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A Systematic Review of Driver Drowsiness Detection using Various Approaches

Sneha N Ashture[1] and Dr.Sunil B Mane[2]
[1-2]College Of Engineering Pune, Wellesley Rd, Shivajinagar, Pune, Maharashtra 411005
Email: snehana20.comp@coep.ac.in, sunilbmane.comp@coep.ac.in

***Abstract*—Drowsiness is one of the leading causes of road accidents, hence a monitoring system is required to identify drowsiness. Driver monitoring systems typically detect three sorts of data: biometric, vehicle, and driver graphic. Nowadays, several devices including navigation systems and warning alarm systems are available to help drivers. The human mistake causes numerous traffic fatalities and injuries worldwide. Drowsiness and mapping while driving is widely recognized as contributing factors to deadly car accidents. This article reviews several sleepiness detecting methods. The characteristics of these approaches are categorized and contrasted. One of them is computer vision-based picture processing. It utilizes the driver's eyes and facial gestures to identify tiredness. This survey study focuses on this strategy.**

***Index Terms*— Drowsiness detection, Internet of Things, Image processing, Driver fatigue, Accidents, Eye Detection, Face Detection, IoT.**

I. INTRODUCTION

The rising number of traffic accidents caused by a driver's inattention is a serious social problem. The condition of the driver is a factor in some of these crashes. The majority of these accidents, however, are caused by driver fatigue or sleepiness. Fatigued drivers are more prone to cause major injuries or fatalities. Drowsiness has been linked to 30% of all road accidents. Drowsiness impairs driving performance, resulting in almost 20% of all vehicle accidents. The traditional transportation system is inadequate. Several methods exist for assessing driver sleepiness. These approaches include image processing, electroencephalography, and artificial neural networks. Techniques based on image processing fall into three groups. These are template matching, eye blinking, and yawning-based. These methods use image processing and computer vision. Researchers employ computer vision to identify driving fatigue using driver facial expressions including eye blinking and head motions. This article reviews several sleepiness detecting methods.

Researchers have invented a variety of approaches to detect driver sleepiness due to the dangers that fatigue brings on the road. Search phrases are created to discover more about various approaches for classification along with Drowsiness Detection Techniques (DDT). This study is restricted to prestigious conferences and journals. A multi-stage method for selecting and analyzing procedures is been designed. Sleepiness detection patterns have improved significantly, although there is still space for improvement. This systematic review seeks to identify and classify the best strategies, metrics, tools, and classification algorithms for detecting driver sleepiness. Organized reviews aid in the identification of what we already know in a domain.

All primary research data has been organized. We collect relevant data and identify current research needs after a thorough review of empirical works. Sleepiness detection research publications are included in the content analysis population.

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II. RELATED WORK

The Researchers employ three different ways to detect tiredness, as seen in figure 1. Below various methods are described that are used for drowsiness detection.

- Techniques based on image processing.
- Techniques based on EEG (electroencephalograph)
- Techniques based on artificial neural networks.

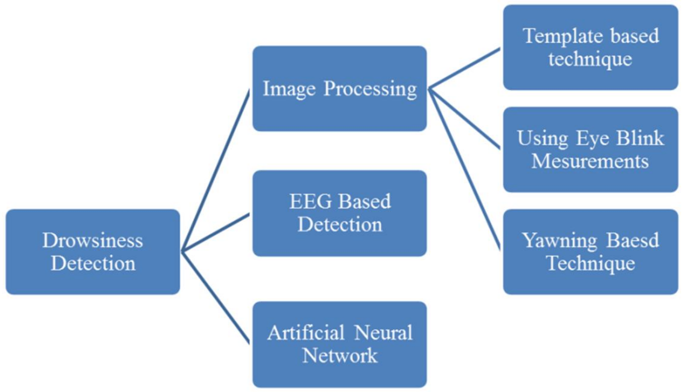

Figure 1: Techniques of image processing

A. Techniques based on image processing

Drivers' faces are processed with computer vision methods to identify their states. The facial picture shows whether the driver is conscious or asleep. Using the same photos, they can determine the driver's tiredness since the driver's eyelids are closed in the image. The facial picture may also identify other sleepiness indicators. These methods fall into three groups.

Template Matching Technique

Using this method, if the driver shuts their eye/s for a period of time, the system will sound an alert. Because this approach includes both closed and open driver’s eyes. To teach this system to acquire driver open and closure eye templates.The system has templates of both open or closed eyeball states depicted in figure 2. This method has been used [4].

Eye Blinking based Technique

In this test, drivers' eye blinking frequency and eye closure time are assessed. Because the driver's eye blinking and looking between the eyelids change when drowsy, they may quickly identify sleepiness. This technology tracks iris position and eye condition over time to determine eye blinking intensity and amount. [5]. This technology takes video from a distant camera and uses computer vision to accurately find the eyes, eyelids along with face in order to determine the ratio of closure. [11] The driver's tiredness may be detected by the eyes and blinking rate.

Yawning Based Technique

A yawn is a tired sign. A big vertical mouth opening is expected for the yawn. Yawning has a wider open mouth than speaking. Face and mouth surveillance can identify yawns. They identify yawning in paper [6] by measuring mouth opening rate and mouth shape changes. To improve performance, several studies [1, 2, 3] used multiple vision-based image analysis approaches to identify driver tiredness.

B. Technique Based on EEG

Drivers must wear an electrode helmet while using this approach. The electrode sensors in this helmet capture information from the brain. Researchers [7] employed EEG signal characteristics in sleepy driving. The degree of exhaustion was suggested using power spectrum analysis and the Fast-ICA algorithm.

The EEG signals of participants were collected by the NT-9200 in two states: sober and sleepy. The Fast-ICA method was used to reduce ocular, myoelectric, and power frequency interferences. Data is collected using EEG-based equipment. The method described in this study effectively determines the degree of weariness in EEG data.

C. Technique Based on Artificial Neural Network

They employ neurons to identify driver sleepiness. One neuron is not precise enough to get decent results compared to several neurons. Some scientists [8] are working on improving driver sleepiness detection by utilizing Artificial Neural Networks. Facial characteristics such as the eyes, head, and face alter when someone is tired. Eyelid movement, gaze, body control, and expression are all visual indicators of weariness. They created an artificial learning algorithm to identify tiredness using visual clues. They examined samples and got 96%.

Figure 2: General process of driver drowsiness detection

Figure 2 shows a general architecture for tiredness detection utilizing vision-based image processing. Firstly, they recorded video by mounting a camera on a car and capturing photos from video frames. Face detection algorithms can recognize the driver from these video frames. Then eyes detection methods are applied. So, eye and facial tracking techniques are applied. These photos may be used to identify tiredness using different symptoms and strategies outlined in their systems. Here are some examples of this technique's use. Proposed Advanced Driver Assistance System (ADAS) [1].

Based on artificial intelligence and computer vision, this article describes a non-obtrusive technique for detecting tiredness. While driving, the device monitors and analyses the driver's state of the eye in real-time. They employ distinct algorithms for face and eye-tracking. there's a distinct outcome for each of them. On the basis of the findings reported in this research, the suggested algorithm for face tracking, eye recognition, and eye tracking is resilient and accurate under varied lighting conditions. This paper's sleepiness detection findings are excellent, yet the system generates false alerts. One proposal [2] is a nonintrusive prototype computer vision system for measuring driver alertness. An active IR illumination is used to capture pictures of a driver in real-time, and software to detect certain visual habits that describe a driver's degree of attentiveness. They employed PERCLOS, eye closure length, blinking, nodding, facial posture, and fixed gaze. This system has four main modules:

A) image capture;

B) pupil detection and tracking;

C) visual habits;

D) driver alertness

They look for tiredness in pupils and visual behaviours. To estimate the driver's degree of distractibility and identify weariness, these variables are integrated that used a fuzzy classifier. This system is self-contained and can self-reinitialize as needed. This system is self-contained and can self-reinitialize as needed. The system's functionality degrades throughout the day, particularly on sunny days, and it currently does not operate with drivers wearing glasses. Driver hypo vigilance (fatigue and distraction) identification using facial and ocular symptoms [3]. (3) customizing, and normalizing the retrieved symptoms utilizing a brief period of training. They employed PERCLOS, eyelid distance variations compared to eye closure rate (CLOSNO), and normal distance in the eyelid (ELDC). Head rotation is a facial symptom (ROT). Eye-related symptoms are extracted using a horizontally projected top half segment, while face-related symptoms are generated by matching face templates. These symptoms can be used to detect drowsiness. The inaccuracy and computational complexity of facial tracking are the main flaws in our method.

TABLE 1: VARIOUS METHODS OF DRIVER DROWSINESS DETECTION USING VARIOUS TECHNIQUES

Reference	Behavioral Features	Method & Classifier	Description	Accuracy
K. Dwivedi et al. [11]	Visual Feature	CNN with SoftMax layer	Used voila and Jones algorithm with the CCN and SoftMax layer of the visual features.	78.00%
B. Reddy et al.[12]	Eye State	MTCNN and DDDN	Used MTCNN and DDDN for the eye state detection	91.6%
F. Zhang et al.[13]	Eye State	CNN	Used the Ada-boost and LBF and PERCLOS with CNN for the Eye State Detection	95.18%
M. A. Assari et al.[14]	Face components (eyebrow-raising, eye closing, yawning)	Background subtraction method, Horizontal projection technique	Used infrared light-based hardware to monitor the eye closing and eyebrows rising to detect drowsiness levels of the driver.	Nil

The technologies discussed in this research are summarized in Table 1. The particular detection accuracy of the systems employed by manufacturers has not been published to the author's knowledge, most likely owing to patent and confidentiality limitations. In terms of the detection and estimating methodologies presented in this work, it is estimated that the agreement rate with the degree of arousal based on subjective evaluation is in between the range of 70% to 90%, based on the number of settings and collaborators. If a technique is shown to be effective, it is likely to be employed in large production. In wakefulness detection and estimation technologies, however, no specific approach is presently being applied. However, with the current usage of deep learning, great accuracy may be ensured regardless of the approach employed provided in-vehicle computers and GPUs can be installed and data from a sufficient number of drivers can be acquired. As a result, advances in deep learning research will aid in the development of technologies for detecting and assessing wakefulness in the future. However, since there have been few instances of real vehicle assessments, it is suspected that environmental factors like as ambient light, road surface disturbances, and individual variations among operators have been overlooked

III. PROPOSED SYSTEM

Initially, we developed an NLP-based feature extraction approach for data selection, and a hybrid classification algorithm was utilized to determine if a certain piece of data was malicious or normal. The KDDCUP99 dataset is used to identify intruders, while blockchain is a secure decentralized architecture designed for data storage in a distributed way. The suggested system architecture is shown in Fig. 1 below, along with a detailed explanation of each step.

Data Pre-processing and Normalization: In this phase, we used the NSLKDDCUP dataset has used for the generation of rules. In pre-processing data, filtration is done by validating with all attributes, and then data normalization is done by selecting a specific attribute set. The chosen matrix is the normalized dataset for module training and testing.

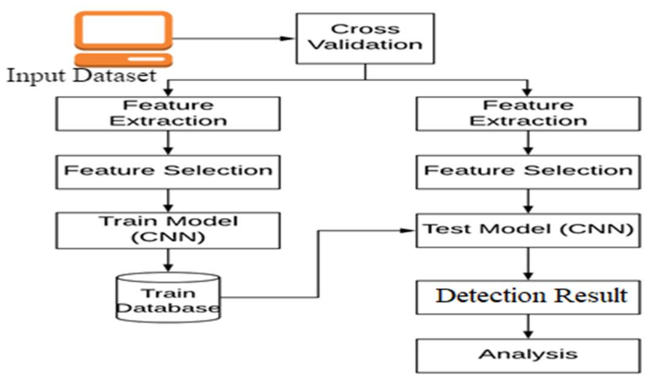

Fig. 1. Proposed System Architecture

Extract Features: Various feature extraction has been done, such as Term Frequency and Inverse Document Frequency (TF-IDF), relational features, and Genetic algorithm-based features. Different GA-based operators have been used for the selection of features such as crossover, mutation fitness, and selection, etc.

Feature Selection: The fitness function of GA has been used for the weight calculation of each input instance. After estimation of the fitness function, the 50% selection criteria have been used to select the best features and generate the training rules using the strategic mining technique. The generated rules have been stored in each blockchain node, and the custom blockchain implementation has been done for achieving the blockchain functionality.

Classification: The proposed methodology uses a modified hybrid classification method similar to the one employed by mRNN for classification. This is an addition to the system. A network log dataset is used to test it. The described method aims to determine if the network connection is normal or abnormal. Many feature extraction approaches have been applied to extract characteristics from a phrase. Each feature is given a weight in the first step of feature selection, and the element with the heaviest weight is picked. In the second step, the remaining characteristics in each category are chosen in total order, considering the connection between features. The weight support gathers and selects distinct and essential elements, while correlation eliminates duplicate data.

Algorithm design

- Based on a low-cost Mind Wave Neuro-signal acquisition device to detect drowsiness using EEG signals
- To identify tiredness using EEG data, a low-cost Mind Wave Neuro-signal collecting equipment was used.
- Drowsiness was detected using characteristics taken from EEG and ECG. This indicates that when both physiological signals are used combined, the HSI color model performs better. The HSI color model is not affected by brightness. To find eyeballs, Sobel edge detection is used.
- SVM was used to train pictures of the mouth and yawing. Cascade is used to detect weariness.
- To identify driver tiredness, infrared light-based technology was used to monitor eye shutting and eyebrows lifting.
- Face extraction, mouth area selection, and broad, mouth open detection were all done using SVM in three phases. The suggested broad, mouth-open detector is subjected to CHT.
- Tiredness is recognized by eye blinking and head position. It is presented as a novel supervised technique formed on WNC.
- The length of eye blinking and yawning were employed to determine weariness. The technology performs better when the driver does not wear glasses or has a mustache.
- From the mat-lab's vision toolbox, a cascade object identification was used to reach the ocular area. The average level of sleepiness is computed, and closed eyes are considered to be zero.
- Provides a user-friendly interface. To run on a mid-range, of the microprocessor, or on a smartphone with hardware and software requirements, the system needs tiny hardware.
- They are non-intrusive and perform effectively in real-time. A clear vision of the eye is required. In low-light situations or while wearing sunglasses, the device is unable to recognize the eye area and fails.
- Detection is based on the rate of eye blinking and the height of the head; however effectiveness suffers in low light and while wearing sunglasses.
- Work is divided into two phases: designing a wearable Bioharness sensor to monitor the driver's biological characteristics, and designing a mobile-based drowsiness detection system.

IV. Results and Discussions

The implementation was carried out using an open-source Java environment, with a 3.0 GHz CPU and 16 GB RAM, running Python 3.7. The RESNET-100 framework has been used for the utilization of deep learning classifiers as well as various machine learning classification methods. The private blockchain custom implementation is designed with a multi-node environment for safe data storage and validation. We performed an initial experiment analysis on blockchain implementation to validate the findings. Table 2 and Figure 2 exhibit the classification accuracy of the proposed system as well as a comparative analysis with many cutting-edge systems.

TABLE II: Assessment of Proposed Methodology using Several State-of-the-Art Techniques and Extraction and Classification

Algorithms	Features	Accuracy
IoT ML [5]	IoT features and relational features	90.60
Computer vision and image processing [14]	Text and numerical	91.30
IoT [23]	TF-IDS	87.00
ML [9]	autoencoder	92.90
CNN (proposed)	Hybrid features	97.50

The classification performance for intruder identifying using suggested hybrid machine learning classification is shown in Table II. We extract multiple features such as luminance, chrominance, and IoT-based relational features and input them to classifications for validation in the suggested work. The CNN has been utilized for intruder detection and has a high accuracy of up to 97.50 percent. During the detection and classification, all nodes generate the majority voting, and based on that it generates the report on whether the connection is normal or abnormal.

Figure 2 displays the accuracy of machine learning and deep learning technique for identifying driver fatigue. The proposed algorithm obtains higher accuracy due to the use of hybrid features such as IoT-based and image

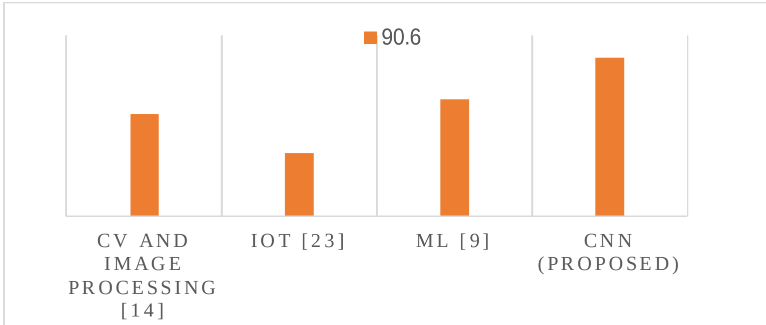

Fig. 2. Comparative analysis of accuracy for intruder detection using a proposed algorithm with other ML classifiers

features. Because the classification algorithm is given the opportunity to evaluate all alternatives, the method delivers more accuracy than that other classification techniques.

V. Conclusions

This systematic review's primary goal is to uncover the latest research in sleepiness detection. The review describes sleepiness detection methods based on behavioral, vehicular, and physiological factors. These strategies are described in-depth, with benefits and downsides. Physiological parameter-based strategies outperform other techniques in terms of accuracy, according to the comparison study. Wearable sensors could be located on the driver's seat, the seat cover, or over the driver's body, the steering wheel, and other areas The use of many features as a hybrid feature selection yields high-performance outcomes, stressing that combining physiological data rather than employing them separately increases performance. The best-supervised machine learning methods are described. The advantages and disadvantages of such tactics are thoroughly investigated. A classifier's accuracy varies depending on the scenario. Although SVM is the most often used classifier, it is not ideal for huge datasets. SVM classifier is faster and cheaper to train than HMM and CNN.

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