Computer vision based fatigue detection using facial parameters

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Abstract. Human face is a clear indicator of the fatigue and tiredness experienced by an individual. There may be many cues that can be derived through the analysis of facial parameters which clearly indicate the tiredness. Most of us feel the fatigue and tiredness but at the same time ignore it due to want of time to complete a task or necessity to complete an important work. However there can be instances when this fatigue may turn fatal. Hence an automated system that can easily predict the fatigue becomes the need of the hour. This work is focussed towards developing an automated application that can detect fatigue by analysing various facial parameters. This work uses Computer Vision and has been implemented using Python programming. The result shows good prediction accuracy when it comes to fatigue prediction using facial parameters.

1. Introduction

There is a common saying \textit{Face is the index of mind}. True to the saying facial expressions can clearly convey the fatigue experienced by individuals. The facial fatigue can be gauged using various clues such as eyeball movements, eye blinking rate, eyes closed, yawning, head posture etc. Figure 1 shows the various clues in faces that can be used to predict facial fatigue.

![Facial features that determine fatigue](image)

\textbf{Figure 1.} Facial features that determine fatigue.
It is very important not to ignore fatigue as the after events may sometimes be catastrophic. Some real-time application areas where this automatic facial fatigue detection will be of great use are in detecting drowsiness level of drivers, predicting the mood of audience in a gathering, student attentiveness in class, sleep detection etc. Figure 2 shows some of these application areas of facial fatigue detection. Some of the after effects of facial fatigue are drowsiness, sleep, tiredness, stress, anger, exhaustion etc. Figure 3 lists some of these cascaded effects of facial fatigue. These after effects have the potential to cause serious events such as accidents, deaths, interpersonal discomfort etc. This clearly undermines the imminent need for an automated system to predict facial fatigue in individuals[26].

![Application areas of facial fatigue detection](image)

**Figure 2.** Some application areas of facial fatigue detection.

![Cascaded effects of facial fatigue](image)

**Figure 3.** Some cascaded effects of facial fatigue.

The objective of this work is to develop a facial fatigue recognition system that can observe the facial parameters listed in Figure 1 and based on some observations predict and alert if the person is experiencing fatigue or not.

2. Related works

As seen from the above section, it is of utmost importance to identify facial fatigue and notify the same. Several works have been carried out related to fatigue detection in human faces. G. Li et.al. [1] have developed an EEG based system that is embedded into a smartwatch and this clearly analyses the EEG signals and alerts if there is any drowsiness experienced by the individual. M. Sunagawa et al. [2] have developed a model that analyses the facial features of 50 drivers and categorizes the drowsiness into different levels ranging from weak to strong. F. You et.al. [3] proposed a method that uses individual differentiation aspect to computing whether the person is experiencing drowsiness or not.
Authors of [4] have developed a drowsiness detection system exclusively for drivers that alerts the drivers using smartphones when drowsiness is detected[24]. A dynamic vision sensor based approach was developed in [5] which analysed the facial features using neuromorphic sensors and predicted the drowsiness experienced[25].

Authors of [6] have performed an exhaustive survey of the various state of the art techniques and models that were developed to address this problem of drowsiness detection. In the work carried out in [7], the authors have used eye aspect ratio as a measure to predict drowsiness in individuals. The authors of [8] have used an optical correlator based approach to determine drowsiness. A wearable sensor based approach was followed in [9] to detect drowsiness in individuals while in [10] an adaptive neural network based approach was followed to predict the drowsiness levels.

3. Proposed System
The proposed system uses a fusion of Computer Vision concepts, OpenCV and Python programming to accomplish this automated facial fatigue detector. Figure 4 depicts the flow diagram of the proposed approach.

![Flow diagram of the proposed approach.](image-url)

**Figure 4.** Flow diagram of the proposed approach.
This is followed by computing the Eye Aspect Ratio (EAR) using the method proposed by Tereza Soukupova & Jan Čech [11]. The Eye Aspect Ratio is computed using the following equation (1).

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

The EAR value is used to determine the drowsiness levels of individuals.

### 4. Experimental results

As discussed in the previous section, computer vision based approaches were followed to extract the facial features. The coding was performed using python programming and google colab. OpenCV was used to leverage the computer vision specific functions while performing pre-processing. Other dependencies include scipy, dlib and imutis. In this experiment, the EAR threshold was set as 55\% (0.55). When the EAR value at any instant is above 0.55, it is assumed that the individual is active. However, when the EAR value falls below 0.55, it is assumed that the individual is drowsy and the system automatically triggers an alert to make the person aware of his fatigue [28].

Figure 6 shows the eyes wide open while performing the experiment which indicates that the person is active while in figure 7, the eyes are closed for a duration and an automated alert is generated for this scenario. The above experiment was also tested in challenging scenarios such as a person wearing glasses [29]. This scenario is depicted in figure 8 when the person is awake wearing glasses while figure 9 depicts the scenario where a person’s eye is closed while wearing glasses. It can be found that the experiment generated automated alert instantaneously when the person’s eyes were closed even while wearing glasses [30].
Figure 6. Person classified as active

Figure 7. Person classified as feeling fatigue and automated alert generated

Figure 8. Person classified as active while wearing glasses
5. Conclusion and future work

A simple and automated approach to determine the fatigue of person using facial parameters was developed. This eye specific features were extracted and the EAR was computed. Based on the EAR value, the system determined if the person has fatigue or not. The system was tested with real time videos and it has provided good accuracy and results. Future work will be directed towards developing a robust fatigue classifier that considers other factors such as yawn, facial gestures, body postures etc. along with EAR in order to make the system more efficient.

6. References

[1] G. Li, B. Lee and W. Chung, "Smartwatch-Based Wearable EEG System for Driver Drowsiness Detection," in IEEE Sensors Journal, vol. 15, no. 12, pp. 7169-7180, Dec. 2015, doi: 10.1109/JSEN.2015.2473679.

[2] M. Sunagawa, S. Shikii, W. Nakai, M. Mochizuki, K. Kusukame and H. Kitajima, "Comprehensive Drowsiness Level Detection Model Combining Multimodal Information," in IEEE Sensors Journal, vol. 20, no. 7, pp. 3709-3717, 1 April1, 2020, doi: 10.1109/JSEN.2019.2960158.

[3] F. You, X. Li, Y. Gong, H. Wang and H. Li, "A Real-time Driving Drowsiness Detection Algorithm With Individual Differences Consideration," in IEEE Access, vol. 7, pp. 179396-179408, 2019, doi: 10.1109/ACCESS.2019.2958667.

[4] A. Dasgupta, D. Rahman and A. Routray, "A Smartphone-Based Drowsiness Detection and Warning System for Automotive Drivers," in IEEE Transactions on Intelligent Transportation Systems, vol. 20, no. 11, pp. 4045-4054, Nov. 2019, doi: 10.1109/TITS.2018.2879609.

[5] G. Chen, L. Hong, J. Dong, P. Liu, J. Conradt and A. Knoll, "EDDD: Event-Based Drowsiness Driving Detection Through Facial Motion Analysis With Neuromorphic Vision Sensor," in IEEE Sensors Journal, vol. 20, no. 11, pp. 6170-6181, 1 June1, 2020, doi: 10.1109/JSEN.2020.2973049.

[6] M. Ramzan, H. U. Khan, S. M. Awan, A. Ismail, M. Ilyas and A. Mahmood, "A Survey on State-of-the-Art Drowsiness Detection Techniques," in IEEE Access, vol. 7, pp. 61904-61919, 2019, doi: 10.1109/ACCESS.2019.2914373.

[7] CaioBezerraSoutoMaior, Márcio José das Chagas Moura, JoãoMateus Marques Santana, Isis Didier Lins, Real-time classification for autonomous drowsiness detection using eye aspect ratio, Expert Systems with Applications, Volume 158, 2020, 113505, ISSN 0957-4174.

[8] ElhoussaineOuabida, AbdelazizEssadike, AbdenbiBouzid, Optical correlator based algorithm for driver drowsiness detection, Optik, Volume 204, 2020, 164102, ISSN 0030-4026.
[9] Victor Javier Kartsch, Simone Benatti, Pasquale Davide Schiavone, Davide Rossi, Luca Benini, A sensor fusion approach for drowsiness detection in wearable ultra-low-power systems, Information Fusion, Volume 43, 2018, Pages 66-76, ISSN 1566-2535.

[10] Charlotte Jacobé de Naurous, Christophe Bourdin, Clément Bougard, Jean-Louis Vercher, Adapting artificial neural networks to a specific driver enhances detection and prediction of drowsiness, Accident Analysis & Prevention, Volume 121, 2018, Pages 118-128, ISSN 0001-4575.

[11] Tereza Soukupova and Jan Čech, Real-Time Eye Blink Detection using Facial Landmarks, 21st Computer Vision Winter Workshop, Luka Cehovin, Rok Mandeljc, Vitomir Struc (eds.) , RimskeToplice, Slovenia

[12] Manickam, M., Balasundaram, A., Ashokkumar, S. (2020). Structure optimized multi layer trespass perception system in cloud. International Journal on Emerging Technologies, 11(3), 77–81.

[13] Magesh Kumar, S., Ashokkumar, S., Balasundaram, A. (2019). Providing enhanced resource management framework for cloud storage. International Journal of Engineering and Advanced Technology, 9(1), 3903–3908.

[14] Subbiah S., Palaniappan S., Ashokkumar S., Balasundaram A. (2020) A Novel Approach to View and Modify Data in Cloud Environment Using Attribute-Based Encryption. In: Ranganathan G., Chen J., Rocha Á. (eds) Inventive Communication and Computational Technologies. Lecture Notes in Networks and Systems, vol 89. Springer, Singapore. https://doi.org/10.1007/978-981-15-0146-3_20.

[15] S. Magesh Kumar, Balasundaram A, Sathish Kumar P J. (2020). An Improved Optimization Algorithm for Word Search on Disk. International Journal of Control and Automation, 13(4), 952 - 957.

[16] B. Ananthakrishnan, “An efficient approach for load balancing in cloud environment,” International Journal of Scientific & Engineering Research, vol. 6, no. 4, pp. 36-40, 2015.

[17] Balasundaram, A., Chellappan, C. An intelligent video analytics model for abnormal event detection in online surveillance video. J Real-Time Image Proc 17, 915–930 (2020).

[18] A. Balasundaram and C. Chellappan, ”Vision Based Motion Tracking in Real Time Videos,” 2017 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Coimbatore, 2017, pp. 1-4, doi: 10.1109/ICCIC.2017.8524504.

[19] A. Balasundaram, C. Chellappan, “Vision Based Gesture Recognition: A Comprehensive Study”, The IIOAB Journal, Vol.8, Issue.4, pp.20-28, 2017.

[20] Balasundaram, A., Ashok Kumar, S., Magesh Kumar, S. (2019). Optical flow based object movement tracking. International Journal of Engineering and Advanced Technology, 9(1), 3913–3916.

[21] Balasundaram, A., Chellappan, C. (2019). Computer vision based system to detect abandoned objects. International Journal of Engineering and Advanced Technology, 9(1), 4000–4010.

[22] Balasundaram, A. Computer Vision based Detection of Partially Occluded Faces. International Journal of Engineering and Advanced Technology, 9(3), 2188-2200.

[23] Balasundaram, A, Ashokkumar, S. Study of Facial Expression Recognition using Machine Learning Techniques. ICR. 2020; 7(8): 2429-2437.

[24] Harshavardhan A, Suresh Babu Dr and Venugopal T Dr 2017 “Brain tumor segmentation methods – A Survey ” Jour of Adv Research in Dynamical & Control Systems 11 240-245

[25] Harshavardhan A , Suresh Babu Dr and Venugopal T Dr 2016 “3D Surface Measurement through Easy-snap Phase Shift Fringe Projection”, Springer conference International Conference on Advanced Computing and Intelligent Engineering Proceedings of ICACIE 1 179-186

[26] Mahender K, Anil Kumar T and Ramesh KS 2017 SER and BER performance analysis of digital modulation schemes over multipath fading channels Journal of Advanced Research in Dynamical and Control Systems 9(2) 287-291

[27] Harshavardhan A, Suresh Babu and Dr, Venugopal T Dr 2017 “An Improved Brain Tumor Segmentation Method from MRI Brain Images” 2017 2nd International Conference On
Emerging Computation and Information Technologies (ICECIT) IEEE 1–7. DOI.org (Crossref) doi:10.1109/ICECIT.2017.8453435.

[28] Rajasri I, Gupta AVSSKS and Rao YVD 2014 Symmetry and its Effects on Structures of Planetary Gear Trains Journal of The Institution of Engineers (India): Series C 95(1) 77-81 10.1007/s40032-014-0101-9

[29] A.Harshavardhan Syed Nawaz Pasha Sallauddin MD D.Ramesh 2019 “Techniques used for clustering data and integrating cluster analysis within mathematical programming” journal of mechanics of continua and mathematical sciences 14(6) 546-57, DOI.org (Crossref)https://doi.org/10.26782/jmcms.2019.12.00038

[30] Sudarshan, E., Satyanarayana, C. and Bindu, C.S., 2017, September. A Parallel RLE Entropy Coding Technique for DICOM Images on GPGPU. In 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC) (pp. 963-966). IEEE