Amity Journal of Computational Sciences
ISSN 2456-6616 (Online)
Volume 7, Issue 2, 2023

Driver's Drowsiness Monitoring and Detection System by the use of Machine Learning and OpenCV

Siddharth Sharma
UG Student, Department of Computer Science,
Uttar Pradesh, India
siddharthsharma7520@gmail.com

Abstract – Everyday, we listen so many road accidents which occurs because of the absent and distracted mindfulness of the drivers. This is popularly known as driver drowsiness. It is actually a very serious condition which leads to various miserable and unlucky consequences. There are numerous methods these days which are inclined on the idea of the movement of automobiles or is inclined on the behavior of the driver driving the automobiles. Here the first and most initial level method would be based on the idea of physiological method which would assist in diverting the mind of driver from getting drowsiness while driving on the roads. As a result of which the driver would always stay aware of the road conditions without getting any sleepy thoughts. As well as some ideas consists of costly sensors and which takes and analyses very large data.

Keywords – Distracted, Mindfulness, Drowsiness, Miserable, Accident, Numerous, Methods, Physiological, Assist, Diverting, Driver Aware, Sleepy.

I. INTRODUCTION

Several mishaps which usually take place on road leads to the demise of the drivers just because of the unexpected drowsiness that they face because of the high amount of fatigue. This problem is generally seen in the drivers who are having their day and night duties. These drivers are most probably those drivers who drive buses as well as trucks. It is extremely dangerous to handle and understand the concept behind the drowsiness because of driving. It is basically the fact that when drivers drive the car a for a very long then due to constantly seeing the road there becames and illusion in our eyes and tend to feel sleepy.

It is extremely dangerous to handle the vehcile with less sleep and in this situation handling the car becomes more difficult because of the exceeded driver's limit which can him/her feel dull and tired, hence leading to a great devastation. In research it is found that Sudden Dozing is a very serious situation especially while driving because 75,000-85,000 accidents happen each year, this data also includes the injures which someone had as well as the crashes which take place on roads. If we see the things from death perspective, then each year there is 1500-2500 deaths which takes place very normally. This data still does not have the count of unofficial deaths which are not confirmed by drivers that was found having drowsiness in his/her eyes while driving. This is actually a very big problem because in such cases chances of death of innocent people is very high. A lot of people have this nightmare while travelling because of the riskiness involved. So it is an important step to identify the drowsiness of driver as well as the alertness while driving to reduce the crashes and accident.

The main aim of this research is to identify whether the driver is in the condition of drowsiness or awake. The acquisition portion, processing portion and warning portion are the three important portions which are there in the detection system. The video which is recorded is of the driver driving the vehicle which is present inside the acquisition portion as well as it is shifted to the next step of i.e. processing portion. This identification is done online as well as if the driver is found having drowsiness symptoms, moreover the system gives a sound warning.

So, basically the main method to detect as well as to find the drowsiness which is there in a driver may be done by the usage of intrusive or nonintrusive methods or without the use of sensors the amount as well as the expenditure of the systems is based on the quality of sensors which are being used in the system. Moreover, the parameters also play a vital role in increasing the efficiency as well as the accuracy of the system to certain extent. Thus, this system will definitely identify and catch the level of tiredness and drowsiness while driving by the use of facial pictures, image processing and machine learning techniques to achieve the cost effectiveness and portable system.

II. LITERATURE REVIEW

This Driver System is actually came by the usual methodology of the opencv, playing a big role in traffic and road safety management area. A myriad of the driver drowsiness detection system solutions is understand the driver driving the vehicle and the way the driver is driving on the road. These solutions range from standalone expense trackers to integrated personal finance management tools, offering various features such as categorization, budgeting, and reporting

III. METHODOLOGY

Machine Learning is one of the technology in the field of computer science which takes the use of computers ability to understand without being programmed explicitly. Machine Learning technology is the concept which is interdependent with many blocks as well as complexes and advanced Algorithms, and it can be used with Python Programming language without any sort of difficulty. The two important python libraries which basically consists of the machine learning algorithms are:

1. Scikit-learn Library
2. Pandas Library

Formatted: Left: 0.5", Right: 0.5", Top: 0.5", Bottom: 0.5", Header distance from edge: 0.1", Footer distance from edge: 0.2"

Formatted: Justified

Formatted: Left: 0.5", Right: 0.5", Top: 0.5", Bottom: 0.5"

The SVM algorithm which is being used in the project is there in the scikit-learn library. It basically depicts individuals with machines, which is nothing but machine learning only. To get increased efficiency as well as increased accuracy, it is very beneficial to use ML algorithms.

A. MACHINE LEARNING WITH PYTHON

Basically the properties of Python Programming Language are based on Platform Independence, Robustness Language and Object Oriented Programming Language. It contains the machine learning algorithms inside the scikit-learn library and pandas library as well as it is an Open-source language.

B. LIBRARIES:

1. *NumPy:* NumPy is mostly known for the NUMERICAL PYTHON portion. It contains mostly every mathematical operation in the code format. It executes matrices and linear algebra also.
2. *Pandas:* Pandas are very useful and effective library in the Python Languages. These are basically imported by the use of pip installer and implemented for controlling and administering the datasets. Here training is a very important part for machines. In order to get the machine trained accurately with the implementation of the datasets. Then datasets should be kept in a format of a variable.
3. *Seaborn:* Seaborn is usually implemented to make things illustrated by the use of bar graphs, curves, etc. By implementing seaborn library, the differentiation and contrast between the characteristics is defined by the use of colors shades i.e., each characteristic is illustrated by a dissimilar color.
4. *Sklearn:* Sklearn library is a widely used library which has a basic usage in machine learning technique. Basically this library is implemented as an open and free software machine learning library. It is also used for executing Clustering, Regression and Statistical Modeling.

C. EXISTING APPROACH

This approach is classified into three very basic methodologies to find drowsiness in driver's eyes. They are: vehicle-based, behavior based as well as physiological-based methods. The overall steering wheel's movement, the vehicle accelerator or pattern of vehicle brakes, vehicle's speed, as well as the changing in the position of road lanes are all strictly checked and watched carefully in the methodology which depends upon the vehicle's overall working. If there is any change found in the final values, then it is said as driver drowsiness. The sensors wouldn't be attached to the driver and the overall measurement found would be non-intrusive.

Visual behavior basically stands for the eyes blinking, closing the eyelids, having no eyeball movement only staring one object, bending of driver head in downwards direction, etc.

An ordinary camera can be used to capture images and photographs which would be the input to SVM algorithm to understand and verify the above mentioned future features which were called as nonintrusive measurement. Understanding the physiological signals of the body like pulse rate, ECG, EOG, EEG, etc. which assists in understanding the driver's drowsiness depending on the physiological method as well as these are intrusive measurement due to the straight connection of the sensors to the driver.

In present scenario the checking of the drowsiness is mainly based on the machine learning algorithms.

D. PROPOSED APPROACH

Mostly every driver today has experienced the problems of drowsiness and sleepiness while driving on long routes. Young people as well as expert drivers are almost affected the most while driving and feeling drowsy because of uninterrupted driving hours without any sort of brakes or rests. In various places, auto drivers and cab drivers have uninterrupted and unbroken overtime hours often to either accomplish there certain set of work or targets at a certain time so that you will get eligible for the bonus profit. Several poor people in the need to meet their basic daily necessity costs as well as to get the beloved people be inclined to execute the work in the time of night shifts for prolonged time, this is one of the major cause for mishappening being done for the reason of drowsiness in eyes.

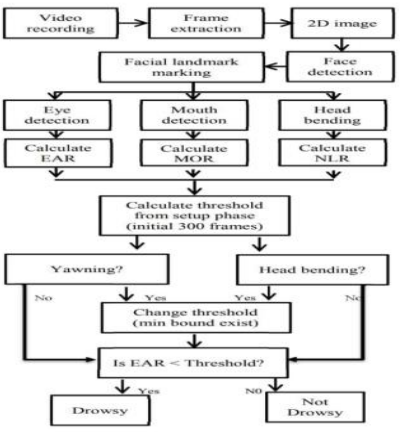

Fig.1 The block diagram of drowsiness detection system

The webcam is most probably used to to make a recording of the driver while he/she is driving on the roads. The placement of webcam is actually done in the way in which the webcam just takes the face recording of the driver with major focus on the eyes balls and eyelids. When the whole video is taken, then the recorded images are being rendered to get a 2D image. The object specified would be checked and found by the use of HOG and SVM algorithms of ML.

IV. IMPLEMENTATION:

A. *ACQUIRING DATA:*

In the beginning, the pictures as well as the videos which are captured using the webcams of the personal computers. After that the fulfillment of the frame's extraction, the pictorial representation uses techniques which are given by the 2D pictures of the recorded videos. So, when the driver's details are being fetched. The volunteers which were given personal computers were being told to focus all the time in personal computers only and execute activities which includes continual eye blinking as well as closing, yawning and bended head.

B. *FACE IDENTIFICATION:*

The driver's face was found in the frame after they were being taken out. In the paper, HOG & SVM algorithms were being used for the extractions of the faces. In this checking, only the positive examples of the stable windows size were being taken for pictures as well as histograms of the oriented gradients(HOG) descriptors were calculated on them. Keeping that in mind, the negative examples of the similar similar measurement were being included ofr HOG descriptors as well as the results were being assessed. Commonly, the counting for the negative example is more than the positive examples.

C. *LOCATING FACE POINTS:*

After the checking of faces, the next step contains the points of location on the face of a human being such as mouth, faces, nose, etc. After that the pictures used for the facial detection should be standardized to decrease the overall distance factors between the vehicle's driver and the camera. Hence, the facial picture would is resized with the width of 500 pixels as well as transformed to gray scaled pictorials. The standardization is taken by regression trees. So the major points which are marked for recognition of facial parts are:

Parts	Landmark Points
Mouth	[13-24]
Right eye	[1-6]
Left eye	[7-12]
Nose	[25-28]

Table I: The location points on face

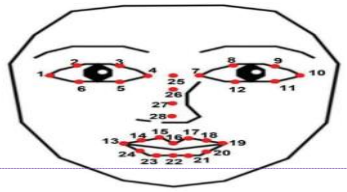

Fig.2 The landmark points on face

V. FEATURE EXTRACTION:

Once the marking of the points are done on the face, the drowsiness features are given below:

A. *EYE ASPECT RATIO(EAR):*

The calculation of EAR is useful for calculating the inverse ratio of length and breadth of the eyes with the height of that eye. Its mathematical representation is:

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

where i tells the points which are marked with i on face markings (i – j) which shows the overall distances between the marks i and j. Once the eyes of the driver is unlatched EAR is at the maximum point and once these eyelids are shut, the EAR is atmost to zero. Hence, the degrading value of EAR depicts the closing of eyes and determines the drowsiness behavior of the driver.

B. *MOUTH OPENING RATIO (MOR):*

–The MOR is basically explained by the understanding and checking of the yawning of the vehicle drivers as well as eventually drowsiness is detected.

$$MOR = \frac{(p_{15} - p_{23}) + (p_{16} - p_{22}) + (p_{17} - p_{21})}{3(p_{19} - p_{13})}$$

C. *NOSE LENGTH RATIO(NLR):*

NLR basically tells and defines about the position of head along with axis of vertical axis, hence by the use of bending angles of head and so the alert of drowsiness is determined. Here is the mathematical representation :

Formatted: Justified
Formatted: Font: 10 pt
Formatted: Font: 10 pt
Formatted: Font: 10 pt, Not Italic, All caps
Formatted: Font: Not Bold, Italic
Formatted: All caps
Formatted: Font: (Default) Times New Roman, 9 pt, Italic, All caps
Formatted: Font: (Default) Times New Roman, 9 pt, Italic
Formatted: List Paragraph, Justified, Numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Indent at: 0.5"
Formatted: Font: Not Bold
Formatted: Font: Not Bold, Italic
Formatted: Font: Not Bold
Formatted: Justified
Formatted: Font: (Default) Times New Roman, 9 pt, Italic
Formatted: List Paragraph, Justified, Numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 3 + Alignment: Left + Aligned at: 0.25" + Indent at: 0.5"
Formatted: Justified

$$NLR = \frac{nose\ length\ (p_{28} - p_{25})}{average\ nose\ length}$$

D. *CLASSIFICATION*:

The ML algorithms as well as the factors of threshold factors should be the determination of the drowsiness of the driver, from the values given by the EAR, MOR and NLR.

Table II. Calculated parameter values of threshold

EAR from setup phase (average of 150 maximum values out of 300 frames)	0.34
Threshold = EAR - offset	0.34 - .045 = 0.295
At Yawning, (MOR > 0.6)	Threshold = Threshold +0.002 *Max bound exist
At Head Bending, (NLR < 0.7 OR NLR > 1.2)	Threshold = Threshold +0.001 *Max bound exist

Once the conversion of the values are taken place from threshold values, even when the features are important for the classes or is not being tested. If these three factors shows just 5 percent significance then the classification depends upon the Bayes Classifier and SVM algorithm is used.

VI. RESULTS:

The personal laptops camera when switched ON will directly take the pictures and video of the vehicle's driver. The taken video is converted to the processing block to understand and find the drowsiness. If any accident is recorded , then the alarm starts to ring loudly.

Fig. Initial picture of the driver

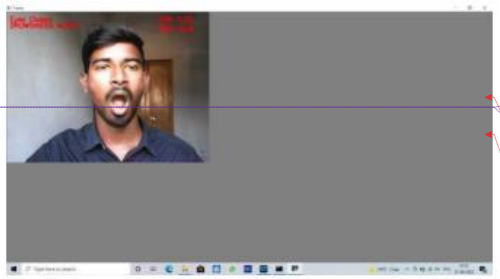

Fig. Drowsiness Identification on Yawning

Fig. Driver's Closed Eyes

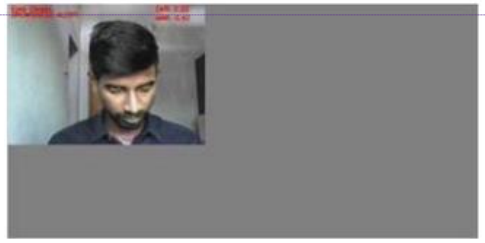

Fig. Drowsiness seen by bent head movement

State	EAR	MOR	NLR
Normal	0.35	0.34	1.003
Yawning	0.22	0.77	0.76
Eye Closed	0.15	0.419	0.876
Head Bending	0.15	0.577	0.66

This system can also define the drowsiness driver when the spectacles are worn.

Formatted: Font: (Default) Times New Roman, 9 pt, Italic, All caps

Formatted: Font: (Default) Times New Roman, 9 pt, All caps

Formatted: List Paragraph, Justified, Numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 3 + Alignment: Left + Aligned at: 0.25" + Indent at: 0.5"

Formatted: Justified

Formatted: Font: 10 pt, Not Bold

Fig. Detection by the usage of specs also.

VII. CONCLUSION:

This research paper has been designed as the application which is used for the overall detection and determination of the drivers sleepyness by the usage of ML algorithms as well as visual behavior features like Eye Aspect Ratio, Mouth Opening Ratio and Nose Length Ratio. These features are basically measured by the the threshold values by taking the videos and capturing the pictures by implementing the personal computers. This is an extremely good technique by which the overall assessment of the threshold value of drowsiness detection is taken place. The application executes mostly with all the given data. Further, the values of the threshold are stored and the algorithms of machine learning performed. Hence, algorithms like Bayesian classifier are usually implemented, which executes the perception of SVM which is 0.569. SVM algorithm gives more accuracy and effectiveness as well as the system development using SVM algorithm gives ideal output. In future, the proposed model can be used in real life as hardware in car and bus to validate the developed application.

VIII. REFERENCES:

[1] P. K. Kushwaha and M. Kumaresan, "Machine learning algorithm in healthcare system: A Review," 2021 International Conference on Technological Advancements and Innovations (ICTAI), Tashkent, Uzbekistan, 2021, pp. 478-481, doi: 10.1109/ICTAI53825.2021.9673220.

[2] P. K. Kushwaha, B. P. Lohani and D. Singh, "Review on information security, laws and ethical issues with online financial system," 2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS-INBUSH), Greater Noida, India, 2016, pp. 49-53, doi: 10.1109/ICICCS.2016.7542350.

[3] G. Gulati, B. P. Lohani and P. K. Kushwaha, "A Novel Application Of IoT In Empowering Women Safety Using GPS Tracking Module," 2020 Research, Innovation, Knowledge Management and Technology Application for Business Sustainability (INBUSH), Greater Noida, India, 2020, pp. 131-137, doi: 10.1109/INBUSH46973.2020.9392193.

[4] D. Pareta, I. N. Verma, B. P. Lohani, P. K. Kushwaha and V. Bibhu, "IoT Enabled Smart and Efficient Musical Water Fountain," 2022 2nd International Conference on Innovative Practices in Technology and Management (ICIPTM), Gautam Buddha Nagar, India, 2022, pp. 369-373, doi: 10.1109/ICIPTM54933.2022.9754129.

[5] B. P. Lohani, M. Trivedi, R. J. Singh, V. Bibhu, S. Ranjan and P. K. Kushwaha, "Machine Learning Based Model for Prediction of Loan Approval," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2022, pp. 465-470, doi: 10.1109/ICIEM54221.2022.9853160.

[6] A. Kumar, B. P. Lohani and P. K. Kushwaha, "Robust Secured Framework for Online Business Transactions over Public Network," 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2021, pp. 555-560, doi: 10.1109/ICIEM51511.2021.9445380.

[7] P. K. Kushwaha and B. P. Lohani, "A review of security of the cloud computing over business with implementation," 2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS-INBUSH), Greater Noida, India, 2016, pp. 192-198, doi: 10.1109/ICICCS.2016.7542342.

[8] M. Chandra, P. K. Kushwaha and S. Saxena, "Modified Fractal Carpets," 2011 International Conference on Computational Intelligence and Communication Networks, Gwalior, India, 2011, pp. 537-540, doi: 10.1109/CICN.2011.115.

[9] P. K. Kushwaha, R. Kohli and D. Singh, "Secret key watermarking in WAV audio file in perceptual domain," 2015 International Conference on Futuristic Trends on Computational Analysis and Knowledge Management (ABLAZE), Greater Noida, India, 2015, pp. 629-634, doi: 10.1109/ABLAZE.2015.7154940.

[10] Ranjan, Ankur A. et al. "An Approach for Netflix Recommendation System using Singular Value Decomposition." Journal of Computer and Mathematical Sciences (2019)

[11] Makkar, Bhavya et al. "Map Reduce concept-based Sentiment Analysis Approach." International Journal of Computer Sciences and Engineering (2019)

[12] Bhatia, Ayush & Bibhu, Vimal & Lohani, Bhanu & Kushwaha, Pradeep. (2020). An Application Framework for Quantum Computing using Artificial intelligence Techniques. 264-269. 10.1109/INBUSH46973.2020.9392164.

[13] A. Kumar, B. P. Lohani and P. K. Kushwaha, "Black Hole Attack in Mobile Ad Hoc Network and its Avoidance," 2021 International Conference on Innovative Practices in Technology and Management (ICIPTM), Noida, India, 2021, pp. 103-107, doi: 10.1109/ICIPTM52218.2021.9388366.

[14] Srivastav, A.V., Lohani, B.P., Kushwaha, P.K., Tyagi, S. (2021). Dual-Layer Security and Access System to Prevent the Spread of COVID-19. In: Prateek, M., Singh, T.P., Choudhury, T., Pandey, H.M., Gia Nhu, N. (eds) Proceedings of International Conference on Machine Intelligence and Data Science Applications. Algorithms for Intelligent Systems. Springer, Singapore. https://doi.org/10.1007/978-981-33-4087-9_28

[15] A. Khuran, B. P. Lohani, V. Bibhu and P. K. Kushwaha, "An AI Integrated Face Detection System for Biometric Attendance Management," 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM), London, United

Formatted: Font: 10 pt, Not Bold
Formatted: Font: 10 pt
Formatted: Font: 10 pt, Not Bold
Formatted: Font: 10 pt, Not Bold
Formatted: Font: 10 pt, Not Bold, No underline

Kingdom, 2021, pp. 29-33, doi: 10.1109/ICIEM51511.2021.9445295.
[16] S. Salagrama, B. P. Lohani and P. K. Kushwaha, "An Analytical Survey of User Privacy on Social Media Platform," 2021 International Conference on Technological Advancements and Innovations (ICTAI), Tashkent, Uzbekistan, 2021, pp. 173-176, doi: 10.1109/ICTAI53825.2021.9673402.
[17] S. Singh, D. Chaudhary, A. D. Gupta, B. Prakash Lohani, P. K. Kushwaha and V. Bibhu, "Artificial Intelligence, Cognitive Robotics and Nature of Consciousness," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2022, pp. 447-454, doi: 10.1109/ICIEM54221.2022.9853081.
[18] S. Suman, P. Kaushik, S. S. N. Challapalli, B. P. Lohani, P. Kushwaha and A. D. Gupta, "Commodity Price Prediction for making informed Decisions while trading using Long Short-Term Memory (LSTM) Algorithm," 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), Uttar Pradesh, India, 2022, pp. 406-411, doi: 10.1109/IC3I56241.2022.10072626.
[19] P. William, Y. V. U. Kiran, A. Rana, D. Gangodkar, I. Khan and K. Ashutosh, "Design and Implementation of IoT based Framework for Air Quality Sensing and Monitoring," 2022 2nd International Conference on Technological Advancements in Computational Sciences (ICTACS), Tashkent, Uzbekistan, 2022, pp. 197-200, doi: 10.1109/ICTACS56270.2022.9988646.
[20] Mridul Bhardwaj and Ajay Rana. 2015. Impact of Size and Productivity on Testing and Rework Efforts for Web-based Development Projects. SIGSOFT Softw. Eng. Notes 40, 2 (March 2015), 1–4. https://doi.org/10.1145/2735399.2735404
[21] Bhardwaj, Mridul, and Rana Ajay. "Estimation of testing and rework efforts for software development projects." Asian Journal of Computer Science and Information Technology 5.5 (2015): 33-37.
[22] Dubey, Gaurav, Ajay Rana, and Jayanthi Ranjan. "A research study of sentiment analysis and various techniques of sentiment classification." International Journal of Data Analysis Techniques and Strategies 8.2 (2016): 122-142.
[23] R. Sharma, M. Mogha, S. Tanwar and A. Rana, "Emerging Part of Industry 4.0: The Digital and Physical Technology," 2020 9th International Conference System Modeling and Advancement in Research Trends (SMART), Moradabad, India, 2020, pp. 149-154, doi: 10.1109/SMART50582.2020.9337064.
[24] Dubey, Sanjay Kumar, and Ajay Rana. "Assessment of usability metrics for object-oriented software system." ACM SIGSOFT Software Engineering Notes 35.6 (2010): 1-4.
[25] Singh, Archana, Jyoti Agarwal, and Ajay Rana. "Performance Measure of Similis and FPGrowth Algo rithm." International Journal of Computer Applications 62.6 (2013): 25-31.
[26] Tyagi, Neha, Ajay Rana, and Vineet Kansal. "Load distribution challenges with virtual computing." Intelligent Computing in Engineering: Select Proceedings of RICE 2019. Springer Singapore, 2020.
[27] Singh, Jaya, and Ajay Rana. "Exploring the big data spectrum." International Journal of Emerging Technology and Advanced Engineering 73 (2013).
[28] N. M., P. Chawla and A. Rana, "A Practitioner's Approach to Assess the WCAG 2.0 Website Accessibility Challenges," 2019 Amity International Conference on Artificial Intelligence (AICAI), Dubai, United Arab Emirates, 2019, pp. 958-966, doi: 10.1109/AICAI.2019.8701320.
[29] Tyagi, N., Rana, A., Awasthi, S., & Tyagi, L. K. (2022). Data Science: Concern for Credit Card Scam with Artificial Intelligence. In Cyber Security in Intelligent Computing and Communications (pp. 115-128). Singapore: Springer Singapore.
[30] Jain, Piyush, Sanjay Kumar Dubey, and Ajay Rana. "Software usability evaluation method." International Journal of Advanced Research in Computer Engineering & Technology 1.2 (2012): 28-33.
[31] Pal, S. K., et al. "Hanging suicides in himachal pradesh: an analysis of forensic cases." Int J Forensic Sci Pathol 4.11 (2016): 297-304.
[32] Rana, A., and S. Manhas. "Significance of diatoms in diagnosis of drowning deaths: a review." Journal of Forensic & Genetic Sciences 5 (2018): 77-81.
[33] Bansal, Sangeeta, and Dr Ajay Rana. "Transitioning from relational databases to big data." International Journal of Advanced Research in Computer Science and Software Engineering 4.1 (2014): 394-400.
[34] R. Kumaran, R. Deepak Kumar, M. Karthick Kumar, B. Rahul, 2020, Driver Drowsiness Monitoring System using Visual Behaviour and Machine Learning, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) RTICCT – 2020 (Volume 8 – Issue 12),
[35] A. Sengupta, A. Dasgupta, A. Chaudhuri, A. George, A. Routray and R. Guha, "A Multimodal System for Assessing Alertness Levels Due to Cognitive Loading," in IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 25, no. 7, pp. 1037-1046, July 2017, doi: 10.1109/TNSRE.2017.2672080.
[36] K. T. Chui, K. F. Tsang, H. R. Chi, B. W. K. Ling and C. K. Wu, "An Accurate ECG-Based Transportation Safety Drowsiness Detection Scheme," in IEEE Transactions on Industrial Informatics, vol. 12, no. 4, pp. 1438-1452, Aug. 2016, doi: 10.1109/TII.2016.2573259.
[37] S. Arefnezhad, A. Eichberger, M. Frühwirth, C. Kaufmann and M. Moser, "Driver Drowsiness Classification Using Data Fusion of Vehicle-based Measures and ECG Signals," 2020 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2020, pp. 451-456, doi: 10.1109/SMC42975.2020.9282867.
[38] "IEEE Smart Grid Vision for Vehicular Technology: 2030 and Beyond," in IEEE Smart Grid Vision for Vehicular Technology: 2030 and beyond, vol., no., pp.1-65, 15 Jan. 2014, doi: 10.1109/IEEESTD.2014.6716939.
[39] B. K. Savaş and Y. Becerikli, "Real Time Driver Fatigue Detection Based on SVM Algorithm," 2018 6th International Conference on Control Engineering & Information Technology (CEIT), 2018, pp. 1-4, doi: 10.1109/CEIT.2018.8751886.
[40] K. Satish, A. Lalitesh, K. Bhargavi, M. S. Prem and T. Anjali., "Driver Drowsiness Detection," 2020 International Conference on Communication and Signal Processing (ICCSP), 2020, pp. 0380- 0384, doi: 10.1109/ICCSP48568.2020.9182237.
[41] S. Menon, S. J., A. S.K., A. P. Nair and S. S., "Driver Face Recognition and Sober Drunk Classification using Thermal Images," 2019 International Conference on Communication and Signal Processing (ICCSP), 2019, pp. 0400-0404, doi: 10.1109/ICCSP.2019.8697908.

[42] H. Kaufman, J. Woods, S. Dravida and A. Tekalp, "Estimation and identification of two-dimensional images," in IEEE Transactions on Automatic Control, vol. 28, no. 7, pp. 745-756, July 1983, doi: 10.1109/TAC.1983.1103311.

[43] F. An, P. Xu, Z. Xiao and C. Wang, "FPGA-based object detection processor with HOG feature and SVM classifier," 2019 32nd IEEE International System-on-Chip Conference (SOCC), 2019, pp. 187-190, doi: 10.1109/SOCC46988.2019.1570558044.

[44] J. Treboux, D. Genoud and R. Ingold, "Decision Tree Ensemble Vs. N.N. Deep Learning: Efficiency Comparison For A Small Image Dataset," 2018 International Workshop on Big Data and Information Security (IWBIS), 2018, pp. 25-30, doi: 10.1109/IWBIS.2018.8471704.