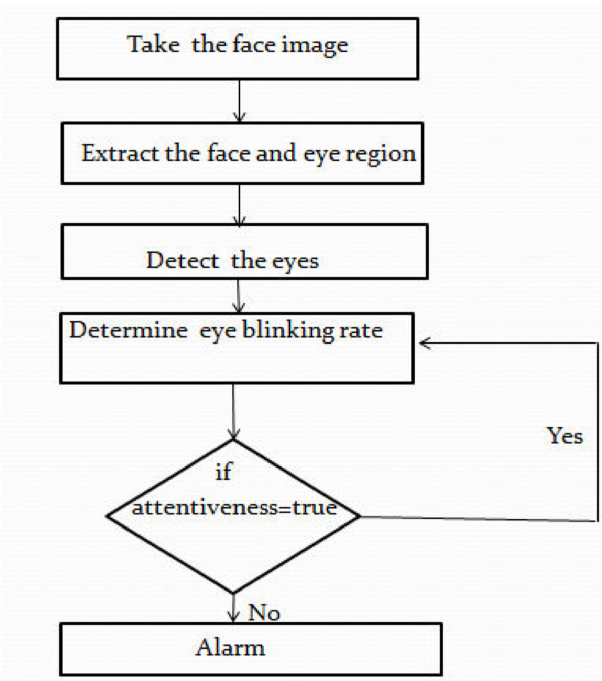

Figure 4. *Flowchart of eye detection with Haar classifier*

7.Eye State Classification

The eyes are detected by the block LBP histogram based approach. The final stage is the classification of state of the detected eyes. Support Vector Machine is reported as strong for the classification of open and closed eye[5] . The weight
components from the previous stage are used for the classification of eyes. SVM is a supervised learning method useful for data classification. The standard SVM is a binary classifier. A support vector machine constructs a hyper plane or set of hyper planes in a high or infinite-dimensional space, which can be used for classification or regression. Good classification accuracy can be obtained if the hyper plane is
maximally distant from the nearest training data from both the classes. When data can not be classified by a linear classifier the original data can be altered into a higher dimension where the classes can be separated by a hyper plane[2]. The essence of SVM is to map the training data from the input space to a higher dimension feature space, where an optimal hyper plane can be found which can separate the data. In the SVM training process the dot product of input vectors have to be calculated in the feature space. The mapping of the input vectors to the feature space is achieved by using kernels, which actually directly computes the dot product of the input vectors in the feature space, instead of first transforming each input vector to the feature space and only then computing the dot product[7]. There are various types of kernels offered quadratic, polynomial, radial basis function .

8. Application

Here the eye state classification is modelled as a binary class problem. The class labels include open class and closed class. In the training phase from the open and closed eyes are feature transformed with Block-LBP and then projected to PCA subspace. The weights obtained are used for the training input of the SVM. The weight data along with the ground truth is used for the training. In the detection phase, the localized eye region is feature changed first and then projected into the PCA feature space to get the weight components[12]. The weights are fed into the SVM and SVM returns the classification result from this eye state is obtained. The value of PERCLOS is found by calculating the ratio in overlapped time windows of one minutes and alarm is given when it is more than a threshold.

9. Future scope

The speed of the algorithm implemented is more than the required frame rate, so more computationally thorough post processing can be used to reduce the false positive rates.
Tracking of face with Condensation algorithm can be used to detect the eyes even if the face detection stage fails. The detection of face in off plane rotation can be solved with the use of suitable tracker algorithms. A specially designed camera can be used which can be concealed in the dashboard, it will reduce the problem of light directly falling on to the camera. The NIR

lighting is to be designed for final implementation. In the future the work can be extended into the applications of this proposed system. Beside with the alarm buzzing into the car to alert the person driving it, we also need to alert others, driving their cars in the close proximity to the one sounding the alarm.

9. Conclusion

The main components of the system consists of an eye blink sensor for user blink acquisition. Advanced technology offers some hope avoid these up to some extent. This study involves measure and controls through alcohol sensor and eye blink using IR sensor. The system is considered by maintaining simplicity, low cost and non-obstructive real time monitoring of drowsiness. The web camera captures the video and the frames are processed for detecting the eye status based on the edges. The derived status is monitored and the user is advised to blink often through pop up message box. The major problem faced in edge extraction from frames is that, it is difficult to extract when captured in poor lighting conditions. Future work is focused on light of these frames under uncontrolled lighting conditions.

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