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Real Time Eye's off the Road Detection System for Driver Assistance

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Abstract

Automated estimation of the allocation of a driver's visual attention may be a critical component of future Advanced Driver Assistance Systems. In theory, vision-based tracking of the eye can provide a good estimate of gaze location. In practice, eye tracking from video is challenging because of sunglasses, eyeglass reflections, lighting conditions, occlusions, motion blur, and other factors. Estimation of head pose, on the other hand, is robust to many of these effects, but cannot provide as fine-grained of a resolution in localizing the gaze. However, for the purpose of keeping the driver safe, it is sufficient to partition gaze into regions. In this effort, we propose a system that extracts facial features and classifies their spatial configuration into six regions in real-time. Our proposed method achieves an average accuracy of 91.4% at an average decision rate of 11 Hz on a dataset of 50 drivers from an on-road study.

1. Introduction

Driver distractions are the leading cause of most vehicle crashes and near-crashes. According to a study released by the National Highway Traffic Safety Administration (NHTSA) and the Virginia Tech Transportation Institute (VTTI) 80% of crashes and 65% of near-crashes involve some form of driver distraction. In addition, distractions typically occurred within three seconds before the vehicle crash. Recent reports have shown that from 2011 to 2012, the number of people injured in vehicle crashes related to distracted driving has increased 9%. In 2012 alone, 3328 people were killed due to distracted driving crashes, which is a slight reduction from the 3360 in 2011.

Distracted driving is defined as any activity that could divert a person's attention away from the primary task of driving. Distractions include texting, using a smart phone, eating and drinking, adjusting a CD player, operating a GPS system or talking to passengers.

This is particularly challenging nowadays, where a wide spectrum of technologies have been introduced into the car environment. Consequently, the cognitive load caused by secondary tasks that drivers have to manage has increased over the years, hence increasing distracted driving. According to a survey, performing a high cognitive load task while driving affects driver visual behavior and driving performance. References reported that drivers under high cognitive loads showed a reduction in the time spent examining mirrors, instruments, traffic signals, and areas around intersections. Especially concerning is the use of hand-held phones and other similar devices while driving. NHTSA has reported that texting, browsing, and dialing cause the longest period of drivers taking their Eyes Off the Road (EOR) and increase the risk of crashing by three fold. A recent study shows that these dangerous behaviors are wide-spread among drivers, 54% of motor vehicle drivers usually have a cell phone in their vehicles or carry cell phones when they drive. Result in drastic changes in the facial features (e.g., pupil and eye corners) to be tracked the system must be accurate for a variety of people across multiple ethnicities, genders, and age ranges.

Monitoring driver activities forms the basis of a safety system that can potentially reduce the number of crashes by detecting anomalous situations. Authors showed that a successful vision-based distracted driving detection system is built upon reliable EOR estimation. However, building a real- time EOR detection system for real driving scenarios is very challenging for several reasons: (1) The system must operate during the day and night and under real world illumination conditions; (2) changes in drivers' head pose and eye movements result in drastic changes in the facial features (e.g., pupil and eye corners) to be tracked; (3) the system must be accurate for a variety of people across multiple ethnicities, genders, and age ranges. Moreover, it must be robust to people with different types of glasses. To address these issues, this paper presents a low-cost, accurate, and real-time system to detect EOR. Note that EOR detection is only one component of a system for detecting and alerting distracted drivers.

Fig 1.1 Eyes off the road (EOR) detection system.

1.2 Problem Definition

Till date there is no effective technique's to monitor driver distractions. DRIVER distractions are the leading cause of most vehicle crashes and near-crashes. Distracted driving is defined as any activity that could divert a person's attention away from the primary task of driving. Distractions include texting, using a smart phone, eating and drinking, adjusting a CD player, operating a GPS system or talking to passengers.

2. Literature Review

Driver monitoring has been a long standing research problem in computer vision. It is beyond the scope of the paper to review all existing systems, but we provide a description of the most relevant work in academia and industry.

Ji and Yang described a system for driver monitoring using eye, gaze, and head pose tracking based on the bright pupil effect. The pupils are tracked using a Kalman filter the system uses image features around the pupil in combination with a nearest neighbor classifier for head pose estimation. The gaze is estimated by extracting the displacement and direction from the center of the pupil to the glint and using linear regression to map to nine gaze directions. This system is not person-independent and must be calibrated for every system configuration and driver. Batista used a similar system but provided a more accurate gaze estimation using ellipse fitting for the face orientation. These near-IR illumination systems work particularly well at night, but performance can drop dramatically due to contamination introduced by external light sources and glasses.

3 Existing method

Toyota has equipped their high-end Lexus models with their Driver Monitoring System. The system permanently monitors the movement of the driver's head when looking from side to side using a near-IR camera installed on the top of the steering wheel column. The system is integrated into Toyota's pre-crash system, which warns the driver when a collision is probable.

Another commercial system is FaceLAB, a stereo-based eye tracker that detects eye movement, head position and rotation, eyelid aperture and pupil size. Face LAB uses a passive pair of stereo cameras mounted on the car dashboard. The system has been used in several driver assistance and inattention systems. However stereo-based systems are too expensive to be installed in mass-produced cars and they require periodic re-calibration because vibrations cause the system calibration to drift over time. Similarly, Smart Eye uses a multicamera system that generates 3D models of the driver's head, allowing it to compute her gaze direction, head pose, and eyelid status. Unfortunately, it is prohibitively expensive for mass dissemination in commercial cars and it imposes strong constraints with respect to the necessary hardware to be installed. As a result, it is unfeasible to install this system in regular cars.

4 Proposed method

This paper presents a low-cost, accurate, and real-time system to detect EOR. Note that EOR detection is only one component of a system for detecting and alerting distracted drivers.

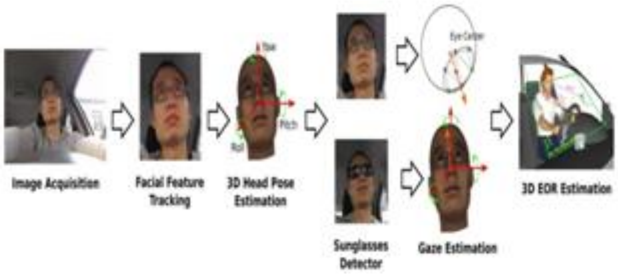

Fig 2. Overview of the eyes off the road (EOR) detection algorithm.

Fig: illustrates the main components of our system. The system collects video from a camera installed on the steering wheel column and tracks facial features. Using a 3D head model, the system estimates the head pose and gaze direction. Using 3D geometric analysis, our system introduces a reliable method for EOR estimation. Our system does not require any specific driver dependent calibration or manual initialization. It supports glasses and operates during the day and night. In addition, the head pose estimation algorithm uses a 3D deformable head model that is able to handle driver facial expressions (i.e., yawning and talking), allowing reliable head pose estimation by decoupling rigid and non-rigid facial motion. Experiments in a real car environment show the effectiveness of our system.

5.System Design

Driver distractions are the leading cause of most vehicle crashes and near-crashes. Distracted driving is defined as any activity that could divert a person’s attention away from the primary task of driving. Distractions include texting, using a smart phone, eating and drinking, adjusting a CD player, operating a GPS system or talking to passengers. This is particularly challenging nowadays, where a wide spectrum of technologies have been introduced into the car environment. Consequently, the cognitive load caused by secondary tasks that drivers have to manage has increased over the years, hence increasing distracted driving. According to a survey, performing a high cognitive load task while driving affects driver visual behavior and driving performance. References reported that drivers under high cognitive loads showed a reduction in the time spent examining mirrors, instruments, traffic signals, and areas around intersections. Especially concerning is the use of hand-held phones and other similar devices while driving. NHTSA has reported that texting, browsing, and dialing cause the longest period of drivers taking their Eyes Off the Road (EOR) and increase the risk of crashing by three fold. A recent study shows that these dangerous behaviors are wide-spread among drivers, 54% of motor vehicle drivers usually have a cell phone in their vehicles or carry cell phones when they drive. Result in drastic changes in the facial features (e.g., pupil and eye corners) to be tracked the system must be accurate for a variety of people across multiple ethnicities, genders, and age ranges. Monitoring driver activities forms the basis of a safety system that can potentially reduce the number of crashes by detecting anomalous situations. Authors showed that a successful vision-based distracted driving detection system is built upon reliable EOR estimation. However, building a real- time EOR detection system for real driving scenarios is very challenging for several reasons: (1) The system must operate during the day and night and under real world illumination conditions; (2) changes in drivers’ head pose and eye movements result in drastic changes in the facial features (e.g., pupil and eye corners) to be tracked; (3) the system must be accurate for a variety of people across multiple ethnicities, genders, and age ranges. Moreover, it must be robust to people with different types of glasses. To address these issues, this paper presents a low-cost, accurate, and real-time system to detect EOR. Note that EOR detection is only one component of a system for detecting and alerting distracted drivers.

There are five main modules: Image acquisition, facial feature detection and tracking, head pose estimation, gaze estimation, EOR detection.

5.1 Image Acquisition

The image acquisition module is based on a low-cost CCD camera (in our case, a Logitech c920 Webcam) placed on top of the steering wheel column. The CCD camera was placed over the steering wheel column for two reasons:

(1) It facilitates the estimation of gaze angles, such as pitch, which is relevant for detecting when the driver is texting on a phone (a major threat to safety).

(2) From a production point of view, it is convenient to integrate a CCD camera into the dashboard.

On the downside, when the wheel is turning there will be some frames in which the driver's face will be occluded by the steering wheel. For night time operation, the system requires an illumination source to provide a clear image of the driver's face. An IR illuminator was installed on the car dashboard.

5.2 Facial Feature Detection and Trackin

Parameterized Appearance Models (PAMs), such as Active Appearance Models and Morphable Models are popular statistical techniques for face tracking. They build an object appearance and shape representation by computing Principal Component Analysis (PCA) on a set of manually labeled data.

Fig 3 (a) Mean landmarks, x0, initialized using the face detector. Black outline indicates face detector. Fig 3 (b) Manually labeled image with 51 landmarks.

Fig 3 (a) Illustrates an image labeled with p landmarks (p = 51 in this case). Our model includes two extra landmarks for the center of the pupils. However, there are several limitations of PAMs that prevent to use them for detection and tracking in our system. First, PAMs typically optimize many parameters (about 50–60), which makes them very prone to local minima. Second, PAMs work very well for person-specific subjects but do not generalize well to other untrained subjects because they use a linear model of shape and appearance. Third, the shape model typically cannot model asymmetric expressions (e.g., one eye open and another closed, or an asymmetric smile). This is due to the fact that in most training datasets, these expressions do not occur.

To address the limitations of PAMs, Xiong and Dela Torre proposed the Supervised Descent Method (SDM) , which is a discriminative method for fitting PAMs. There are two main differences from the traditional PAMs. First, it uses a non-parametric shape model that is better able to generalize to untrained situations (e.g., asymmetric facial gestures). Second, SDM uses a more complex representation. This provides a more robust representation against illumination, which is crucial for detecting and tracking faces in driving scenarios.

5.3 Head Pose Estimation

In real driving scenarios, drivers change their head pose and facial expression while driving. Accurately estimating driver's head pose in complex situations is a challenging problem. In this section, a 3D head pose estimation system is proposed to decouple rigid and non-rigid head motion.

5.4 Gaze Estimation

The driver's gaze direction provides crucial information as to whether the driver is distracted or not. Gaze estimation has been a long standing problem in computer vision .Most existing work follows a model-based approach to gaze estimation that assumes a 3D eye model, where the eye center is the origin of the gaze ray. In this paper, we used a similar model .We make three main assumptions: First, the eyeball is spherical and thus the eye center is at a fixed point (rigid point) relative to the head model; Second, all the eye points, including the pupil, are detected using the SDM tracker. Third, the eye is open and therefore all the eye contour points can be considered rigid. Our algorithm has two main parts: (1) Estimate the 3D position of the pupil from the rigid eye contour points, and (2) estimate the 3D gaze direction from the pupil position and the eye center.

The 3D position of the pupil is computed as follows: Triangulate the eye contour points in 2D and determine which triangle mesh contains the pupil. See Fig

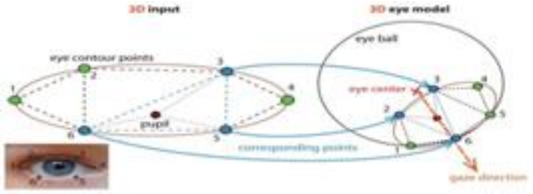

Fig 4.2 3D Gaze estimation

Compute the bar centric coordinates of the pupil inside the triangle mesh that contains the pupil.

Apply the bar centric coordinates to the corresponding eye contour points in 3D to get the 3D position of pupil.

After we obtain the 3D position of the pupil, the gaze direction can be simply estimated as the ray that goes through the 3D eye center and the 3D pupil. We can thus obtain the gaze angles.

5.5 Eyes off the Road Detection

The EOR estimation is based on a 3D ray tracing method that uses the geometry of the scene as described in Fig... Our EOR estimation algorithm computes the point where the driver's 3D gaze line, vgaze in Fig. , intersects the car windshield plane Π. If the intersection point lies outside of the defined on-the- road area, an alarm is triggered. In our approach, we only used the gaze from the driver's left eye since it suffers from less occlusion (only short head movements to check the driver mirror) than the right eye.

To compute the 3D gaze vector, we need the 3D position of the eye and the gaze direction (gaze yaw and pitch angles).

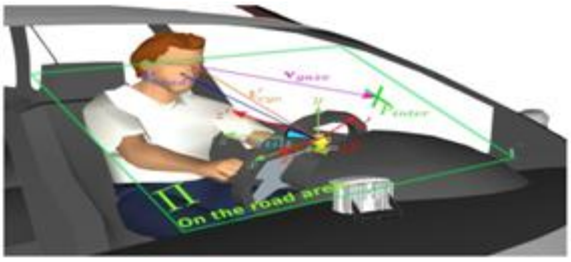

Fig 4.3 Geometric analysis for EOR estimation.

6 BLOCK DIAGRAM:

Transmitter Block

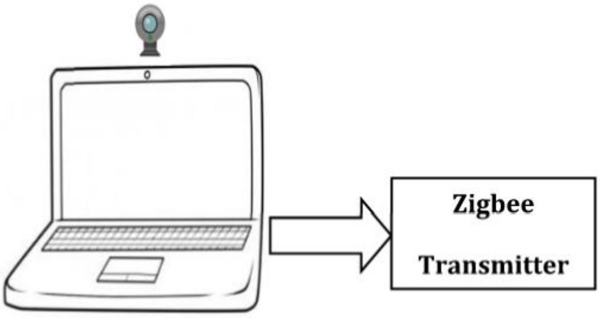

Fig 4.4 Transmitter Block

Receiver Block:

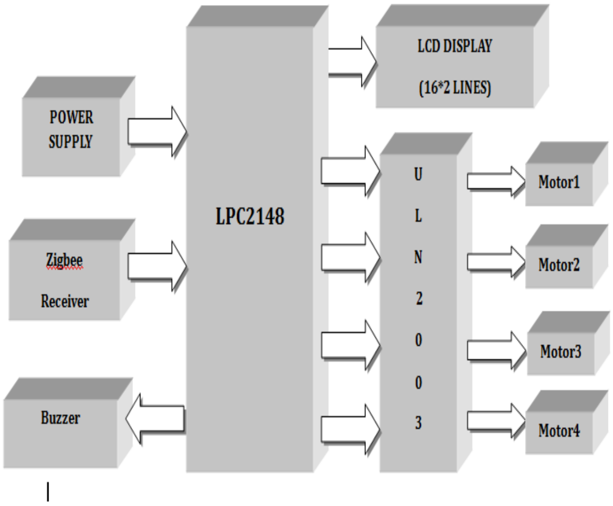

Fig 7 Block Diagram of proposed system

BLOCK DIAGRAM DESCRIPTION AND WORKING:

The proposed system consists of two sections: 1. Transmitter

2. Receiver

Here the Transmitter consists of a camera, PC for processing the head moment and EOR detection, and transmitter to send the commands to control the vehicle. The receiver consist micro controller and a driving circuit which will drive the current for operating the stepper motors. The motors are controlled by a PWM from microcontroller. If any EOR or head off is detected, controller gives the buzzer to the driver for safety and avoids the accident or crash.

7. FIRMWARE IMPLEMENTATION

7.1 Flow Charts:

Software Applications:

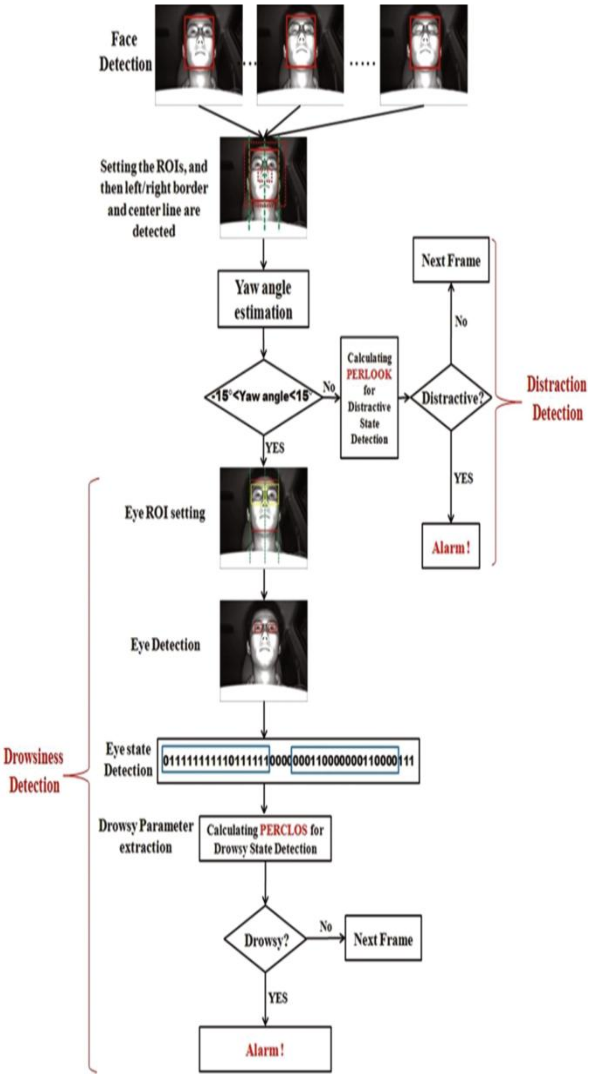

Fig 8 Flow Diagram of EOR detection system

The application software flow chart is helps to explain that how to use this software to monitoring the attention of driver's while driving.

8. RESULT AND ANALYSYS

8.1 Kit prototype

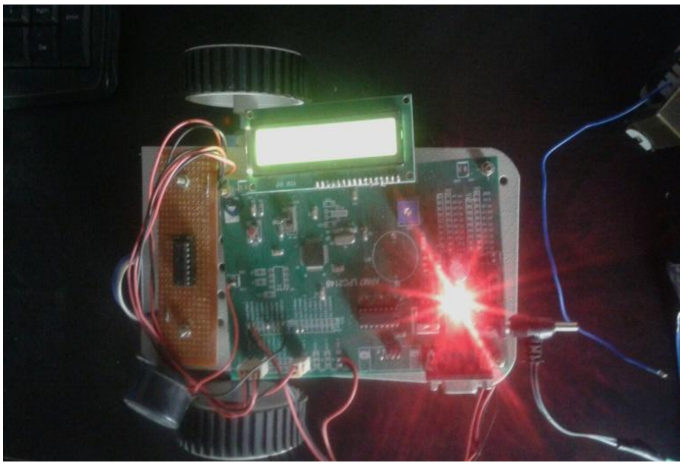

Fig 9 Prototype of EOR detection system

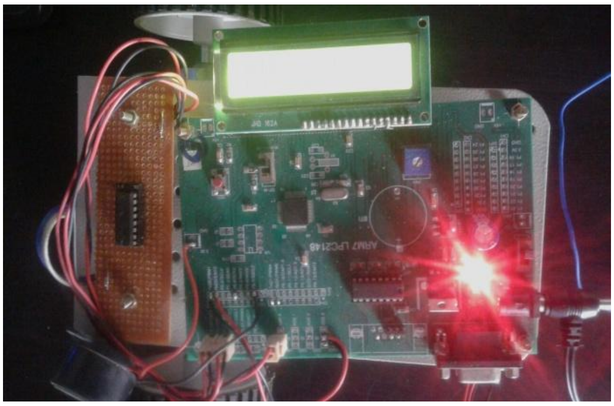

Fig 10 working of EOR detection system

Fig 11 LED display for EOR detection system

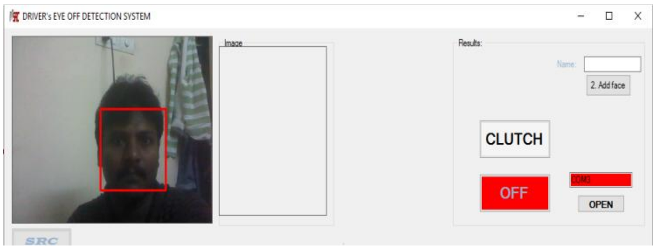

Fig 11Face Detection using Visual Studio
Fig 7.4 Driver's face and eye's off detection system using camera

CONCLUSION AND FUTURE SCOPE

This paper describes a real-time EOR system using the video from a monocular camera installed on steering wheel column. Three are the main novelties of the proposed sys- tem: (1) Robust face landmark tracker based on the Super- vised Descent Method, (2) accurate estimation of 3D driver pose, position, and gaze direction robust to non-rigid facial deformations, (3) 3D analysis of car/driver geometry for EOR prediction. The proposed system is able to detect EOR at day and night, and under a wide range of driver's characteristics. The system does not require specific calibration or manual initialization. More importantly, no major re-calibration is necessary if the camera position is changed or if we re-define a new on- the-road area. This is due to the explicit use of 3D geometric reasoning. Hence, the installation of the system in different car models does not require any additional theoretical development. Our experiments showed that our head pose estimation algorithm is robust to extreme facial deformations.

In future improving the facial feature detection in challenging situations (e.g. faces with glasses with thick frames) and improving the pupil detection using Hough transform-based techniques to further improve the gaze estimation will boost the performance of our system.

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