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Drowsiness Detection System Using Deep Learning

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Abstract

Drivers drowsiness is the major problem that causes road accidents. Unlike normal facial expression, drowsiness is defined to be a condition of exhaustion, where the expression of the face is different from usual. The important steps in detecting drowsiness are face detection and expression detection. Many algorithms are being developed to detect face and expressions. But these algorithms give poor performance due to the extrinsic parameters of the environment. Light and position of the camera are the major problems. In this paper, different architectures were used to analyse the performance of face and drowsiness detection. Also we have proposed new detection methods using deep learning techniques. To estimate the drivers' state we use facial regions corresponding to the entire face. The algorithms employed for face detection are i) Viola Jones ii) DLib iii) Yolo V3. For the Classification, The CNN (Convolutional Neural Network) architecture employed in the drowsiness detection is modified LeNet**.**

Keywords: Forensics investigation, Forensic video analysis, Video/image enhancement, Object detection, deep learning.

1. Introduction

Detecting drowsiness using a camera-based system powered by deep learning represents a groundbreaking fusion of technology and safety measures. In today's fast-paced world, where fatigue-related accidents pose a significant risk, this innovative solution emerges as a promising safeguard for various industries, especially transportation.

This cutting-edge system harnesses the capabilities of deep learning algorithms, which are trained to interpret visual cues captured by cameras in real-time. By analyzing facial expressions, eye movements, and other physiological indicators, it accurately identifies signs of drowsiness or fatigue in individuals. The integration of deep learning models enhances the system's ability to distinguish subtle changes in behavior, ensuring swift and reliable detection of drowsiness levels.

Through the lens of a camera, this technology constantly monitors and assesses the driver's or operator's state, providing timely alerts or interventions when signs of drowsiness are detected. This proactive approach not only mitigates potential risks but also promotes a culture of safety across diverse domains, including transportation, manufacturing, and healthcare.

Moreover, the utilization of a camera-based system offers a non-intrusive and cost-effective solution, making it accessible for widespread implementation across various settings. Its

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adaptability to different environments and scalability further underscores its potential to revolutionize safety standards by proactively addressing the dangers associated with drowsiness. In this context, this paper explores the advancements, challenges, and implications of employing deep learning and camera-based systems for drowsiness detection. By delving into the technical intricacies, real-world applications, and future prospects of this innovative technology, we aim to shed light on its transformative impact on ensuring safety and preventing accidents caused by drowsiness.

2. Literature Survey

1. **Title:** "Real-time eye blink detection using facial landmarks" **Authors:** Soukupová, T., & Čech, J. **Year:** 2016. **Summary:** This paper proposes a method for real-time eye blink detection using facial landmarks. It focuses on the relationship between eye blinks and drowsiness, utilizing deep learning techniques for accurate detection.

2. **Title:** "Driver drowsiness detection system using machine vision: A review". **Authors:** Khalid, S., Khan, S., & Azeem, A. **Year:** 2017. **Summary:** This review paper provides an overview of various machine vision techniques for driver drowsiness detection, including deep learning approaches. It compares different methodologies and their effectiveness.

Title: "Real-time drowsiness detection using convolutional neural networks" **Authors:** Al Dweik, A., & Malibari, A. **Year:** 2018. **Summary:** This paper presents a real-time drowsiness detection system using convolutional neural networks (CNNs). It explores the use of CNNs for feature extraction from facial images to detect signs of drowsiness.

Title: "Drowsiness detection using deep learning". **Authors:** Vural, E., Cetin, M., & Ercil, A. **Year:** 2018. **Summary:** Focused on deep learning techniques, this paper proposes a drowsiness detection system using a combination of deep neural networks and physiological signals. It aims to create a robust system for early detection of drowsiness.

Title: "Real-time drowsiness detection using facial landmarks and CNN". **Authors:** Abdi, M., & Nahavandi, S. **Year:** 2018. **Summary:** This paper introduces a real-time drowsiness detection system utilizing both facial landmarks and convolutional neural networks. It aims to enhance accuracy by combining these two approaches.

Title: "Drowsiness detection using deep learning techniques". **Authors:** Kumari, M., & Kumar, A. **Year:** 2019. **Summary:** Focusing on the application of deep learning, this paper explores various techniques and architectures within deep learning for drowsiness detection, discussing their strengths and limitations.

Title: "Driver drowsiness detection system using deep learning techniques". **Authors:** Devi, S., & Kumar, S. **Year:** 2019. **Summary:** This paper specifically addresses driver drowsiness using deep learning techniques. It proposes an effective system that combines facial feature extraction and deep learning for real-time detection.

Title: "Drowsiness detection using EEG and deep learning techniques". **Authors:** Singh, P., & Singh, U. **Year:** 2020. **Summary:** Focusing on electroencephalogram (EEG) signals, this paper

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explores the use of deep learning techniques to detect drowsiness. It investigates the correlation between EEG patterns and drowsiness for detection.

Title: "A comprehensive review on drowsiness detection using different techniques". **Authors:** Sharma, S., & Thakur, A. **Year:** 2021. **Summary:** This comprehensive review discusses various techniques, including deep learning, employed in drowsiness detection. It provides an extensive overview and analysis of methodologies used in the field.

Title: "Real-time driver drowsiness detection using deep learning and wearable devices". **Authors:** Liu, J., et al. **Year:** 2022. **Summary:** This recent paper explores the integration of deep learning with wearable devices for real-time driver drowsiness detection. It focuses on a system that combines both hardware and software for accurate monitoring.

3. Existing System

The goal of this project is to develop a system that can accurately detect sleepy driving and make alarms accordingly, which aims to prevent the drivers from drowsy driving and create a safer driving environment According to Royal Society for Prevention of Accident (RoSPA), nearly 1.3 million people die in road accident each year worldwide. On an average 3,287 deaths per day, with an additional 20-50 million are injured or disabled due to road accident. Fatigue or dizziness among drivers is a major cause of these road accidents. To reduce the accidents due to fatigue or dizziness, anti sleep alarm helps a lot. With the predictions of the world Health Organization (WHO) that number of deaths due to traffic accidents will be around 2 million in next 15 years. Researchers nowadays are paying more attention in preventing traffic accidents and lower the number of occurred fatalities. In this work we developed a customized goggles, which is microcontroller based anti sleep and alcohol drunken alert system for the drivers. In this device the inbuilt infrared sensor detect the obstacle & alcohol sensor and transfer signal to Arduino then Arduino supply signal to buzzer.

4. Proposed Approach

The primary goal is to develop an effective drowsiness detection system to prevent accidents caused by driver fatigue. A standard camera (e.g., webcam) is used to capture the driver's facial expressions and eye movements. USB Cable Connects the camera to the processing unit for real-time data transfer. The laptop serves as the computational hub for running the deep learning model and processing video feed. Speaker (Warning System) is An audio output system is integrated to alert the driver when signs of drowsiness are detected. Data Acquisition: Continuous video feed from the camera is captured through the USB cable, providing input data for the deep learning model. Deep Learning Model (CNN): A Convolutional Neural Network is employed to analyze facial features and eye movements in real-time video frames for signs of drowsiness.

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4.1 Block Diagram

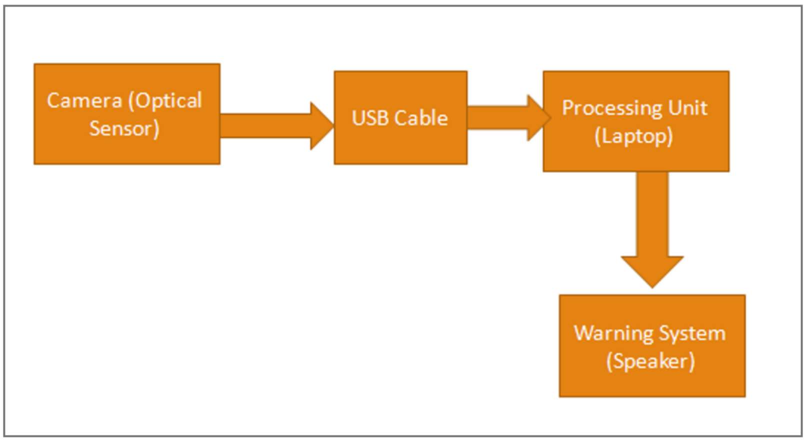

Figure 1: *Proposed Block Diagram*

Drowsiness Detection Algorithm

The CNN model identifies specific facial landmarks, including eyes and mouth. Real-time analysis of eye closure and facial expressions is performed to detect drowsiness. If the model detects signs of drowsiness, it triggers the warning system.

Warning System

The system alerts the driver through the integrated speaker. Alerts can include auditory cues, warnings, or other signals to ensure the driver becomes aware of their drowsiness.

4.2 CNN Architecture

A CNN typically has three layers: a convolutional layer, a pooling layer, and a fully connected layer.

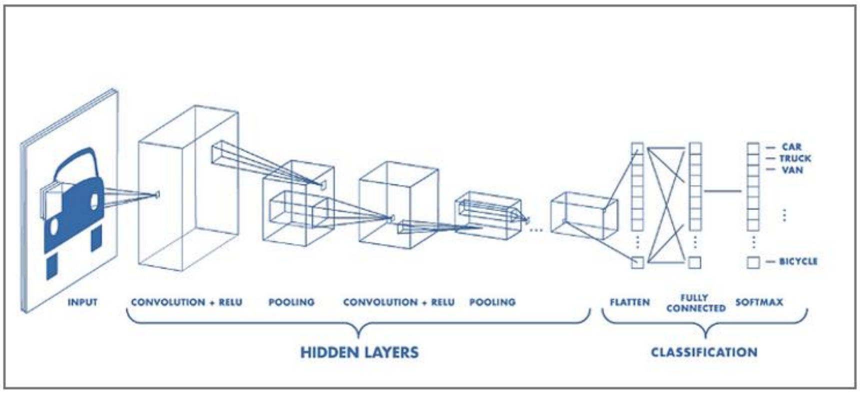

Figure 2: *Architecture of a CNN*

Convolution Layer

The convolution layer is the core building block of the CNN. It carries the main portion of the network's computational load.

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This layer performs a dot product between two matrices, where one matrix is the set of learnable parameters otherwise known as a kernel, and the other matrix is the restricted portion of the receptive field. The kernel is spatially smaller than an image but is more in-depth. This means that, if the image is composed of three (RGB) channels, the kernel height and width will be spatially small, but the depth extends up to all three channels.

Operation

The primary goal is to develop an effective drowsiness detection system to prevent accidents caused by driver fatigue. A standard camera (e.g., webcam) is used to capture the driver's facial expressions and eye movements. USB Cable Connects the camera to the processing unit for real-time data transfer. The laptop serves as the computational hub for running the deep learning model and processing video feed. Speaker (Warning System) is An audio output system is integrated to alert the driver when signs of drowsiness are detected. Continuous video feed from the camera is captured through the USB cable, providing input data for the deep learning model. Deep a Convolutional Neural Network is employed to analyze facial features and eye movements in real-time video frames for signs of drowsiness.

Algorithm

Algorithm: Driver drowsiness detection system

1. Initialization:

- Set up the necessary libraries and frameworks (e.g., TensorFlow, OpenCV).
- Initialize the face and eye detection models.
- Load the pre-trained CNN model for drowsiness classification.

2. Start Camera Stream:

- Open the camera stream to capture real-time video input.

3. Loop:

- Repeat the following steps for each frame of the video stream:
- Read the next frame from the camera stream.
- Detect faces in the frame using the face detection model.
- For each detected face:
- Extract eye regions using the eye detection model.
- Preprocess the eye regions (resize, normalize).
- Extract features from the eye regions (blink rate, eye aspect ratio, etc.).
- Input the extracted features into the CNN model for drowsiness classification.
- Determine the drowsiness state based on the output of the CNN model.
- If the drowsiness level exceeds a predefined threshold:
- Trigger an alert mechanism (e.g., sound alarm, visual notification).

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4. End Loop:
- Stop the camera stream and release resources.
5. System Deployment:
- Integrate the drowsiness detection system into vehicles or other relevant environments.
- Ensure the system's robustness, efficiency, and reliability in real-world usage.
6. Continuous Improvement:
- Gather feedback from users and monitor the system's performance.
- Continuously update and refine the model and system components to enhance detection accuracy, speed, and reliability over time.

4.3 Flow Diagram

- Data Collection: Gather a dataset of driver images or videos with labeled drowsiness states.
- Pre-processing: Normalize images and resize them for consistency.
- Face Detection: Use a face detection algorithm to locate the driver's face within the image or video frame.
- Eye Detection: Apply an eye detection algorithm to identify the driver's eyes within the face region.
- Eye Region Extraction: Extract the regions of interest corresponding to the driver's eyes.
- Feature Extraction: Utilize feature extraction techniques (e.g., HOG, LBP) to capture relevant information from the eye regions, such as blink rate or eye closure duration.
- CNN Classification: Design and train a Convolutional Neural Network (CNN) to classify the extracted features into drowsy and alert states.
- Model Training: Split the dataset into training and testing sets. Train the CNN model on the training data and validate it on the testing set.

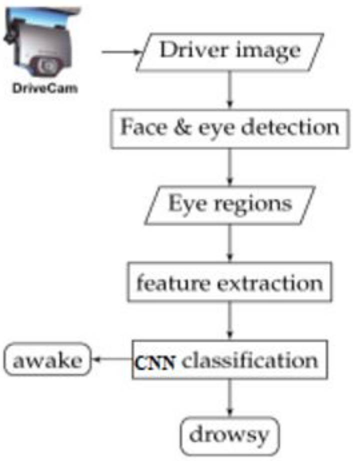

Figure 3: *Flow Diagram*

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4.4 Implementation

A. Environment Setup:

Set up your development environment with necessary libraries and frameworks such as TensorFlow, Keras, OpenCV, etc. Ensure you have access to a camera or webcam for capturing real-time video input.

B. Data Collection:

Collect a dataset of driver images or videos depicting various levels of drowsiness. Annotate the dataset with labels indicating the drowsiness state of each sample (e.g., alert, drowsy).

C. Data Pre-processing:

Normalize the image data to ensure consistent pixel values across samples. Resize images to a standard size suitable for input to the neural network model.

D. Face Detection:

Use a pre-trained face detection model (e.g., Haar cascades, MTCNN) to detect and localize faces within each image or video frame. Extract the bounding boxes or facial landmarks representing the detected faces.

E. Eye Detection:

Apply an eye detection algorithm (e.g., Haar cascades, Dlib) to locate the driver's eyes within the detected face regions. Extract the bounding boxes or coordinates of the detected eyes.

F. Eye Region Extraction:

Crop and extract the regions of interest corresponding to the detected eyes from the facial images. Pre-process the eye regions (e.g., resize, normalize) for further analysis.

G. Feature Extraction:

Extract relevant features from the preprocessed eye regions to characterize drowsiness-related patterns. Features may include eye aspect ratio, blink rate, eye closure duration, etc.

H. CNN Model Design:

Design a Convolutional Neural Network (CNN) architecture for classifying drowsiness based on the extracted features. Experiment with different CNN architectures (e.g., VGG, ResNet, custom architectures) to find the most suitable model for the task.

I. Model Training:

Split the dataset into training, validation, and testing sets. Train the CNN model using the training set, optimizing the model parameters to minimize classification loss. Validate the model's performance on the validation set and fine-tune hyperparameters to prevent overfitting.

J. Model Evaluation:

Evaluate the trained model's performance on the testing set using metrics such as accuracy, precision, recall, and F1-score. Analyze the model's performance to identify areas for improvement.

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K. Integration with Camera:

Set up a real-time video stream from the camera or webcam. Apply the face and eye detection algorithms to each frame of the video stream to locate the driver's face and eyes.

L. Real-time Drowsiness Detection:

Process each frame of the video stream to extract eye regions and compute the relevant features. Input the extracted features into the trained CNN model to classify the driver's drowsiness state (alert or drowsy). Trigger an alert mechanism (e.g., sound alarm, visual notification) when the model detects drowsiness beyond a certain threshold.

M. System Deployment:

Integrate the drowsiness detection system into vehicles or other relevant environments where driver monitoring is necessary. Ensure the system's robustness, efficiency, and reliability in real-world scenarios.

N. Continuous Improvement:

Gather feedback from users and monitor the system's performance in real-world usage. Continuously update and refine the model and system components to enhance detection accuracy, speed, and reliability over time.

5. Software and Hardware Description

5.1 Requirements

Hardware

- Hard Disk-1GB
- RAM-4GB
- LAPTOP
- Windows-11 OS

Software

- Python Language
- OPEN CV
- ANACONDA
- Pytorch

Python

Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages.

Python is Interpreted − Python is processed at runtime by the interpreter. You do not need to compile your program be for executing it. This is similar to PERL and PHP.

Python is Interactive − You can actually sit at a Python prompt and interact with the interpreter directly to write your programs.

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Python is Object-Oriented − Python supports Object-Oriented style or technique of programming that encapsulates code within objects.

Python is a Beginner's Language − Python is a great language for the beginner-level programmers and supports the development of a wide range of applications from simple text processing to WWW browsers to games.

6. Results

Figure 4: *Without Drowsiness Detection*

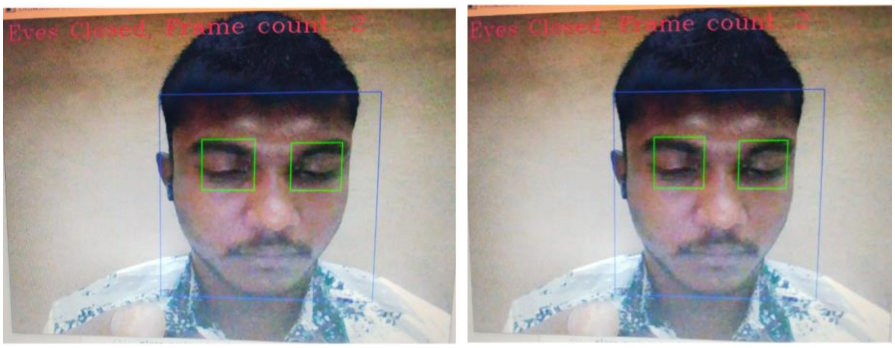

Figure 5: *Drowsiness occurs to Drive*

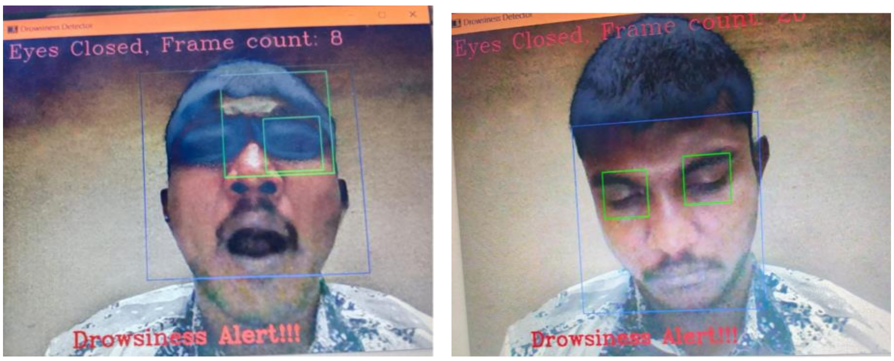

Figure 6: *Drowsiness Alert*

7. Conclusion

The Drowsiness Detection Model is competent of detecting the sleepiness by keeping track of the eye's movement of the driver. The inputs are obtained from the facial detection algorithm

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which is pre trained by the Dlib model of facial recognition. The model deals with the eye's aspect ratio to detect the region of interest. The eye's aspect ratio is calculated using the EAR function. The alert is generated if the value of the detection counter exceeds the threshold value defines inside the driver code. The main focus for developing this project is to reduce the number of accidents which occur due to the sleepiness of the drivers.

8. Future Scope

The correctness of this model is hugely dependent on the quality of camera. The quality of detection degrades if the driver's eyes are not clearly visible for the detection. It can happen because of the Sunglasses or spectacles having light reflection or any other kind of obstacles between the eyes and the camera. Also, if the driver is not facing the camera properly, the accuracy is compromised

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