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

Gradient Based Edge Detection of Traffic Image using Second Derivative Method Compared with First Derivative Method

K. Srinivasulu[1]; S. Premkumar[2*]

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

[1]kundasrinivasulu55@gmail.com

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

[2*]premkumar@saveetha.com

Abstract

Aim: *To detect traffic images using Gradient based edge detection by Second derivative method compared with First derivative method.* ***Materials and materials:*** *A second derivative method is used in this study. Canny algorithm is the edge detection technique used in traffic images. With the help of this traffic has been detected in the images.26 is the sample size taken with p-value 0.8 and has been used to improve detection rate of Gradient based in terms of accuracy and sensitivity using better skewness.* ***Result:*** *According to the results obtained the Second derivative method has Accuracy 88.6% and Sensitivity is 83.4% compared with the accuracy of First derivative method has accuracy 83.22% and also sensitivity is 78.5%. It appears to be Accuracy (0.134) and Sensitivity (0.286) of the second derivative method compared with the First derivative method.* ***Conclusion:*** *it appears to be that the detection rate is better using a Second derivative method compared with the First derivative method in terms of Accuracy and Sensitivity.*

Key-words: First Derivative Method, Image Processing, Novel Edge Detection Method, Second Derivative Method.

1. Introduction

In a picture, a foothold may be a curve that follows a path of rapid change in intensity of that image. Edges are often related to the boundaries of the thing during a scene environment. Edge detection is employed to spot the sides in a picture to form the image processing easily. Edge detection works by detecting the images. In this study we are using edge detection of traffic images

using a second derivative method compared with the first derivative method.(Jacob and Unser 2004).It is very important to identify the traffic in the images and videos. Nowadays edge detection has many applications in this advanced world. They are mainly used in Medical imaging, study of anatomical structure, Automatic traffic controlling systems, Face recognition, and fingerprint recognition.(Saito and Cunningham 1990).

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.

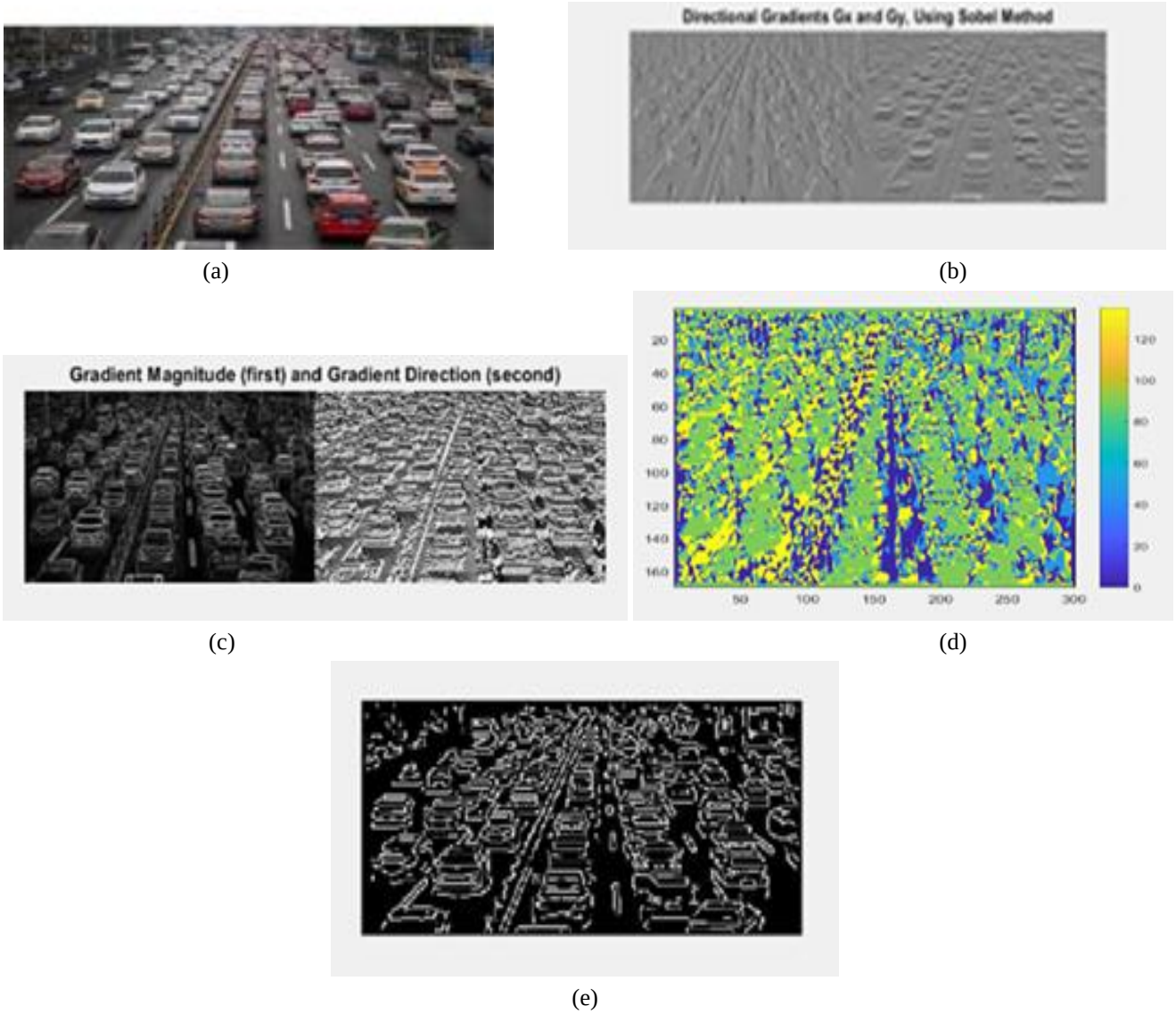
The main aim of this research is to improve the detection rate of traffic images using Gradient based edge detection by the Second derivative method in terms of accuracy and sensitivity. Because, the detection rate of traffic images using the First derivative method is poor.

2. Materials and Methods

Study setting of the proposed work is done in our university. The number of groups identified for the study is 2. The group 1 is the Second derivative method and group 2 is the First derivative method. Matlab 2014a toolkit will be used to write the code and simulate. Using matlab accuracy and sensitivity has been calculated for the required algorithm and then results have been compared. Sample size per group is 26 and with pre test power value 0.8.(Kane, Phar, and BCPS n.d.) First derivative and Second derivative methods are explained below SPSS software has been used to compare the results and to find the graph.

The majority of various methods could also be grouped into two categories: The gradient method detects the sides by trying to find the utmost and minimum within the derived function of the image. (Vincent and Folorunso 2009). It searches for zero crossings within the second derivative of the image to seek out edges. when the primary derivative method is at a maximum (Canny 1986), the second derivative method is zero. The result, another alternative to finding the location of an edge is to locate the zeros in the second derivative method. This method is known as the gaussian method and it is shown in **Fig. 1.** (Law, Itoh, and Seki 1996).

Fig. 1: (a) Shows the input traffic image.(b) Represents Directional gradients Gx andGy.(c) Shows the Gradient magnitude for first and Gradient direction for second.(d) Shows the gray scale image.(e) Shows the canny image.



(a) (b)

(c) (d)

(e)

In sample preparation group 1:It is a gaussian based operator in detecting edges. This operator is not susceptible to noise. It is a Novel edge detection method used in this Algorithm using Second derivative method to detect the traffic in the images. It extracts image features without affecting or altering the feature. Canny edge detectors have advanced algorithms derived from the previous work of Laplacian of Gaussian operators. It's widely used as an optimal edge detection technique. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection zero crossing edge detectors). The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise. It detects edges based on three criteria(a)Low error rate. (b)Edge points must be

accurately localized. (c)There should be just one single edge response. The second directional derivative is the second derivative computed in the direction of the gradient. It uses compute second and third directional derivatives in the direction of a gradient, if the second derivative is equal to zero, and the third derivative is negative, then that point is an edge point.

In sample preparation group 2: Most edge detection methods work on the assumption that the edge occurs where there is a discontinuity in the intensity function or a very steep intensity gradient in the image. (Yuan and Xu 2015) Using this assumption, if one takes the derivative of the intensity value across the image and finds points where the derivative is maximum then the edge could be located. The gradient is a vector, whose components measure häow rapid pixel values are changing with distance in the x and y direction. (Alazzawi et al. 2015). A descriptive algorithm for sobel image edge detection the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image. (Vincent and Folorunso 2009)

Matlab toolkit (2014a) will be used for the simulation with required add-ons installed, these are predefined functions in the matlab for the image processing. Open Matlab software and open new m.file. Write a code for gradient based edge detection of traffic image give the input to the code using JPG/JPEG/PNG with file name. The input image should be a RGB traffic image .Then run the code. The out image should display the edge detected image. We will do the same method for different pixels of image. find the detection rate using the formula. Traffic images are taken as input images which are independent variables. Accuracy and sensitivity will be as output variables. By comparing the results a better algorithm has been decided. Detection rate of the algorithms will be calculated using the formula.

Detection rate =(no of output image /total input images)*100

3. Results

Figure 1 represents (a) Shows the input traffic image.(b) Represents Directional gradients Gx andGy.(c) Shows the Gradient magnitude for first and Gradient direction for second.(d) Shows the gray scale image.(e) Shows the canny image. Edge detection using Second derivative method and First derivative method in Matlab simulation tool the output obtained for edge detection.

Fig 2 and **Fig. 3** shows the graph for comparison of accuracy and sensitivity between First and Second derivatives respectively.

Fig. 2: Accuracy graph which shows the comparison between First derivative and Second derivative

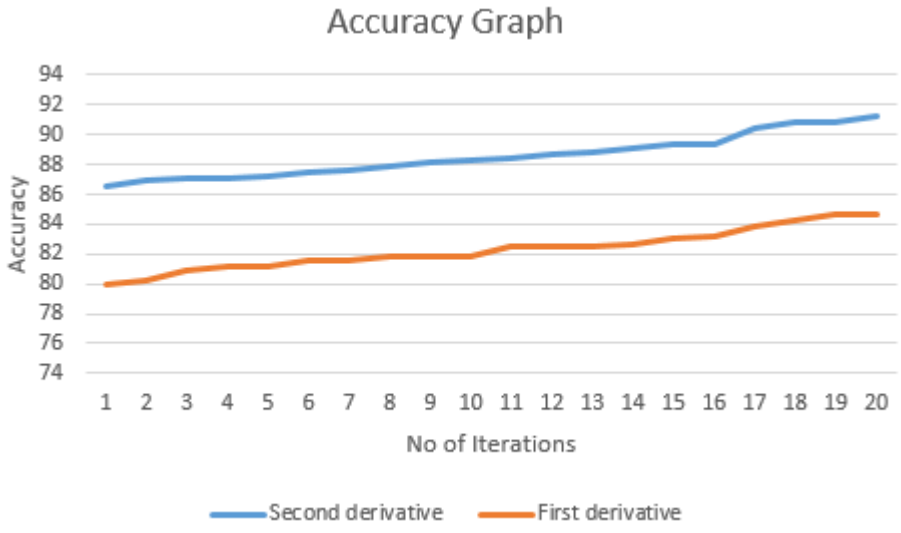
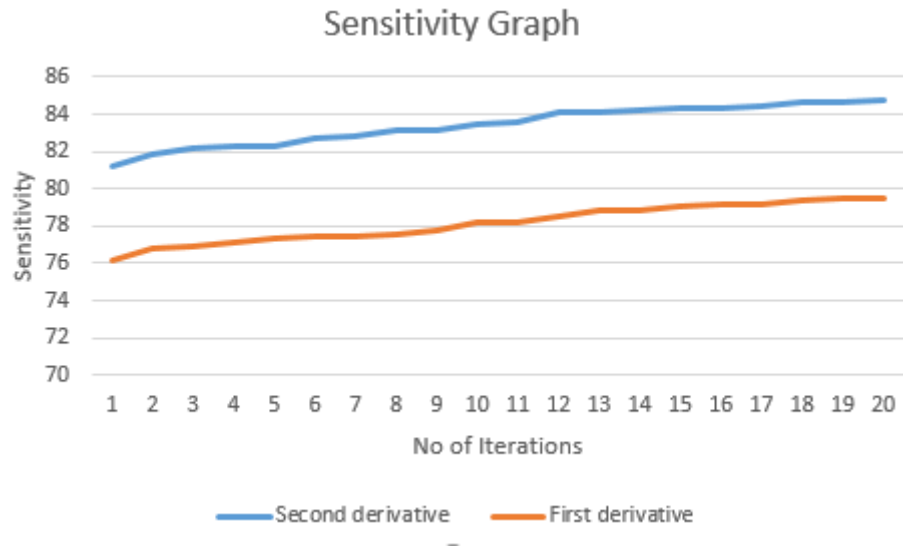


Fig. 3 - Sensitivity graph which shows the comparison between First derivative and Second derivative



Accuracy and sensitivity are taken for 26 sample images are taken in table 1. These were used in the SPSS software and get the group statistics for the algorithm which contains the mean value of the accuracy and sensitivity and standard deviation has been given in table 2 which is taken from SPSS outputs. Table 3 shows the testing of independent variables in which significance has been given for the sobel and canny. **Fig. 4** gives the comparison graph for First and Second derivative in which accuracy and sensitivity of the both algorithms were compared and helps in finding better algorithm using SPSS.

Table 1 - The tabulation gives the accuracy and sensitivity for different samples for First and Second derivatives. These results were obtained by simulating the images in Matlab. In this 20 results for sample images has been taken and were shown in the table. This can be useful in comparing the both algorithms.

S. No	Second derivative		First derivative	
	accuracy	sensitivity	accuracy	sensitivity
1	88.3	83.2	80.2	78.2
2	87.5	84.3	81.2	79.5
3	89.1	82.2	84.6	79.2
4	88.7	84.1	82.5	78.2
5	90.5	81.2	81.9	77.3
6	86.9	84.3	83.2	78.5
7	87.1	82.8	84.6	76.2
8	89.3	84.8	82.5	76.9
9	87.1	81.9	81.9	79.5
10	89.3	82.3	82.7	79.4
11	87.9	84.4	83.1	77.5
12	88.2	83.5	81.5	78.8
13	91.2	82.3	81.8	77.8
14	90.8	84.6	84.2	76.8
15	88.4	83.6	80.9	77.6
16	87.2	84.2	81.6	77.1
17	86.5	84.7	82.5	79.1
18	90.8	84.1	83.9	79.2
19	87.6	83.1	81.2	78.9
20	88.8	82.7	79.9	77.5

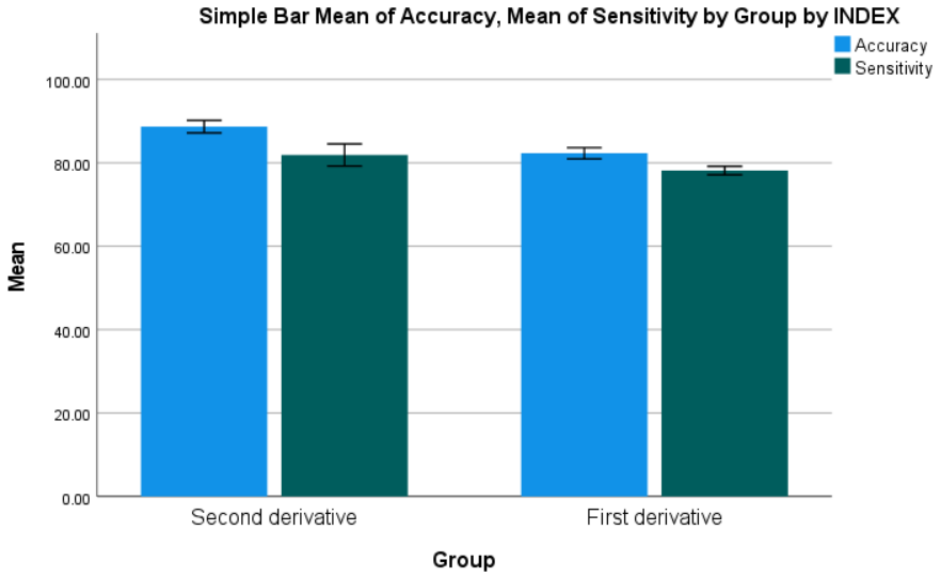
Table 2 - Group statistics: The above table shows the number of samples taken and mean values of accuracy and sensitivity for the 26 samples and standard deviation were obtained for 26 samples using SPSS software. In the table standard error means for the accuracy and sensitivity for First derivative and Second derivative

Group		No of samples	mean	Std.deviation	Std.mean error
Accuracy	Second derivative method	26	88.65	1.471	.314
	First derivative method	26	83.22	3.356	.716
Sensitivity	Second derivative method	26	83.45	1.014	.216
	First derivative method	26	78.57	1.777	.379

Table 3 - Independent sample test: The above table shows the mean difference, standard error difference and significance of the First derivative and Second derivative obtained in SPSS and were used to find which algorithm gives significant results.

Levene's test for equality of variances				T- test for equality of means						
		F	Sig	t	df	Sig (2-tailed)	Mean difference	Std. error diff	95% confidence interval of the difference	
									lower	upper
accuracy	Equal variances assumed	2.338	.134	6.941	56	.000	5.423	.781	3.846	6.999
	Equal variances not assumed			6.941	28.779	.000	5.423	.781	3.824	7.021
Sensitivity	Equal variances assumed	1.166	.286	11.191	56	.000	4.882	.436	4.001	5.762
	Equal variances not assumed			11.191	49.025	.000	4.882	.436	3.995	5.762

Fig. 4 - Graph obtained using SPSS that compare Sensitivity and Accuracy of First derivative and Second derivative. In this graph the Second derivative and First derivative are compared in x-axis and Mean of Accuracy and Sensitivity with +/- 1SD.



Using matlab tool kit simulation has done and got the result as below and have seen that sobel like features have given significant results compared to canny. Edge is detected using Second derivative method compared with First derivative method. IBM SPSS software analysis was done for the project. The mean accuracy and sensitivity for has analysed by iterating 20 samples and group statistics and independent sample test has done and results were analysed Using SPSS and obtained the graphs.

4. Discussion

The Second derivative method has Accuracy 88.6% and Sensitivity is 83.4% compared with the accuracy 83.22% and also sensitivity is 78.5% of the First derivative method. It appears to be a better detection rate in terms of accuracy and sensitivity using the second derivative method compared with the First derivative method. The analysis has done with the pre power value p=0.8(80%)

The edge detection of images by using First and Second derivative methods we will find the edges for image by using these methods (Alazzawi et al. 2015). The gradient based image edge detection techniques. The gradient is a vector. The future work to test the turning of canny parameters that facilitate detecting edges. The problem of gradient based image edge detection, several algorithms are tested, as a result of these algorithms binary images are produced (Saif, Hammad, and Alqubati 2016). The Adaptive image edge detection Algorithm based on canny operator The global

edge detection can obtain the whole edge, which uses adaptive smooth filter algorithm based on Canny operator. Compared with the effect of edge detection from the Canny operator and Sobel operator, the edge from the improved Canny operator is the most complete and rich, and does not contain false edges. (Yuan and Xu 2015). Canny edge detection techniques are used to find edges. The product of the two criteria for scale multiplication is greater than that for a single scale, which Experimental results are presented. It leads to better edge detection performance (Bao, Zhang, and Wu 2005). The performance analysis of edge detection algorithms for image processing is based on improved canny operators. Canny operator represents the improvement of the traditional single threshold method, in which the high and low threshold is selected according to the gradient of the image histogram. (Vani and Singh 2020). The performance analysis of edge detection algorithms on various image types analysis on various edge detection algorithms is really worth enough in Image processing. Canny edge detection algorithm is performing better among the others. (Nagasankar and Ankaryarkanni 2016). A descriptive algorithm for sobel image edge detection the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image. (Vincent and Folorunso 2009). The image processing is a far more efficient method of traffic control as compared to traditional techniques. a system for emergency vehicle detection based on image processing techniques (R.b et al. 2015).

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.

Edge detection is used to identify the edges in an image to make the image processing easy**.** The Diagonal direction points are not preserved always. It is very sensitive to noise and Not very accurate in edge detection. In canny edge detection false zero crossing. In this study the digital image processing Edge detection is used to identify the edges in an image to make the image processing easy. In future the edge detection techniques by using this method can find better results because of this. Accuracy of the image can be still improved using advanced techniques.

5. Conclusion

Based on the results and tabulations, it appears to be a better detection rate in terms of Accuracy (88.6%) and Sensitivity (83.4%) using the Second derivative method compared with the Accuracy (83.2%) and Sensitivity (78.5%) of the First derivative method.

Declaration

Conflict of Interests

No conflict of interest in this manuscript.

Author Contribution

Author KS was involved in image collection, analysis of image and manuscript writing. Author SP was involved in conceptualization, image validation and critical review of manuscript.

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.

1. Qbec Infosol Pvt. Ltd.,
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences
4. Saveetha School of Engineering

References

Alazzawi, Abdulbasit, Husam Alsaadi, Abidaoun Hamdan Shallal, and Saad Albawi. 2015. "Edge Detection-application of (First and Second) Order Derivative in Image Processing." *Second Engineering Scientific Conference-College of Engineering –University of Diyala*, December. http://dx.doi.org/.

Bao, P., Lei Zhang, and Xiaolin Wu. 2005. "Canny Edge Detection Enhancement by Scale Multiplication." *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/tpami.2005.173.

Canny, John. 1986. "A Computational Approach to Edge Detection." *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/tpami.1986.4767851.

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.

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

Jacob, M., and M. Unser. 2004. "Design of Steerable Filters for Feature Detection Using Canny-like Criteria." *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/tpami.2004.44.

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.

Kane, Sean P., Phar, and BCPS. n.d. "Sample Size Calculator." Accessed March 25, 2021. https://clincalc.com/stats/samplesize.aspx.

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.

Kognule, Snehal M., Rahul R. Talawadekar, and Monica S Jadhav Swapnesh. 2018. "Image Processing Using Edge Detection Filters." *International Journal of Engineering Research & Technology* 2 (4). https://www.ijert.org/image-processing-using-edge-detection-filters.

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.

Law, T., H. Itoh, and H. Seki. 1996. "Image Filtering, Edge Detection, and Edge Tracing Using Fuzzy Reasoning." *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/34.494638.

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., S.R. Samuel, A.J. Soni, and K.B. Roopa. 2020. "Evaluation of Adhesion of Streptococcus Mutans, Plaque Accumulation on Zirconia and Stainless Steel Crowns, and Surrounding Gingival Inflammation in Primary …." *Clinical Oral Investigations*. 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.

Nagasankar, Tamilselvi, and B. Ankaryarkanni. 2016. “Performance Analysis of Edge Detection Algorithms on Various Image Types.” *Indian Journal of Science and Technology*. https://doi.org/10.17485/ijst/2016/v9i21/95207.

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.

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.

R.b, Brinda, R. B. Brinda, Namratha Venkatesh Murthy, B.M. Ramya, and Vijaya Prakash A.M. 2015. “Edge Detection (Image Processing) Smart Traffic Control.” *IJIREEICE*. https://doi.org/10.17148/ijireeice.2015.31127.

Saif, Jamil A.M., Mahgoub H. Hammad, and Ibrahim A. A. Alqubati. 2016. “Gradient Based Image Edge Detection.” *International Journal of Engineering and Technology* 8 (3): 153–56.

Saito, N., and M.A. Cunningham. 1990. “Generalized E-Filter and Its Application to Edge Detection.” *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/34.57671.

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.

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.

Tan, H. L., S. B. Gelfand, and E. J. Delp. 1992. “A Cost Minimization Approach to Edge Detection Using Simulated Annealing.” *IEEE Transactions on Pattern Analysis and Machine Intelligence*. https://doi.org/10.1109/34.107010.

Vani, Shi, and Harjeet Singh. 2020. “The Performance Analysis of Edge Detection Algorithms for Image Processing Based on Improved Canny Operator.” *International Journal of Computer Trends & Technology*. https://doi.org/10.14445/22312803/ijctt-v68i10p106.

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.

Vincent, O. R., and O. Folorunso. 2009. “A Descriptive Algorithm for Sobel Image Edge Detection,” January. http://dx.doi.org/.

Yuan, Liying, and Xue Xu. 2015. “Adaptive Image Edge Detection Algorithm Based on Canny Operator.” *2015 4th International Conference on Advanced Information Technology and Sensor Application (AITS)*, August, 28–31.