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Driver Drowsiness Detection using Novel Deep Learning

Bhupesh Rawat[1*], Untung Rahardja[2], Marviola Hardini[3], Aulia Rahma Dina[4]
[1]Department of Computer Science, Graphic Era Hill University, India
[2]Faculty of Engineering, Universiti Teknologi Malaysia, Malaysia
[3]IAIC Bangun Bangsa, Indonesia
[4]UR Mart, Indonesia
[1]bhr222@gmail.com, [2]untung@raharja.info, [3]marviola@raharja.info, [4]aulia.rahma@raharja.info
***Corresponding Author**

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ABSTRACT

Road accidents remain one of the leading causes of death worldwide, with driver drowsiness identified as a major contributing factor, particularly during long-distance travel. Fatigue reduces a driver's alertness, reaction time, and decision-making ability, significantly increasing the risk of accidents. Therefore, developing an intelligent system capable of detecting driver drowsiness in real time is essential to enhance road safety. Artificial Intelligence (AI), particularly deep learning, has emerged as a promising technological approach to address this issue due to its strong capability in image processing and facial recognition tasks. This study focuses on the development of a deep learning–based driver drowsiness detection system using facial features as the primary indicators of fatigue. The proposed approach involves collecting and preparing a dataset consisting of driver facial images under various conditions, including normal and drowsy states. Key facial indicators such as eye closure, blinking frequency, and yawning patterns are analyzed to identify signs of drowsiness. A convolutional neural network (CNN) architecture is then employed to learn these visual patterns and classify the driver's state into alert or drowsy categories. The system is designed to operate in real time using a camera-based monitoring mechanism that continuously captures facial data while the driver is operating the vehicle. When signs of drowsiness are detected, the system can trigger an alert to warn the driver and prevent potential accidents. The results demonstrate that deep learning models are highly effective in recognizing fatigue-related facial patterns, providing a reliable solution for intelligent driver monitoring systems. This research contributes to the advancement of AI-based safety technologies aimed at reducing traffic accidents and improving transportation safety.

1. INTRODUCTION

In recent years the power of artificial intelligence can be seen in all areas of life including e-commerce [1], e-governance, e-learning domain and image detection among others [2]. AI is a vase area which comprises machine learning, deep learning and natural language processing [3]. The selection of a particular technology depends upon many factors such as size of data set and type of problem one is dealing with [4, 5]. With the increasing usage of social media and the internet we are inundated with huge amounts of data.

The real challenge is to preprocess and analyze this data and retrieve useful information which can be utilized for making effective decision [6]. Deep learning is one of the promising subsets of machine learning

which finds its application in many areas such as the health sector [7], face recognition attendance system, banks with face aging and face recognition, retailer, travel, airports, amazon Alexa, google home for voice help, YouTube, Netflix for recommendation system and image recognition [8]. Systems based on deep learning also learn from its experience [9], but a huge database is employed to learn the patterns. The word deep in deep learning means to have multiple layers between input and output in neural networks [10].

Face recognition is finding many uses such as security purpose, automatic attendance system among others. One of the main causes of road accidents is to suffer from the problem of drivers' drowsiness which occurs after a long drive and not taking enough rest before destination. An alert system can be designed and developed which can alert a driver well ahead of time before an accident takes place. Although there are many techniques to detect drivers' drowsiness, we propose a system which collects real time data and uses a deep learning approach to predict in advance about the accident.

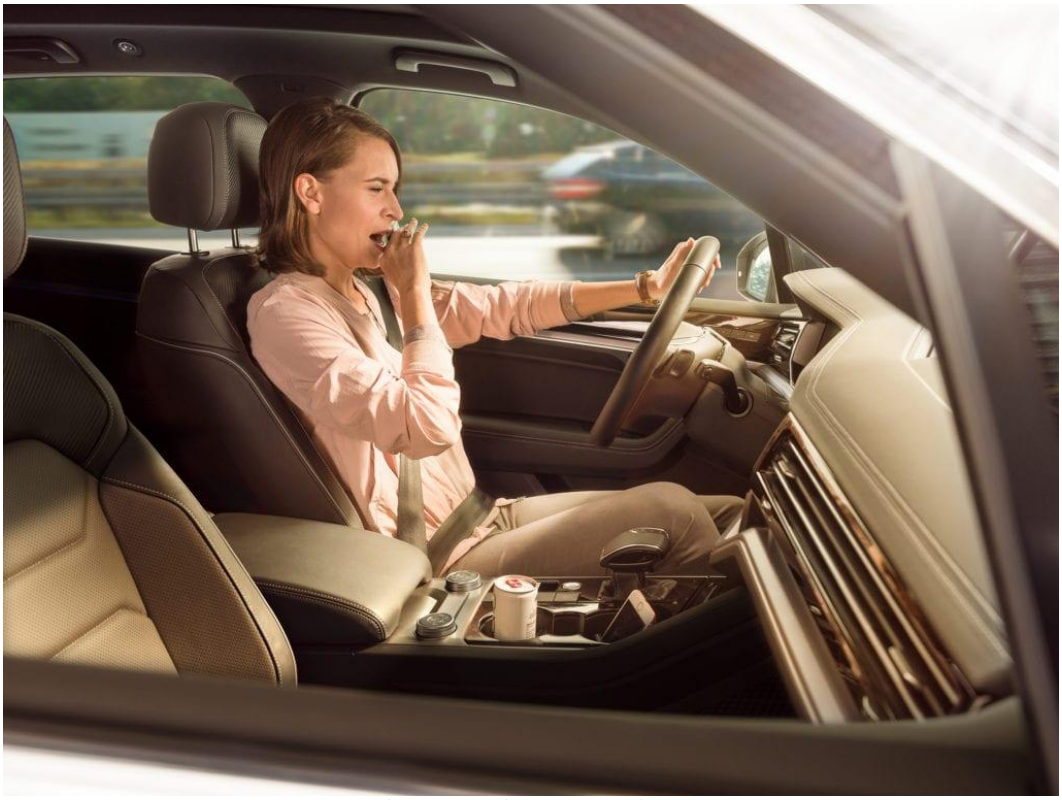

Figure 1. Driver's Drowsiness

This paper is organized as follows: Firstly, we discuss various deep learning techniques to find the most suitable one for our purpose. Secondly, a novel framework is proposed based on deep learning algorithms selected in the first phase. Initial results are obtained and discussed. Finally, the conclusion is provided and discussed at last.

2. RELATED WORK

in recent years, a significant amount of work has been going on in the field of detection of drivers' drowsiness as it is one of the major causes of road accidents worldwide. This section reviews and analyzes some of the most prominent works done in this area. In [11] the authors have proposed a methodology for detecting the drowsiness of a person based on capturing facial and eye features from the camera and detect the blinking of eyes and threshold value for a minimum value of eye closing. Another factor which has been considered is Arduino module which is integrated with elastomeric sensor for real time calculations of drivers' hand pressure on the car steering wheel. The results obtained from this method is used to alert a driver. In yet another work [12], they have proposed a fully wearable system based on a smart wristband equipped with stretchable strain gauge sensor [13] and readout electronics have been assembled and tested to detect a set of movements of

a hand crucial in rehabilitation procedures. The authors have evaluated the results produced by the system using linear discriminant analysis [14] and support vector machine. They were able to get a reproducibility of 98% and 94% respectively.In addition to detecting drivers' drowsiness using above approaches, drivers' blink behavior can also be detected by analyzing drivers' blink behavior changes [15]. In [16] The proposed model assumes that all participants develop drowsiness in the same way. The result of analysis shows that the method identified some participants as being drowsier and some less compared to the references. The proposed methods have not considered inter individual differences in the mode which is a crucial aspect which can affects the results.It has been found that, blink rate is not the only criterion to detect drivers' drowsiness. In [17] the authors have discovered few more parameters such as performing arithmetic manipulation, vocalizing vs quite solving a problem, social vs nonsocial task performance, being engaged in discussions vs listening among others. In yet another work [18] the authors have proposed a model based on deep learning techniques which can be implemented on android applications. Minimal network structure is designed based on facial landmark key point detection to recognize whether the driver is drowsy. The proposed model can achieve an accuracy of more than 80%

After studying literature review on applications of different approaches to determine drivers' drowsiness we have found that, no approach has taken into consideration the suitability of applying a particular algorithm to given data [19]. In contrary to this, we have made a comparative analysis to select the best algorithm for the problem [20]. For example, we have compared HCNN, CNN and RESNET for finding the best algorithm to the problem.

This paper is organized as follows: firstly, we provide the notion of drowsiness and gives an overview of various factor contributing to this phenomenon. Although several approaches have been proposed in the past to tackle this issue, we propose a novel approach based on deep learning to deal with the issue of drowsiness. In the next section, real time data is collected, and deep learning techniques are compared and applied. The results obtained are discussed. To enhance the proposed model future work is given which is followed by conclusion.

3. PROPOSED WORK

Drowsiness detection is one of the serious issues as discussed. We proposed a novel deep learning network to solve this problem. Data is the concern to solve the problem. We are using data from public domain and data is collected from live feed too. Public data link is as follows: data link is as follows: https://github.com/nishagandhi/DrowsyDriverDetection. We are using HCNN (hierarchical convolution neural network) to solve this problem. Architecture is shown in figure 2.

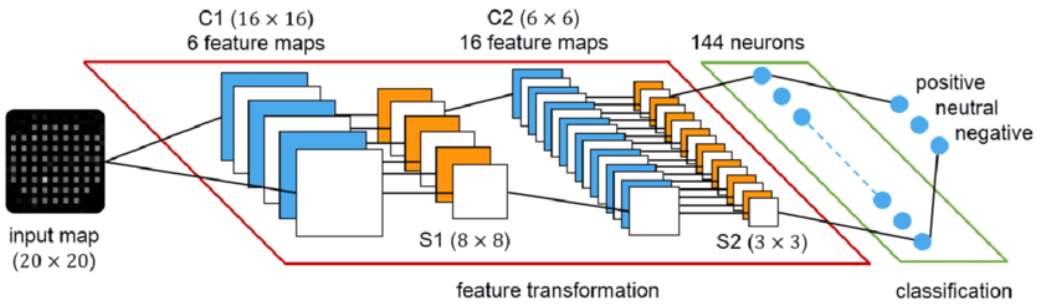

Figure 2. HCNN Network

We compared HCNN with CNN, RESNET, MobileNet. HCNN was outperforming as compared to other techniques. We obtained accuracy of 99.2% on our custom data. Details are mentioned in Table 1:

Table 1. Comparative analysis on drowsiness detection

S.No.	Data	Techniques for Drowsiness Detection	Accuracy
1	**Custom**	CNN	90%

Table 1 presents a comparative analysis of several deep learning techniques used for driver drowsiness detection based on a custom dataset. The comparison shows that different architectures produce varying levels

2	**Custom**	RESNET	95.60%
3	**Custom**	MobileNet	97.50%
4	**Custom**	CNN	99.20%

of accuracy in detecting driver fatigue. The conventional Convolutional Neural Network (CNN) approach achieved an accuracy of 90%, while the deeper architecture ResNet improved the performance to 95.60%. MobileNet, which is optimized for efficient computation and lightweight deployment, further increased the detection accuracy to 97.50%. In comparison, the proposed HCNN-based approach demonstrated the highest performance with an accuracy of 99.20%, indicating its superior capability in capturing facial patterns related to drowsiness. This result highlights that the proposed model provides a more reliable and effective solution for real-time driver monitoring systems compared with other commonly used deep learning techniques.

4. CONCLUSION

This paper focuses on the development of an intelligent driver drowsiness detection system using deep learning techniques. The study highlights the importance of detecting driver fatigue as a critical factor in reducing road accidents worldwide. A review of existing literature shows that various deep learning architectures have been applied to address this issue with promising results. In this research, a Hybrid Convolutional Neural Network (HCNN) model was implemented and evaluated using a custom dataset. The experimental results demonstrate that the proposed method achieved an accuracy of 99.2%, outperforming several commonly used models such as CNN, ResNet, and MobileNet. These findings indicate that the proposed approach is highly effective in identifying facial indicators of driver drowsiness and can contribute to improving road safety.

Although the proposed model achieved high accuracy, several improvements can be explored in future research. One of the main directions is expanding the dataset to include more diverse driving conditions, lighting environments, and driver demographics in order to improve model generalization. Additionally, further experimentation with different variants and architectures of HCNN can be conducted to enhance detection robustness and computational efficiency. Integrating the system with real-time embedded platforms and testing it in real driving scenarios will also be important steps to validate its practical applicability.

The findings of this study provide important implications for the development of intelligent transportation and driver safety systems. The proposed deep learning-based drowsiness detection framework can be integrated into advanced driver assistance systems (ADAS) to monitor driver alertness continuously and provide early warnings when signs of fatigue are detected. Such technology has the potential to significantly reduce accident rates caused by driver drowsiness. Furthermore, this research contributes to the growing field of artificial intelligence applications in transportation safety, offering a foundation for future innovations in smart vehicle monitoring systems.

5. DECLARATIONS

5.1. About Authors

Bhupesh Rawat (BR) https://orcid.org/0000-0001-7445-760X
Untung Rahardja (UR) https://orcid.org/0000-0002-2166-2412
Marviola Hardini (MH) https://orcid.org/0000-0003-3336-2131
Aulia Rahma Dina (AR) https://orcid.org/0009-0008-5861-6904

5.2. Author Contributions

Conceptualization: BR; Methodology: UR; Software: MH; Validation: BR and UR; Formal Analysis: AR and MH; Investigation: BR; Resources: UR; Data Curation: UR; Writing Original Draft Preparation: MH and AR; Writing Review & Editing: MH and AR; Visualization: UR; All authors, BR, UR, MH, and AR, have read and agreed to the published version of the manuscript.

5.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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The authors received no financial support for the research, authorship, and/or publication of this article.

5.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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