

## An Accurate Morphological Drowsy Detection

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**Abstract.** In this paper we propose a new method for eye state analysis, in which we incorporate four step system for drowsiness detection: face detection, eye detection, eye state analysis and drowsy decision. Our novel eye detection first uses face detection to remove the background and then by using an eye detection method which uses brightness and roundness of the eye and iris it would detect whether the eyes are open or not.

**Keywords:** drowsy detection, face detection, eye detection, morphological processes.

### 1. Introduction

There are many technologies for drowsiness detection. They can be divided into three types: biological indicators, vehicle behavior, and face analysis [1]. The first type measures biological indicators such as brain waves, heart rate and pulse rate. These techniques have the best detection accuracy but they require physical contact with the driver thus they are not practical. The second type vehicle behaviors such as speed, lateral position and turning angle are measured. These techniques may be implemented non-intrusively, but they have several limitations such as the vehicle type, driver experience and driving conditions. Furthermore, it requires special equipment and can be expensive. The third type is face analysis. Although it can be less accurate than biological indicators, this type is non-intrusive and easily implemented. It can be employed independent of driver experience and vehicle type. Further, it is both more practical and accurate than vehicle behavior analysis. It is limited by lighting conditions and the driver's distance from the camera. In this paper, we present a new four step system for drowsiness detection which is fast enough and so accurate. In the first step, we detect face region by using a popular approach of utilizing support vector machines (SVMs) to crop the face region and remove the background.

After detecting the face region, we detect eye region. It would be useful to detect the face before detecting the eye because in this way we would reach higher accuracy by omitting other objects which may be detected wrongly as the eye. Many works on eye detection have been used IR illuminators which can be dangerous for retina [1]-[4] or required training data and used circle Hough transform [5]. As we are only interested in detecting the eye and not the exact position of it, it would be easier than eye tracking or gaze tracking.

After eye detection, we perform eye state analysis-determination of whether the eye is open or not. Orazio et al [5] used training data for closed eye detection. Our proposed method is based on the brightness of the eye and roundness of iris. This method can determine open or closed eye with a high accuracy without using any training data and IR source. Finally, we decide about drowsiness and give a warning message for drowsy state. In this paper we propose a system which does not require any special hardware and training data and also is fast enough and more accurate than pervious methods. Fig. 1 gives an overview of our proposed system.

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In the rest of this paper we would describe the face detection method, eye detection method in cropped facial image, determination of the eye state and also we would present our experimental results.

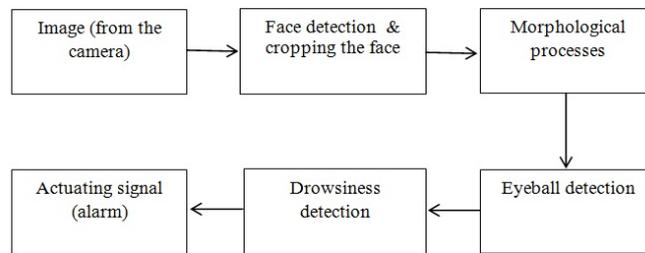


Fig. 1. Block diagram of the proposed drowsy detection system.

In our method we would first detect the face and crop the facial image which will isolate the face region from the background image and makes the eye detection more accurate because in this case instead of processing the whole image we would just focus on the facial image. We use a simple webcam which takes gray scale frames and by using a face detection library [6] we can accurately determine the position of the face and crop it. We can define a threshold for face detection which can be varied from -10 to 10 depend on the environment to reach better results. Another advantage of using face detection before eye detection is that you can use this system in higher distances which is not accessible in many previous works. In this project we first used the system without enhancing face detection which resulted in about 95% accuracy [8] which was not satisfactory since the other methods would result in higher accuracy but after enhancing face detection to our system the accuracy reached 97% when the eyes are open and 98% when the eyes are closed. In the face detection processes we have used a new reduced set method for support vector machines (SVMs) which creates sparse kernel expansions that can be evaluated via separable filters. The detail of this method was described in [6]. Fig.2 shows the detected faces using this method for different distances.

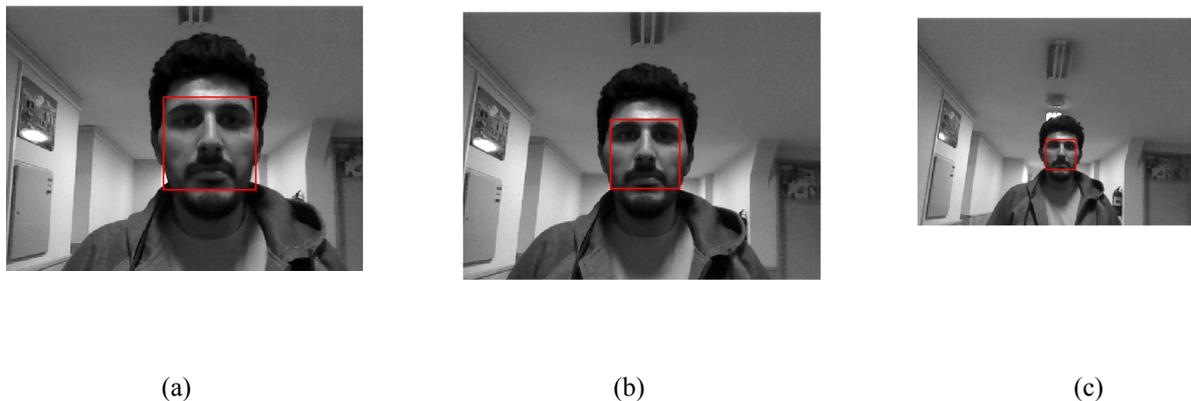


Fig. 2. Detected faces for different distances, (a) 0.5m, (b) 1m and (c) 2m

## 2. Eye Detection

After isolating the face from the background image, it is time to process the facial image to find the eyes in the cropped image. As we are using the grey scale images it is easy to separate the whole eye from the face by using its brightness and then after removing other parts of the face from the image we can use the roundness of the iris to determine the position of the eye. As we know the iris is the roundest object in the face so by defining two limits for the roundness we will check the roundness of the remained objects with these limitations and finally find the position of the eyes. Fig.3 shows a sample of detected eye. As we can see in this figure there are other detected objects that can be omitted by defining limitations for the roundness of detected objects and then by doing some morphological process the exact location of the eyes is

determined. Fig.3 shows the detected eye by red circles. As can be seen in fig.4 when the eyes are closed no round object is detected according to our definition and so no eye is detected.

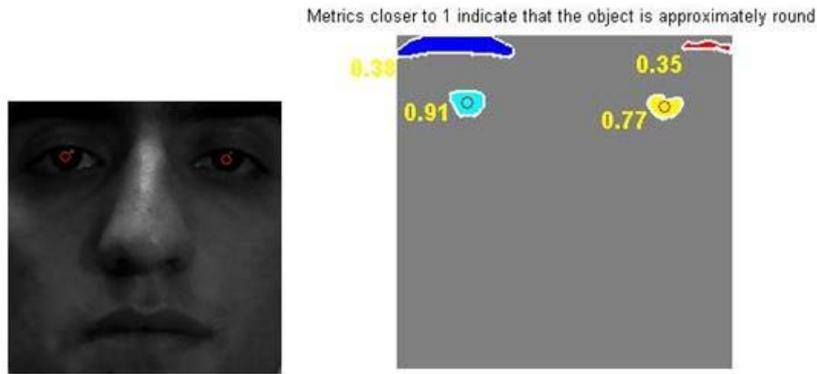


Fig. 3. The eyes are detected and are separated by red circles at their center

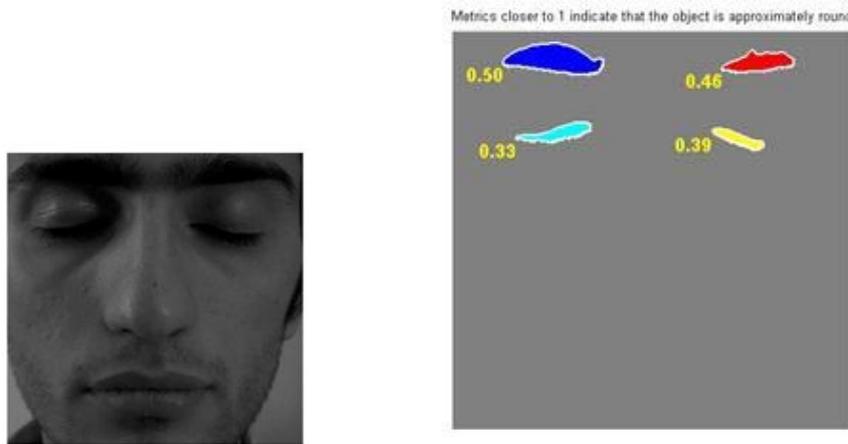


Fig.4. No eye is detected when the eyes are closed.

### 3. Eye State Determination

Eye state determination is done by analyzing the existence of at least one eye in the processed image. When the pupil is covered by the upper eyelid, the person cannot see anything and in this case we would not be able to detect the eyes and so we would consider it as closed eyes. Detecting at least one eye is enough for us to make sure that the driver is not sleep. Typical blink duration is 0.3 s (approximate 9-10 closed eye image) for a non-drowsy person. We repeat this process for every one among ten frames to avoid blink which may causes a wrong response for the system.

### 4. Experimental Results

In this project we used a simple webcam with a resolution of 640×480 and we changed the light condition and the distance from the camera. We have compared our results with previous which is shown in Table I. The positive influence of adding the face detection step to our algorithm can be understood by comparing the last two columns of Table I.

We have also found the optimum distance from the camera which obtained about 20-40 Cm that is very suitable for our task.

TABLE I .comparison with other methods

Eye state	Variance based algorithm	Eyelids distance-based algorithm[2]-[4]	Brightness based algorithm[7]	Our previous algorithm without face detection[8]	Our proposed algorithm

	Accuracy (%)				
Open	96.4	100	96.4	95.5	97
Close	67.5	72.5	94.7	96	98

We have also determined the detected number of the face, one eye, both eyes and closed eyes in 10 frames which can be seen in table II.

The eyebrows were an obstacle in this project which would have high roundness in some cases. In order to find the limits for the roundness that are mentioned above and omitting the wrong detections we had to calibrate the system with a person who has thick eyebrows.

TABLE II .number of correct detection in 100 frames

Facial features	Number of detected in 10 frames
face	100/100
One eye	83/100
Both eye	75/100
Closed eye	17/100

## 5. Conclusion

In this paper we proposed a new algorithm for drowsy detection which uses face detection to reduce errors and then by a simple and confident method we detect the region of the eyes and their states. The advantage of this system is that by using face detection before eye detection the accuracy of the system would improve and also this method does not need any IR illuminators, training data or special camera.

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## 7. References

- [1] Q. Ji, Z. Zhu, and P. Lan, "Real-time nonintrusive monitoring and prediction of driver fatigue," *IEEE Trans. Vehicular Technology*, vol. 53, no. 4, Jul. 2004, pp. 1052–1068. J. Breckling, Ed.
- [2] SH. Ueno, M Kaneda and M. Tsukino. "Development of drowsiness detection system," *Proc. IEEE Int. Conf. Vehicle Navigation and Information Systems*, Yokohama, Japan, Jun 1994, pp.15-20
- [3] T. Hayami, K. Matsunaga, K. Shidoji, and Y. Matsuki, "Detecting drowsiness while driving by measuring eye movement – a pilot study," *Proc. 5th IEEE Int. Conf. Intelligent Transportation System*, Singapore, Sep. 2002, pp. 156-161.
- [4] M. Suzuki, N. Yamamoto, O. Yamamoto, T. Nakano, and S. Yamamoto, "Measurement of driver's consciousness by image processing - a method for presuming driver's drowsiness by eye-blinks coping with individual differences -," *Proc. IEEE Int. Conf. Systems, Man, and Cybernetics*, Taipei, Taiwan, Oct. 2006, pp. 2891-2896.
- [5] T. Orazio, M. Leo, C. Guaragnella, and A. Distanto, "A visual approach for driver inattention detection," *Pattern Recognition*, vol. 40, Jan. 2007, pp. 2341–2355.
- [6] W. Kienzle, G. Bakir, M. Franz and B. Scholkopf: *Face Detection - Efficient and Rank Deficient*. In: *Advances in Neural Information Processing Systems 17*, pg. 673-680, 2005.
- [7] P. R. Tabrizi and R. A. Zoroofi. "Drowsiness Detection Based on Brightness and Numeral Features of Eye Image." *Proc. IEEE Int. Conf. Intelligent Information Hiding and Multimedia Signal Processing*. 2009
- [8] M. Tanha, H. Seifoory. *Morphological drowsy detection*. IEEE international conference on signal & image processing Applications 2011, Kuala Lumpur, Malaysia