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Fatigue Detection of Workers using Supervised Learning

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ABSTRACT: For worker fatigue detection, machine vision and image processing could be helpful. There have been many research developed in this field in recent years for driver drowsiness detection but not for workers in software industries. A new method for worker fatigue detection has been proposed in this paper that uses eye condition for fatigue state. There are many techniques used for driver drowsiness detection but the same cannot be used for fatigue detection as one of the important factors is screen illumination for the workers who are working day and night on the systems (laptops or computers). Screen illumination is the light of the computer screen or laptop screen that is casted on the workers face that affects the eyes of the workers. Fatigue not only degrades quality but also acts as a health risk factor resulting in sleep disorder, depression, stress and also decreases the productivity of the company. To avoid the mistakes occurring due to fatigue a mechanism is proposed to measure their fatigue level and alerting them by a message with a beep sound on their system. This alert will tell the workers about their stress condition and forcing them to take some refreshment by moving out. Several datasets of open-eyes and closed-eyes are used in this method for training the system to extract eyes features. In this proposed method the alert message with beep sound will appear on the system when the eyes of the worker is closed for 15 frames and when the worker eyes are normally open then no message will appear on the screen. This proposed work will help the workers to increase productivity also help them to improve their health condition.

Keywords: Face Detection, Extraction, Drowsiness, Estimation

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INTRODUCTION

Fatigue is the condition that affects mind state and decreases an individual's ability to do any work which results in faulty output which finally degrades the productivity of the company. Fatigue is the condition where a person is feeling very tired, sleepy or full of stress. Repetitions in the tasks can intensify the feelings of fatigue. Fatigue is of two types acute or chronic. Employers and Workers should known about the fatigue and its impact in the workplace as it is considered as a workplace hazard. However, fatigue levels cannot be easily measured which makes it difficult to resolve the effect of fatigue in workplace. Behavioural changes are one of the methods to identify fatigue. Shift rotations in workplace with repetitive activities are the factors that can influence fatigue. Workers who work for longer hours or additional time may be at risk, as shown by an article in the NSC's Safety + Health magazine. A progressing report by the National Institute for Occupational Safety and Health (NIOSH) found that workers in progress occupations will undoubtedly rest less than 7 hours of the day than all others (source:https://ehsdailyadvisor.blr.com/2017/06/fatigued-workers-hazard-company/). Advancement of the frameworks for checking a worker's level of weakness and alarming them, when he is lazy or non-mindful condition in the work can prevent many mistakes. The prevention of such mistakes can be a research topic which can help workers and employer to increase productivity.

Measuring fatigue is a big problem as there are direct measures to measure it (Hajare and Dule, 2012). Work related health factors are generated when there is long working hours that includes physical or mental activity with no proper break time between shifts, facing shift rotations, taking improper rest, having multiple jobs etc. Over the past decade, most research has focused on the development of systems to monitor the fatigue state through different techniques for driver fatigue detection (Wang, 2011) while driving the car, but no research has been done on the software companies for workers fatigue detection.

In this paper as we concentrate on fatigue detection of software developers. There are some factors that need to be taken care of while detecting fatigue of software developer. As we concentrate on facial features, and specially eye expressions for fatigue detection, the need of capturing images of the face is required. Once the algorithm captures the images of the face, different features can be extracted and fatigue and be detected. But the most important factor that the algorithm faces while extracting data from image captured through a webcam or an inbuilt camera on the computer screen is illumination.

A new approach towards safety and security of the workers who are working day and night in the software companies is proposed here.

This paper further divides in many sections which includes issue regarding the problem their solution then literature review, proposed approach and at last the experimental results with conclusion.

THE ISSUE

The main issue behind this research is that there is no proper system for worker fatigue detection which measures the level of stress developing from their work. Workplace fatigue is silently increasing in many industries all across the world resulting in decreased performance which results in increase job of site accidents. Employees are unable to get the rest they need .Workers fall asleep during their shifts because of the fatigue. And also the illumination of the systems effective the workers eyes which can cause eye problem. The issue behind this proposed work is that workers don't get proper rest during their shift time .They are working continuously without taking any break which results in mistakes in their work and also their health is affected.

The best solution is that the fatigue or stress level should be detected before any error or mistake occurs.

LITERATURE REVIEW

Chao *et al,* (2018) proposed a new methodology to recognize expressions based on cognitive and mapped binary patterns. First approach depends on the LBP operator to remove facial highlights, second was the foundation of the pseudo 3-D model to segment the facial region into six featured parts. Finally they played out a similar investigation on the extension of Cohn-kanade(CK+) outward appearance dataset.

Dange and Yengantiwar, (2013) built up an eye estimation method by a machine vision based ideas. A little monochrome camera for security was utilized that directly concentrating on the driver's face which scans the driver's eyes to distinguish tiredness. This paper portrays the condition of eyes whether they are open or close dependent on the Viola Jones calculation.

Manu, (2016) portrayed a strategy for detecting the drowsiness by three stages. These stages were utilized for facial highlights recognition with the use of Viola Jones, the eyes tracking and yawning identification. In order to classify the consecutive frames into two states, a binary linear support vector machine classifier was first fatigue and another non-fatigue state and then the alarm sound was formed if it was above the threshold time.

Ren Kai *et al,* (2018) proposed a framework for recognizing the eyes state with the deep learning approach, which shows collection of the data that improves quality of anti-fake and finally results in the promotion of performance of biometric identification.

Ashlock, (2013) includes previous work modeling stress in the workplace. Use of agent training was done by binary automata to adopt the successful behavior of highly productive mentors. This paper was only based on the Stress that is accumulated through long working hours which affects the performance of the agent by decreasing productivity.

Singh *et al,* (2016) proposed a new approach for eyes extraction from frontal facial pictures. Sobel edge operator and morphological operation was used by them for extraction of the eyes.

Fatima *et al,* (2016) includes emotion recognition from facial expressions in three steps: face detection, features extraction and classification of expressions on the bases of two databases JAFEE and COHEN.

Suwarna *et al,* (2011) presents different techniques of modeling the mood and also fatigue in any individual. Lots of parameter like facial expression, tone of voice that is speech synthesis, posture, gesture etc.was used for mood detection and fatigue detection of human.

Hajare and Dhule (2012) presents the effect of fatigue on the lives of workers. When employees / workers were tired, they were not able to work fast. Due to fatigue, it is possible to increase the risk of fatigue on the site because fatigued employees are less able to respond actively in several circumstances.

Kashyap and Sharma, (2017) proposed a new methodology of detecting the fatigue level of the driver using the MATLAB tool. Drowsiness Detection System has been developed with the use machine vision based concepts. The framework utilizes a little camera that straight forwardly centered around driver's face and screens the driver's eyes to recognize exhaustion or tiredness.

PROPOSED APPROACH

The proposed system includes the sequence of images captured by the laptop's webcam and then imported into the training system as input. The system follows four steps: face detection, extraction of facial components, tracking of facial components, and detection of fatigue. The image is generated in real time at the beginning. Then images are tested by the machine learning algorithm facial landmark detection(source:https://www.learnopencv.com/facemark-facial-landmark-detection-using-opencv/) that detects the eyes contour to find whether the eyes(Wang, 2018) are closed or open.

The facial landmarks algorithm is used to detects all 68 points in the face by 68facial landmark detector(source:https://www.pyimagesearch.com/2017/04/03/facial-landmarks-dlib-opencv-python/). This algorithm is used to training the shape predictor on the captured datasets.

-The 68 facial landmarks mean that there are 68 points on the face which are detected for processing the facial landmarks detection.

-Secondly, the image is captured in real time is passed through the trained model 68 facial landmarks detector. The facial components including eyes are extracted through the Haar classifiers.

-Then the extracted eyes are trained by the facial landmark detection algorithm .The facial landmark detector algorithm makes the contours across the eyes.

-After extracting the eyes contours template matching is performed, a reference template from the dataset is used for matching the eyes state for detecting the fatigue condition.

-In training phase the datasets of 230 images of open eyes and 230 images of closed eyes with 630*480 dimensions each is trained by the shape predictor with 68 facial landmark detection algorithms.

-It is assumed that if worker eyes are closed for 15 frames in one go then the alert message with beep sound will appears as output. If the workers eyes are open normally then no message appears on the system screen.

-Fatigue detection is done on the basis of the status of eyes. If eyes are in closed the state is matched with the expressions from the datasets and an alert will be created with a warning message.

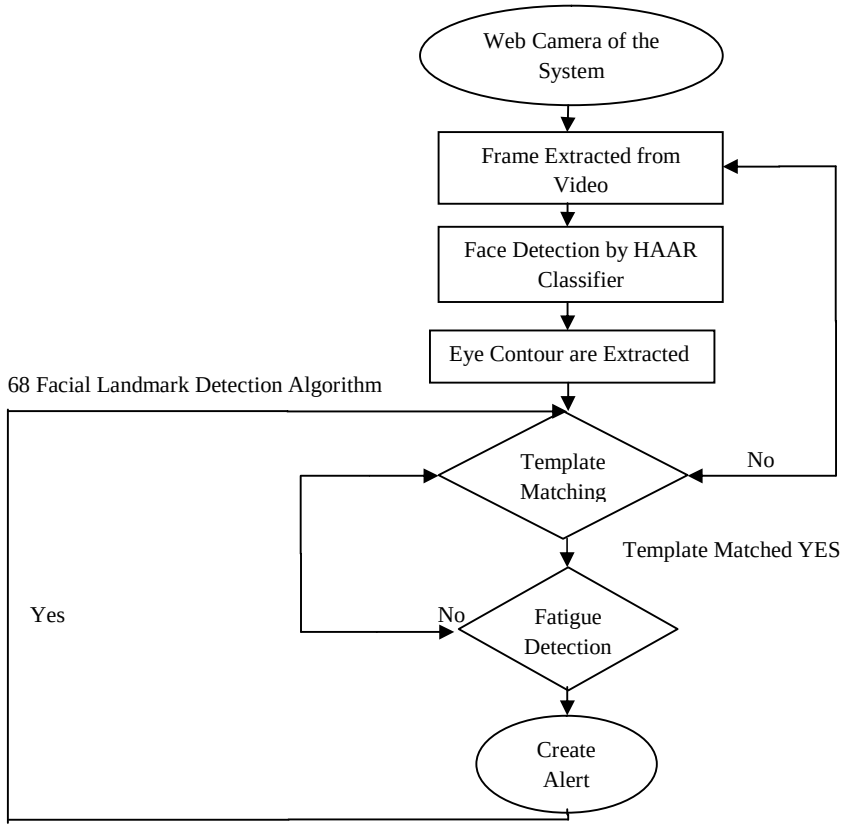

Fig. 1. Flowchart showing proposed methodology.

A. Face detection and eyes localization

The proposed approach is based on the face landmark detection with Haar classifiers to detect the face and eyes. This method is used to extract image features.

B. Eye Blinks detection by Facial Landmarks

Facial landmarks can be used to detect eye blinks. This feature is used by Python's dlib library. Use of facial training set can be performed to understand where certain points exist on facial structures. Then plotting is performed in other images of the same points on region of interest, if they exist. This library can produce output as a 68-point plot on a given input image.

The algorithm focuses on points 37-46 for eye blinks detection. There are points describing the eyes.

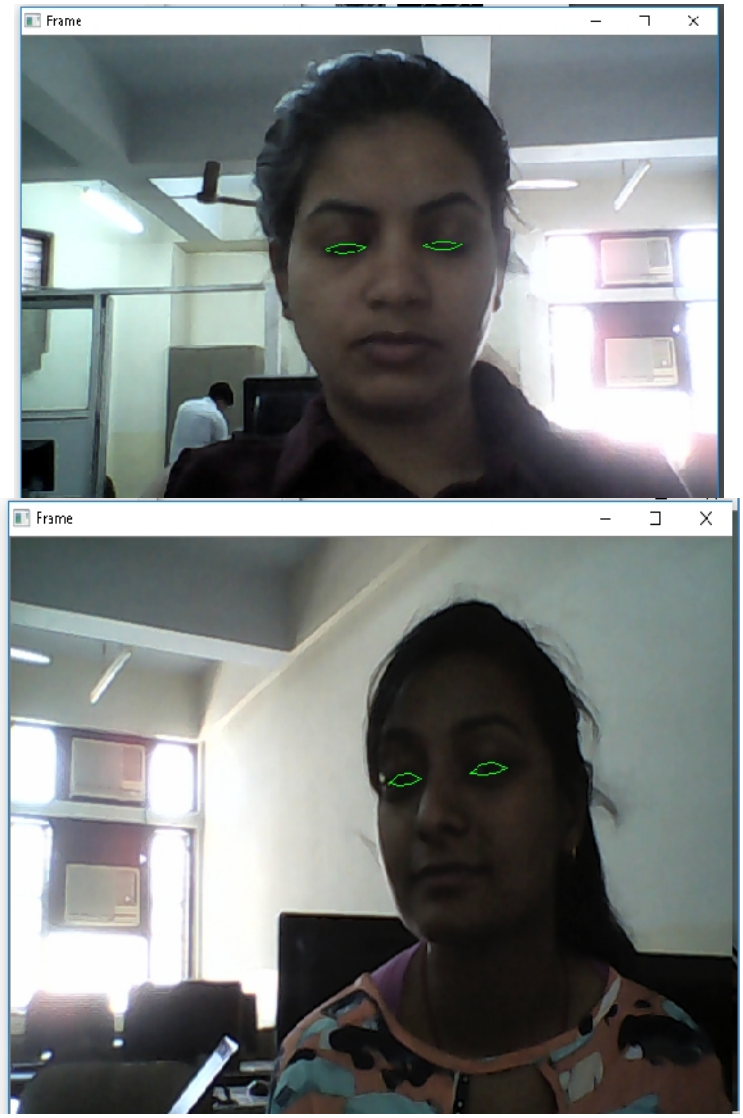

Fig. 2. Eye localization from the face.

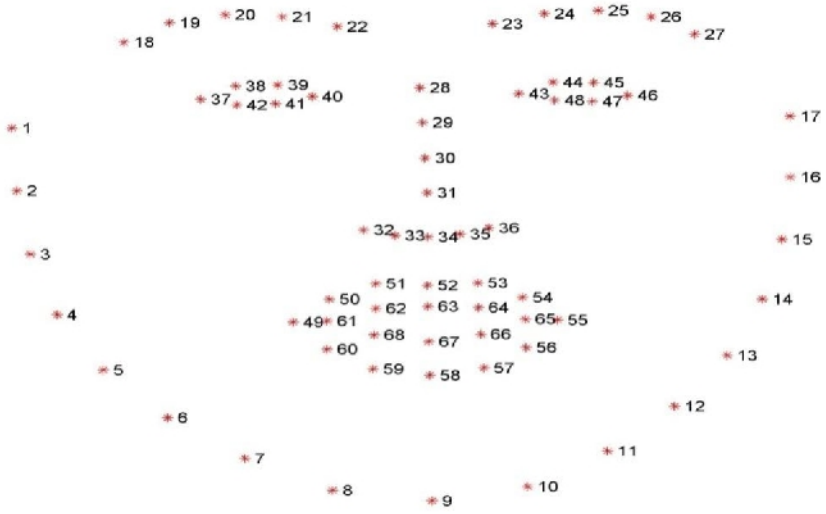

Fig. 2. The 68 facial landmarks.

The Eye Aspect Ratio is an estimate of the eye opening state in Real Time Eye Blinking.

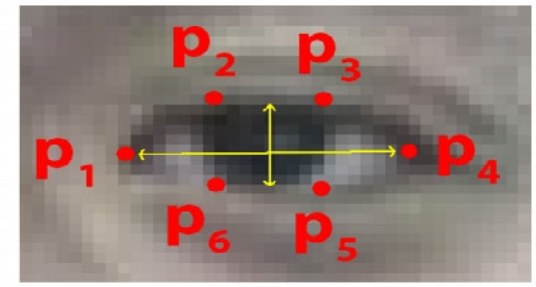

Fig. 3. Eye aspect ratio.

1. The eye aspect ratio can be defined by the equation below.
2. Facial Landmarks of eye can be calculated by using this equation as shown in below:

$$EAR = \frac{\| p_2 - p_6 \| + \| p_3 - p_5 \|}{2 \| p_1 - p_4 \|}$$

3. Equation to find Eye Aspect Ratio

The Eye Aspect Ratio is a constant value when the eye is open and when the eye is closed it then falls rapidly to 0.

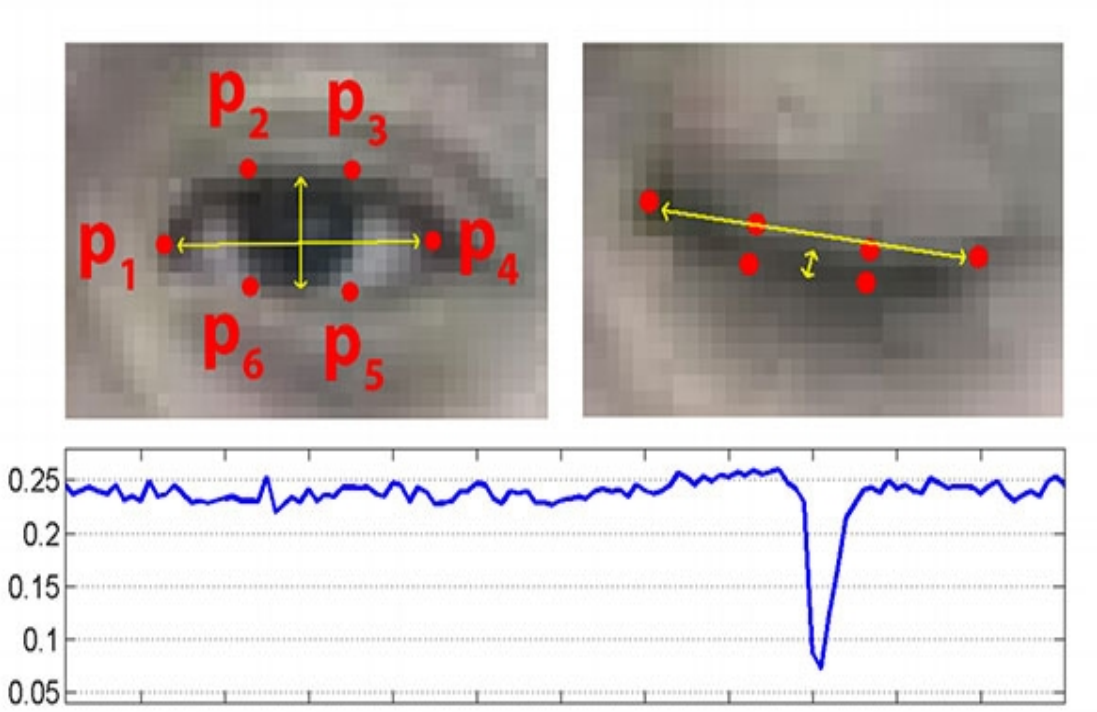

Fig. 4. Eye Aspect Ratio over time.

C. Facial Landmark Detection Algorithm

Load face detector: This algorithm takes a cropped facial image as an input. Therefore, the first step is to detect all faces in the image and pass those facial rectangles to the landmark detector.

Create Face mark Instance: Create an instance of the Face mark class.

Load landmark detector: Next, load the detector of the landmark. This landmark detector is trained on several thousand images of facial images and corresponding landmarks.

Capture frames from webcam: Grab a video frame and process it.

Detect faces: Face detector have to run on every frame of the video.

D. Fatigue Detection

Drowsiness is detected on the basis of eye features (Kumar *et al.*, 2002) in the presented system. In the detection of drowsiness, eyes are very essential components. During darkness, the opening state of the eyes is changed to a closed state. In this phase, facial components will be removed and sleepiness will be identified. When frame is captured from real time video it goes to the training phase firstly then the fatigue is detected (Qiang *et al.*, 2004). If the state of eyes found to be closed for 15 frames and above the threshold then the system shows the output in form of alert message and if the state of eyes is found in open state then the system gives no alert message.

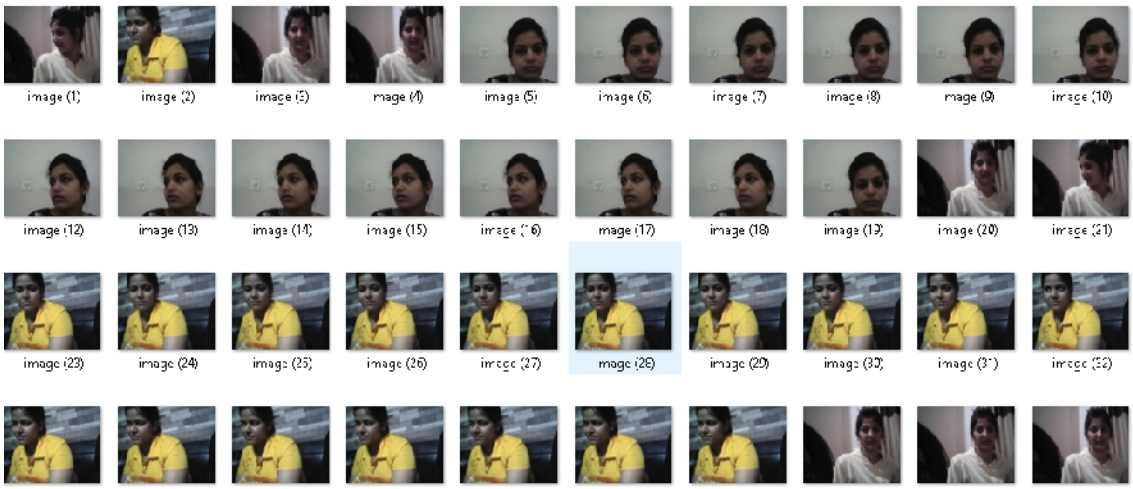

Fig. 5. Datasets of Open Eye state.

Fig. 6. Datasets of Closed Eye state.

EXPERIMENTAL RESULTS

The image sequence is processed with a real-time video frame rate equal to 15 frames per second and a scale of 630* 480 pixels with 230 images. The proposed method has been implemented with Open cv in python. The system is programmed in the proposed system to start web cam to capture real-time video from the laptops. Then the face detection process and the detection of facial components, the tracking is performed. The fatigue detection process is performed by investigating the eye state (Zhao and Lu, 2011). If eyes are closed for 15 frames continuously then the system detects fatigue with alert message and if the eyes are not closed for 15 frames continuously then no alert message is displayed by the system (Kanchan, 2015). In Table 1 comparison of the working methodology has been shown below:

Table 1: The comparison of Proposed Methodology.

S. no.	Frames Tested	Eye State	Fatigue Detection	Generated Alarm	Experimental Accuracy
1.	2	Open	No	No	No output
2.	10	Open	No	No	No output
3.	15	Closed	Yes	Yes	100%
4.	16	Closed	Yes	Yes	99.4%
5.	20	Closed	Yes	Yes	80%

CONCLUSION

The proposed approach presents worker fatigue detection system which is based on computer vision with machine learning. The proposed system uses eyes state of the worker who is working on the system with the help of real time frame capturing from video. In the first, we locate face and eyes of the worker using Haar feature. Shape predictor allows the iris centre detection and the points of intersection for the two to calculate aspect ratio of the eyes. This analysis is confirmed by the facial landmark detection algorithm to find bests results for the benefit for the workers. The results of this approach show a good precision rate for features of the eyes. It can therefore be concluded that worker fatigue can be detected in advance by using the proposed method before any error or fatal health condition occurs. It will not only measure productivity, but it will also ensure software workers ' health condition.

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