Integrating Lane Departure and Driver Drowsiness

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***Abstract*—Road accidents in India remain a critical issue, with over 4.6 lakh accidents reported in 2022 according to the Ministry of Road Transport and Highways, resulting in 1.68 lakh deaths and 4.43 lakh injuries. These numbers highlight the need for effective measures to mitigate accidents caused by speeding, reckless driving, and driver fatigue. To address this, we propose an integrated system that combines Lane Departure Detection and Driver Fatigue Detection to accurately detect driver drowsiness and reduce false alarm rates. Leveraging OpenCV for real-time video processing, the system monitors lane markings and vehicle position to detect lane departure, while also detecting driver fatigue through facial recognition and eye and mouth aspect ratios using Dlib. On detection, alerts and SOS notifications to dependents and healthcare facilities will be triggered ensuring timely assistance, improving road safety.**

***Index Terms*—Computer Vision, OpenCV, Dlib, False Alarm Rate, Lane Departure, Drowsiness Detection**

I. Introduction

Each year, drowsy driving accounts for about 328,000 crashes, 109,000 injuries and about 6,400 fatalities per year, according to the latest study [1]. Drowsy and tired driving is dangerous because many people are unaware of how tired they are until they are behind the wheel of a car, potentially putting themselves and others at risk. This paper presents an advanced integrated solution combining Lane Departure Detection (LDD) and Driver Fatigue Detection (DFD) systems to trigger alarms accurately. The goal is to tackle these prevalent issues while substantially reducing the occurrence of false alarms, which are common in traditional systems.

This innovative system leverages sophisticated facial recognition technology to continuously monitor indicators of driver fatigue, such as prolonged eye closure and frequent yawning. Concurrently, it analyzes vehicle dynamics to identify unintended lane deviations. The integration of these models allows for a more accurate correlation between the driver's state of alertness and potential lane departures, thereby enhancing the system's precision in issuing warnings.

One of the critical challenges addressed in this research is the minimization of false alarms. To achieve this, a robust multi-layered verification process is employed. This process meticulously cross-references potential triggers, such as consistent lane departure, sustained yawning, and eye closure, ensuring that alerts are triggered only when there is a high likelihood of genuine driver impairment. This significantly reduces unnecessary distractions and improves the overall reliability of the system. Furthermore, the system is equipped with an automatic SOS feature, designed to activate in critical situations. When a severe level of drowsiness or a dangerous lane departure is detected after multiple alarms, this feature automatically sends the driver's exact geolocation to predetermined contacts via a public messaging platform, using a geolocation API. This functionality ensures that emergency assistance can be quickly mobilized, potentially averting accidents.

The aim of this paper is to advance road safety by creating a highly dependable driver assistance system. This system not only detects drowsiness and lane departures with remarkable accuracy but also minimizes false alarms, thereby prioritizing the safety of drivers, passengers, and other road users through timely and trustworthy alerts, complemented by an automated emergency response mechanism.

The paper is structured as follows. Section II discusses previous works related to various DFD and LD detection methodologies. Section III covers our proposed methodology. Section IV illustrates the experimental setup. Section V contains the results and analysis. At last, the research is concluded in Section VI.

II. Literature Survey

A. Maintaining the Integrity of the Specifications

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III. Methodology

The entire project is divided into three sections: Drive Fatigue Detection System, Lane Departure Detection System and finally integration of both the systems.

A. Driver Fatigue Detection

Driver Fatigue is detected using OpenCV and Python. The Dlib library is used to detect and localize facial landmarks using Dlib's pre-trained facial landmark detector. It consists of a shape predictor model [2] trained on the i-Bug 300-W dataset, that localizes 68 landmark points respectively within a face image. The camera is placed on the dashboard of the car with the help of a mobile stand. Frame width is taken to be 1024x576 in accordance with modern day smartphones.

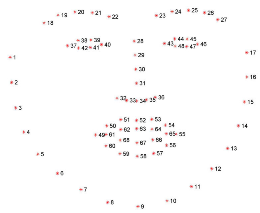


Fig. 1: 68 landmarks mapped on the detected face.

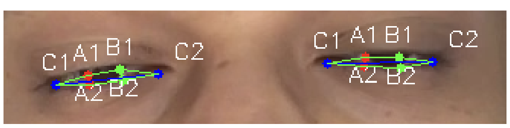
In each frame of the real time video, the system detects faces using the Dlib frontal face detector. If a face is detected, facial landmarks: (left eye, right eye and mouth coordinates) are extracted to identify the regions of the eyes and mouth. The eyes are then analyzed for Eye Aspect Ratio (EAR), and the mouth for Mouth Aspect Ratio (MAR).

The Eye Aspect Ratio (EAR) is defined as:

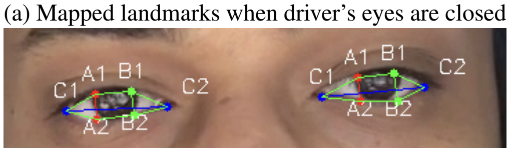
$$EAR = \frac{||A_1 - A_2|| + ||B_1 - B_2||}{2 \times ||C_1 - C_2||} \tag{1}$$

where:

- $A_1, A_2, B_1, B_2, C_1, C_2$ are the 2D coordinates of the eye landmarks.
- $||A_1 - A_2||$ denotes the Euclidean distance between the points A_1 and A_2.



(a) Mapped landmarks when driver's eyes are closed



(b) Mapped landmarks when driver's eyes are open

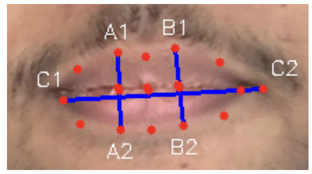
Fig. 2: Calculating EAR

The Mouth Aspect Ratio (MAR) is defined as:

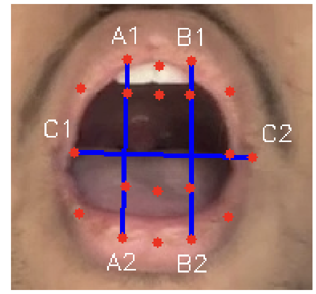
$$MAR = \frac{||A_1 - A_2|| + ||B_1 - B_2||}{2 \times ||C_1 - C_2||} \tag{2}$$

where:

- $A_1, A_2, B_1, B_2, C_1, C_2$ are the 2D coordinates of the mouth landmarks.
- $||A_1 - A_2||$ denotes the Euclidean distance between the points A_1 and A_2.



(a) Mapped landmarks when driver is not yawning



(b) Mapped landmarks when driver is yawning

Fig. 3: Calculating MAR

EAR and MAR are calculated for each frame in the real time video and their values are checked against the experimentally derived thresholds. A yawning counter is set which increases by 1 every time the driver yawns. If the driver yawns for more than 20 times (experimentally set up), an alarm is run informing the driver to take a break. Similarly an blink counter is set which increases if the EAR comes within the threshold. If this counter value increases above 10, a drowsy alarm is triggered which corrects the driver's unnatural behavior.

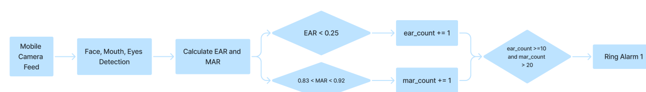


Fig. 4: Block Diagram of Driver Fatigue Detection

B. Lane Departure Detection

A web-camera of frame dimensions 1280x720 is placed on the windscreen of the car to capture video for lane departure.

1) Calibration: The camera calibration function uses multiple chess board images to correct lens distortion. Using inbuilt OpenCV functions the corners of the chessboard patterns are detected and on positive detection of the corners the 3D and 2D array values of images are stored respectively. OpenCV's calibrateCamera function estimates the camera matrix and distortion coefficients which are later saved into a dictionary prepared to load into a pickle file.

2) Frame Preprocessing: The image is first converted from BGR to HLS (Hue, Lightness, Saturation) color space from where the S channel is extracted. A binary mask is created based on a threshold applied to the S channel, highlighting areas with a specific saturation level.

- Sobel operator is a convolution operation used to calculate the gradient of the image intensity in both the x and y directions. We calculated the gradient only in the x-direction to decrease the computation time and focus only on the vertical features of the frame. The resulting gradient approximations were combined to find the absolute gradient magnitude at each point and thus highlighting regions of high spatial frequency that correspond to edges. The gradient magnitude is scaled to 8-bit

size. A binary threshold is applied to further highlight the detected lane markings.
- The gradient direction is computed, and a binary mask is created based on the direction threshold to detect edges that are oriented within a specific angle range.
- Both binary images resulting from Sobel Edge Detection and Direction and Color Thresholding are efficiently combined to finally produced a processed frame which highlights lane lines.

3) Warping: The image is warped to be converted to Bird's Eye View with the help of a perspective matrix transformation. By warping the image the Lane Detection Algorithm easily identifies the already converging original (feed) lane lines to the parallel lines trying to match the destination (ideal) points.

4) Lane Detection Algorithm: This is divided into two subparts - Full Search Algorithm and Sliding Window Search Algorithm

- Full Search: It is used to perform search for lane lines in a warped binary image assuming no previous lane lines are known. The peaks in each half of the histogram of the converging lane correspond to the start and end points of both the lanes. All identified nonzero pixels are marked as potential lane line pixels.
- Window Search: It updates the position of lane lines in each frame of a video based on previous lane positions. By fitting a polynomial to the detected lane pixels, it can accurately track curved lanes.The binary image after full search is divided into horizontal layers where each layer act as a margin to identify lane lines with non-zero pixels. The function returns the new fitting polynomials for the current frame which are used for the next frames to continue tracking the lanes.

5) Road Curvature: To accurately calculate the curvature, the left and right lanes are converted from pixels to meters using real-world space using scaling factors. Average of both the curvatures is calculated using a second-degree curve fitting polynomial.

$$R = \frac{\left(1 + \left(\frac{dy}{dx}\right)^2\right)^{3/2}}{\left|\frac{d^2y}{dx^2}\right|} \tag{3}$$

where R is the radius of curvature.

6) Off-center: If the distance between the right lane and centre is greater than the left lane and centre then its turning towards the right with consideration of the lane width and vice versa.

All of this is done real time by taking sliced input from the video feed frame by frame.

C. Integration

IV. Experimental Results

A. Some Common Mistakes

- The word "data" is plural, not singular.

Fig. 5: Real-time lane detection with road curvature and off-center warning display

- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

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Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

D. *Figures and Tables*

a) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 6", even at the beginning of a sentence.

TABLE I: Table Type Styles

Table	**Table Column Head**		
Head	***Table column subhead***	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

Fig. 6: Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization {A[m(1)]}", not just "A/m". Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)", not "Temperature/K".

Acknowledgment

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

References

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

References

[1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

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