





This section can be further divided into two segments

- A. Technique for visual based fatigue detection in drivers
- B. Face Detection
- C. Rubbing of the Eyes
- D. Head inclination detection

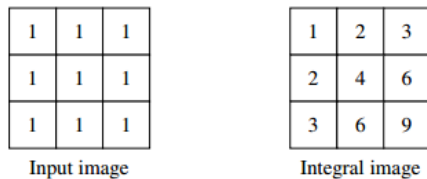
A. Technique for visual based fatigue detection in drivers  
 In this paper a built-in library in MATLAB is used which is known as the *Vision, Cascade.Object Detector System* is used. This detects objects using the Viola-Jones algorithm. Here framing of an object is done. Framing of an image allows to specify the ROI( Region of Interest ). The ROI defines location of the object which is used to train the object.

Viola-Jones is the one of the best face detection algorithm because they are robust- very high detection rate and very low false positive, real-time- for best result at least two frames must be used and finally its face detection not recognition, the basic idea is to identify face from non face area. The algorithm has mainly 4 stages –

- 1) Creating Integral Image
- 2) Haar Features Selection
- 3) AdaBoost Training algorithm
- 4) Cascaded Classifiers

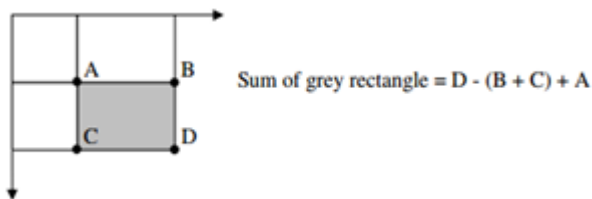
### 1. Creating Integral Image

The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. This is demonstrated in figure 2



**Figure 2:** The integrated image

This allows the calculation of the sum of the pixel can be done based on the four values. These values are the pixels in the integral image that coincide with the corners of the rectangle in the input image. This is demonstrated in Figure 3

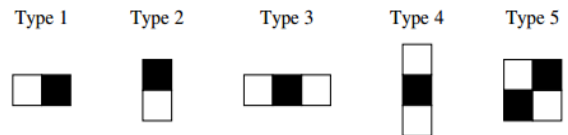


**Figure 3:** Sum calculation

### 2. HAAR like Features

According to Viola-Jones, all human faces share some similar properties. This knowledge is used to construct certain features known as Haar Features. The properties that are similar for a human face are:- The eyes region is darker than the upper-cheeks, the nose bridge region is brighter than the eyes, location - size: eyes & nose bridge region. This detection is done based on a set of rectangles which

forms the features. These are also known as sub-windows. The different types of features are shown in Figure 4.



**Figure 4:** Different types of features

Each feature results in a single value which is calculated by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s).

### 3. AdaBoost Training Algorithm

AdaBoost is a machine learning boosting algorithm capable of constructing a strong classifier through a weighted combination of weak classifiers. To match this terminology to the presented theory each feature is considered to be a potential weak classifier. A weak classifier is mathematically described as:

$$h(x, f, p, \theta) = \begin{cases} 1 & \text{if } pf(x) > p\theta \\ 0 & \text{otherwise} \end{cases}$$

Where x is a 24\*24 pixel sub-window, f is the applied feature, p the polarity and  $\theta$  the threshold that decides whether x should be classified as a positive (a face) or a negative (a non-face).

### 4. Cascaded Classifiers

The basic principle of the Viola-Jones face detection algorithm is to scan the detector many times through the same image – each time with a new size. Even if an image should contain one or more faces it is obvious that an excessive large amount of the evaluated sub-windows would still be negatives (non-faces). This realization leads to a different formulation of the problem:

Instead of finding faces, the algorithm should discard non-faces.

The thought behind this statement is that it is faster to discard a non-face than to find a face. With this in mind a detector consisting of only one (strong) classifier suddenly seems inefficient since the evaluation time is constant no matter the input. Hence the need for a cascaded classifier arises.

### B. Face and Eye Detection

The initialization of the video sequencing is done by connecting the video cam (laptop cam for this study) and positioned in such a way that maximum face area can be focused. Therefore it is assumed that the eye plane is orthogonal to the optical axis of the camera. This approach tolerates some vulnerability in distance, since it can detect objects that are close and considerably far.

The segmentation of the face area is calculated based on the boundary box function provided by the vision library. This will help to separate the face area from the background. When the video sequencing is turned on, first the bbox will form a boundary around the face. The face area is detected

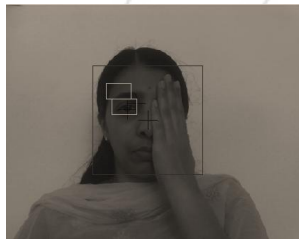
based on the HAAR like objects. Same way the eye region is also detected (fig 5) .the detected region of the eye is marked with another box known as the eye box. The eye region when detected can be used for fatigue detection.



**Figure 5:** Face and eyes detection

### C. Rubbing of the Eyes

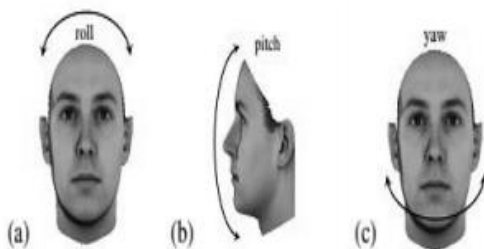
Rubbing of the eyes is one of the symptoms of fatigue. Usually a person never realizes how many times he is actually rubbing his eye when they are tired. They will not take it seriously. Tired eyes always have an itching sensation which will make the driver to rub his eyes. This also might be because of several reasons such as sleep deprivation or long drive. When the driver rubs his eye, the eye portion is covered by his hand or fingers(fig 6). The video sequencing cannot detect the eyes because of this. If the rubbing is continued in more than the predefined set of frames that is if the frequency of rubbing is more, then an alert must be produced to alert the driver.



**Figure 6:** Rubbing of the eye

### D. Head Inclination Detection

One of symptoms related to drowsiness is head nodding resulted from dozing. During drowsiness, head is gradually bent Head pose estimation is a key element of human behavior analysis. Many applications would benefit from automatic and robust head pose estimation systems such as driver drowsiness detection, it gives the vital information. Many methods are there to estimate the head pose from monocular images. One method of detection is to view the head angle by 3D orientation (fig 7). Determination of head orientation is an effective symptom for detection of driver distraction and prediction of driver intent to lane change.



**Figure 7:** 3D view of the head

Another simpler yet efficient method is to view the image as a 2D form where the threshold can be set accordingly. Here

the sensor will sense the lightness and the darkness accordingly. If '0' represents darkness and if '1' represents white then the alarm can be set accordingly.

$$Alarm = \begin{cases} 1 & HDP \leq Thr \\ 0 & HDP \geq Thr \end{cases}$$



**Figure 8:** Nodding of head

## 5. Results and Discussion

The hardware used in the current implementation of the proposed approach consists of a laptop with attached webcam. Inexpensive hardware was deliberately chosen in order to demonstrate that the prototype system can function with low cost components and therefore could be affordable to a large segment of the driving population.

Experimental results were acquired using DELL XPS L501X laptop with 2.53GHZ i5 processor with 4.00 GB RAM and 64-bit Operating System. The videos were taken as 24 frames per second. The experiment was conducted using MATLAB version 2013a on WINDOWS 7 platform.

The following table (fig 9) was acquired by combining all the symptoms. Here the frame threshold is set as three. If three consecutive frames show warning then the fourth frame will be taken as a critical. All through the warning frames a low pitched short alarm is played in the background which would help the driver to come back to the alert state if it is the starting state of the drowsiness. If the driver is not responding in all the three frames then during the fourth frame a high pitched and long alarm is blared. In the table zero represents non severe warning and one represents severe warning.

	Year	Month	Date	Hour	Min	Warning Level	
1	2015	1	30	10	36	0	Driver Error Table
2	2015	1	30	10	36	0	
3	2015	1	30	10	36	0	
4	2015	1	30	10	36	1	

**Figure 9:** Table showing driver statistics

## 6. Conclusion

A nonintrusive prototype computer vision system for the real-time monitoring of a driver's vigilance was constructed. This system tries to look at the emerging technologies and determine the best approaches in trying to prevent the number one cause of fatal vehicle crashes. It is based on the capturing system which will process the data online. Here only two parameters were used, such as rubbing of eye and nodding of the head. The system is fully autonomous. It was tested under different illumination condition with different

users. The system works accurately under proper light and if the person is not wearing dark goggles or sun glasses. The performance of the system decreases as the light falling on the face increases. This system provides an accurate technique for fatigue detection in drivers. The proposed system is considerably more reliable than the existing system. Another benefit is the diminished false rate by judging the conventional approach.

## 7. Future Scope

The accuracy of this method can be further increased in this future by adding more parameters. Other parameters such as blinking of the eye and the yawing frequency can increase the accuracy up to 100%. In future studies, we intend to test the system with more users for longer periods of time in order to obtain real fatigue behaviours. With this information, we will be able to generalize our fuzzy knowledge base. Then, we would like to enhance our vision system in order to solve the problems for daytime operation and to improve the system for use with drivers wearing glasses. Finally, this system could be easily extended to other types of vehicles, such as aircraft, trains, subways, etc., consequently improving safety in transportation systems.

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