DROWSINESS DETECTION FOR CAR ASSISTED DRIVER SYSTEM USING IMAGE PROCESSING ANALYSIS

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ABSTRACT

The current technology in digital computer system allows researchers around the world to study the fatigue behavior. Although the current technology of drowsiness detector has been created, it is lack of efficient since the detection is used ordinary sensor. This project is to develop a driver drowsiness detection system by using histogram analysis. It is known that a driver is under drowsiness influences by looking at the eyelid. Based on the previous research, there is none used histogram for analysis. The result can be not accurate because histogram analysis analyzed the whole image. Therefore, if the analysis area is not specified, the result will be not accurate and efficient. The retina movement shows the fatigue level of the driver. For example, if the driver’s eyes are closed about more than 5 seconds in the last 60 seconds, the driver considered as drowsiness. Based on the fact that driver’s eye movement can be used to recognize the level of drowsiness, a sensor can be developing by using image processing analysis in MATLAB. The image processing analysis that will be used is histogram analysis. This system will be developing only on software part.
**ABSTRAK**

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1.1 Introduction

Safe driving is a major concern of societies all over the world. Thousands of people are killed, or seriously injured due to drivers falling asleep at the wheels each year. Recent studies show those drivers’ drowsiness accounts for up to 20% of serious or fatal accidents on motorways and monotonous roads, which impair the drivers’ judgment and their ability of controlling vehicles [6]. Therefore, it is essential to develop a real-time safety system for drowsiness-related road accident prevention.

Many methods have been developed and some of them are currently being used for detecting the driver’s drowsiness [7], including the measurements of physiological features like EEG, heart rate and pulse rate, eyelid movement, gaze, head movement and behaviors of the vehicle, such as lane deviations and steering movements. Among those different technologies, ocular measures, such as eye-blinking and eyelid closure, are considered as promising ways for monitoring alertness.
Typically, after long hours of driving or in absent of alert mental state, the eyelids of driver will become heavy due to fatigue. The attention of driver starts to lose focus, and that creates risks for accidents. These are typical reactions of fatigue, which is very dangerous. Usually many exhausted drivers are not aware that they are in falling asleep. In fact, many such drivers can fall asleep any time during their driving. In an image fatigue detection, correct and real time decision is important. Therefore, in this project eyelid closure is chosen to be the method for drowsiness detection when driving.

The current technology in digital computer system allows researchers around the world to study the fatigue behavior. Although the current technology of drowsiness detector has been created, it is lack of efficient since the detection is used ordinary sensor. This project is to develop a driver drowsiness detection system by using histogram analysis. It is known that a driver is under drowsiness influences by looking at the eyelid. Based on the previous research, there is none used histogram for analysis. The result can be not accurate because histogram analysis analyzed the whole image. Therefore, if the analysis area is not specified, the result will be not accurate and efficient. The retina movement shows the fatigue level of the driver. For example, if the driver’s eyes are closed about more than 5 seconds in the last 60 seconds, an alarm will sound to alert the driver. Based on the fact that driver’s eye movement can be used to recognize the level of drowsiness, a sensor can be developing by using image processing analysis in MATLAB. The image processing analysis that will be used is histogram analysis. This system will be developing only on software part.
1.2 **Objective**

The objective of this project is to:

i. To develop a system that able to detect drowsiness of a driver based on eyelid detection in digital image.

ii. To make analysis of the eyelid by using histogram features.

1.3 **Scope of Project**

The scopes that need to be proposed in this project:

i. Focus on image processing tool which is histogram.

ii. Develop on software only.

1.4 **Problem Statement**

This project is to develop a driver drowsiness detection system by using histogram analysis. It is known that a driver is under drowsiness influences by looking at the eyelid. Based on the previous research, there is none used histogram for analysis. The result can be not accurate because histogram analysis analyzed the whole image. Therefore, if the analysis area is not specified, the result will be not accurate and efficient.
1.5 Thesis Outline

Chapter 1 will describe the introduction of this system, the objectives of this project, the problem statement, the work scopes and overview of this project.

Chapter 2 will review about the information found on all the material or data used in the development of the system.

Chapter 3 will explain all the method used to develop this system. This chapter will explain briefly about MATLAB in designing the drowsiness detection system.

Chapter 4 will include all the results and the explanations about the results after all development process has done.

Chapter 5 will show the summary after all and come up with some recommendations for some improvements.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are some previous researches that are used to be referred to develop a real-time system on drowsiness detection. These are researches and journals that are related to this project either directly or indirectly.

For the first journal titled “Detecting eye blink states by tracking iris and eyelids” by Huachun Tan and Yu-Jin Zhang (2005). This paper works on the simultaneous exploitation of intensity and edge information for detecting the eye state as well as the record of the patterns of eyelids before closing for tracking the reopened eyes. In the method proposed by Tian et al. (2000), the open eye boundary is tracked by two key points of the eye template (the center points of the upper and the lower eyelids). The eye template parameters are obtained from the two points and the eye corners.
However, in the author’s experiments, there are problems in tracking eyelids. When the iris is redetected, the eye boundaries are tracked through the center points of the upper and the lower eyelids. However, the center points of the upper and the lower eyelids are the same point because of the line model. The patterns of the two center points are same, which lead to the two points moving to the same point in the following frames. Thus, at least one of the eyelids (upper or lower) trackers would be in error. And in the following image sequences, the error would be propagated.

Figure 2.1 illustrates the problem of tracking eyelids. From Figure 2.1, it can be found that when eye is reopened, the upper eyelid is failed to be tracked because the pattern of center point of upper eyelid is changed. In the following sequences, the error is propagated, even enlarged.

![Figure 2.1: The problem of tracking eyelids of the method proposed by Tian et al. (2000), where the upper eyelids are not correctly tracked when the eye is reopened.](image)

The problem of tracking eyelids lies in the wrong pattern when the iris is redetected. Assume the illumination is invariable in the process of blink, the patterns when the eye is open before blinking can be used to predict the patterns of eyelids when the eye is re-open. In addition, in order to track the eyelids more robust, we use AR model to predict the patterns of center points of eyelids when the iris is redetected. That is, the patterns of eyelids are predicted by
\[ p_n = \sum_{i=1}^{m} W_i p_{n-i}, \]

where \( p_n \) is the pattern of center point of eyelid in the \( n \)th frame where the eye is open; \( m \) is the number of frames that account for prediction; \( W_i \) is the prediction coefficient.

In the author’s system, they set the order of the model as 2. Then the prediction process can be described as follows;

\[ p_n = w p_{n-1} + (1 - w) p_{n-2}, \]

where \( W \) is the prediction coefficient.

Figure 2.2 shows an example of eyelid tracking using proposed method for the same image sequence in Figure 1, where \( w \) is set as 0.5. Due to the correctness of the patterns used to track the eyelids, both the lower and upper eyelids are tracked accurately.

Figure 2.2: An example of eyelid tracking using proposed method, where the eyelids can be correctly tracked.
For the second journal is titled “Development of a drowsiness warning system based on the fuzzy logic image analysis” by Jian-Da Wu and Tuo-Rung Chen (2007). In this paper, a vehicle driver drowsiness warning system using image processing technique with fuzzy logic inference is developed and investigated. The principle of the proposed system is based on facial images analysis for warning the driver of drowsiness or inattention to prevent traffic accidents. The facial images of driver are taken by a charge coupled device (CCD) camera which is installed on the dashboard in front of the driver. A fuzzy logic algorithm and an inference are proposed to determine the level of fatigue by measuring the blinding duration and its frequency, and warn the driver accordingly.

An image which taken inside a vehicle includes the driver as well as other items as shown in Figure 2.3.

![Figure 2.3: An image taken by CCD in vehicle](image)

Hence, the proposed system applies a facial detection technique to single out the driver’s face from the rest of the image [8]. Typically, CCD takes images within the RGB model (Red, Green and Blue). However, the RGB model includes brightness in addition to the colors. When it comes to human’s eyes, different brightness for the same color means different color. When analyzing a human face, RGB model is very sensitive in image brightness. Therefore, to remove the brightness from the images is necessary.
To accomplish this, the images are converted from RGB to HIS colour model, where H stands for hue, S stands for saturation, and I stands for intensity of image. The characteristics of skin among different human races are similar. The only major difference between a people with a lighter complexion versus one who has a darker complexion is in the different lighting conditions. Hue and saturation will determine the facial skin in an image. Equations (1) and (2) can be used to determine the skin tone.

\[
0.23 \leq \text{Saturation} \leq 0.63, \quad 10^\circ \leq \text{Hue} \leq 50^\circ
\]  

(1)

The formula to convert RGB to HSV is as followed:

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

(2)

\[
H = \begin{cases} 
\theta & B \leq G \\
360 - \theta & B > G 
\end{cases}
\]

\[
S = 1 - \frac{3 \cdot \text{Min}(R, G, B)}{R + G + B}
\]

\[
I = \frac{R + G + B}{3}
\]

After to determine the skin tone, the author’s then use vertical and horizontal projection. Projection basically uses every pixel in the skin to progress vertically and horizontally until it reaches a specific threshold value. When projection is done, the driver’s face area can be determined as shown in Figure 2.4. The area with the most of dense projection is the center of the face.
Since the center of every person’s face is around the nose area and that blinking of the eyes usually happen concurrently, the author’s assumed that the right eye will be positioned at the upper left-hand side of the center of the face is showed as Figure 2.5. Therefore, calculation will be based on only one eye. By taking these assumptions, the search for the eye will be limited to the area between 70° and 90°. This limited area will make the search more efficient and converting this particular area to grayscale will speed up the search even more.

Normally, a grayscale image can be divided with colors in the image into 256 values. Besides having 0 as black and 255 as white, there are 254 different shades of gray in the middle. Since a color image is three times the size of a grayscale image, the author’s decided to use the following grayscale formula to facilitate the calculations:

\[ \text{Grayscale value (Y)} = 0.299R + 0.587G + 0.114B \]  \hspace{1cm} (3)
The eye is in a $20 \times 15$ matrix within the eye region. Therefore, the author’s used a $20 \times 20$ mask to begin search. The four corners of search area are smaller than the threshold value but the center area is larger than the threshold value. From such search, the author’s determined the smallest matrix for the eye.

![Figure 2.5: Eye region before eye detection](image)

Figure 2.5: Eye region before eye detection

Figure 2.6 shows the search results. Only the lower right-hand side image fits the criteria.

![Figure 2.6: Searching the eye region](image)

Figure 2.6: Searching the eye region

In this section, the concept of threshold is used to detect the openness of the driver’s eyes. Thresholding is the operation of setting a pixel to black if the value is below a given threshold. On the other hand, a pixel is set to white if the value is above the threshold. From this process, we can generate a black-and-white image. In the following formula, $n$ is the thresholding value.
\[ n = \sum_{i=1}^{t} g(x, y) \]  

where \( g \) is the image, \( t \) is the number of pixels, \( g(x,y) \) is pixel coordinates and \((x,y)\) is pixel’s grayscale.

If \((x, y) > n\), then \((x, y) = 255\)
If \((x, y) < n\), then \((x, y) = 0\)

This paper requires the calculation of the eyelid closure duration. After obtaining the thresholding value based on tests, set the skin pixel to white and the pupil to black. Based on the number of black pixels in an image, we are able to determine whether the eye is open or closed as illustrated in Figure 2.7.

![Figure 2.7: Thresholding the eye area](image)
For the third journal is titled “Face detection for video summary using illumination-compensation and morphological processing” by Jae-Ung Yun, Hyung-Jin Lee, Anjan Kumar Paul, Joong-Hwan Baek (2009). This paper presents a simple and robust face detection algorithm that can be utilized to video summary. Because the characteristic of the face can be changed from unexpected condition like as shadows or lighting, firstly process the illumination-compensation for maintaining face components. Then analyze color-based face region in YCbCr space to obtain the skin color. Also, apply the morphological processing to improve the detection performance and reducing the number of false detected face regions. This process finds the candidates in face region and removes noise from the non-face region. For localization of the face region, make a proper face ratio based on golden ratio. Then evaluate the algorithm in the various genres. Experimental results demonstrate the effectiveness of the face detection algorithm that leads 96.7% in precision ratio on the average. The proposed method is applicable to video summary because of these high performances with low complexity.

In this paper, we present a robust face detection method through the illumination-compensation algorithm using YCbCr space and morphological processing as supplement that is able to remove noise and can help to find clear face. Using some attribute of face, this gives the information about face of interest (FOI) that helps increasing the performance on face databases. Figure 2.8 shows our face detection system.

This paper is organized as follows. Firstly we introduce the illumination-compensation algorithm to detect even under the unclear brightness conditions in Section 2. Section 3 describes the skin tone analysis and shows the processing of FOI to improve detection ratio. Localization of face is discussed in Section 4. Section 5 presents the detection results of our algorithm on several face databases. Conclusion and future works are given in Section 6.
The skin tone color depends on the illumination conditions like an artificially created light inside, strong sunlight as brightness cases and like the shadow, fading effects as dark cases. In this paper, firstly introduce the compensation method to remove the illumination effects. The illumination-compensation algorithm shown in figure 2.9 consists of 4 steps.

They use a 20 x 20 window to compute the minimal value which generates 16 x 12 minimal brightness plane (the size of the original image: 320 x 240) shown in figure 2.10c. These brightness planes are resized by bilinear-interpolation method in figure 2.10c. At last, the illumination-compensation images are further normalized by applying histogram equalization.