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A Systematic Review on Evaluation of Driver Fatigue Monitoring Systems Based on Existing Face / Eyes Detection Algorithms

[1]Maryam Ameen Sulaiman, [2]Idress Sarhan Kocher
[1]Department of Information Management, Duhok Polytechnic University, Duhok , Iraq
[2]Department of Energy Engineering Technical College of Engineering Duhok Polytechnic University

ABSTRACT

Among the many issues facing the world, the issue of traffic accidents, many security facilities have developed research on fingerprints, palmistry biometrics and other biometrics. In modern technologies, facial and eye detection algorithms have been developed and identified. This paper includes comparisons of face and eye tracking methods, which are extremely useful for identifying individuals in a variety of situations. Facial biometrics are more stable due to their distinct features, which gives them an advantage over other biometrics such as palmistry and fingerprint. This work dealt with 74 studies of face and eye detection and a comparison of algorithms that were used in previous researches, where the Viola-jones algorithm was identified as the best facial algorithm in terms of accuracy up to 98% for different types of face databases because this algorithm depends on geometry of face and also able to detect all faces in the same image, Furthermore, it has been determined that SVM is the best eye detection algorithm due to the accuracy of its characteristics and the speed of execution in Real-Time so, the highest accuracy achieved was 98% accurate .

Keywords: Driver Drowsiness Monitoring, Real-time, Face detection, Eye Detection, Geometry of Face, Eye Tracking and Feature Extraction, SVMs Algorithm, Viola-Jones Algorithm, Accuracy.

1. Introduction

The topic of face-detection is a basic problem in applications such as video monitoring, assistance driving and facial-recognition[1][2][3]. Clearly, because of differences in look, human face recognition is a difficult task. The location and position of human face in the picture, the appearance of glasses, beard, hat or any other items that partially mask the face and its expression are due to these variations. Moreover, it is essential to detect faces in many of these applications in the shortest possible time [4] [5]. Face detection is the first stage in identification of the object, for example, for recognition, orientation, modeling, verification and monitoring [6] [7]. Facial images or videos data containing different locations, dimension and backgrounds are often searched for or indexed [8] [9]. All the problems mentioned above are a challenge for the researcher to reach a clear result for detect the human face [10] [11].

The essential goals of Intelligent Transportation Systems (ITS) are enhancing/ improving of ensuring public safety and reducing the number of accidents. The most common causes of accidents, especially on rural roads, are driver tiredness and drowsiness. Fatigue impairs a driver's senses and decision-making skills when it comes to controlling a vehicle. [5] [12] [13].

The driver face monitoring system is a Real-Time system that uses the analysis of driver face pictures to analyze the driver's physical and mental state. Eye closure, blinking, eyelid distance, yawning, head rotation, and gaze position, head rotation can all be used to determine the driver's condition. Figure 1: depicts a system that has been designed will alarm in the hypo-vigilance states including fatigue and distraction[4] [7].

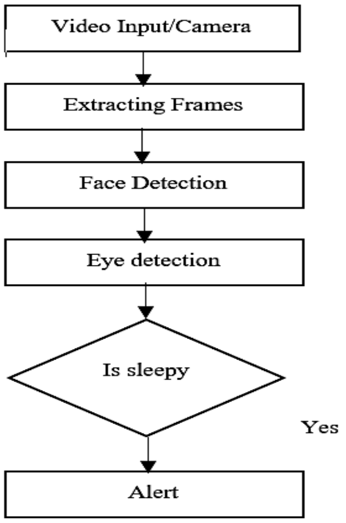

Figure 1: Drowsiness Detection (General Architecture)[4].

In general, face detection algorithms are classified into two groups [14] : first, Feature-Based methods and the second, Learning-Based methods. The first group algorithms are based upon the premise that the face of the picture is recognizable on the basis of certain basic characteristics, regardless of environmental illumination, facial rotation or pose. To detect faces, a basic method employs picture projection., assuming that the base is uniform and the facial location is defined by the vertical projection of the Gray-Level image [3]. Another Feature-Based face detection method is based on a skin color model that uses the distribution of chance in a color context. The face is detected in the image with a threshold on the modelled distribution as shown in[4] [15]. The second category algorithms are more robust, but they require greater machine effort.

A number of training samples are used (learning-based methods) and mathematical models and algorithms are used to learn machines. [Viola-Jones] face detection method is among the most commonly employed in this group. It is possible to expand the detector to other objects[5].

The convergence of this algorithm's training process relies heavily on trained data. The front detector [Viola-jones] can be execute on the basis of[6] in Real-Time:

Quick calculation by using the integral image of "Haar-like" features.

The "AdaBoost" classified to choose the most advantageous features.

The attention-based cascade structure, which rejects the majority of subscribers in the early layers of the detectors to ensure an extremely successful detection process [14].

Because of the relevance of symptoms associated to the eyes in all driver face monitoring systems, the eye area is always analyzed for symptom extraction. As a result, eye recognition is necessary prior to processing of the ocular area[16]. Methods for detecting eyes can be classified into three broad categories:

Imaging in the infrared spectrum-based methods: The approach based on imaging in the infrared (IR) band is one of the quick and generally accurate methods for eye detection[6]. The physiological and optical characteristics of the eye in the IR spectrum are employed in this approach. When the angle of the IR source and imaging device is appropriate, the eye pupil reflects IR rays and appears as a bright spot. The pupil and eye are detected by this intriguing feature.

Feature based methods: Various techniques are used in the feature-based eye detection approach. Two feature-based eye identification approaches, image binarization[17] and projection, are based on the assumption that the eye is darker than the face skin[5] [11] Because these approaches are basic and have a significant mistake rate in comparison to researchers (A. Elhossini, M. Moussa) [17], more complex processing is usually required to determine the proper position of eyeballs.

Some other methods: There are a few ways for detecting eyes that are based on other methodologies used in driver’s face monitoring systems. To detect eyes in[10], a geometrical face model with several feature-based techniques was employed. Furthermore, certain systems, such as[18], employed hybrid techniques for eye detection. For eye recognition during the day and at night, elliptical gray-level template matching and an infrared imaging system were employed.

In general, for detecting the face/eye, the whole picture is searched. Searching the whole image increases the system's computational complexity. As a result, face/eye tracking is often conducted in the following frames after early recognition of the face/eyes [19]. The Kalman filter [20] [4] or expanded variants of the Kalman filter, such as the Unscented Kalman Filter (UKF) [21], were utilized in the majority of driver face monitoring systems. In certain studies, however, the search window [18] and the Particle Filter (PF) [22] [23] were utilized for monitoring.

In several studies in previous years, the topic of face detection in two-dimensional images was studied. As ever, the researcher was a great achievement in[2] due to the fact that it was the first algorithm with a high accuracy rate and it was fast. Its main contributions were a cascade of classifiers for quick computation time, by employing a mixture of basic classifiers to build a boosted classifier, as well as simple rectangular "Haar-like" features that could be retrieved and computed in a few steps owing to an integral picture. This study was so important that it served as the foundation for a lot of later studies, including[6].

Biometric is a technology that identifies and verifies a person by using only a few sources. Based on their physical and facial actions, such as color, voice, facial expressions, etc., it is a specific measure of an individual person[24] [1].

2. Related Work

The symptoms of fatigue and distraction appear in Eye as it is the most important area of the face. Therefore, many of the driver face monitoring systems detect driver fatigue and distraction only based on the symptoms extracted from the eyes. The symptoms related to eye region include PERCLOS[4][1][25][26], eyelid distance[7][27], eye blink speed[1][25], eye blink rate[1] [19], and gaze direction[28].

The driving state must be identified once the symptoms have been extracted. The categorization challenge is the determination of the driving status. The most basic approach for detecting driver weariness or attention [22][29] is to apply a threshold to the extracted symptom.

Knowledge-based methods are another option for identifying the driving state. In a knowledge-based approach, decisions concerning driver tiredness and distraction are made based on an expert's knowledge, which is typically expressed in the form of if-then rules. Fuzzy expert systems were utilized as a knowledge-based technique to estimate the driving state in [7] [19].

For determining driver state, more complex methods such as Bayesian network[28] and nave dynamic Bayesian network[30][31]were employed. These methods are typically more accurate than threshold- and knowledge-based methods, but they are also more difficult.

(Tipprasert et al., 2019) Work on identifying drivers' diseases is a problem when it comes to low light sleepiness. In this article, we proposed a way to predict the driver's eye closure and infrared sleeping research predation. This process consists of four phases, including nose, head, mouth, and head closure identifiers. The system output test was performed with 3,760 images. In the field of eye closing and yeast identification respectively, 98% and 92.5% were correct. The experimental findings demonstrated the success of the approach. The advantage of this work is that the eye closure and yawning can be detected in low light [32].

(Choi et al., 2018) It is extremely dangerous for the driver to fall into a momentary somnolence. Previous tests to prevent this focus mainly on functionalities in cases of driver disease. Currently, the state of the driver is not evaluated with insufficient information on only one data (physical information, visual data). We are proposing a deep learning system multi-model in which changes in visual and physiological somnolence are recognized. Since the use of different data types is an issue with heterogeneity. The phenomenological model of representations is therefore employed as a transition that takes time to minimize the heterogeneity between data as sleepiness[33].

(Ramzan et al., 2019) This paper provides a comprehensive summary of current methods to diagnose drivers' somnolence and a thorough analysis of commonly used classification techniques. In this study, the strategies already in use are first divided into three categories: mental, vehicle and physiological. Secondly, supervised methods of learning to recognize drowsiness at the highest level are also studied. Third, the advantages and disadvantages, as well as comparative analysis of the various methods, are discussed. In addition, diagrams are developed to better understand the research frameworks. Finally, the overall results of the study are based on a detailed survey that will enable young researchers to identify future potential work in a given field[34].

3. Face Detection Methods

Face detection is one of the most researched problems in all sub-directions of target detection at present, and it has strong application value in security monitoring, witness comparison, human-computer interaction, social and entertainment, etc.[3]. The aim of face detection is to locate all of the faces in an image's associated locations, and the algorithm output is the image's coordinates for the rectangle that surrounds the face, and it may also include information such as the position, and also the angle of inclination. The face detection algorithms are presented in the following subsections. are the face detection algorithms of an image[35]:

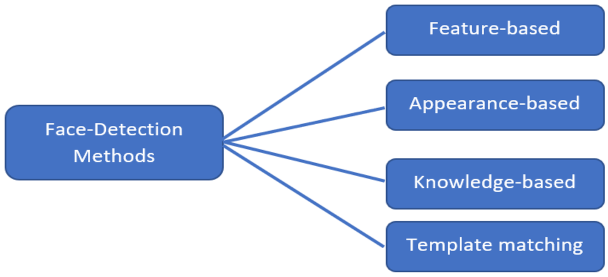

Figure 2: Different types of Face Detection Methods[3].

3.1 Feature-Based

The Feature-Based method finds faces by eliminating structural characteristics of the face. It is trained first as a classification system and then used to distinguish facial and non-facial regions[36]. The idea is to transcend the boundaries of our instinctive facial awareness. This is a several steps approach and even pictures with many faces show a 94% rate of success [2]. Several point that 'Feature-based method' depend on:

3.1.1 Facial Features

These features depends on the system of position to the segmentation of a face for facial recognition from a confused background[2] [36]. The edge map (Canny detector [18]) and heuristic devices are applied to delete and group edges in order to retain only the edges in the contour. The boundary between the head and context is then fitted with an ellipse. In a 48image database with cluttering backgrounds, this algorithm achieves 80 percent precision.

3.1.2 Skin Color

In several cases, from face detection to hand tracking, the color of human skin has been exploited. and has been shown to be an effective function. Despite the fact that various people have varying skin tones, Several investigations have revealed that the primary distinction is to a large extent between their intensity and their chrominance[23] [11] [2].

3.1.3 Texture

There is a distinct texture to human faces that can be used to distinguish them from other objects. A technique was established in [15] that detects face-like materials and infers the presence of a face. Textures are computed using second-order statistical characteristics (SGLD)[36] on 16 x 16 pixel sub-images. There are three categories of characteristics considered: skin, hair, and others. In order They utilized a cascade correlation neural network for supervised texture classification and a (Kohonen self-organizing) function map to create clusters for distinct texture groups. [37].

3.2 Appearance-Based Methods

The appearance-based approach relies on a selection of delegated face images for facial models to be found[35]. The look-based approach is better than other efficiency approaches. In general appearance-based methods the related characteristics of face images depend on methods of statistical analysis and machine learning. This approach is also used for facial recognition extraction[38] [1].

In a probabilistic system, several appearance-based approaches can be understood. An imagery or feature vector extracted from an image is seen as a random x variable, and the class-conditioning density functions p(x | non face) and p(x | face) and this random variable should be defined for both faces and non-faces. A candidate's picture position can be categorized in face, or as nonface with Bayesian classification[20] .

3.2.1 Distribution-Based Methods

A distribution-based face detection system [39] [11] has been developed, This shows how the distribution of picture patterns from a single object class may be learnt from positive and negative instances (i.e. photos) of that class. This system consists of two parts, Distribution-Based Models and a Multilayer Perceptron Classifier for Face/Nonface Patterns. Each face and non-face instance are first normalized and converted to a (19×19) pixel picture before being handled as a vector or pattern with 361 dimensions. Next, the patterns are then classified using a modified k-means algorithm. into six clusters of faces and six nonfaces, as seen in Figure 3. Every cluster is a multidimensional group.

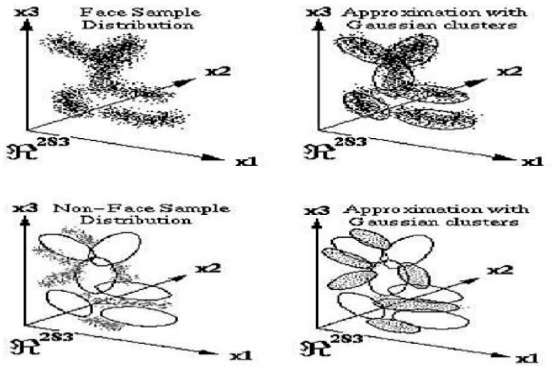

Figure 3: Clusters for face and Non-face sample [39].

3.2.2 Support Vector Machines

Support Vector Machines (SVMs) were first used by[39] for face detection. A modern paradigm for training neural networks, Radial Basis Function (RBF) or polynomial function classifiers can be considered as SVMs[15] [36]. Although most classifier training methods (e.g., neural networks, Bayesian and RBF) are focuses on reducing training error, i.e., empirical risk, SVMs operate on another concept of induction, called structural risk mitigation, which aims to minimize the upper bound on the predicted error of generalization. A Support victor machine [SVM] classifier is a linear classifier chosen to minimize the predicted unseen test pattern categorization issue by the separating hyper-plane[18] [1].

3.2.3 Hidden Markov Model

The HMM Model underlying assumption is that patterns may be represented as a parametric random process. and that it is possible to estimate the parameters of this process in an accurate, well-defined way. When building a HMM for a pattern recognition issue, a number of hidden states must first be identified in order to shape a model. Then, using the instances, each of which is given as a sequence of observations, one may train HMM to learn the transitioning probabilities between states. The objective of the HMM training is to optimize the likelihood of examining the data for training by modifying the parameters of the Standard Viterbi Segmentation Method and Baum-Welch algorithms [39] [28] in an HMM model. The performance probability of an observation specifies the class it belongs to after the HMM has been trained.

3.3 Knowledge-Based TopDown Method

The method based on knowledge depends on the set of laws, and the detection of faces is based on human knowledge. A nose, eyes and mouth must have a face at certain distances and positions. The great problem with these methods is that a suitable set of rules needs to be defined. If the rules are too general or too specific, several false positives can be identified. This method is not enough on its own and cannot find multiple images of many faces [40] [21].

Researchers use a hierarchical system for detecting faces [41], which is based on information. Their scheme is composed of three laws. On the highest level, a scan window over the input image and the application of a set of rules at each position would find all potential facial candidates. The higher rules are general explanations of the appearance of a face, while the lower rules rely on facial characteristics in detail.

A rules-based system of localization was Presented[42]. Face characteristics are first of all located with a projection system (Canada) used to locate a face's boundary [39] [42]. Let’s I (x, y) be the strength of an image of [m, n] (x, y), the image projections horizontal and vertical are described as:

$$HI(x) = \sum_{y=1}^{n} I(x,y) \quad (1)$$

$$VI(y) = \sum_{x=1}^{n} I(x,y) \quad (2)$$

First, the horizontal profile of the input picture will be reached, and then, by detecting sudden shifts in HI on the left and right sides, the two local minima will correspond. The vertical profile and local minima for the mouthpieces are also determined, nose tip and eyes are calculated. The applicants are subsequently validated by eyebrows/eyes, nose and mouth detection rules. The approach proposed was checked using the frontal views derived from the European Actions Multi -modal Verification for Teleservices and Security Applications [M2VTS] databases [39] containing the video sequences of 37 separate individuals with a series of faces. Only one face in a single context is present in each image sequence. In all tests, their approach offers right face candidates as shown in figure 4.

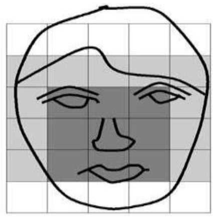

Figure 4: Face shape used in Top-Down Knowledge-Based Approaches [39].

3.4 Template Matching Method

Template Matching approach uses a predefined, or parameterized face templates for the connection between the templates and the input images to locate or detect the faces. The eyes, facial contour, nose and mouth can be separated into a person's face. In addition, the edges of a face model can just be created by edge detection. It is easy to use but insufficient for the detection of the face. Deformable templates to solve these problems have nevertheless been suggested[21] [41].

The benefit of this method is that it is easy to execute. However, facial identification has proven insufficient because the variety in size, posture and form cannot be dealt with effectively. The subsequent proposal to achieve invariance in size and shape was multi-resolution, multi-scale, sub-templates and deformable templates. The matching template researches can be divided into two subcategories: Researches using predefined templates and researches using deformable templates. The two steps consist of a general concept to use predefined models. First, face with templates separates face, and second step candidate positions are shown. And these areas are concentrated in depth in the second step to assess a face's existence [43] [15].

While, the Deformable Templates approach parameterized templates define the facial features. A function of energy is described in the image to connect edges, peaks and valleys with their corresponding template parameters. By minimizing the energy function of the parameters, the most appropriate Elastic model fit. Although their experimental findings show good success in the monitoring of non-stiff features, one downside is that a deformable prototype needs to be initialized near the object of the interest [15] [38] [21].

4. Eye and Gaze Detection Methods

Eye-gaze monitoring has become one of the most important human-computer interfaces and has been shown to be useful in a variety of applications. The way to calculate the point of view or the move of the eye with regard to the head is known as eye-gaze tracking. Eye tracking is a technique for determining eye location and movement.

There are several places that benefit from eye monitoring systems. Specific applications include such systems in the fields of language reading, music reading, understanding of human behavior, advertisement interpretation, sporting activities, especially for people with disabilities suffering from diseases Human-Computer Interaction (HCI), medical research and other areas[31] [28].

In the field of cognitive language, psychology, visual systems and product design, eye trackers are employed. There are a variety of techniques for tracking eye movements. The most widely used method employs video pictures from which the location of the eye is obtained [44] [6]. Eye studies can be classified as follows:

- **Eye detection:** Given an arbitrary image of the face, the goal of eye detection is to identify the position of the eyes. Simply said, eye detection identifies the locations where both eyes are situated, or two eyes are independently positioned. As a result of the procedure, the ocular regions are often represented by a rectangle [12] [28].
- **Detailed feature extraction:** The purpose of this category, on the other hand, is to provide details such as the visible eyelid region's contour, the circle formed by the iris and pupil, the position of the pupil in the visible eye area, and the state of the eye (blink/not blink). This form of work is more challenging in the computer vision field because small detail detection or Real-Time tracking is highly influenced by changing environmental conditions, and the results may easily fail [31] [7].

A great deal of work has been done in the field of eye detection, includes the detection of pupil movement in the eyes, eye state detection, eye feature extract, and detecting eye gaze in still pictures and video sequences for Real-Time applications utilizing multiple approaches [45] [46]. Eye/gaze detection can be done in a variety of ways; in some cases, a simple webcam is all that is needed. Several eye detection methods are described in the following subsections.

4.1. Electrooculography

Electrooculography (EOG) is a method of determining the retina's resting potential. The region around the eyes may capture low voltages, which vary as the eye location changes, due to a permanent potential difference of approximately 1mV between the cornea and the fundus. Above and below the eye, or to the left and right of the eye, electrode pairs are mounted. It is possible to monitor horizontal and vertical movements separately by carefully positioning electrodes[47]. As the eye is shifted from the middle position to one electrode, that electrode sees the positive side of the retina, while the opposite electrode sees the negative side. As a result, there is a potential difference between the electrodes. The recorded potential is a measure of the eye location, assuming that the resting potential is constant. When there is no eye movement, however, the signal will shift. It is caused by metabolic changes in the eye and is dependent on the condition of dark adaptation (used clinically to determine the Arden ratio as a measure of retinal health)[47].

4.2. Infra-Red Oculography

The amount of light reflected back to a fixed detector varies with the location of the eye when a fixed light source is aimed at it. A variety of commercially available eye trackers make use of this concept. Infrared light is used because it is "invisible" to the naked eye and does not distract the subject. The ambient lighting level has no effect on measurements because infrared detectors are not affected by other light sources[48] .

This technique has good spatial resolution (the size of the smallest movement that can be reliably detected), on the order of 0.1°, and temporal resolutions of 1ms can be achieved. Horizontal eye movements are easier to measure than vertical eye movements. Blinks can be problematic because not only do the lids cover the eye's surface, but the eye also retracts slightly, affecting the amount of light reflected for a brief period of time after the blink[49].

4.3. Image Based Methods

Different methods for automatically extracting the eye location from photographs of the eye have been developed as video and image processing technology has progressed. A bright light source is used in some systems to create "Purkinje" images, which are reflections of the light source from different surfaces in the eye (the front and back surfaces of the cornea and lens). An eye location signal can be obtained by tracking the relative movements of these images[50] [51]. To measure the location of the pupil and its middle, Typically, video pictures are integrated with computer software. This allows for the measurement of both vertical and horizontal eye motions. Image-based methods, on the other hand, have lower temporal resolutions than IR techniques. It's also possible that spatial resolution will be reduced. The resolutions that these systems can produce will increase as technology advances[52] [51].

5. Analysis of several facial and eye detection methods

The purpose of this work is to compare and determine which of the methods for face and eye detection are highly effective and feasible for implementation in the face monitoring framework depending of previous researchers' papers. The accuracy of the feature implementation and the ability to function in Real-Time were given special attention. The chosen methods are evaluated in the dark, light and complex background scenery with web-camera sequences[4] [29].

5.1 Face Detection

Multiple approaches are used to incorporate facial detectors. These methods include facial detection using ellipses searching, SIFT detection[21] and SURF characteristics[42], Viola-jones facial detector application[38] [12] and the use of the feature extraction module mentioned in[9] [15].

Due of the human head's proximity to an ellipse, attempting to find this ellipse by looking for ellipses in a specific picture is easy. Generalized Hough Transform[21] can be found for ellipses, but this method is intensive computationally. The method for ellipse detection has recently been proposed to[53], which Reduces Circle Hough Transformation to the entire issue. However, running in Real-Time is not quick enough. Often, considering the several false positive variables, certain learning protocols have to be applied, which further slows down the process of identification.

[SIFT] and [SURF] are known object matching algorithms. Both these techniques work in a slightly faster way to fit facial characteristics on template and target images. Sadly, both have a huge disadvantage: even minor changes in lighting conditions are extremely sensitive to them. In this case the detection is much slower than in other cases, a preliminary attempt was made to eliminate this problem by employing histogram equalization and histogram fitting. [54].

The Viola-Jones detector is known for it using in different applications involving face determination. It does well in view of the precision and speed required to process it in Real-Time. An additional task of facial detection is the facial feature detector mentioned by (Made Kris Raya et al.)[6] which integrates some feasibility of the Viola-Jones detector.

5.2 Detection of Eye

Many techniques are used to detect eyes. These techniques include the Viola Jones eye detector, this algorithm was described by ("Valenti and Gevers")[21], the approach proposed by (Barth and Timm)[51], and the feature extraction proposed by (Ribarić, Pavešič and Lovrenčić)[44]. All of these methods rely on the face previously detected and the Viola-Jones detector is used for the purpose of detecting the face as it performs best. The exception is the (Ribarić, Lovrenčić, and Pavešič) method[44], because he employs his own facial detector.

The Viola Jones works fairly well but produces a slightly greater quantity of false positives, particularly in the mouth corner regions.

In terms of both speed and accuracy, the detector described by Valenti and Gevers[21] is excellent. It is never ineffective. to locate the eyes, but it is also not perfect for the exact position of the eye centers, since the eye corner is more often than not mistaken for the eye center.

The (Timm and Barth) [51] detector performs the best of all four eye detectors. It runs slightly slower (Valenti and Gevers) [21]than the detector, but almost never fails to locate the center of the eye correctly.

Finally, the[44] feature extractors are not as good for the eye detection task as they are for the face detection task. In the dependency chain of detected functions, the cause of this lies. The defined face is a prerequisite for the identification of in plane rotation. The detection of out-of-plane rotation involves in-plane rotation previously observed, and ultimately the detection of mouth and eyes takes place after the detection of out of the plane rotation. In each stage of this cascade, the error detection thus grows larger and the greatest value is found towards the end of the chain, i.e., when detecting eyes and mouth.

5.3 Real-Time Eyes Detection

The Real-Time approach currently presents an important challenge for driver drowsiness recognition studies. In general, the Real-Time method combines images collected from entrance devices as well as static studies for preprocessing, feature gathering, and classification. such as a normal web cam's Real-Time eye detection sequence. Faster algorithms and minimum memory and Central Processing Unit (CPU) use should be applied to the Real-Time eye detection. [ENCARA2] a system proposed by [Castrillon et al.] which includes facial and eye detection Real-Time. The eyes will be identified pair-wise, as is shown in Figure(5), which indicates the eye pair detection process[55].

By using the skin color model, the frontiers of the blob face are detected. The components that are not a part of the face are heuristically removed and the ellipse is attached to the blob so that it can be rotated vertically[56]. Once the blobs have been found, the eyes are detected using different options. Due to the darker eye pixels than the pixels in the environment, dark areas have been searching[57]. In Viola-Jones, a minimum eye detector is used to find eyes, which are estimated to deliver fast performance. The eye position is roughly estimated. If the eyes have not yet been found, a Viola-Jones-based minimum size eye pair detector[10] is used. Determined eye positions are then used to standard-size the face region. After normalization, the major component analysis "Principal Component Analysis" (PCA) is projected and reconstructed around both eyes of the normalized face image. Incorrect detections of the eye are identified and eliminated[56] as a result of the reconstruction error. The PCA is an orthogonal space made up of your own eyes.

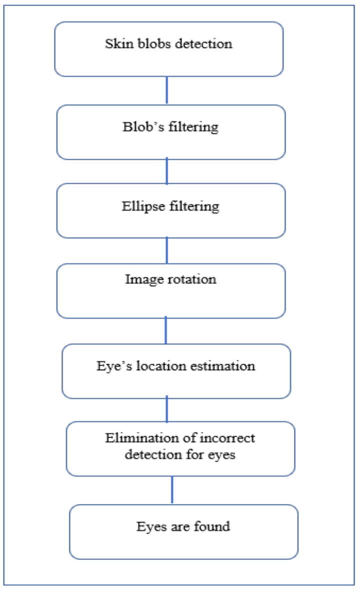

Figure 5: Eye detection process[57].

5.4 Artificial Neural Networks

Human intelligence uses a biological neural network system to carry out a variety of sophisticated information processing (nonlinear) activities. Many complex linkages that interact with one other are controlled by neural cells or neurons. through the exchange of electrical pulse short action potentials. Several scientists have developed informatics to build what is currently called the artificial neural network (ANN). The ANN study on the biological neural brain network system was designed over several years. A neuron is regarded as the ANN computer unit. The neuron gains power through its combined behavior in a network with the interconnection of all neurons.

There is no need for prior knowledge of input-output variables connection in artificial neural networks. The [ANNs] were thus chosen among the most practical and arithmetic methodology. Because of their advantages, ANNs were used extensively in many different applications. Applications included image processing, Speech Processing and Recognition, Data Compression, Pattern Recognition, Robotics-Like Speech Recognition, Signal Processing and Classifying, intelligent image analysis for the security camera, and fingerprint identification[58].

5.4.1 Basic Structure of Artificial Neural Network (ANN)

The ANN's neuron structure is inspired by the actual biological neuron structure consisting of three main sections shown in Figure (6). Apart from the nucleus, because of its responsibility for the treatment of information the cell body is the most important part of the neuron. The axon is the second part. Every neuron only has one axon that transmits nervous signals. The axon is linked by synapses with other neurons. This axon is heavily connected to the maximum number of other neurons. The third part is the dendrites, the nerves that transmit inbound signals to the body cells from other neurons.

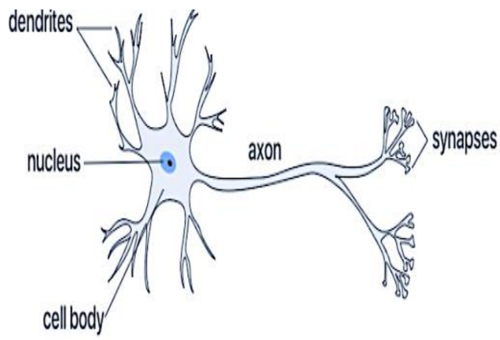

Figure 6: the structure of a biological neuron[59].

This true construction of a biological system inspired scientists to build the ANN structure. However, the nature of the applications depends on the ANN neurons. So, unlike biological neurons, they are randomly arranged (Lin et al.)[59]. Figure (7) shows the ANN structure most approximately and frequently used.

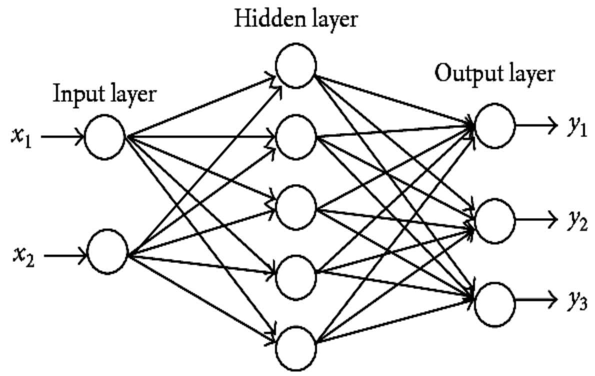

Figure 7: ANN Multi-layered[58].

The ANN structure is explained as follows:

- **Input-Layers:** The total amount of neurons in a neural network is equal to the number of entries. This layer contains passive nodes (neurons) that only transfer signal to the next layer.
- **Hidden-Layers:** This layer has an arbitrary number of layers and neurons. The active layer in charge of signal modifications is the hidden layer.
- **Output-layers:** The number of neurons in the output layer depends on how many neural network values are produced. This layer's nodes are active[58].

5.4.2 Neural Network Types

Depending on the design, ANNs come in a variety of forms. The following are the most common types[60].

- Perceptron.
- Multi-layer perceptron.
- Back-Propagation Network (BP).
- Kohonen Network.
- Radial Basic Function Network.

5.4.2.1 Back-propagation Network

One of ANN's frequently used multilayer algorithms is the back-propagation (BP) algorithm. The back-propagation method (BP) has surpassed the problem of the XOR logic gate that the simple ANN layer could not solve. The structure of the BP Neural Network comprises of basic processing nodes working together to create a complicated output. Input, middle and output layers are arranged Nodes Figure (8). The back-propagation neural network output is calculated by the technique for a forward pass. By propagating the output error backwards, the weights are adjusted to reduce the error between the actual output and the required output. This procedure is first used in the output layer for connected weights, then in the hidden layer for connecting weights and then in the output layer[61].

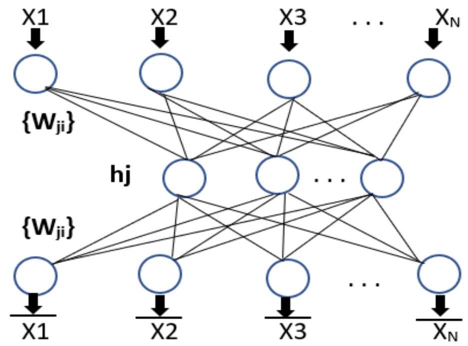

Figure 8: BP(back-propagation) neural network algorithm[61]

The procedure for forward passage is as follows:

- The input layer is passed on to every node in the middle layer of a particular input vector.
- The center layer nodes calculate the output values that become input to the output layer nodes.
- The output layer nodes calculate the output of the network for the specific vector[61].

A backward pass procedure propagates the output error through the network. The steps behind the reverse pass process include:

- For each node in the output layer the error values are calculated. These error values are calculated because each node has the desired output.
- The error for middle layer nodes can be calculated if the middle layer node that feeds this output node contains a portion of the error of each output layer node. The error amount from each center layer node depends on the weight of the connection between the two nodes.
- The value of weight is adjusted with the delta rule to upgrade network performance.
- In order to assess network efficiency, an overall error is calculated. The BP method behind this technique is the most popular method. But BP has

the inconvenience of converging slowly into an optimal solution. The disadvantage leads to uncertain training times, in which the network is no longer able to improve its problem resolution. As a result, the results are ineffective and the pattern is poor[61].

5.4.3 Advantages-Disadvantages of Artificial Neural Network [ANN]

Every new field has benefits and disadvantages. The neural networks therefore have their own advantages and disadvantages as well. ANN research focuses on complicated non-linear data-learning problem solving. The following are some of the related advantages and disadvantages[58]:

A. Advantages:

- Nonlinear and unknown systems responses.
- Faster molding than standard mathematical molding.
- Strong fault control.
- Imperfect than conventional systems to process interference
- Model Black Box ensuring flexibility of use and variability of application.
- It is possible to implement easily and effectively (software and hardware).

B. Disadvantages:

- With the increase of neurons, the cost of calculation increases exponentially.
- Data generation is expensive and time consuming.
- Sometimes data definition may be hard.
- When extrapolating, neural networks may perform poorly because they may be faster than linear functions[58].

The pros and cons of each Face/Eye detection methods are summarized below in table 1:

Table 1. A comparative table of existing algorithms for Driver Drowsiness using Face Detection Methods.

Ref	Year	Author Name	Face Detection Methodology	Accuracy	Advantages of System	Disadvantages of System
[13]	2019	Lim William et al.	Viola-Jones	100%	good training and testing accuracy	--------------
[62]	2016	Saranya et al.	knowledge-based method	high accuracy	improve safety, reduce complexity, much cheaper and smarter than traditional ones	Faces not in front of the camera are not detected
[14]	2015	Elena Alionte et al.	Viola-Jones	high accuracy	Adjust the layer number and false alarm rate of the cascade.	--------------
[63]	2019	Kowsalya et al.	Face detection method	80%	Save time and effort, automatically record student attendance, user safe system.	can detect the face only from a limited distance, may produce false results in poor light.
[11]	2018	Srikrishnaswetha et al.	Skin Color	92.7%	Represent pixels in the appropriate color space	Low accurate in dark light
[36]	2019	Richhariya et al.	PCA	85.71%	provides good performance with lower costs of computation	Incorrect selection of universe points leads to a deteriorating model performance
[35]	2015	Palash Dutta et.al	Iris detection	99.25%	The face is found by matching genetic components of the left and right eyes.	Problem in the calculation of classification performance
[23]	2018	Yaman et al.	Building Security System	Good accuracy	The faces of CCTV cameras are recognized from different directions and can record up to 5 meters and an angle of up to 15 degrees.	--------------
[2]	2018	Vikram.k. *et.al*	Pattern reorganization	92%	particularly each part of a face	Detection of some non-facial areas as a face
[24]	2020	Yao et al.	PCNN	High accurate	Improves CNN performance over existing methods of pooling.	Single functionality and lack of autonomy, loosing information
[64]	2017	Yusuf et al.	Skin color	97.22%	Basic color spaces nullify the differences in brightness between pixels.	The fundamental color spaces give high positive and negative rates.
[15]	2020	Vijayalaxmi et al.	SVM & Gabor filter	96 %	Determine driver tiredness	Rotation
[18]	2017	Sun et al.	Line edge map	91.67%	economical design	The nearest pairs contain numerous spurious corresponding points.
[21]	2013	Valenti et al.	Valenti and Gevers	Low accurate	Reliable and very fast	May eyes are as centers of the eye
[51]	2011	Timm et al.	Timm and Barth	High accurate	Very accurate in eye center detection	Less speed than Valenti and Gevers detectors
[44]	2010	Ribaric et al.	Ribarić, Lovrenčić, Pavešič	Low accuracy	Fast detector	Low precision owing to the dependence chain characteristics

Due to the previous researches referred to in this paper, Face monitoring technique Viola Jones is quick and strong due to the simplicity of the processes extracting characteristics and the choice of the most effective features. OpenCV has been successfully deployed. Viola Jones face monitoring method provides a complete algorithmic definition with a learning code and a studied face detector. The Viola and Jones Algorithm also contains six distinct types of feature images to enhance their performance.

Table 2. A comparative table of existing algorithms for Driver Drowsiness using Eye Detection Methods.

Ref	Author Name	Drowsiness Measurement	Eye Detection Methodology	Feature Extract	Classification	Accuracy	Light
[4]	Reddy et al.	Facial landmark	MTCNN & DDDN	Eyelid closure & Eye blink	Use MTCNN& DDDN for the eye state detection	89.5%	day
[65]	Zhang et al.,	Eye blink	HMM	Cooccurrence Matrix of Oriented Gradients (CMOG) to extract eye features	Used for detect eye state	95.9%	-----------
[66]	Manu	Eye closure and Yawning	Binary SVM with linear kernel	Correlation Coefficient Template Matching	Uses Binary SVM with linear kernel to detect Eye closure & Yawning	94.5%	Different lights
[67]	Pauly and Sankar	eye blinks	HOG & SVM	HOG is a feature extraction algorithm	SVM is used to detect the current state of the eye	91.6%	Normal lighting
[68]	Shen, W et al.	Pupil	Ada-boost	Red eye effect, Method of Texture Detection	Eye-height, Eye-width Ratio	92%	Low Light Level
[69]	Knapik & Cyganek	Yawning	Gravity-center template & projection in grayscale	Gabor wavelets	LDA	91.97%	Day & Night
[70]	Vural et al.	Facial action	Gabor filter	Wavelet Decomposition	SVM	96%	----------
[71]	D'Orazio et al.	Eye Closure Duration & Frequency of eye closure	Hough Transform	Discrete Wavelet Transform	Neural Classifier	95%	Different Lights
[72]	Richhariya et al.	Advanced Driver Assistance System (ADAS)	Gabor filter	Condensation algorithm	SVM	93%	Diurnal and Nocturnal driving
[73]	Danghui Liuet.al	Eye blink	Face and Diamond searching algorithms are detected to trace the face	Eyelid closure duration, No. continuous blinks, Eye Blink Frequency	Region Mark Algorithm	98%	-----------
[74]	Zhang and Zhang	PERCLOS	Haar Algorithm (to detect face)	Unscented Kalman filter algorithm	SVM	98%	Diurnal and Nocturnal driving

Few research studies try to detect driver sleepiness by merging various methods[53] [72]. By reviewing previous studies, it was found that there are many ways to detect and determine the state of the eye in the state of fatigue through high-accuracy algorithms, which were chosen as the best algorithms for detecting and determining the state of vehicle driver's drowsiness these are (Support Vector Machine [SVM] and Region Mark algorithm), which obtained the highest accuracy by 98 % with lowest Real-Time.

6. Conclusion

In this review, a number of techniques for facial and eye detection are reviewed to find out which techniques are most useful for the facial and eye monitoring system. Of the facial sensors, the face (Viola-Jones) was the fastest and confidence-built, with most of the eye detectors exceeding the proposed algorithm (Timm and Barth). Face and eye detection technologies implemented more effectively in various databases but the excellent results give from Viola and Jones is up to 98% percentage. In the future, each face detection technique, i.e., even Electronic Voting Machine based on facial recognition will be utilized in one application. According to the study that was mentioned, the best eye detection algorithms are SVM, while the poorest algorithms in terms of accuracy and time consumption are MTCNN and DDDN.

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