Driver's Drowsiness Detection Using Circular Hough Transform and Iris Visibility Ratio Analysis

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Abstract— **This paper presents a system that detects driver fatigue. Drowsy driver detection is a car safety mechanism which detects dangerous situation caused by inattention of driver. This paper consist of following four steps: Face detection, Eye detection, Iris detection and Drowsiness detection. For face detection, Viola-Jones algorithm is applied. In the second step, Eye detection, the position of eyes is calculated using a new self developed image processing algorithm. This approach is simple to implement and faster than others. Segment the eyes from the face region and the third step, Iris detection, process on this extracted region. Iris detection is carried out based on Circular Hough Transform. Blinks are detected based on the ratio of visible part of iris and drowsiness is recognized by comparing the frame to the previous. Experimental results show that the proposed method provides high detection rates.**

Keywords—Viola-Jones algorithm, Eye position extraction, Circular Hough transform, Iris detection, Drowsiness detection.

I. INTRODUCTION

Road accidents are most unwanted thing that happens to the road users, though they happen quite often. Main cause of road accidents and crashes are due to human errors, that means, driver errors remain the most common cause of road accidents. Some common behavior of human which results in accidents are over speeding, drunken driving, distraction to driver, red light jumping and avoiding safety gears like seat belt, helmet etc.

Majority of road accidents are related to driver fatigue, drowsiness and driver inattention. The national safety administration conservatively estimates that 100,000 police reported crashes are the direct result of driver fatigue. Other than driver fatigue, activities such as toggling car audio system, speaking on phone, and text messaging will leads to accidents.[1]

To avoid or to control such accidents, we need a system that detect and prevent drowsiness while driving. Symptoms of driver fatigue will be reflected through eyes. So it can be detected by monitoring the eyes. The detection process involves a sequence of face images (video frames) and observation of eye movement and blinks.

Face image analysis is a popular research area with application such as, face recognition, virtual tools, human identification security systems, Expression detection etc. In our proposed system, we focused on eye localization. A self developed image processing algorithm is used to determine the position of eyes. This paper describes a system that determines whether eyes are closed or open and detect driver fatigue.

The detection process consists of four steps:

1. Face detection: based on Viola-Jones algorithm.

2. Eye position extraction: a new approach.

3. Iris detection: using circular Hough transform.

4. Drowsiness detection: based on iris visibility ratio and previous frame condition.

II. MATERIALS AND METHODS

This paper describes a method of driver fatigue detection. To recognize driver fatigue, eye monitoring is the best way. Because of inattention or drowsiness strongly reflect on eyes. The system prefers cameras with IR illumination to capture videos. Because of camera with IR illumination simplify the problem of iris detection. Due to IR illumination the iris appear as bright spots caused by the reflection of retina. Flow chart of the system is given in the Fig.1.
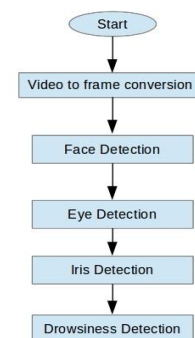

Fig. 1. Flowchart of drowsiness detection system

A. Face Detection

Numerous approaches have been proposed for detecting face. Face detection based on neural networks, Viola-Jones

algorithm and skin color detection method are most commonly used and famous approaches for face detection.

Neural network based method is most accurate. It consists of learning and performing stages. In the former stage the system is learned from a huge set of training images to identify skin and non skin colored pixels. This knowledge is used when an unknown image is given. Accuracy is appreciable for this method but it is time consuming.

Viola-Jones algorithm overcomes this difficulty. It is faster and having moderate accuracy. This method uses some sub windows (masks) that are capable of detecting facial region. Scanning with sub window is a common method. But such methods are time consuming due to the use of different sized images. That means rescale the input image in different sizes and run the fixed sized detector through them. In Viola-Jones method, rescale the detector instead of input image. Run the detector through image many times but each time use different sized mask.

Another specialty of Viola-Jones method is that, it uses a special image representation called 'Integral image'. Integral image is only other kind of input image representation which makes feature extraction faster. Integral image formation is based on the following criteria: [2]

$$ii(x,y) = \sum_{x'\leq x, y'\leq y} i(x',y') \qquad (1)$$

Benefit of Integral image: Sum of pixels in a rectangular region can be calculated with only four array reference. This is shown in Fig.2
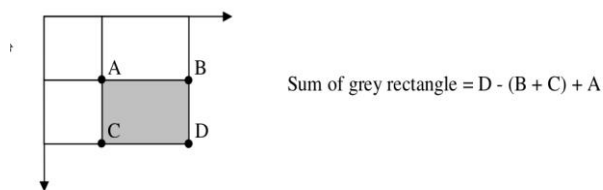

Fig. 2.   Benefit of integral image

There are mainly four different types of sub masks, called features, are used. Each features having white and black rectangular regions. Each feature results a single value, calculated by subtracting the sum of pixel values corresponding to white rectangle(s) from that of black rectangle(s).

B. Eye Detection

The next step is eye detection from the detected face region. Here we suggest a new method for eye detection. It is based on the assumption that, the left eye is at the left upper corner of face and right eye is at the right upper corner of face region. After detecting the face, crop the face as a rectangular region. The left and right eyes are located in a rectangular region having width 1/3width of face region. By knowing the coordinates of face region, eye region coordinates can be calculated by the following equations.

Equation for left eye:
$$eye[1,:] = [out(1,1) + siz * 0.58, out(1,2) + siz * 0.28, siz * 0.22, siz * 0.22] \qquad (2)$$

Equation for Right eye:
$$eye[2,:] = [out(1,1) + siz * 0.2, out(1,2) + siz * 0.28, siz * 0.22, siz * 0.22] \qquad (3)$$

Where, eye[] is a 2×4 matrix, in which first row will store left eye corner coordinates and second row contains right eye coordinates , out[] is 1×4 matrix which contains face region corner coordinates and 'siz' is the width of face region extracted.

Fig. 3.   Left and right eyes

C. Iris detection

Iris detection is the major phase in drowsiness detection. So this phase must have appreciable accuracy. Here we choose circular Hough transform for this purpose.

Hough transform is a feature extraction technique used in image analysis, computer vision and digital image processing. The purpose of this technique to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as a local maxima in an accumulator space that is explicitly constructed by the algorithm for computing the Hough transform.[3]

In this system, cropped eye image and maximum and minimum radius of iris is given as input for taking circular Hough transform. For an adult human, average radius of iris is between 5mm and 7mm. So we use 10 and 25 pixel points as maximum and minimum radius of iris. As an initial step, edge detection is performed. Canny edge detection is used because of it detects strong and weak edges and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than others to be fooled by noise.

Hough transform can be used to find any geometrical figure in an image. More complex shapes are described using parameters. A circle might seem easy to represent using three parameters. The equation of a circle is $r^2 = (x-a)^2 + (y-b)^2$ and it has three parameters r, a and b. r is the radius of circle while a and b is the center in X and Y direction. The parameter space of a circle belongs to R^3. Now we need to convert the edge detected binary image to the parameter space. This is easy since the pixel coordinate can be directly translated to a and b in the parameter space. If the radius is known, a constant radius may be used to simplify the computation. Otherwise a finite list of radii must be evaluated. Radius of iris is different in person to person, but it is in a specified range.

In this paper suggest the second method. For each radius find out the coordinate positions, which have non zero value in both edge image and circle with that radius. If such a pixel position is detected, increment the value corresponding to that position in accumulator space. After complete voting, find out the maximal points and number of non zero valued pixels in the circumference of the circle with the maximal point as center. The circle having larger number of such points in its circumference is the iris. Fig.4 shows the detected iris.
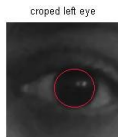

Fig. 4. Detected iris

D. Blink and Drowsiness detection

Drowsiness can be detected based on the visibility ratio of iris. Iris is not visible completely in two situations, during blinking of eye and in drowsy condition. Differentiate these two is the next task.

In this paper, if the iris's visible ratio is less than 60%, that frame will be consider for further analysis. ie, to detect it is blink r drowsiness. For that, analyze the previous frame. If it also in the same condition, consider the situation as drowsy otherwise it is just a blink.

Fig. 5. Drowsiness detected frame

III. RESULTS AND DISCUSSIONS

We experimented with videos captured through 6 Mega pixel cameras. The cameras are attached to the car's dash board or steering column to take these videos. This positioning of camera gives a clear view of driver's face.

The frame rate of input videos are 30 frames per second. And our system can perform only 2 frames per second. Analyzing each and every frame is difficult and time consuming. To avoid lagging, we sample the frames and select 2 frames from 30 frames. ie, first and 15th frames are processed.

The Fig.6. Shows a graph indicates frame number and visible pixel count along the circumference of iris. Zero pixel count indicates drowsiness.
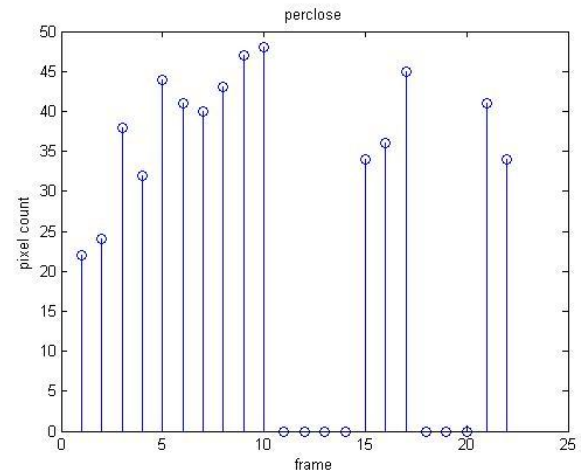

Fig. 6. Frame number Vs Pixel count: zero count indicates drowsy condition

IV. Conclusions

This paper describes an eye monitoring system for drowsiness detection. The system detects and tracks eye as well as determines whether the eye is closed or not. For detecting face, Viola-Jones algorithm is used. Eye positions are calculated by a new algorithm and for Iris detection the concept of Circular Hough transform is used. After detecting face, crop the facial region and after detecting eye crop eye regions to reduce the area for further processing and make procedures faster.

Iris detection is carried out to analyze the eye condition. That is to detect eye is closed or open. Drowsy condition is detected based on the visible ratio of iris and previous frame condition.

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