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RESEARCH ARTICLE

Novel Alphabet Deduction Using MATLAB by Neural Networks and Comparison with the Fuzzy Classifier

Bapatu Siva Kumar Reddy[1] • P. Vishnu Vardhan[2*]

[1]*Research Scholar, Department of Biomedical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, Tamil Nadu, India. E-mail: sivabapatu123@gmail.com*

[2*]*Project Guide, Department of Biotechnology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, Tamil Nadu, India. E-mail: vishnuvardhan.palem@gmail.com*

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ABSTRACT

Aim: The study aims to identify or recognize the alphabets using neural networks and fuzzy classifier/logic. **Methods and materials:** Neural network and fuzzy classifier are used for comparing the recognition of characters. For each classifier sample size is 20. Character recognition was developed using MATLAB R2018a, a software tool. The algorithm is again compared with the Fuzzy classifier to know the accuracy level. **Results:** Performance of both fuzzy classifier and neural networks are calculated by the accuracy value. The mean value of the fuzzy classifier is 82 and the neural network is 77. The recognition rate (accuracy) with the data features is found to be 98.06%. Fuzzy classifier shows higher significant value of P=0.002 < P=0.005 than the neural networks in recognition of characters. **Conclusion:** The independent tests for this study shows a higher accuracy level of alphabetical character recognition for Fuzzy classifier when compared with neural networks. Henceforth, the fuzzy classifier shows higher significant than the neural networks in recognition of characters.

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Introduction

The identification by electric means of printed or written characters (letters). Plays an important role in transforming printed materials into digital text files. Digital text can be used with software programs that support reading in a variety of ways. They can be used for: Data entry for business documents, e.g., Cheque, passport, invoice, bank statement and receipt. Machine simulation of human reading has been the subject of concentrated exploration throughout the previous 30 years (Bezdek et al. 2006). Character recognition systems can improve human-computer interaction and better integrate computers into human society(Goyal, Diwakar, and Agrawal 2010). A fuzzy classifier is an associate formula that assigns a category label to associate objects, supporting the article description. It's conjointly aforesaid that category (Fonseca et al. 2011).

Neural networks exhibit characteristics such as mapping capabilities or pattern association, generalization, robustness, fault tolerance, and parallel and high speed informatics. Neural Network design has been broadly speaking classified as single layer feed forward networks, multilayer feed forward networks (Fonseca et al. 2011; Abdurahman 2019).

Recognition accuracy is heavily dependent on the input document's quality. Applications such as receipt OCR, invoice OCR, check OCR, legal billing document OCR. Pre-processing includes steps required to shape the input image into a form suitable for segmentation("Preprocessing Local Features and Fuzzy Logic-Based Image Segmentation" 2016). Neural Network has been successfully applied to drawbacks within the field of pattern recognition("Preprocessing Local Features and Fuzzy Logic-Based Image Segmentation" 2016; Paliouras, Karkaletsis, and Spyropoulos 2003). This paper proposed a system for text extraction based on the open-source OCR algorithm. Preparation steps for OCR were developed, which

* Corresponding author: vishnuvardhan.palem@gmail.com

detected text regions within the image, and OCR was run on detected regions to scan the text(Madre and Gundre 2018). This paper focuses on recognizing the English alphabet in a very given scanned text document with Neural Networks' assistance. This paper explores assorted feature primarily based classification techniques for offline written character recognition(Joarder, Barman, and Islam 2017). Most studies within the literature referring to optical graphene readers have targeted internal partitioning, redisplaying, and letter recognition. Different aspects, like pre-processing, external partitioning, and post-process, are rarely studied(Hansmann and Squire 2016). Therefore, the proposed handwritten character recognition system that supported a hybrid feature extraction technique has been given. Among these literature surveys, Hansmann et al. shows the best results when compared with our study in character recognition. The system comprised three main stages, i.e., pre-processing, feature extraction technique, and SVM, based mostly on training/classification.

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 existing research used alphabet recognition alone for neural networks only. Since it shows the recognition of alphabets with accuracy. So suitability we use a fuzzy classifier to get a better outcome. The aim of the study is to identify the alphabets using fuzzy neural network rules.

Materials and Methods

In this study, two groups are involved for emotion recognition. The sample used in this study is 20. The required samples for this study are tested using G power calculation. The minimum power for this study is fixed as 1.0 and maximum accepted error is fixed as 0.5. The study setting was done in the DSP lab of Saveetha School of Engineering. Ethical approval is not needed for this study. In this section, there is only the use of software tools and no use of hardware. Two different groups were taken for the analysis: Group A, Fuzzy classifier(26): Group B, Neural networks(26). Sample size calculation is done using clinical cal.com by applying the parameter values from previous works of literature. The materials used in the study are MATLAB software in operating systems using Windows 8 in the English language.

There is an involvement of the recognition method in which it includes 4 phases. They are pre-processing, Image segmentation, feature extraction and character recognition. The MATLAB software (version R2018a) was used to predict the recognition of characters. The images ought to have a particular format like JPG, BMP etc. The algorithm was implemented in the editor box, and the input images were taken in BMP form. The process was done with both classifiers (Neural networks and Fuzzy classifier). Input image characters are alphabets (a to z). The pre-processing may be a series of operations performed on the scanned input image. The alphabetical character recognition technique was done as per standard procedures by (Perwej and Chaturvedi 2011).

Statistical package for social and sciences (SPSS) is a widely used program in the market. It is used to manage and analyze quantitative data, which has been popular for more than thirty years. These character recognition results are implemented in the SPSS to compare results like mean, std. Deviation, std, error Mean, significance, t-test for equality of means and graphs are plotted. Independent sample tests and group statistics have been taken for the results. Results obtained were satisfactory, particularly once input characters were near to printed letters.

Results

All the accuracy levels are recorded by testing and training. Totally the method is carried out in three phases: pre-processing, feature extraction and recognition. In this paper only the study has been done on english. There is a similarity of finding alphabets through software which is a handwritten pattern also. We recognise it from the input images. SPSS is a widely used program in the market. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organisers and others. It is used to manage and analyse quantitative data which has been popular for more than thirty years.

In Table 1 it was observed that all the alphabets were tested and trained in both neural and fuzzy classifiers to get the accuracy level. The recognition rate of each alphabet was calculated with approximately 90%. The Fuzzy classifier gives the best outcome when compared with neural networks.

Table 1. Comparison in Accuracy between Neural networks and Fuzzy classifier

Alphabet	No. of samples for training	No. of samples for testing	% Recognition Accuracy in Fuzzy classifier	% Recognition Accuracy in Neural networks
A	20	5	94.0	94.0
B	20	5	83.0	92.0
C	20	5	71.0	65.0
D	20	5	88.0	76.0
E	20	5	64.0	66.0
F	20	5	85.0	75.0
G	20	5	89.0	73.0
H	20	5	92,0	86.0
I	20	5	72.0	65.0
J	20	5	73.0	69.0
K	20	5	91.0	88.0
L	20	5	71.0	70.0
M	20	5	86.0	83.0
N	20	5	82.0	88.0
O	20	5	94.0	74.0
P	20	5	88.0	75.0
Q	20	5	82.0	64.0
R	20	5	70.0	73.0
S	20	5	88.0	88.0
T	20	5	79.0	70.0
U	20	5	80.0	77.0
V	20	5	77.0	71.0
W	20	5	94.0	87.0
X	20	5	91.0	78.0
Y	20	5	71.0	67.0
Z	20	5	90.0	92.0

In Table2 analysis of the Independent samples test it was calculated mean difference, standard deviation and

significance. The significance value is 0.002 where the mean difference values in both classifiers are 5.34615 and standard error difference is also the same for both classifiers (2.55098). The F value is 0.15 in equal variances assumption and there is no change in equal variances not assumed.

Table 2. Comparison of group statistics and independent samples test values between fuzzy and neural network classifiers

	Variances	F	Sig	t	df	sig. (2-tailed)	Mean difference	Std. Error Difference	Lower	Upper
Accuracy	Equal variances assumed	.150	.002	2.096	50	0.41	5.34615	2.55098	.22235	10.46995
	Equal variances not assumed			2.096	40.811	0.41	5.34615	2.55098	.22187	10.47044

In Table 3 Group statistics values were recorded, the neural and fuzzy 'N' size is 26. The mean value is greater in fuzzy classifier (82.5000) when compared to neural networks (77.1538). The standard deviation is low in the fuzzy classifier (8.90955), but the neural networks is having higher value (9.47710). The standard error mean is higher in neural networks (1.85861) and fuzzy is lower (1.74731).

Table 3. Group statistics for Fuzzy classifier and neural networks

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Accuracy	Fuzzy classifier	26	82.5000	8.90955	1.74731
	Neural networks	26	77.1538	9.47710	1.85861

In Figure.1 it indicates the recognition rate of alphabets using the Fuzzy classifier and the Figure. 2 indicates the recognition rate of alphabets using neural networks. In Figure. 3 the error free bar chart was drawn between the neural and fuzzy classifiers and the performance is higher in the Fuzzy classifier. The accuracy was taken in Y-axis and Groups were taken in X-axis.

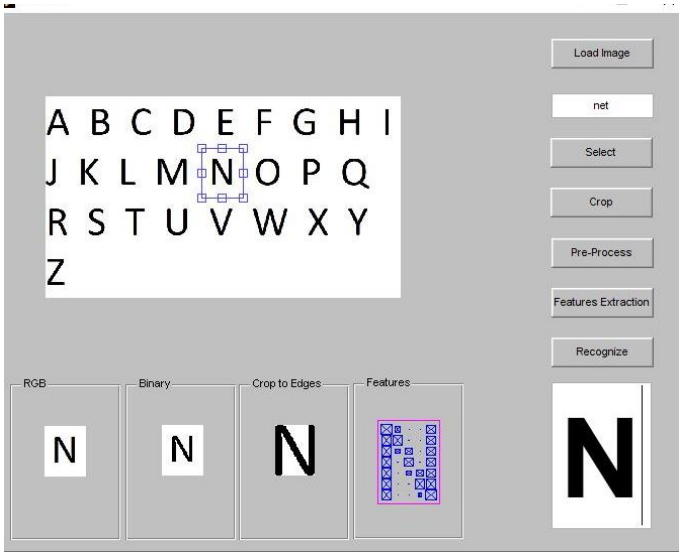

Fig. 1. Recognition of character using Fuzzy classifier

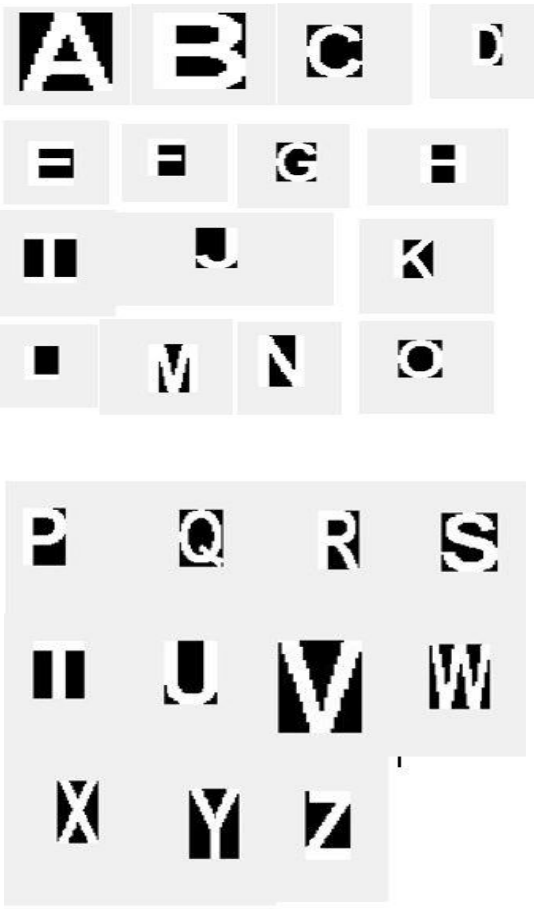

Fig. 2. Recognition of each letter using Neural networks

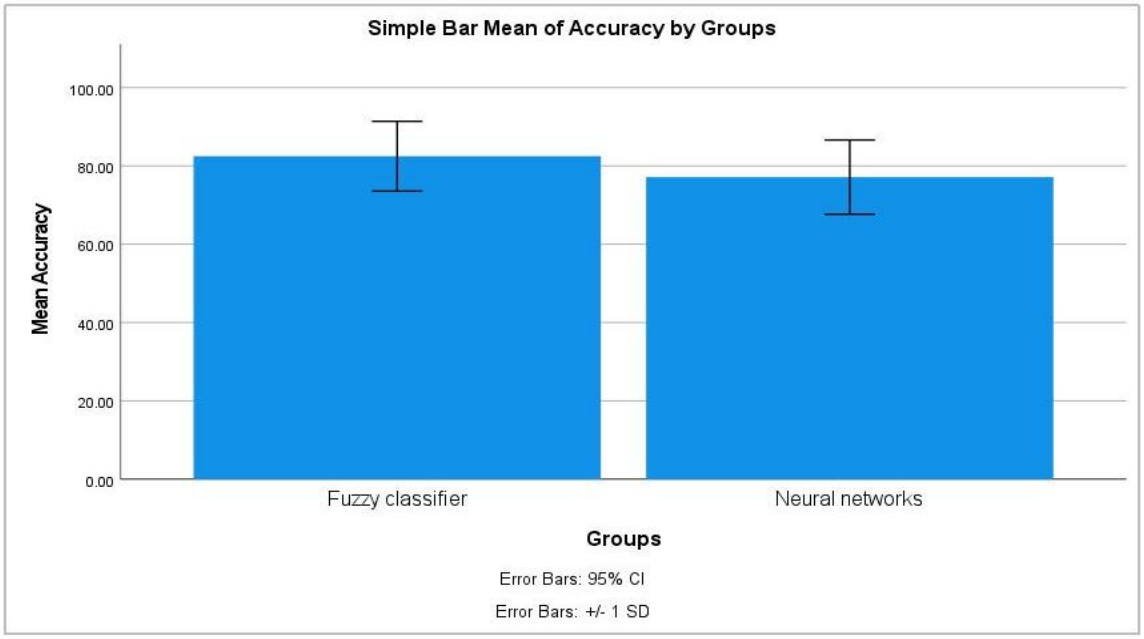

Fig. 3. The simple bar graph compares the mean accuracy values of Fuzzy and neural networks. Based on the mean accuracy, it is said that the Fuzzy classifier is more efficient when compared to neural networks. The mean accuracy of Fuzzy is denoted as 52.218, and the mean accuracy of neural networks is denoted as 20.470. X- axis: Fuzzy classifier vs neural networks. Y-axis: Mean accuracy of detection +/_ SD.

While performing the statistical analysis for 20 samples from the both Fuzzy classifier and neural networks, Fuzzy classifier obtained 8.9 standard deviation with 1.7 standard mean error. However, the neural network obtained 9.4 standard deviation with 1.8 standard mean error (Table 3). The significance value of P=0.002 obtained for the Fuzzy classifier which is lower than the P=0.005 showed that our work holds significantly good.

Independent t-test was used to compare the accuracy levels for both fuzzy and neural networks; the statistical significant difference was noticed P=0.002 < 0.005. The Fuzzy classifier obtained 98.06% accuracy (Figure. 3). When compared with the other algorithms, the performance of the proposed Fuzzy classifier achieved better performance than neural networks in novel character recognition.

Discussions

In this study two methods used in alphabetical recognition namely neural networks and Fuzzy classifier. Based on independent sample T test results, the Fuzzy classifier is better than neural networks with significant Fuzzy values(P=0.002; P<0.005). Fuzzy classifier obtained 8.9 standard deviation with 1.7 standard mean error. However, the neural network obtained 9.4 standard deviation with 1.8 standard mean error. Some researchers that handle alphabet recognition using neural networks and Fuzzy classifier have given the result similar to our result ((Fanty, Barnard, and Cole, n.d.)) (Bezdek et al. 2006). The findings are almost convincing with our study. We cannot find any research articles that can oppose our study. There is another technique called Hidden markov model which gives less accuracy level and results are not convincing with our study (Wei and Guanglai 2009). Low contrast, high noise, high blur and high distortions are the possible factors that may affect the quality of image. Quality of scan, smudged input image and original document may also play a major role in affecting the quality of image. The significance of our research is significant and it is an independent t-test.

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.

The limitations of this study are computationally expensive, algorithms and massive amount of data. The quality of the ultimate depends on the quality of the first image. Text works efficiently with the printed text only and Handwriting must be learnt by the pc. Enabling the production of bigger, more efficient algorithms. We can also design neural nets capable of processing more data or processing data faster, so it may learn to recognize patterns with just 1,000 examples, instead of 10,000.

Conclusion

This study was proposed and developed a scheme for recognizing English alphabets. It has tested all english alphabets. Experimental results showed that the machine has successfully recognized the alphabets with the average accuracy of 98.05% for fuzzy classifier in recognition of characters, which is significant and might be acceptable in some applications.

Declarations

Conflict of Interests

No conflict of interest in the manuscript.

Authors Contribution

Author BSKR was involved in image collection, algorithm development, image analysis, manuscript writing. Author VV was involved in data validation, conceptualization and critical review of manuscript.

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References

Abdurahman, Fetulhak. 2019. "Handwritten Amharic Character Recognition System Using Convolutional Neural Networks." *E-Journal of New World Sciences Academy*. https://doi.org/10.12739/nwsa.2019.14.2.1a0433.

Bezdek, James C., James Keller, Raghu Krisnapuram, and Nikhil Pal. 2006. *Fuzzy Models and Algorithms for Pattern Recognition and Image Processing*. Springer Science & Business Media.

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.

Fanty, Mark, Etienne Barnard, and Ron Cole. n.d. "Neural Networks for Alphabet Recognition." *Handbook of Neural Computation*. https://doi.org/10.1887/0750303123/b365c95.

Fonseca, Jose Manuel, Nuno Miguel Rodrigues, Andre Damas Mora, and Rita Almeida Ribeiro. 2011. "Optical Character Recognition Using Automatically Generated Fuzzy Classifiers." *2011 Eighth International Conference on Fuzzy Systems and Knowledge Discovery (FSKD)*. https://doi.org/10.1109/fskd.2011.6019585.

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

Goyal, Pulkit, Sapan Diwakar, and Anupam Agrawal. 2010. "Devanagari Character Recognition towards Natural Human-Computer Interaction." https://doi.org/10.14236/ewic/ihci2010.7.

Hansmann, Henry, and Richard Squire. 2016. "External and Internal Asset Partitioning." *Oxford Handbooks Online*. https://doi.org/10.1093/oxfordhb/9780198743682.013.3.

Joarder, Y. A., Paresh Chandra Barman, and Md Zahidul Islam. 2017. "Enhancement of ANN-Based Offline Hand Written Character Recognition Using Gradient and Geometric Feature Extraction Techniques." *Communications in Computer and Information Science*. https://doi.org/10.1007/978-3-319-58750-9_20.

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.

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.

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.

Madre, Sneha C., and S. B. Gundre. 2018. "OCR Based Image Text to Speech Conversion Using MATLAB." *2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS)*. https://doi.org/10.1109/iccons.2018.8663023.

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.

Paliouras, Georgios, Vangelis Karkaletsis, and Constantine D. Spyropoulos. 2003. *Machine Learning and Its Applications: Advanced Lectures*. Springer.

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.

Perwej, Yusuf, and Ashish Chaturvedi. 2011. "Machine Recognition of Hand Written Characters Using Neural Networks." *International Journal of Computer Applications*. https://doi.org/10.5120/1819-2380.

"Preprocessing Local Features and Fuzzy Logic-Based Image Segmentation." 2016. *Biomedical Image Segmentation*. . https://doi.org/10.4324/9781315372273-9.

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.

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.

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.

Wei, Wu, and Gao Guanglai. 2009. "Online Handwriting Mongolia Words Recognition Based on HMM Classifier." *2009 Chinese Control and Decision Conference*. https://doi.org/10.1109/ccdc.2009.5191525.