www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC
Gestão, Inovação e Tecnologias

Novel Vehicle Detection in Real Time Road Traffic Density Using Haar Cascade Comparing with KNN Algorithm based on Accuracy and Time Mean Speed

K. Pavani[1]; P. Sriramya[2*]

[1]Research Scholar, Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India.

[1]katlatipavani666@gmail.com

[2*]Project Guide, Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India.

[2*]sriramya82@gmail.com

Abstract

Aim: *The main objective of the paper is to detect objects in iconic real time traffic density videos from CCTVs and Cameras using Haar Cascade algorithm and to compare algorithms with K-Nearest Neighbour algorithm (KNN). In this case we tried improving the rate of accuracy in predicting the traffic density.* ***Materials and methods:*** *Haar Cascade algorithm is applied on 5 realistic videos and which consists of more than 250 frames. For the same we evaluated the Accuracy and Precision values. Harr-like function displays the vehicle's visual structure, and the AdaBoost machine learning algorithm was used to create a classifier by combining individual classifiers. The significance value achieved for finding the accuracy and precision was 0.445 and 0.754 respectively.* ***Results and Discussions:*** *Detection of vehicles in high speed videos is performed by using Haar Cascade which has mean accuracy with 85.22% and mean precision with 90.63% and 60% of mean accuracy and 58.53% mean precision in KNN classifiers.* ***Conclusion:*** *The performance of the Haar Cascade appears to be better than KNN in terms of both Accuracy and Precision.*

Key-words: Haarcascade, KNN, Machine Learning, Novel Vehicle Detection, Real Time road Traffic Density, Digital Image Processing.

1. Introduction

The aim of this research is to detect objects in real time traffic density videos from CCTVs and Cameras using Haar Cascade algorithm and to compare algorithms with K-Nearest Neighbour

algorithm. In this case improving the rate of accuracy in traffic density. (Zhang and Zhang 2020). Nowadays, transportation is becoming very necessary for all in terms of regular transportation. However, there is a big problem that needs to be discussed, it has been more particularly in large metropolitan areas and on highways linking towns. During this period with heavy traffic, traffic delays are high and should be reduced. Increasing vehicles has resulted in increasing traffic congestion, especially when it is not properly detected and maintained. This would be the primary source of traffic congestion. To control the flow and to maintain smooth journeys introduced transportation systems with detection vehicles and counting them in order to manage traffic flow. (Gupta, Solanki, and Singh 2017) An application to count particular types of vehicles using traffic video as data, analysed using the Haar Cascade Classifier system, in crucial problem solving. This approach was previously used in research (Arifin 2020) to identify traffic cones as obstacles to be avoided by a wheeled robot, and it was also used in research (Committee and F09 Committee, n.d.) to locate region of eyes for making region of interest to catch eye winks as an alternative method of feedback According to these research, (Cuimei et al. 2017) Haar Cascade Classifier has been shown to be an efficient and precise way of detecting and recognising individual objects.

Novel vehicle detection process is carried out by researchers to promote the business. Around 87 related articles published in IEEE Xplore and about 48 articles are published in Google scholar (Kim et al. 2012). Object detection on vehicles using DIP is crucial for developing a control system or as an alternative method of collecting statistical data (Lee et al. 2015). Here they analysed a vehicle detection tool that could be integrated into the system. (Viola and Jones, n.d.). PIN-based password authentication necessitates users entering a physical PIN, which is vulnerable to password cracking or hacking (Islam, Ahsan, and Acharjee 2019). ITS focuses on novel, hybrid approaches that enable macro traffic control(T) at the road and transport conditions. (Ramadhani, Minarno, and Cahyono 2017). From omnidirectional images, creates panoramic images. It detects cars on a single image without having to generate multiple perspective images. (Karaimer and Bactanlar 2014). A real-time eye gaze tracking device is presented in this paper. Based on the rectangular features of the human eye (Li et al. 2016). Using a mobile device, this study aims to detect the number of faces in an image and determine the status of the medium's fullness. (Savas, Ilkin, and Becerikli 2016). Based on detection hit rate and detection speed, this paper compares and contrasts two methods of face detection (Kadir et al. 2014). Real-time face detection is not only a component of an automated face recognition system, but it is also becoming a separate research subject. As a result, there are several approaches to solving the problem of face detection (Fan et al. 2012). Computer Vision-based device

for detecting and counting moving vehicles in this paper. (Sriramya, Parvathava, and Balamuruga 2012) To detect moving vehicles, photographs from video sequences are taken, and the background is extracted from the images (Fan et al. 2012; Kaaniche and Vasseur 2005).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S.R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

The drawbacks of the existing system are the accuracy of the data determines its consistency, Prediction stage may get late when the dataset is taken larger in size, Irrelevant in features and sensitive and Requires more memory as it needs to save whole training data. (Voznesenskaya 2018)**.** The main aim of the study is to improve the accuracy by proposing Haar Cascade Classification Algorithm for novel vehicle detection.

2. Materials and Methods

The research work was performed in the department of computer science and engineering, Saveetha school of Engineering, SIMATS. The process was carried out with a 5 video from where we extracted more than 250 images. The accuracy in detecting vehicles was performed by evaluating two groups. A total of 10 iterations was performed on each group to achieve better accuracy. Some of the dependent variables are Speed, Size of the vehicle.

Implemented novel vehicle detection using Haar cascade with sample size of 2507 is taken for testing and divided into 2 groups and tested using IBM SPSS analysis. Group 1 was taken as KNN and group 2 was taken as Haar Cascade algorithm. The required samples for this analysis is done using G power calculation (Kane, Phar, and BCPS n.d). Minimum power of the analysis is fixed as 0.8 and maximum accepted error is fixed as 0.5.

KNN Algorithm

The KNN algorithm is a fundamental supervised machine learning algorithm for solving classification and regression problems. It is easy to set up and understand, but it is slow compared to

others. Firstly we load the dataset with video as input. Choose the value of K. (Any integer that should be nearer to the data),Find the distance using the Euclidean method. Based on the results sort them in ascending order. Chooses top K rows from the order and assigns a class on most frequent classes.

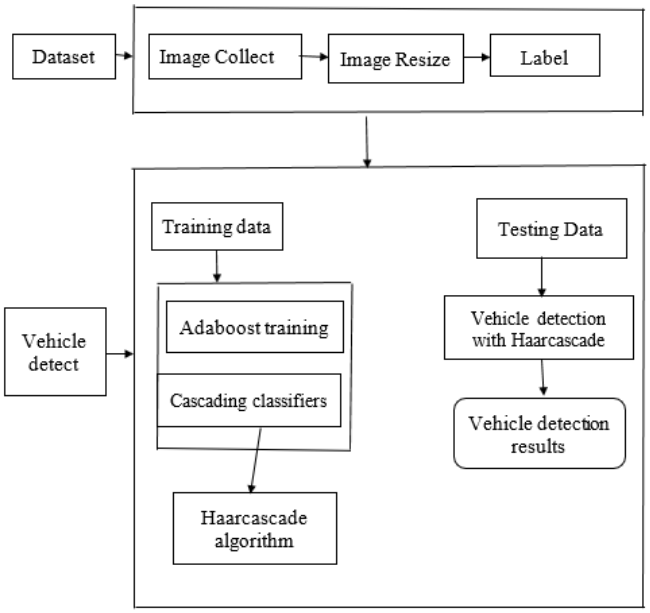
Haar Cascade Algorithm

Haar Cascade is a machine learning vehicle detection algorithm that can be used to detect objects in images or videos. Fig.1 gives the overall architecture of the proposed system. Data collection is for both Existing algorithms and Proposed algorithms are the same. Here we have taken five videos for both algorithms. (i.e., KNN, Haarcascade).

Table 1- Collection of Videos from different Sites

Testing Video	**Source**
projectvedio.mp4	Kaggle (Vehicle video)
testingvedio.mp4	Kaggle (Vehicle video)
SunnyDay.avi	Vision Traffic
Dense.avi	Vision Traffic
Urban.avi	kaggle(Vehicle video)

Fig. 1- Architecture of Performing Haar Cascade Algorithm for Vehicle Detection



Algorithmic follows the below procedure, Table 1 gives the source of input videos. Testing videos are collected from Kaggle (Vehicle videos) which contains five different videos. The videos

are taken to test. Image is extracted from the video and that is resized to label the name and classify the algorithm with adaboost and train the dataset with haar like features. The video which is taken should be extracted into frames for every 0.6sec to get about 250 images. Once we received frames from videos that are to be converted into grayscale image processing done where colored frame images are converted into grayscale. Here background extraction and subtraction can be done. Once image is detected, vehicles are bounded with boundary box and gives count to the vehicle thus counted.

Physical computer resources, also known as hardware, are the most common set of specifications specified by any operating system or software application. In the case of operating systems, a hardware specifications list is often followed by a hardware compatibility list. The following are the minimum hardware requirements: Processor-Pentium IV, RAM of capacity 8 GB, Processor with minimum space of 2.4GHZ, Main memory-8GB RAM, Processing speed of 600 MHZ, Hard disk drive of 1TB.

Software specifications are concerned with specifying the resources and prerequisites that must be installed on a device in order for an application to work. These prerequisites must be installed before the programme can be installed. The following are the minimum software requirements: Front end with python language, Operating system -7/8/10, IDE-jupyter notebook.

Besides experimental analysis, the work was evaluated statistically using IBM Statistical Package for Social Sciences (SPSS). The analysis was done to obtain Mean, Standard Deviation and Standard Error Mean. Independent T Test analysis was carried out to compare the parameters on both the groups**.** Statistical analysis for two independent variables means KNN and Haarcascade done using the "IBM SPSS Independent T test Analysis". The TP rate, FP rate, Precision, Recall, F-measure and ROC area used to calculate the accuracy of the model.

Equation(1) gives the formula for calculating the accuracy. It identifies the number of instances that were correctly classified.

$$Accuracy = \frac{Tp+Tn}{Tp+Tn+Fp+Fn} \quad (1)$$

Equation (2) gives the formula for precision calculation which part of prediction data is positive.

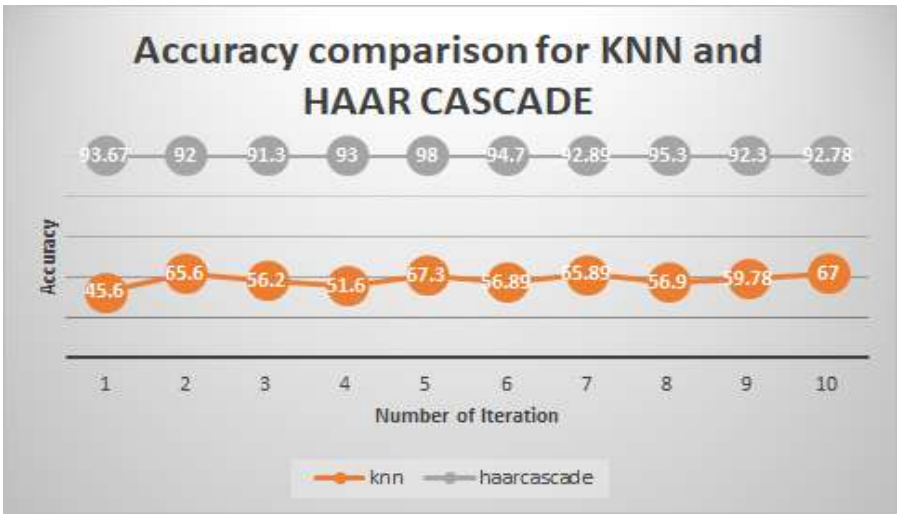
$$Precision = \frac{Tp}{TP+Fp} \quad (2)$$

Where "TP" means True positive, "TN" means True Negative, "FP" means False positive, "FN" means false negative.

3. Results

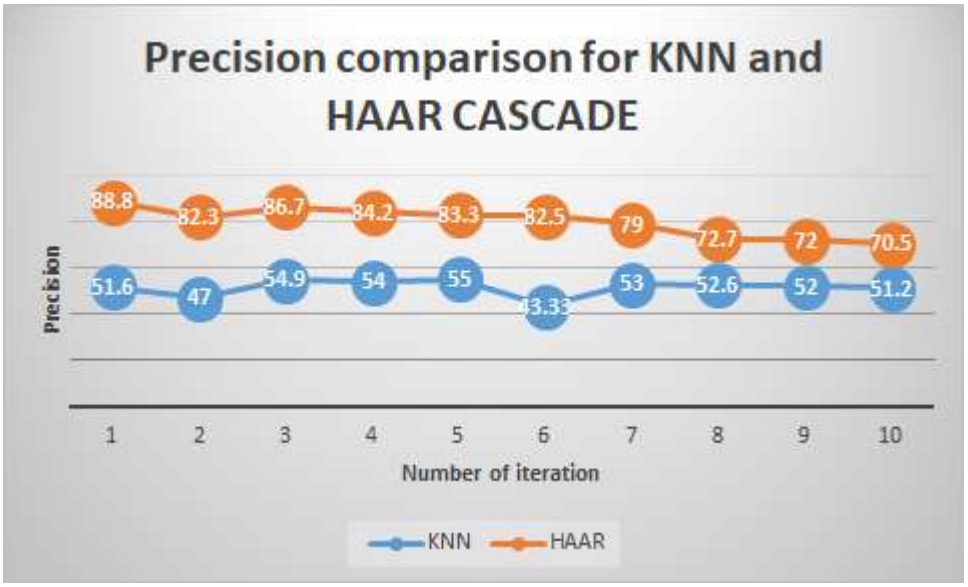
Table 1 tells about the Collection of Video Datasets from different websites. Which contains different types of vehicle recorded videos, which we use for testing pour algorithms to test their accuracy and precision values.

Fig. 2- Comparison of Accuracy Value for 10th Iteration of KNN (67%) and Haarcascade (92.78)



From Fig. 2, it was observed that the increase in iteration increased the accuracy of the algorithm. At the 10th iteration, Haar cascade was found to achieve an accuracy of 92.78%. Further increase in the iteration values, showed constant accuracy by the classifier.

Fig. 3- Comparison of Precision Value for 10th Iteration of KNN (51.2%) and Haarcascade (70.5%)



Received: 04.03.2021 – Accepted: 10.04.2021

From Fig. 3 it was observed that the increase in iteration increased the precision of the algorithm. At the 10th iteration, Haar cascade was found to achieve a precision of 67%. Further increase in the iteration values, showed constant precision by the classifier.

Table 2- Calculated Accuracy and Precision Percentage of Haar Cascade and KNN Algorithm for 10 Iterations. Haar Cascade appears to have Higher Accuracy (94.7%) and Precision (98%) Values when 10 Iterations Values are taken.

ITERATIONS	**ACCURACY (%)**		**PRECISION (%)**	
	KNN	**Haarcascade**	**KNN**	**Haarcascade**
1	45.6	93.67	65	98
2	65.6	92	54	87
3	56.2	91.3	45	89
4	51.6	9.3	65	87
5	67.3	98	56	87
6	56.89	94.70	61.89	94
7	65.89	92.89	56.89	92.89
8	56.9	95.3	61.9	93.45
9	59.78	92.3	57.78	91
10	67	92.78	61.89	87

In Table 2, it was observed that for novele vehicle detection accuracy, precision of Haarcascade was significantly better than KNN. In this novel vehicle detection it was observed that detection accuracy, precision performance of Haar cascade was significantly better than KNN. In all the iterations it was observed that the detection accuracy and sensitivity performance of Haar cascade was significantly better than KNN 0.000. From the above values, it was clearly evident that the Haar cascade algorithm performed significantly better than KNN algorithm.

Table 3- Group Statistics Results Haar Cascade appears to have Higher Accuracy (93%) and Precision (89.2%) than KNN. (Mean of Haar Cascade 93 is more Compared with KNN 60 and Std.Error Mean for Haar Cascade is 0.8367 and KNN is .0.9165)

GROUP	N	Mean	Std.Deviation	Std.Error Mean
ACCURACY KNN	10	60.200	2.0494	0.9165
HAAR	10	93.000	1.8708	0.8367
PRECISION KNN	10	60.800	4.944	2.0100
HAAR	10	89.200	4.3652	1.9522

Table 3 tells about Group statistics results Haar Cascade appears to have higher Accuracy (93%) and Precision (89.2%) than KNN. (Mean of Haar Cascade 93 is more Compared with KNN 60 and Std.Error Mean for Haar Cascade is 0.8367 and KNN is .0.9165). Table 4 tells about Independent Sample T- test the comparison of Significance Level with value p <0.05 and fixed Confidence

Interval with 95% and we got 93%. (Haar cascade appears to perform significantly better than KNN with the value of p=0.000).

Table 4- Independent Sample T- test the Comparison of Significance Level with Value p <0.05 and Fixed Confidence Interval with 95% and we got 93%. (Haar Cascade appears to perform Significantly better than KNN with the Value of p=0.000)

	Levene's Test for Equality of variances		**T-test for Equality of Means**						
	F	**Sig**	**t**	**df**	**sig(tailed)**	**Mean difference**	**Std.error difference**	**Lower**	**upper**
Precision Equal variance assumed	0.105	0.754	-17.977	8	0.000	-29.440	1.638	-33.216	-25.664
Equal variance not assumed			-17.977	7.981	0.000	-29.440	1.638	-33.216	-25.662
Accuracy Equal variance assumed	0.646	0.445	-14.315	8	0.000	-31.920	2.230	-37.062	-26.778
Equal variance not assumed									

Fig. 4- Comparison of KNN Algorithm and Haar Cascade Classifier in Terms of Mean Accuracy and Mean Precision. The Mean Accuracy and Mean Precision of Haar Cascade is better than KNN and the Standard Deviation of Haar Cascade is Slightly Better than KNN. X Axis: KNN vs Haar Cascade Algorithm Y Axis: Mean Accuracy and Mean Precision of Detection ± 2 SD

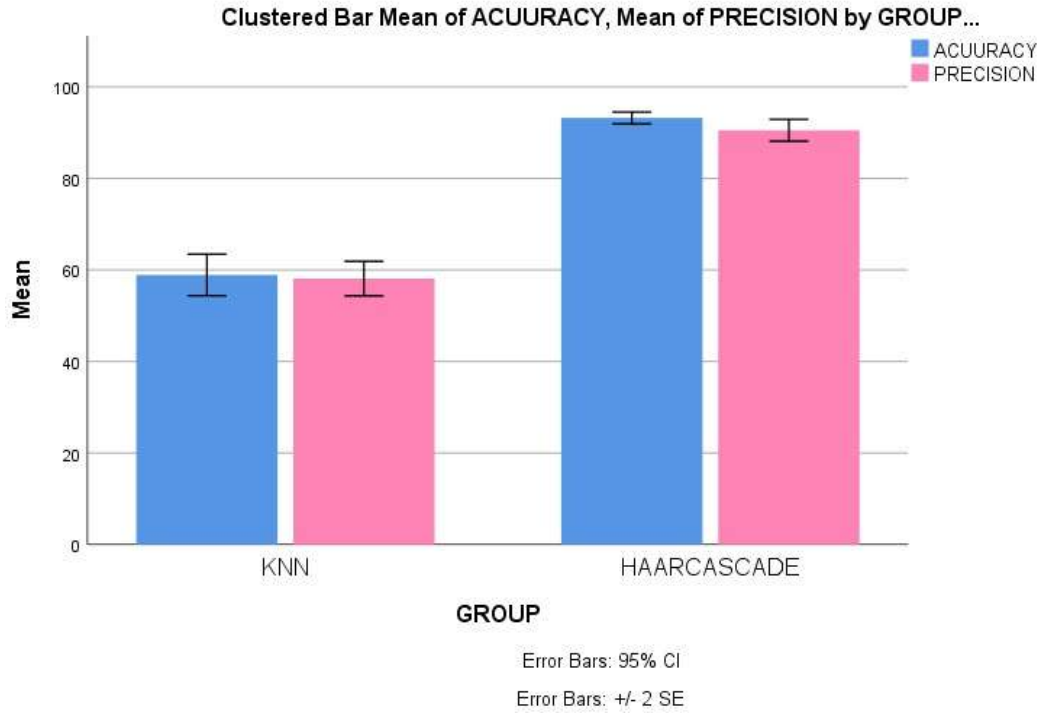


Fig. 4 is the Bar chart representing the comparison of Mean Accuracy and Mean Precision for Vehicle detection using Haar Cascade and KNN. The mean error of Accuracy and Precision of Haar Cascade (0.05) is found to be lesser than KNN (0.10).

4. Discussion

In this study we observed that the Haar Cascade algorithm seems to have better accuracy than KNN based on the significance values that is achieved in statistical analysis. The mean of Accuracy for Haarcascade (93%) and KNN (60%) From the fig. 2 and fig. 3, we observed that Haar Cascade classifiers have better Accuracy and Precision values than KNN classifiers with 92.78% and 87% respectively over the run of 10 iterations. Table 3 shows the values of Mean Std. deviation, Std. Error Mean for KNN and Haar cascade algorithms. Fig. 4 shows that Mean Error of Accuracy and Precision values seem to be lesser in Haar cascade (0.05) than KNN (0.10).

This research resulted in the development of a vehicle counter programme based on traffic video feed for a particular category of vehicle using Haar Cascade with accuracy of 83%. (Viola and Jones, n.d.). This paper presents about vehicle tracking and vehicle detection based on static images extracted from a video using Haar Cascade classifier here with increased accuracy of 20% on comparison of other algorithms and gives more than 93% (Karaimer and Bastanlar 2015). Traditional. convolutional neural network (i.e., Haar Cascade) methods estimate data in two stages but are slow in time. In YOLO method for real time object detection uses only a single neural network and gives more than 96% accuracy (Cepni, Atik, and Duran 2020). The factors affecting the resultant parameters are quality of the input video taken and length of the video taken.

Our institution is passionate about high quality evidence based research and has excelled in various fields (Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

Although the results of the study are better in both experimental and statistical analysis, there are certain limitations in the work. Providing an effective and stable vehicle detection system will continue to be a difficult challenge in the area of intelligent transportation surveillance systems. However the work can be enhanced on comparing background subtraction and the Haar Cascade Classifier system and to combine both background subtraction and the Haar Cascade classifier method to identify more vehicle types with better accuracy.

5. Conclusion

Haar Cascade algorithm was used to identify an object as a vehicle and count the number of passing vehicles on a particular road using traffic vedios as an input. Based on the significance value

achieved through SPSS, the work shows that Accuracy (93%) and Precision (89.2%) for vehicle detection using Haar cascade seems to be better than KNN algorithm. Hence concluded that the Haar cascade algorithm has acceptable accuracy and precision than KNN.

Declarations

Conflicts of Interest

The author declares no conflict of Interest.

Acknowledgement

The authors would like to express their gratitude towards Saveetha School of engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank the following organizations for providing financial support that enabled us to complete the study.

Qbec Infosol Pvt. Ltd., Chennai.

Saveetha University.

Saveetha Institute of Medical and Technical Sciences.

Saveetha School of Engineering.

Authors Contributions

Author KP was involved in data collection, data analysis, manuscript writing. Author PSR was involved in conceptualization, data validation, and critical review of manuscript.

References

Arifin, Muhammad Fahmiriyan Nur. 2020. "The Impact of Migrant Population Activities and Their Push Factors on The Issue of Traffic in Malang City." *Journal of International Conference Proceedings*. https://doi.org/10.32535/jicp.v2i4.791

Cepni, Sumeyye, Muhammed Enes Atik, and Zaide Duran. 2020. "Vehicle Detection Using Different Deep Learning Algorithms from Image Sequence." *Baltic Journal of Modern Computing*. https://doi.org/10.22364/bjmc.2020.8.2.10

Committee, F09, and F09 Committee. n.d. "Test Method for Measuring Groove and Void Depth in Passenger Car Tires." https://doi.org/10.1520/f0421-15

Cuimei, Li, Qi Zhiliang, Jia Nan, and Wu Jianhua. 2017. "Human Face Detection Algorithm via Haar Cascade Classifier Combined with Three Additional Classifiers." *2017 13th IEEE International Conference on Electronic Measurement & Instruments (ICEMI)*.

https://doi.org/10.1109/icemi.2017.8265863

Ezhilarasan, Devaraj, Velluru S. Apoorva, and Nandhigam Ashok Vardhan. 2019. "Syzygium Cumini Extract Induced Reactive Oxygen Species-Mediated Apoptosis in Human Oral Squamous Carcinoma Cells." *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48 (2): 115–21.

Fan, Xianghua, Fuyou Zhang, Haixia Wang, and Xiao Lu. 2012. "The System of Face Detection Based on OpenCV." *2012 24th Chinese Control and Decision Conference (CCDC)*. https://doi.org/10.1109/ccdc.2012.6242980

Gheena, S., and D. Ezhilarasan. 2019. "Syringic Acid Triggers Reactive Oxygen Species-Mediated Cytotoxicity in HepG2 Cells." *Human & Experimental Toxicology* 38 (6): 694–702.

Gupta, Meenu, Vijender Kumar Solanki, and Vijay Kumar Singh. 2017. "Analysis of Datamining Technique for Traffic Accident Severity Problem: A Review." *Proceedings of the Second International Conference on Research in Intelligent and Computing in Engineering*. https://doi.org/10.15439/2017r121

Islam, Mohammad Zahirul, Ali Ahsan, and Ratul Acharjee. 2019. "A Semi-Autonomous Tracked Robot Detection of Gun and Human Movement Using Haar Cascade Classifier for Military Application." *2019 International Conference on Nascent Technologies in Engineering (ICNTE)*. https://doi.org/10.1109/icnte44896.2019.8945848

Jose, Jerry, Ajitha, and Haripriya Subbaiyan. 2020. "Different Treatment Modalities Followed by Dental Practitioners for Ellis Class 2 Fracture – A Questionnaire-Based Survey." *The Open Dentistry Journal* 14(1): 59–65.

Kaaniche, K., and P. Vasseur. 2005. "Event Detection Based on 'Common Fate' Principle: Application to Vehicles Detection from Aerial Sequences of Road Traffic." *IEEE International Conference on Image Processing 2005*. https://doi.org/10.1109/icip.2005.1529948

Kadir, Kushsairy, Mohd Khairi Kamaruddin, Haidawati Nasir, Sairul I. Safie, and Zulkifli Abdul Kadir Bakti. 2014. "A Comparative Study between LBP and Haar-like Features for Face Detection Using OpenCV." *2014 4th International Conference on Engineering Technology and Technopreneuship (ICE2T)*. https://doi.org/10.1109/ice2t.2014.7006273

Karaimer, Hakki Can, and Yalin Bactanlar. 2014. "Car Detection with Omnidirectional Cameras Using Haar-like Features and Cascaded Boosting." *2014 22nd Signal Processing and Communications Applications Conference (SIU)*. https://doi.org/10.1109/siu.2014.6830225.

Karaimer, Hakki Can, and Yalin Bastanlar. 2015. "Detection and Classification of Vehicles from Omnidirectional Videos Using Temporal Average of Silhouettes." *Proceedings of the 10th International Conference on Computer Vision Theory and Applications*.

https://doi.org/10.5220/0005259101970204.

Ke, Yang, Mohammed Saleh Al Aboody, Wael Alturaiki, Suliman A. Alsagaby, Faiz Abdulaziz Alfaiz, Vishnu Priya Veeraraghavan, and Suresh Mickymaray. 2019. "Photosynthesized Gold Nanoparticles from Catharanthus Roseus Induces Caspase-Mediated Apoptosis in Cervical Cancer Cells (HeLa)." *Artificial Cells, Nanomedicine, and Biotechnology* 47(1): 1938–46.

Kim, Soojin, Sangkyun Park, Seonyoung Lee, Seungsang Park, and Kyeongsoon Cho. 2012. "Design of High-Performance Pedestrian and Vehicle Detection Circuit Using Haar-like Features." *TENCON 2012 IEEE Region 10 Conference*. https://doi.org/10.1109/tencon.2012.6412165.

Krishnaswamy, Haribabu, Sivaprakash Muthukrishnan, Sathish Thanikodi, Godwin Arockiaraj Antony, and Vijayan Venkatraman. 2020. "Investigation of Air Conditioning Temperature Variation by Modifying the Structure of Passenger Car Using Computational Fluid Dynamics." *Thermal Science* 24(1 Part B): 495–98.

Lee, Chung-Jung, Teng-Hui Tseng, Bo-Jhen Huang, Jun-Weihsieh, and Chun-Ming Tsai. 2015. "Obstacle Detection and Avoidance via Cascade Classifier for Wheeled Mobile Robot." *2015 International Conference on Machine Learning and Cybernetics (ICMLC)*.

https://doi.org/10.1109/icmlc.2015.7340955.

Li, Yunyang, Xin Xu, Nan Mu, and Li Chen. 2016. "Eye-Gaze Tracking System by Haar Cascade Classifier." *2016 IEEE 11th Conference on Industrial Electronics and Applications (ICIEA)*. https://doi.org/10.1109/iciea.2016.7603648.

Malli Sureshbabu, Nivedhitha, Kathiravan Selvarasu, Jayanth Kumar V, Mahalakshmi Nandakumar, and Deepak Selvam. 2019. "Concentrated Growth Factors as an Ingenious Biomaterial in Regeneration of Bony Defects after Periapical Surgery: A Report of Two Cases." *Case Reports in Dentistry* 2019 (January): 7046203.

Mathew, M.G., Samuel, S.R., Soni, A.J., & Roopa, K.B. (2020). Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. *Clinical oral investigations, 24*(9), 3275-3280. https://link.springer.com/article/10.1007/s00784-020-03204-9

Mehta, Meenu, Deeksha, Devesh Tewari, Gaurav Gupta, Rajendra Awasthi, Harjeet Singh, Parijat Pandey, et al. 2019. "Oligonucleotide Therapy: An Emerging Focus Area for Drug Delivery in Chronic Inflammatory Respiratory Diseases." *Chemico-Biological Interactions* 308 (August): 206–15.

Muthukrishnan, Sivaprakash, Haribabu Krishnaswamy, Sathish Thanikodi, Dinesh Sundaresan, and Vijayan Venkatraman. 2020. "Support Vector Machine for Modelling and Simulation of Heat Exchangers." *Thermal Science* 24 (1 Part B): 499–503.

Pc, J., T. Marimuthu, and P. Devadoss. 2018. “Prevalence and Measurement of Anterior Loop of the Mandibular Canal Using CBCT: A Cross Sectional Study.” *Clinical Implant Dentistry and Related Research*. https://europepmc.org/article/med/29624863.

Ramadhani, Moch Ilham, Agus Eko Minarno, and Eko Budi Cahyono. 2017. “Vehicle Classification Using Haar Cascade Classifier Method in Traffic Surveillance System.” *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*.

https://doi.org/10.22219/kinetik.v3i1.546.

Ramadurai, Neeraja, Deepa Gurunathan, A. Victor Samuel, Emg Subramanian, and Steven J.L. Rodrigues. 2019. “Effectiveness of 2% Articaine as an Anesthetic Agent in Children: Randomized Controlled Trial.” *Clinical Oral Investigations* 23(9): 3543–50.

Ramesh, Asha, Sheeja Varghese, Nadathur D. Jayakumar, and Sankari Malaiappan. 2018. “Comparative Estimation of Sulfiredoxin Levels between Chronic Periodontitis and Healthy Patients - A Case-Control Study.” *Journal of Periodontology* 89(10): 1241–48.

Samuel, Melvin S., Jayanta Bhattacharya, Sankalp Raj, Needhidasan Santhanam, Hemant Singh, and N. D. Pradeep Singh. 2019. “Efficient Removal of Chromium (VI) from Aqueous Solution Using Chitosan Grafted Graphene Oxide (CS-GO) Nanocomposite.” *International Journal of Biological Macromolecules* 121 (January): 285–92.

Samuel, Srinivasan Raj, Shashidhar Acharya, and Jeevika Chandrasekar Rao. 2020. “School Interventions-Based Prevention of Early-Childhood Caries among 3-5-Year-Old Children from Very Low Socioeconomic Status: Two-Year Randomized Trial.” *Journal of Public Health Dentistry* 80(1): 51–60.

Sathish, T., and S. Karthick. 2020. “Wear Behaviour Analysis on Aluminium Alloy 7050 with Reinforced SiC through Taguchi Approach.” *Journal of Japan Research Institute for Advanced Copper-Base Materials and Technologies* 9(3): 3481–87.

Savas, Burcu Kir, Sumeyya Ilkin, and Yasar Becerikli. 2016. “The Realization of Face Detection and Fullness Detection in Medium by Using Haar Cascade Classifiers.” *2016 24th Signal Processing and Communication Application Conference (SIU)*. https://doi.org/10.1109/siu.2016.7496215.

Sharma, Parvarish, Meenu Mehta, Daljeet Singh Dhanjal, Simran Kaur, Gaurav Gupta, Harjeet Singh, Lakshmi Thangavelu, et al. 2019. “Emerging Trends in the Novel Drug Delivery Approaches for the Treatment of Lung Cancer.” *Chemico-Biological Interactions* 309(August): 108720.

Sridharan, Gokul, Pratibha Ramani, Sangeeta Patankar, and Rajagopalan Vijayaraghavan. 2019. “Evaluation of Salivary Metabolomics in Oral Leukoplakia and Oral Squamous Cell Carcinoma.” *Journal of Oral Pathology & Medicine: Official Publication of the International Association of Oral Pathologists and the American Academy of Oral Pathology* 48(4): 299–306.

Sriramya, P., B. Parvathava, and T. Balamuruga. 2012. “A Novel Evolutionary Selective Breeding Algorithm and Its Application.” *Asian Journal of Scientific Research*.

https://doi.org/10.3923/ajsr.2013.107.114.

Varghese, Sheeja Saji, Asha Ramesh, and Deepak Nallaswamy Veeraiyan. 2019. “Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students.” *Journal of Dental Education* 83(4): 445–50.

Venu, Harish, V. Dhana Raju, and Lingesan Subramani. 2019. “Combined Effect of Influence of Nano Additives, Combustion Chamber Geometry and Injection Timing in a DI Diesel Engine Fuelled with Ternary (diesel-Biodiesel-Ethanol) Blends.” *Energy* 174(May): 386–406.

Venu, Harish, Lingesan Subramani, and V. Dhana Raju. 2019. “Emission Reduction in a DI Diesel Engine Using Exhaust Gas Recirculation (EGR) of Palm Biodiesel Blended with TiO2 Nano Additives.” *Renewable Energy* 140(September): 245–63.

Vignesh, R., Ditto Sharmin, C. Vishnu Rekha, Sankar Annamalai, and Parisa Norouzi Baghkomeh. 2019. “Management of Complicated Crown-Root Fracture by Extra-Oral Fragment Reattachment and Intentional Reimplantation with 2 Years Review.” *Contemporary Clinical Dentistry* 10 (2): 397–401.

Vijayakumar Jain, S., M.R. Muthusekhar, M.F. Baig, P. Senthilnathan, S. Loganathan, P.U. Abdul Wahab, M. Madhulakshmi, and Yogaen Vohra. 2019. “Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Lefort One Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study.” *Journal of Maxillofacial and Oral Surgery* 18 (1): 139–46.

Vijayashree Priyadharsini, Jayaseelan. 2019. “In Silico Validation of the Non-Antibiotic Drugs Acetaminophen and Ibuprofen as Antibacterial Agents against Red Complex Pathogens.” *Journal of Periodontology* 90 (12): 1441–48.

Viola, P., and M. Jones. n.d. “Robust Real-Time Face Detection.” *Proceedings Eighth IEEE International Conference on Computer Vision. ICCV 2001*.
https://doi.org/10.1109/iccv.2001.937709.

Voznesenskaya, Tamara. 2018. “Automatic Text Summarization System Using a Stochastic Model.” *Machine Learning and Data Analysis*. https://doi.org/10.21469/22233792.4.4.04

Zhang, Zhuowei, and Weibin Zhang. 2020. “Traffic Pattern Analysis and Traffic State Prediction of Urban Traffic Road Network Based on Correlated Routes.” *2020 39th Chinese Control Conference (CCC)*. https://doi.org/10.23919/ccc50068.2020.9189082