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Drowsy Driver Detection System

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Abstract: ***This system uses a small monochrome security camera that points directly towards the driver's face and monitors the driver's eyes in order to detect fatigue. In such a case when fatigue is detected, a warning signal is issued to alert the driver. This project describes how to find the eyes, and also how to determine if the eyes are open or closed. If the eyes are found closed for 5 consecutive frames, the system draws the conclusion that the driver is falling asleep and issues a warning signal.***

Keywords: Drowsy Driver detection, Monochrome Camera, Sleep Detection, Automobile Sleep Detector, Threshold values

1. Introduction

This system deals with information obtained for the binary version of the image captured by a monochrome camera to find the edges of the face, which narrows the area of where the eyes may exist. Once the face area is found, the eyes are found by computing the horizontal averages in the area. Taking into account the knowledge that eye regions in the face present great intensity changes, the eyes are located by finding the significant intensity changes in the face. Once the eyes are located, measuring the distances between the intensity changes in the eye area determine whether the eyes are open or closed. A large distance corresponds to eye closure. If the eyes are found closed for 5 consecutive frames, the system draws the conclusion that the driver is falling asleep and issues a warning signal.

2. Related Work

Driver fatigue is a significant factor in a large number of vehicle accidents. Recent statistics estimate that annually 1,200 deaths and 76,000 injuries can be attributed to fatigue related crashes.

The development of technologies for detecting or preventing drowsiness at the wheel is a major challenge in the field of accident avoidance systems. The focus will be placed on designing a system that will accurately monitor the open or closed state of the driver's eyes in real-time. By monitoring the eyes, it is believed that the symptoms of driver fatigue can be detected early enough to avoid a car accident. Detection of fatigue involves a sequence of images of a face, and the observation of eye movements and blink patterns. The analysis of face images is a popular research area with applications such as face recognition, virtual tools, and human identification security systems. This project is focused on the localization of the eyes, which involves looking at the entire image of the face, and determining the position of the eyes by a self-developed image-processing algorithm. Once the position of the eyes is located, the system is designed to determine whether the eyes are opened or closed, and detect fatigue.

3. System Requirements

The requirements for an effective drowsy driver detection system are as follows:

1) A non-intrusive monitoring system that will not distract the driver.
2) A real-time monitoring system, to insure accuracy in detecting drowsiness.
3) A system that will work in both daytime and nighttime conditions.

The above requirements are subsequently the aims of this project. This project will consist of a concept level system that will meet all the above requirements.

4. Design Issues

The most important aspect of implementing a machine vision system is the image acquisition. Any deficiencies in the acquired images can cause problems with image analysis and interpretation. Examples of such problems are a lack of detail due to insufficient contrast or poor positioning of the camera: this can cause the objects to be unrecognizable, so the purpose of vision cannot be fulfilled.

5. Camera Hardware

1) The important image acquisition item is the video camera.
2) Review of several journal articles reveals that face monitoring systems use an infrared-sensitive camera to generate the eye images.
3) This is due to the infrared light source used to illuminate the driver's face.
4) CCD cameras have a spectral range of 400-1000nm, and peak at approximately 800nm.
5) The camera used in this system is a Sony CCD black and white camera.

6. Frame Grabbers

The next stage of any image acquisition system must convert the video signal into a format, which can be processed by a computer. The common solution is a frame grabber board that attaches to a computer and provides the complete video signal to the computer. The resulting data is an array of grey scale values, and may then be analyzed by a processor to extract the required features.

7. Concept Design

There are several different algorithms and methods for eye tracking, and monitoring. Most of them in some way relate to features of the eye (typically reflections from the eye) within a video image of the driver. The original aim of this project was to use the retinal reflection (only) as a means to finding the eyes on the face, and then using the absence of this reflection as a way of detecting when the eyes are closed. It was then found that this method might not be the best method of monitoring the eyes for two reasons. First, in lower lighting conditions, the amount of retinal reflection decreases; and second, if the person has small eyes the reflection may not show, as seen below in Figure

Figure 1: Showing small eyes having less retinal deflection

8. Background and Ambient Light

Because the eye tracking system is based on intensity changes on the face, it is crucial that the background does not contain any object with strong intensity changes. Highly reflective object behind the driver, can be picked up by the camera, and be consequently mistaken as the eyes. Since this design is a prototype, a controlled lighting area was set up for testing. Low surrounding light (ambient light) is also important, since the only significant light illuminating the face should come from the drowsy driver system. If there is a lot of ambient light, the effect of the light source diminishes.

This setup is somewhat realistic since inside a vehicle, there is no direct light, and the background is fairly uniform.

9. Camera

The drowsy driver detection system consists of a CCD camera that takes images of the driver's face. The camera is placed in front of the driver, approximately 30 cm away from the face. The camera must be positioned such that the following criteria are met:

1. The driver's face takes up the majority of the image.
2. The driver's face is approximately in the center of the image.

10. Light Source

For conditions when ambient light is poor (night time), a light source must be present to compensate. Initially, the construction of an infrared light source using infrared LED was going to be implemented. It was later found that at least 50 LEDs would be needed to create a source that would be able to illuminate the entire face. To cut down cost, a simple desk light was used. However, light from light bulbs and even daylight all contain infrared light; using this fact, it was decided that if an infrared filter was placed over the desk lamp, this would protect the eyes from a strong and distracting light and provide strong enough light to illuminate the face. A wideband infrared filter was placed over the desk lamp, and provides an excellent method of illuminating the face.

11. Eye Detection Function

An explanation is given here of the eye detection procedure.

1) After inputting a facial image, pre-processing is first performed by binarizing the image.
2) The top and sides of the face are detected to narrow down the area of where the eyes exist.

The spectral plot of the wideband infrared filter is shown in figure II.

3) Using the sides of the face, the center of the face is found, which will be used as a reference when comparing the left and right eyes.
4) Moving down from the top of the face, horizontal averages of the face area are calculated. Large changes in the averages are used to define the eye area.

12. Binarization

The first step to localize the eyes is binarizing the picture. Binarization is converting the image to a binary image.

Examples of binarized images with threshold values 100,150 and 200 respectively are shown in Figure III.

The following explains the eye detection procedure in the order of the processing operations. All images were generating in *Matlab* using the image processing toolbox. A binary image is an image in which each pixel assumes the value of only two discrete values. In this case the values are 0 and 1, 0 representing black and 1 representing white. With the binary image it is easy to distinguish objects from the background. The grayscale image is converting to a binary image via thresholding. The output binary image has values of 0 (black) for all pixels in the original image with luminance less than level and 1 (white) for all other pixels. Thresholds are often determined based on surrounding lighting conditions, and the complexion of the driver. After observing many images of different faces under various lighting conditions a threshold value of 150 was found to be effective. The criteria used in choosing the correct threshold was based on the idea that the binary image of the driver's face should be majority white, allowing a few black blobs from the eyes, nose and/or lips. Figure demonstrates the effectiveness of varying threshold values. Figures use the threshold values 100, 150 and 200, respectively. Figure b is an example of an optimum binary image for the eye detection algorithm in that the background is uniformly black, and the face is primary white. This will allow finding the edges of the face, as described in the next section.

13. Face top and width detection

The next step in the eye detection function is determining the top and side of the driver's face. The following algorithm describes how to find the actual starting point on the face, which will be used to find the top of the face.

1) Starting at (100,240), increment the x-coordinate until a white pixel is found. This is considered the left side of the face.
2) If the initial white pixel is followed by 25 more white pixels, keep incrementing x until a black pixel is found.
3) Count the number of black pixels followed by the pixel found in step2, if a series of 25 black pixels are found, this is the right side.
4) The new starting x-coordinate value (x1) is the middle point of the left side and right side.
5) Using the new starting point (x1, 240), the edges of the head can be found.
6) Using the edges of the face, the eyes of the driver will be found accurately.

14. Determining the state of eyes

The state of the eyes (whether it is open or closed) is determined by distance between the first two intensity changes found in the above step. when the eyes are closed, the distance between the y – coordinates of the intensity changes is larger if compared to when the eyes are open. this is shown in figure

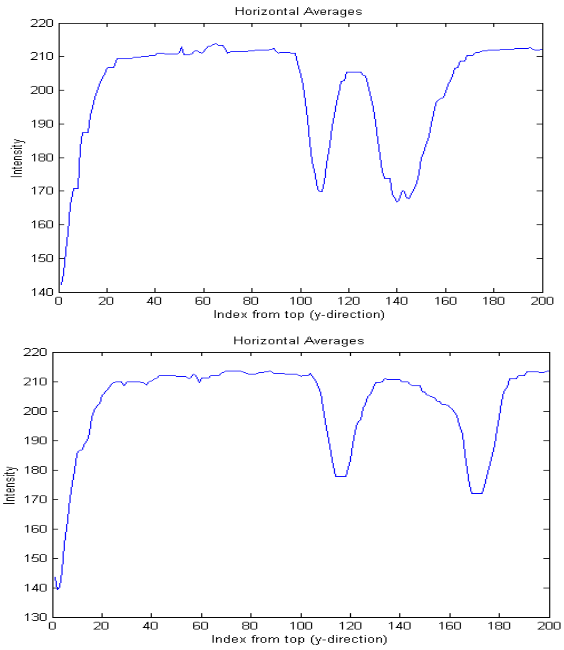

Figure 4: Showing intensity changes between open and closed eyes respectively

The limitation to this is if the driver moves their face closer to or further from the camera. If this occurs, the distances will vary, since the number of pixels the face takes up varies, as seen below. Because of this limitation, the system developed assumes that the driver's face stays almost the same distance from the camera at all times.

15. Judging Drowsiness

When there are 5 consecutive frames find the eye closed, then the alarm is activated, and a driver is alerted to wake up. Consecutive number of closed frames is needed to avoid including instances of eye closure due to blinking.

16. Conclusion

A Non-invasive system to localize the eyes and monitor fatigue was developed. Information about the head and eyes position is obtained through various self-developed image processing algorithms. During the monitoring, the system is able to decide if the eyes are opened or closed. When the eyes have been closed for too long, a warning signal is issued. In addition, during monitoring, the system is able to automatically detect any eye localizing error that might have occurred. In case of this type of error, the system is able to recover and properly localize the eyes. The following conclusions were made:

1) Image processing achieves highly accurate and reliable detection of drowsiness.
2) Image processing offers a non-invasive approach to detecting drowsiness without the annoyance and interference.
3) A drowsiness detection system developed around the principle of image processing judges the driver's alertness level on the basis of continuous eye closures. Knowing all these advantages of drowsy driver detection system, one should be aware of that and encourage it.

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