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Driver Assistance System Using Eye Gaze Estimation

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Abstract

A driver assistance system (DAS) constantly monitors the behavior of the vehicle, behavior of the driver and road scene events and provides the relevant information to the driver in case of any threat events. This paper presents the automated detection and recognition of road signs, combined with the monitoring of the drivers response. The complete system reads traffic signs, compares the drivers gaze, and provides immediate feedback if it appears the sign has been missed by the driver. The driver video captured is processed to detect the eye pair and determine the eye gaze using DWT and Neural Networks. The road scene video captured is processed to detect the presence of speed sign board and speed limit on it. Based on these detections driver is alerted. The system is tested with different scenarios and the performance is estimated to 92.308%.

Keywords: *Driver Assistance System, Eye Gaze tracking, Artificial neural networks, Discrete Wavelet Transforms.*

1. Introduction

More than 1.2 million people are facing death in road accidents every year. Many other people are severely injured and have become disabled. 90% of the accidents can be prevented by strictly following the traffic signs specifying rules to be followed on road [7]. If rules and regulations are not followed then it may result in fine or arresting or severe road accidents.

Day today newspapers are depicting increasing articles related to road accidents. The ever increasing number of traffic accidents is due to the reduced driver's vigilance level which has become a problem of serious concern to society. For the drivers with a reduced vigilance level the ability of perception reduces and the driver cannot control the vehicle effectively which poses a serious danger to their own life as well as lives of other people. Statistics show that the main cause for injury-causing or fatal death causing traffic accidents is due to drivers with a reduced vigilance level. Driver fatigue causes reduced vigilance level of the driver. In the trucking industry 57% fatal truck accidents are due to driver fatigue. Seventy percent of drivers report driving fatigued [5]. Driver fatigue is the condition of the driver where he feels extreme physical or mental tiredness.

2. Problem Definition

2.1 Previous work

In [1] the authors introduced a method to accurately and rapidly detect faces within an image. This technique can be adapted to accurately detect facial features. The area of the image being analyzed for a facial feature needs to be regionalized to the location with the highest probability of containing the feature. By regionalizing the detection area, false positives are eliminated and the speed of detection is increased due to the reduction of the area examined. With the successful detection of facial features, the next goal is to research the ability for more precise details, like individual points, of the facial features to be gathered. Recognition of human emotion would require detection and analysis of the various elements of a human face, like the eyes and the mouth, to determine an individual's current expression. The expression can then be compared to what is considered to be the basic signs of an emotion.

In [2] the authors discuss about the neural networks for classification and its survey. Classification is the most researched topic of neural networks. This paper has presented a focused review of several important issues and recent developments in neural networks for classification problems. These include the posterior probability estimation, the link between neural and conventional classifiers, the relationship between learning and generalization in neural network classification, and issues to improve neural classifier performance. The research efforts during the last decade have made significant progresses in both theoretical development and practical applications. Neural networks have been demonstrated to be a

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competitive alternative to traditional classifiers for many practical classification problems.

In [3] the authors compare the three back-propagation training algorithms with two case studies. Levenberg Marquardt, conjugate gradient and resilient back propagation training algorithms are discussed and compared. All the three training algorithms are applied for both two case studies. They are compared according to the convergence velocities in training and performances in testing. It is inferred that the resilient back propagation has best accuracy in testing period. Levenberg Marquardt algorithm is the faster and has the better performance than the other algorithms during training.

In [4] the authors focuses on correlating measures of driver gaze direction with the position of signs in the road scene and improving recognition of signs through image enhancement. By enhancing the image signs can be classified reliably sooner. The correlation drops slightly as the sign approaches the edge of the field of view as motion blur introduces repeated strongly non-Gaussian noise in the observations. As an additional advancement the speed of the vehicle is also monitored. The speed limit identified and the speed of the vehicle is correlated.

In [5] authors discuss about the cause of increasing number of traffic accidents. The authors discuss the classification of technologies used for system that actively monitor the driver vigilance level. Survey is done on the developing active real-time image-based fatigue monitoring systems and from this survey it is evident that a lot of work is being carried out in the field of driver drowsiness detection. The existing techniques for sensing, have used physiological or image processing techniques. No much progress is found in the area of optimizing the driver drowsiness detection system using Artificial Neural Networks. Experiments were conducted with varying number of layers in ANN. The system was trained by using Levenberg Marquardt training function. Percentage of correct driver drowsiness detection was calculated and it is inferred that more accuracy can be obtained with increasing number of layers.

2.2 Motivation

- Eyes are important organs of human that provides visibility. Eye gaze tracking determines what human is seeing.
- Eye gaze is an important biometric that can be used for human-machine interaction.
- Driver's eye gaze tracking provides the information of what driver is seeing. This allows the determination of driver's consciousness of traffic signs.

2.3 Proposed system

In the proposed system eye pair is detected from the driver video using viola jones object detection and speed sign is detected from road scene video using Hough transforms. The general architecture of the system is shown in Fig 1.

The system takes two videos i.e. video of a driver and a road scene video as input. Eye gaze of the driver is detected from the driver video. Simultaneously speed sign is detected from the road scene video. Gaze direction and speed sign detected are correlated. Based on this correlation the driver is alerted of the speed sign.

3. System Design

The system must detect the eye gaze simultaneously with detecting the speed sign. Initially DWT is applied on the cropped eye pair. These eye pairs are trained using Artificial Neural Network to determine the gaze direction. Along with the speed sign board, the speed limit written on it is recognized. An algorithm is proposed to design the system. The steps of the proposed algorithm are mentioned below:

1. Read the driver video frames one by one.
2. Detect face using Viola-Jones classifier.
3. Detect eye pair using Viola-Jones classifier.
4. Detect eye gaze by using DWT feature extractor and ANN classifier.

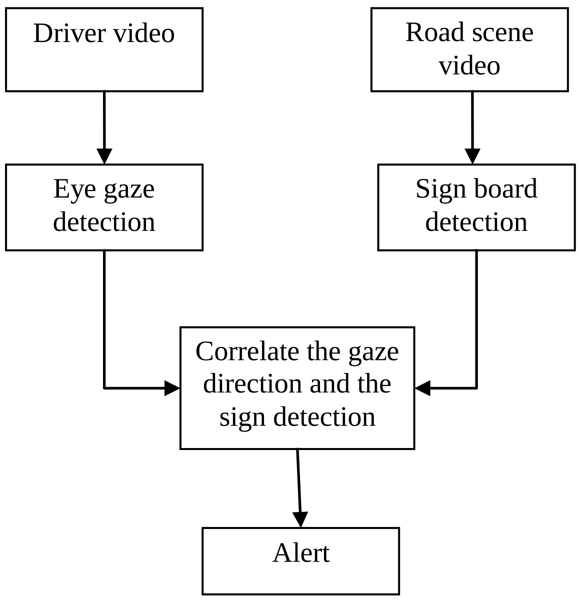

Fig 1: General Architecture

5. Read sign board video frames one by one.
6. Detect speed sign board using ha-ugh transforms.
7. Detect the speed limit on sign board using correlation coefficient.
8. Correlate the gaze direction and detection of sign board to alert the driver.

3.1 Read Video

The proposed system works with two videos as input. One video belongs to the driver behavior and the other video belong to the road scene environment. Both the videos are processed

frame by frame i.e. a frame is read and the series of functions are applied on the frame, then next frame is read and series of functions are applied on the frame and so on.

3.2 Face and Eye Pair Detection

In each frame read from the driver video, face and then eye pair should be detected in order to detect the gaze of the eye. This is done by using Viola-Jones algorithm.

3.3 Eye Gaze Detection

After the detection of the eye pair, gaze of the eye should be detected to know the direction in which the driver is seeing. This is achieved by using DWT and ANN classifier. DWT (Discrete wavelet transform) is a form of WT which transforms a discrete time signal to a discrete wavelet representation. DWT highlights the details in the image. One level DWT results in four equal sized images called sub bands which are generally named as LL, LH, HL, and HH. LL is an approximation image, LH is an horizontal detail image, HL is an vertical detail image, HH is an diagonal detail image. Second level DWT is applied on the LL image. This results in four subbands. The LL subband is given as input to ANN (Artificial Neural Network) for training. The artificial neural networks are capable of machine learning and recognizing the patterns. To train the ANN input and targets should be given to ANN. The inputs are the feature image set obtained by applying DWT. Targets are the labels. Labels will be the directions of eye gaze like left, right, straight etc. Before implementing the ANN each frame is labeled. These DWT feature image and respective labels are input to the ANN. The ANN is trained with these input set and gives the weights as output.

The ANN takes the input and weights obtained from training as input and gives the estimated target as output. Input is an image and estimated target is the label. The label gives the gaze direction. A video frame from the driver video is taken, eye pairs are identified and 2 level DWT is applied on the eye pair which results in LL2 image. LL2 image is given as input to the ANN along with the weights obtained by training ANN. This results in the estimated label, the gaze direction.

3.4 Speed Sign Board Detection

The video containing road scene environment is read and processed frame by frame. Each frame is processed to detect the presence of the sign board. The detection is done by using the hough transforms. In each frame by using hough transforms the thick red bordered circle is detected which specify the characteristics of the sign board.

3.5 Speed Limit Detection

Detection of the speed limit is done by using correlation coefficient. Initially a database of the digits should be created. To create the database videos containing different digits from 0-9 are processed. After the detection of the sign board the area of the sign board is segmented. The segmentation is done by finding the row range and column range. Row range is found by adding and subtracting the radius from the y coordinate of the center. Similarly column range is found by adding and subtracting the radius from the x coordinate of the center. The area covered by this row and column ranges in the red component of the frame is cropped. This cropped image represents the sign region. This cropped sign image is binarised.

The image is enhanced by applying morphological operations like area opening where only the connected components with higher number of pixels are chosen. This results in a binary image consisting of connected components. These connected components are labeled column wise. Each labeled component is a digit and is segmented. This results in bi nary image consisting of digit. All the images corresponding to a digit are stored in the folder named after that digit.

When the video representing the road scene is given to the system, frames are read and processed one by one from the video representing the road scene. The speed sign board is detected by using the hough transforms and the digits within the sign board are detected as discussed above. The digit image is compared with all the images in the database. If both the images are matched completely then the correlation value will be 1 else if the images are completely different then the correlation value will be zero. If the match is found but not the complete match then the value will be in between 0-1. Thus by comparing the digit image with all the images in the database, all the images will get the correlation coefficients. Mean of correlation coefficients for all the images in a subfolder is calculated. Thus each folder will get the mean correlation coefficient. Maximum of the means calculated is considered. The folder indicated by the maximum value contains the images of higher matching. The folder name gives the digit. This is how the digits on the speed sign board are detected.

3.6 Alert the driver

Based on the gaze direction and the sign board detected the driver will be alerted. If the gaze is not towards left and the sign board is detected then the driver is alerted as shown in Fig 2. The driver is alerted of the missed speed limit. If the gaze is towards left and the sign board is detected than the driver has seen the sign board.

4. Result and Discussion

The system detects the eye gaze of the driver and speed sign of the road and alerts the driver if he misses the sign. After identifying the speed sign the system waits for certain amount of time to monitor the driver whether he sees the sign or not. For this system monitoring is done for 40 frames. The system considers that the driver has seen the sign only if the driver gaze is towards the sign for a period of 1.5 sec. The system is tested with different scenarios. To test the system with different scenarios the system is experimented on ten videos including four road scene videos. Based on these experiments the performance of the system is estimated to 92.308%. All these observations are organized in the following table.

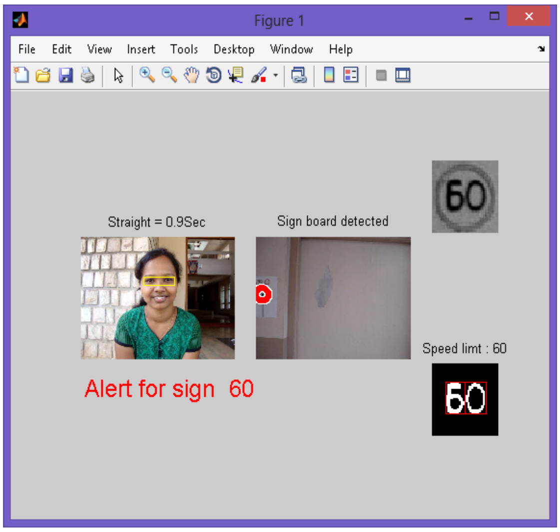

Fig 2: Alert to driver

TABLE I. OBSERVATIONS FOR POSSIBLE INPUTS

Eye Gaze		**Time of sight**	**Speed Sign**		**System output**
In video	*System estimation*		*In video*	*System detection*	
Straight	Straight	8.8	-	No	No Alert
Straight	Straight	10.5	60	Yes	Alert
Left	Left	1.8	-	No	No Alert
Right	Left	0.4	-	No	No Alert
Straight	Straight	8.1	-	No	No Alert
Straight	Straight	9.1	45	Yes	Alert
Straight	Straight	12.2	45	Yes	Alert
Straight	Straight	15.1	45	Yes	Alert
Straight	Straight	17.1	-	No	No Alert
Straight	Straight	7.8	50	Yes	Alert
Straight	Straight	10.5	50	Yes	Alert
Left	Left	1.6	50	Yes	No Alert
Straight	Straight	2.0	-	No	No Alert
Right	Right	2.0	-	No	No Alert
Straight	Straight	7.9	-	No	No Alert
Straight	Straight	8.0	60	Yes	Alert
Left	No Detection	-	-	No	No Alert
Left	Left	2.0	-	No	No Alert
Right	Left	0.4	-	No	No Alert
Straight	Straight	10.1	-	No	No Alert
Left	Left	2.8	60	Yes	No Alert
Straight	Straight	6.2	-	No	No Alert
Right	Straight	0.6	-	No	No Alert
Right	Right	1.0	60	Yes	Alert
Up	Up	2.7	60	Yes	Alert
Left	Left	3.0	60	Yes	No Alert
Straight	Straight	17.5	-	No	No Alert
Right	Right	4.7	-	No	No Alert
Right	Right	4.8	60	Yes	Alert
Straight	Straight	4.0	-	No	No Alert
Straight	Straight	7.8	70	Yes	Alert
Straight	Straight	10.5	70	Yes	Alert
Left	Left	1.6	70	Yes	No Alert
Straight	Straight	2.0	-	No	No Alert
Right	Right	2.0	-	No	No Alert
Straight	Straight	8.1	-	No	No Alert
Straight	Straight	9.1	50	Yes	Alert
Straight	Straight	12.2	50	Yes	Alert
Straight	Straight	15.1	50	Yes	Alert
Straight	Straight	17.1	-	No	No Alert

Straight	Straight	8.8	-	No	No Alert
Straight	Straight	10.5	45	Yes	Alert
Left	Left	1.8	-	No	No Alert
Straight	Straight	8.1	-	No	No Alert
Straight	Straight	9.1	50	Yes	Alert
Straight	Straight	12.2	50	Yes	Alert
Straight	Straight	15.1	50	Yes	Alert
Straight	Straight	17.1	-	No	No Alert
Straight	Straight	17.5	-	No	No Alert
Right	Right	4.7	-	No	No Alert
Right	Right	4.8	45	Yes	Alert
Straight	Straight	4.0	-	No	No Alert

5. Conclusion

An algorithm is proposed and implemented which detects the eye gaze of the driver, detects the speed limit and alerts the driver if he misses the speed limit. The system estimates the eye gaze using Discrete Wavelet Transforms and Artificial Neural Network classifier. Speed sign and its limit are detected using Hough transforms and co efficient correlation. The system that assists the driver based on the gaze direction is built. The system is tested with different possible inputs and is found that its performance is 92.308. The proposed system does not include too expensive and complicated hardware to configure and maintain. The driver need not worry about any wearable hardware. The hardware used does not have any physical contact with the driver. The system is flexible i.e. other application programs can be integrated. There is a drawback for this system. Although the system gives the alert it does not interfere in the drivers action, i.e. its aim is only to alert the driver. It is not concerned whether the driver acts according to alert or not.

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