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DRIVER DROWSINESS DETECTION

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Abstract. The state of the driver of being extremely tired or sleepy through the operation of the vehicle is called driver drowsiness. Different factors caused this state such as alcohol, lack of sleep, and the side effect of some medication. The drowsiness of drivers is a serious safety lead to accidents or fatalities on external and internal roads. The increased number of road accidents resulted from drowsy driving. A special smart, reliable, and accurate system, Using Python language 3.6 for Windows, was designed to build an alert system for drivers in detecting drowsiness driver. This system is crucial in reducing accidents road by the ability to concentrate, react quickly, and produce sound decisions through driving. This system implements a real-time detector that can monitor the states of drivers through driving.

Smart cameras with 16-megapixel were used to ensure that capturing photos have a high quality. These cameras were used in gathering the driver's dataset in different alertness states, including both alert states and drowsy. The collected dataset is processed by extracting all relevant features such as head movement, yawning, and eye closure, which were used in identifying the driver's drowsiness. Python's libraries such as TensorFlow, OpenCV, Keras, and Pygame are used for extracting all the above features. Viola-Jones algorithm is used in face eye region detecting and extracting from the image of the face in the proposed system. A Support Vector Machine (SVM) algorithm was used in classifying between drowsy and non-drowsy drivers. The system is tested and evaluated in the real world, to ensure that the system is reliable and robust; it has high performance and accuracy, and the accuracy is about 99.1%. This system can be used in manufacturing vehicles.

Key words: sensors, driver, drowsiness, driving, accident, smart camera

1. Introduction and Preliminaries. Driver Drowsiness considered a significant contributor to road accidents worldwide. To enhance road safety a special detection system was developed to detect driver drowsiness. Such a system becomes very crucial in enhancing road safety.

The proposed system can monitor the physiological signs and behaviors of drivers to detect drowsiness and alert the driver early before the accident occurs. Various techniques have been used in a proposed system including facial expression analysis, The proposed system can be used in eye tracking, and Viola-Jones algorithm; future in the car industry to reduce road accidents resulting from drowsy drivers and keep a safe driver.

2. Literature Review. The research on driver drowsiness contributed significantly to improving the safety of external and internal roads to increase safety and reduce or prevent all drowsy driving risks. These researchers try to identify the warning signs that cause driver drowsiness. This information is used in developing a different technology for detecting and preventing driver drowsiness such as physiological sensors, steering behavior analysis, and eye-tracking systems. Such technologies alert the drowsy driver through becoming incapacitated, to take control vehicle. The benefit of this is to reduce accidents number and save people's lives. With the increasing of road accidents number caused by drowsy driving has become a driver drowsiness detection system very important field in transportation safety. Through the availability of digital cameras, it has been increasing the amount of archived recorded videos around the world and it became an effectively growing processing of these video data. Different studies have been conducted to develop and evaluate several techniques in detecting driver drowsiness.

The most popular technique is using electromyogram (EMG) [1], electroencephalogram (EEG), and electrocardiogram (ECG) signals in monitoring the driver's muscle activity, brainwaves, and heart rate respectively. Dong and colleagues (2015) introduced a study that used EEG signals in detecting driver [2] drossiness, with

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an accuracy of 94%. Lee and colleagues (2017) introduce a study that used a combination of ECG, EEG signals in detecting driver drowsiness, with an accuracy of 98%. Chakraborty (2019) [3] used the data of eye tracking in the detection of driver's drowsiness with an accuracy of 85%. Wu and colleagues (2021) applied facial expression analysis in the detection of driver's drowsiness with an accuracy of 87%. Different machine language algorithms have been used in the detection of driver's drowsiness by using data pattern recognition and deciding the accurate predictions. Malik (2019) [4] applied a support vector machine (SVM) classifier in the detection of driver's drowsiness with an accuracy of 92%. Vishwakarma used a process called object tracking of the saved video in his survey [5]. M. Zhang [6] used extensive hardware sensors in detecting. But C. Anil used the generalizability of models in enhancing the detection of drowsy by increasing the dataset size [7]. M. Jafari introduced a new technology for enhancing the accuracy of system detection [8]. M. Aljasim suggested an expensive experiment detection method [9]. A. M. Leeuwenberg used more complex algorithms that used more variables and increased the tested samples [10]. The accuracy of the previous works is low in more time and most of these papers are surveys, that why it prepared a real-world practical system to protect people from the high numbers of accents. The real-world, low-cost cost with larger data sets proposed system is reliable and robust and is used in different scenarios like Viola-Jones algorithm, face eye region detecting and extracting from the smart camera's images. After evaluation of the proposed system, the accuracy is 99.1%. This system is more practical and it is easy to use in manufacturing different vehicles.

3. Architecture of the Proposed System. The proposed system consists of different steps; Figure 1 shows the steps of the proposed system. Input data: Input picked videos and images as a dataset to identify the driver's physiological signals, such as eye movement, and facial expression. Face Detection and Extract eye region: The identification of the driver's physiological signals is preprocessed for extracting the relevant features of him(her), such as eye blinking which are used to detect the driver's drowsiness. The Viola-Jones algorithm is used to detect each object in videos or images. This step is very important in improving the accuracy of the proposed system. Classification: All the extracted features are fed to the SVM (Support Vector Machine) classifier. This binary classifier is a supervised learning algorithm used for pattern identification to distinguish between (Drowsy, and non-drowsy) drivers based on input features. A sound will be produced by the proposed system to alarm drivers as a notification to stop driving and prevent accidents.

4. Dataset and Preprocessing. After collecting different data set images, the data is extracted from videos by cutting the continuous streams into discrete frames to identify the objects (face, mouth, eye,..., etc). The OpenCV technique is used. OpenCV is a Python library (tool for image processing) with the deep learning algorithm Support Vector Machine. The dataset of the proposed system depends on sequences of videos and images captures by webcam, which is based on eye estimation motion.

The Viola-Jones algorithm was applied to detect the parts of the face and eyes [11], [12]. While the area of eye motions was estimated frame to frame by sparse track from optical flow. Different adaptive thresholding values were used to decide whether the eyes were closed or opened.

The data preprocessing is an essential step in the detection of driver drowsiness, and it helps to prepare and clean data for analysis. The preprocessing steps that applied to the proposed system are:

Collection of data: Collect all captured camera videos or images of drivers exhibiting different levels of fatigue or drowsiness, to detect the face and extract the eye region, facial expression, [13] head position from the face images. Figure 4.1 represents the preprocessing of data.

Cleaning of data: Remove all irrelevant noisy data points that affect the analysis accuracy [14], [15].

Normalization: Try to normalize the captured data according to a common scale to be easier to analyze and compare.

Features selecting and extracting: Selecting and extracting most of the relevant features is important, because, not all extracted features are useful in drowsiness detection. So the selection of the most important features can improve analysis accuracy. Examples of data extraction like determining the location of eyes, blinking of eyes (closed, opened), etc. The Python libraries (dlib, OpenCv) are used in performing feature extracting. From every captured video the landmarks eyes were detected by eye aspect ratio

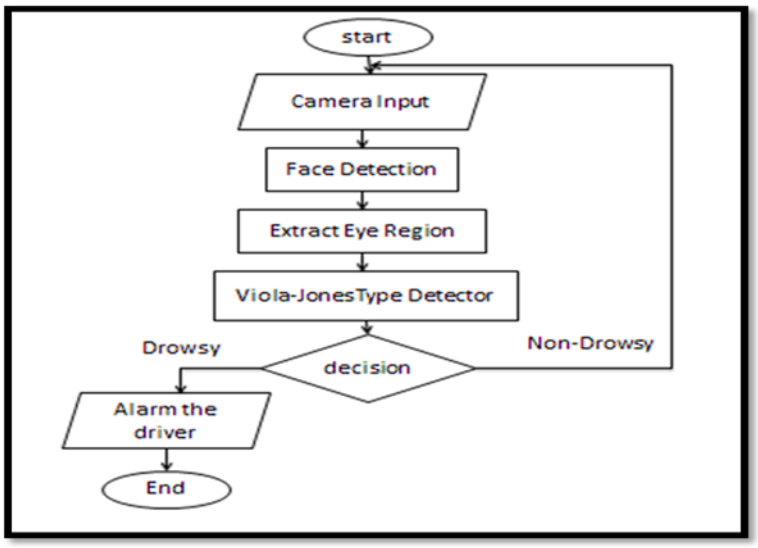

Fig. 4.1: Architecture of the Proposed System

Fig. 4.2: The preprocessing of data for Face detection

(EAR) between the width and height of the eye will be computed by using equation 4.1.

$$\text{EAR} = \frac{||P2 - P6|| + ||P3 - P5||}{2||P1 - P4||} \tag{4.1}$$

where $p1$, $p2$, $p3$, $p4$, $p5$, $p6$ are the landmark location of two dimensions drawn in Figure 3 [9].
The EAR ratio is mostly constant when the eye is opened and EAR=0 when the eye is closed. EAR ratio for an open eye has a small variance, in plane rotation of the face, and is fixed to a uniform scaling for each image [16], [17]. The blinking of each eye is performed synchronously by both eyes, and the EAR of them is averaged.
Figure 4.2 represents an example of signals of EAR over the video sequence.

Classifying of data: Classifying the data into two cases drowsy or drowsy by using the Support Vector Machine (SVM) algorithm. The last step is creating special samples of data by applying small variations or adding noise to existing data. This step is done to improve the accuracy and performance of this proposed system [18].

Evaluate the proposed system: The evaluation is done in real words by testing the dataset using some metrics such as precision, accuracy, and recall. The Python library sklearn. metrics used in performing the evaluation. This system can detect drowsy drivers to alert them to stop driving and take a rest.

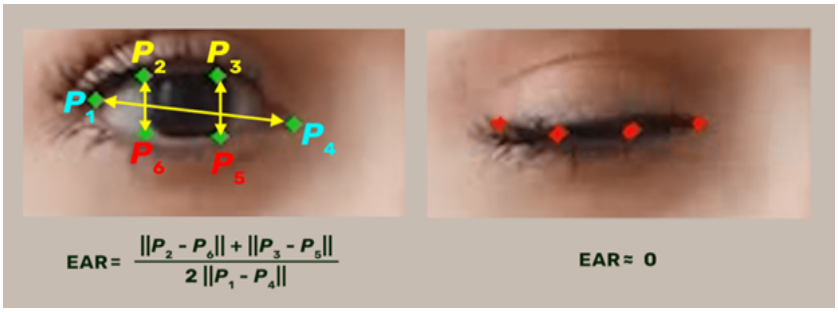

Fig. 4.3: Closed and open eyes with 2D landmark location

5. Viola-Jones algorithm. This is the most algorithms popular today in object detection for digital videos and images. This algorithm applies a series of image classifications [14], [15]. At first, this algorithm will convert each image into ("Haar-like features) a series of rectangular sub-images. This algorithm used Haar-like features, Figure 5.1 represents these features. These sub-images a binary images that have different highlights in brightness between adjacent pixels. This algorithm is used to determine and detect the features of the object. Like detection of eyes in the face image, which is very high real-time framework training [21], [22].

There are three ideas that used in this algorithm for face detection:

1. Integral Image: This idea represents an image where each pixel value represents the sum of all the above pixels and the left of it. This idea is very useful for quickly computing all sum values of pixels in any rectangle region of the image.
2. The classifier AdaBoost: This is an algorithm used in classification tasks. It is work combining different weak classifiers to form a strong one. It has multiple iterations, each one assigns higher weights to misclassified samples and trains a new one to get the final classifier from the weighted sum of all weak classifiers.
3. Attentional cascade structure: This is an algorithm in computer vision used for object detection. The idea of this algorithm is to break down the problem of object detection to a sequence of smaller sub-problems that are solved by a special detector. Each detector is applied to a small region of an image to form a successful detector in object detection [23].

The Viola-Jones used features of rectangles instead of pixels in face detection. Generally, the details of the eyes and face are detected by this algorithm automatically. The eye motion is estimated by the differences in optical flow intensity frame after frame, to decide if the eyes are covered or not by eyelids [24], [25].

This algorithm is used in a wide range of applications because it is the speed and accuracy in detecting objects, especially faces [26], [27].

6. Support Vector Machine Algorithm. Support Vector Machines (SVM) is a supervised machine learning algorithm that is used in classification of Driver Drowsiness Detection to identify drowsy or non-drowsy drivers depending on all based features [28]. After this classification, a sound will generate to alarm and prevent the driver from accidents caused by drowsy driving. SVM is used in regression analysis. In the context of the proposed system, the SVM is trained on different of dataset-labeled examples. Each example has a set of extracted features from a driver's face [29]. The most important features are head pose, eye closure duration, and all other factors of drowsiness indication.

The goal of SVM is creating the best boundary line for segregating the space of n-dimensional into classes [30]. To easily put the new data in the correct group. The hyperplane of the SVM algorithm called for the best decision boundary created by choosing the maximum points or vectors. These points are called support vectors. Figure 6 shows two different groups that are classified by using a hyperplane.

The model of drowsy or non-drowsy drivers is created using the SVM algorithm by training this model using a lot of images of the driver with drowsy and non-drowsy by learning different features of them. So the SVM algorithm will create a boundary between these features (support vectors) to simplify the decision of

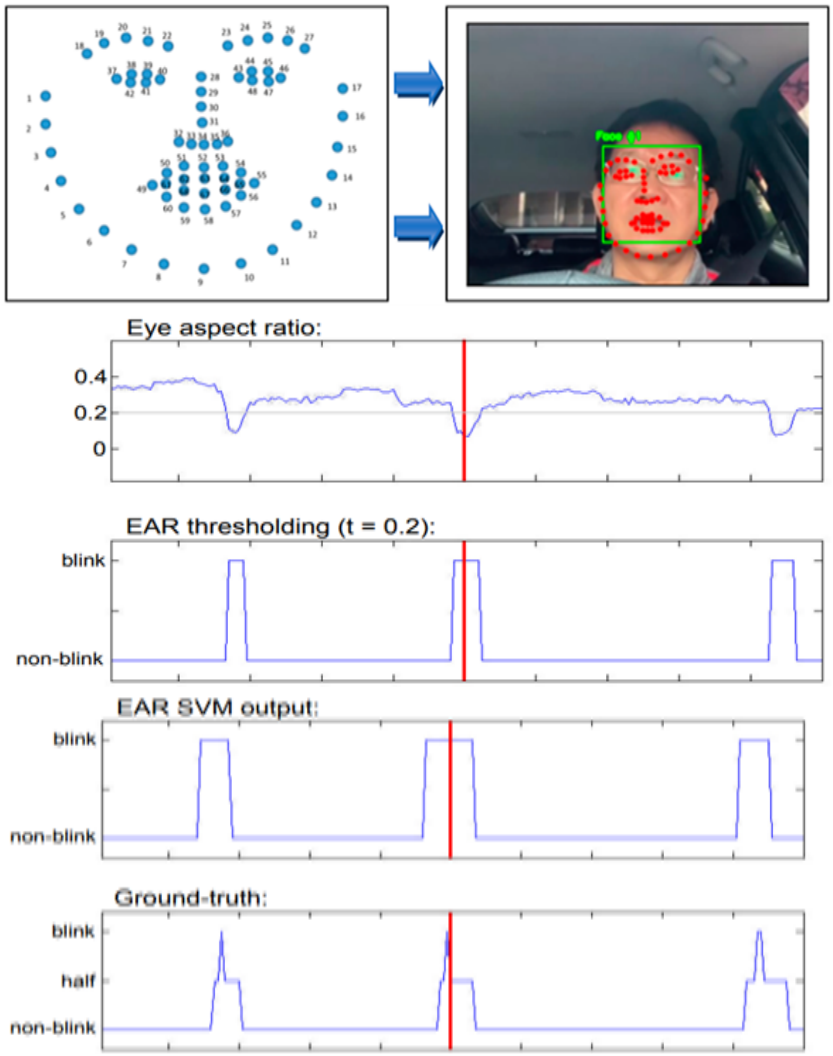

Fig. 5.1: An example of signals of EAR over the video sequence [19], [20]

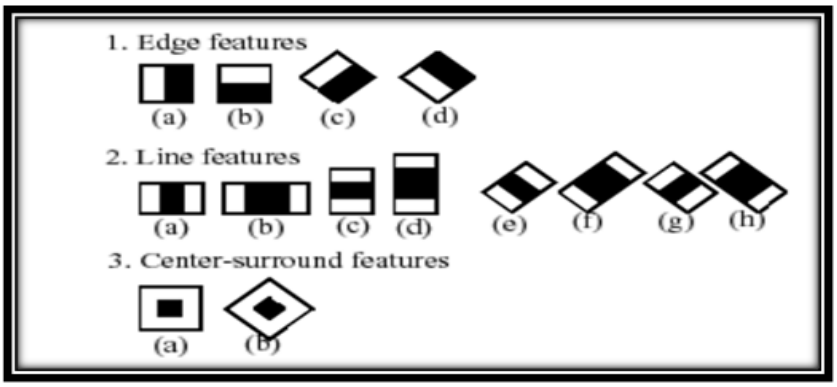

Fig. 5.2: The Features of Haar

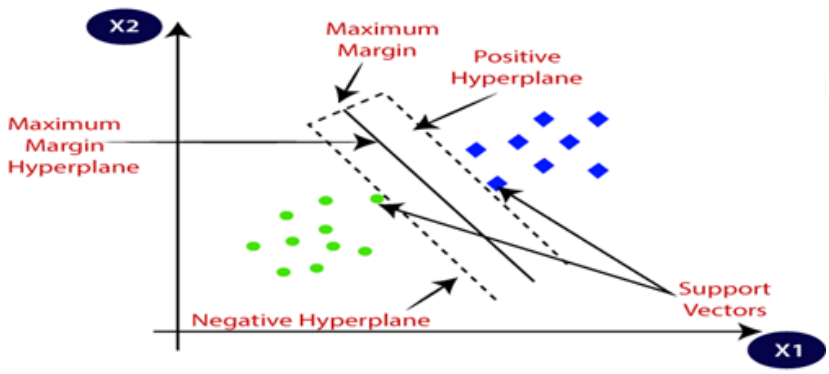

Fig. 6.1: Two different groups [31]

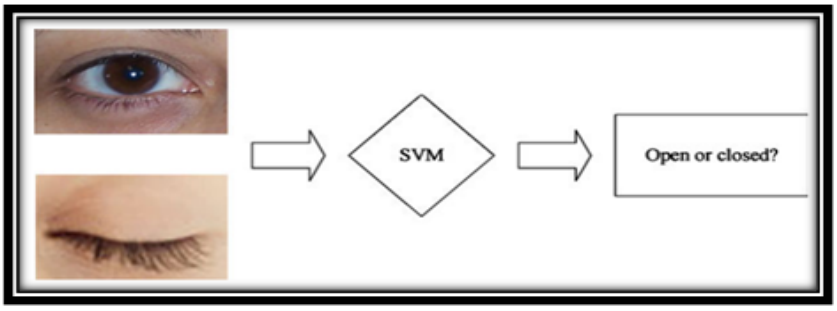

Fig. 6.2: Two different groups [31]

classification between drowsy and non-drowsy shown in Figure 6.1.

7. Python Language. This language is a powerful and easy, multi-programming language, often used for building an application of data science, machine learning, web applications, cyber security, and many development systems. The Python language is an Object Oriented Programming language that has an extensive standard modules library. The Python tools used in this proposed system are TensorFlow, OpenCV, eras, Pygame [32], [33]. These Python tools are used in detecting the closed eyes of drivers. TensorFlow is a free flexible open source library in Python. It was developed by specialists of the Google AI organization. This library has high support in deep neural networks like training and inference. OpenCV is a free open-source library in Python. It has a high performance in machine learning, computer vision, and image processing tasks such as object tracking, face detection, and many more tasks. It can recognize faces, eyes, and all objects from videos and images. This tool will monitor every image picked by the webcam and then feed this image into the proposed system model of deep learning to classify the eyes of the driver if it is opened or closed.

Keras is a free open-source library in Python. It is a built-in library that provides a high-performance Artificial Neural Network. This tool is used in building the proposed system classification model. Pygame is a free open-source library in Python. This tool is used to produce sound to alarm the drivers immediately to pay attention by detecting the driver's closed eyes. Figure 7.1 represents part of the Python code for the proposed system.

8. Smart cameras. Smart cameras are used in the proposed system to monitor the behavior of the driver and detect all the sign of drowsy or non-drowsy. 16-megapixel cameras were used for capturing the photos to be ensured photos with high quality. These cameras are equipped with the advanced of computer vision and image processing algorithms that responsible for analyzing different movement and facial features for detecting

```
import cv2
data = []
labels = []
for j in [60]:
for i in [10]:
vidcap = cv2.VideoCapture('drive/My Drive/Fold5_part2/' + str(j) +'/' + str(i) + '.mp4')
sec = 0
frameRate = 1
success, image = getFrame(sec)
count = 0
while success and count < 240:
landmarks = extract_face_landmarks(image)
if sum(sum(landmarks)) != 0:
count += 1
data.append(landmarks)
labels.append([i])
sec = sec + frameRate
sec = round(sec, 2)
success, image = getFrame(sec)
print(count)
else:
sec = sec + frameRate
sec = round(sec, 2)
success, image = getFrame(sec)
print("not detected")
```

Fig. 7.1: Part of Python code for the proposed system

all drowsiness signs. The most common features of driver are blinking eye rate, the duration of driver's eye closure and head pose. If the camera detect the closing of his eyes for period of time or his head was drooping, sound alarm will produce to stop driving and take a break. [34] [35]This type of cameras will combined with sensors and artificial intelligent or machine learning algorithms to increase the accuracy of this proposed system. Figure 8.1 shows the smart cameras.

Overall using of smart cameras in this proposed system can help in reducing the accidents risk that caused by drowsy driving and improve overall driver safety [36].

9. Alert device. The alert device is very important part in proposed system. The purpose of this part is to alert the driver when the system detects signs of fatigue and drowsiness. It is used in helping to avoid accidents caused by driver's inattention [37]. The alert device used in proposed system is Audible alerts that can include chimes, beep, or other sound that can triggered when the system detects signs of drowsiness. This type of alert is very effective at getting the attention of driver and can be customized and suitable for the driver's preferences. There are different factors the alert device used in this proposed system such as the type of vehicle, the preferences of driver, and the specific requirements of the system. The alert device that is choice is very powerful at getting the driver's attention to take action to avoid accident trough drowsiness.

10. Stacked deep convolution. This type of convolution called stacked con-volutional neural networks (CNNs) is used in the proposed system to improve the accuracy of this system. CNNs are a kind of deep learning algorithm was designed for processing all visual information such as videos and images. The stacking

Fig. 8.1: Smart cameras

Fig. 10.1: The images in different states Drowsy or None

with multiple CNN layers allows for more complex features to be detected and leads to high performance in classification. In the context of the proposed system this type of convolution used in analyzing video data and fed as CNNs input ,from the camera mounted on the vehicle dashboard , and the output of the proposed system is a prob-ability score indicating the driver's drowsy by producing a beep sound from an alert device. The CNNs are trained for detecting all drivers' features such as head nodding, changes in facial expression, and eye closure that are indicative of drowsiness [30]. Through building the proposed system using CNNs a dataset is gathered of images shows the drivers with open, closed eyes, and images that show drivers with different levels of drowsiness. In addition of that the images include different angles of driver position and lighting condition to ensure that CNN can recognize the drowsiness in different real world. Figure 10.1 shows the images in different states.

Also, CNN can be trained in learning all the features like (head nods, droopy eyelids, slower eye movements) that are indicative of drowsiness. CNN output has the ability of driver's classification as asleep, drowsy, or alert.

In this proposed system it is used a technique called data augmentation which include creating variations of the original images for increasing the dataset size.

Overall, CNN is a powerful tool for driver's drowsiness detection because it can be accurate in recognizing the patterns in real-time for indicating drowsiness and producing an alert to the driver to take action to prevent accidents.

Table 11.1: The experiment of the proposed system

Samples	Total	Training	Validation	Testing
Number	3000	1500	800	1500
Drowsy	1500	700	300	500
Non-Drowsy	1500	800	500	1000

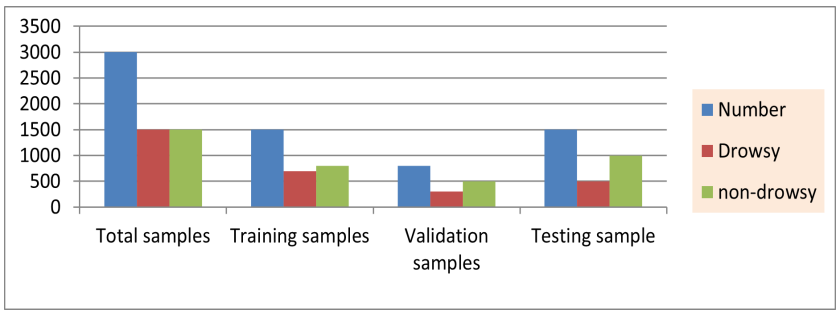

Fig. 11.1: Chart represents experiment data of the proposed system

11. Experiments and Analysis. The proposed system "Driver Drowsiness Detection" is an important area of research that aims to prevent accidents caused by drivers fatigued. It used a deep learning algorithm and some Python tools for feature extraction and classification (drowsy or not). This system is prepared to analyze the driver's faces depending on dynamic sequences of captured photos. There are two types of experiments were performed here. The first experiment is collecting a dataset, it generates a dataset with 3000 images see Table 11.1. The second experiment is performed in videos.

Out of 3000 images used for the experiment in the proposed system, 1500 images are drowsy and others are non-drowsy. For experimenting, 1500 images were used for training, 800 images were non-drowsy, and 700 images were drowsy. A total of 800 images were used for validation samples, 300 images were drowsy, and 500 images were non-drowsy it was diagnosed in several milliseconds. An l500 images are used for testing, out of 500 images are drowsy, and 1000 images are non-drowsy Figure 11.1 shows a chart for experiment data. The accuracy of the proposed system is about 99.1% after testing the dataset. During the second experiment, the video frame was captured through smart cameras and generated an alarm by an alert device when the proposed system predicts drowsy. The static images are used in the training phase, but through the testing stage, the keyframe is extracted from continuous videos captured by smart cameras.

12. Conclusion. In this paper a new tool was proposed as a saver strategy for vehicle drivers through taking alcohol, drugs, and lack of sleep to protect them from expected accidents. In this state, it builds a monitoring system for detecting drowsiness. This system distinguishes between non-drowsy and drowsy and generates an alarm sound when the eyes are closed.

There are different algorithms and materials are used in such detection. A Viola-Jones detection algorithm is used for detecting the face and eye portion. The learning phase includes extracting all features of the driver's face by using a neural network algorithm called stacked deep convolution. The accuracy of the previous works is low in more time and most of these papers are surveys, which is why it prepared a real-world practical system to protect the people from the high numbers of accents. Support Vector Machines (SVM) is a supervised machine learning algorithm that is used in the classification of Driver Drowsiness Detection to identify drowsy or non-drowsy drivers depending on all based features. An alert device is used proposed system to alert the driver when the system detects signs of fatigue and drowsiness. Smart cameras with 16-megapixel were used for capturing the photos and videos to ensure that the photos were of high quality to monitor the behavior of the driver and detect all the signs of drowsy or non-drowsy. Python tools are used in this system like TensorFlow,

OpenCV, eras, and Pygame. These Python tools are used to detect the closed eyes of drivers. The accuracy of the proposed system is about 99.1%. Out of 3000 images used for the experiment in the proposed system, 1500 images are drowsy and others are non-drowsy. Generating alarm sound from the alert the device effectively when the proposed system identifies drivers' drowsiness.

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