DENTAL-DIAG*
AI-POWERED DISEASEDETECTIONFROM DENTAL X-RAYS

Dr.ViswanadhamRavuri
*Department of Electronics and Communication EngineeringBVRIT HYDERABAD College of Engineering for Women*Hyderabad, Telangana, India viswanadh.r@bvrithyderabad.edu.in

InduPallapothula
*Department of Electronics and Communication EngineeringBVRIT HYDERABAD College of Engineering for Women*Hyderabad, Telangana, India21wh1a0424@bvrithyderabad.edu.in

YasaswiniJangala
*Department of Electronics and Communication EngineeringBVRIT HYDERABAD College of Engineering for Women*Hyderabad, Telangana, India21wh1a0415@bvrithyderabad.edu.in

RuchithaAdigoppula
*Department of Electronics and Communication EngineeringBVRIT HYDERABAD College of Engineering for Women*Hyderabad, Telangana, India21wh1a0462@bvrithyderabad.edu.in

SathithiBanala
*Department of Electronics and Communication EngineeringBVRIT HYDERABAD College of Engineering for Women*Hyderabad, Telangana, India21wh1a0405@bvrithyderabad.edu.in

Doi: https://doi.org/10.37285/bsp.SACAD2025.76

Abstract—Early detection of dental diseases is crucial to preventing severe oral health issues. This project utilizes machine learning in MATLAB to analyze dental X-ray images and predict possible diseases along with their likelihood. The process involves image preprocessing, feature extraction, and training a classification model using supervised learning techniques.Different machine learning techniques, such as convolutional neural networks (CNNs) and support vector machines (SVMs), are explored to determine the most efficient model. The effectiveness and reliability of the trained model are assessed using test datasets to evaluate its accuracy. To enhance accessibility, the project integrates its predictive results with Power BI, enabling real-time data visualization. This integration allows dentists and healthcare professionals to efficiently analyze patient conditions through interactive dashboards displaying disease probabilities, patient records, and statistical insights. By combining artificial intelligence with visualization tools, this project aims to support early diagnosis, improve treatment strategies, and enhance patient care. The fusion of machine learning and data analytics bridges the gap between medical imaging and clinical decision-making, contributing to more advanced and efficient dental diagnostics.

Index Terms—Dental X-ray Analysis, Machine Learning, Disease Prediction, MATLAB, Power BI Integration

I. INTRODUCTION

Dental diseases, including cavities, gum infections, and periodontal issues, are widespread health concerns that can lead to severe complications if not diagnosed and treated early. Timely detection is essential to prevent further damage and improve patient outcomes. Traditionally, dentists rely on visual examinations and manual interpretation of X-ray images for diagnosis. This approach, however, istime-consuming, subjective, and susceptible to human error. With the progress in artificial intelligence (AI) and machine learning, automated systems can improve diagnostic precision and efficiency, minimizing the risk of misinterpretation.

Identify applicable funding agency here. If none,delete this.

This project utilizes machine learning techniques in MATLAB to analyze dental X-ray images and predict potential diseases along with their respective probabilities. The approach includes several stages, such as image preprocessing to improve quality, feature extraction to identify critical patterns, and classification using machine learning algorithms. This approach, however, is time-consuming, subjective, and susceptible to human error. With the progress in artificial intelligence (AI) and machine learning, automated systems can improve diagnostic precision and efficiency, minimizing the risk of misinterpretation.

To make the results more accessible, this project integrates the predictive model with Power BI, a data visualization tool that enables interactive analysis. This integration provides healthcare professionals with an intuitive interface to examine disease predictions, monitor patient records, and analyze statistical trends. Utilizing AI-powered diagnostics and real-time visualizations, the system is designed to support dental professionals in making well-informed clinical decisions, optimizing treatment planning, and enhancing the quality of patient care.

This project bridges the gap between medical imaging and digital healthcare solutions by combining AI and interactive analytics.The proposed system enhances diagnostic precision while simplifying the decision-making process, leading to improved healthcare outcomes. The integration with Power BI

enhances usability, making it easier for dentists to interpret and act upon the results, ultimately leading to more effective and timely dental treatments.

II. LITERATURE SURVEY

As mentioned in their work, IF Rimi, MAI Arif, S Akter,
MR Rahman, AHMS Islam, MT Habib [1] Oral diseases are increasing globally at a rate comparable to infectious and noncommunicable diseases. among the most prevalent. rephrase this without plagarismChatGPT said: More than 80 percentage of the population experiences at least one dental issue, with common conditions including periodontitis, gingivitis, and carcinoma. In this study, a machine learning-based approach was utilized to predict dental diseases, taking into account the daily habits and behaviors of individuals within a specific region. To identify key factors contributing to these conditions, consultations were conducted with medical professionals and dentists. Based on these insights, data was collected from both the general population and individuals diagnosed with dental diseases.

After data collection and preprocessing, nine wellestablished machine learning algorithms were applied for disease prediction. These algorithms included k-nearest neighbors (KNN), logistic regression, support vector machines (SVM), naive Bayes, classification and regression trees (CART), random forest, multilayer perceptron (MLP), adaptive boosting (AdaBoost), and linear discriminant analysis (LDA). Each model's performance was evaluated based on accuracy and other essential assessment metrics. Among all classifiers, logistic regression demonstrated the highest effectiveness, achieving an accuracy of approximately 95.89 percent . In contrast, AdaBoost exhibited the lowest performance, yielding an accuracy of around 34.69 percent, along with suboptimal results in other evaluation measures.

As mentioned in their work, Alharbi, Mafawez T., and Mutiq M. Almutiq [2] Artificial intelligence (AI) is increasingly recognized for its transformative impact on the healthcare sector, enhancing efficiency

and introducing innovative approaches to service delivery. In recent years, AI adoption has grown rapidly across various sectors, including government, private enterprises, and especially healthcare. Numerous studies highlight AI's crucial role in disease detection and the identification of optimal treatment strategies. In dentistry, there is an increasing demand for innovative techniques that enhance the quality and accessibility of medical care for both patients and healthcare providers. AI offers transformative potential in this field, enabling early diagnosis and predictive analysis, especially in the realm of dental implants.

This study aims to develop four machine learning models to predict the likelihood of a patient needing a dental implant. The models used include the Bayesian network, random forest, AdaBoost, and an improved version of the AdaBoost algorithm. The findings of this study demonstrate that the proposed models effectively identify the need for dental implants, providing valuable insights for healthcare professionals and decision-makers in targeting patients with specific conditions.

Performance analysis of the models indicates promising results, with the improved AdaBoost algorithm outperforming the other approaches. The enhanced model achieves a notable prediction accuracy of 91.7percent, significantly improving upon the baseline methods. This study highlights the potential of AI-powered solutions to enhance dental care and improve patient treatment planning.

According to the work of Tuan, Tran Manh, Nguyen Thanh Duc, and Pham Van Hai [3], clinical dentistry often relies on the expertise of dentists to analyze dental X-ray images and interpret patient symptoms for disease diagnosis. This process is largely influenced by the individual experience and judgment of each dentist. To support and improve decisionmaking, an automated dental diagnosis system using X-ray images has been proposed.

This study presents a consultation system for detecting dental diseases based on fuzzy rule-based analysis. Fuzzy rule systems are widely used in fields like computational intelligence, data mining, and machine learning due to their ability to handle uncertainty effectively. Using a dataset of dental X-ray images, the Fuzzy C-Means (FCM) clustering algorithm is applied to group the images into distinct categories, followed by the creation of a corresponding rule set. The Fuzzy Inference System (FIS) then evaluates these rules using three validity indices.

By combining these rule-based classifications with patientreported symptoms, the system helps dentists diagnose dental conditions with greater accuracy. The proposed method was implemented and validated with a real-world dataset from Hanoi Medical University Hospital in Vietnam. Comparative analysis with existing algorithms demonstrated its effectiveness in improving dental disease diagnosis.

[4]Software metrics are crucial in the software industry as they offer key measurements for managing software processes and products. These metrics help evaluate aspects like software quality, complexity, maintainability, and size. By using metrics, project teams can assess whether development is on track or if there are any deviations from expected progress. However, while numerous studies introduce various software metrics, many fail to include reference values or threshold limits that offer guidance on ideal ranges. The effectiveness and adoption of metrics could improve significantly if reliable reference values were consistently provided.This study carries out a Systematic Literature Review (SLR) to identify research that proposes thresholds and reference values. An initial keyword search yielded 6,654 articles from databases including IEEE Xplore, ACM Digital Library, EiCompendex, SCOPUS, and Elsevier Science Direct. After a thorough filtering process, only 19 articles were identified as explicitly addressing reference values and thresholds. This paper reviews and analyzes these studies, highlighting variations in the reported values and thresholds. The results are intended to provide a basis for future research in this field.

[5]Addressing major oral health issues has become a vital focus of research in today's world. Advanced methods like data mining, image processing, and computational intelligence play a key role in biomedical studies. In particular, dental image processing supports early detection and

classification of oral diseases, contributing to accurate diagnoses. Radiographic 2D dental images are commonly used to examine various dental conditions.

This study presents a comprehensive approach that includes classification, segmentation, and pre-processing of dental images. During the pre-processing phase, a histogram-based adaptive method is applied to improve contrast and maintain consistent brightness across radiographic X-ray images, effectively distinguishing teeth from surrounding bone structures. Image segmentation, a crucial step in the analysis, divides 2D dental images into separate regions corresponding to anatomical features. A hybrid graph-cut segmentation technique is used to isolate the oral cavity and nearby tissues.

Additionally, a deep learning-based Convolutional Neural Network (CNN) is employed to process dental images, achieving highly promising results with an accuracy of 97.07 percentage.

[6] In dentistry, experts examine various dental X-ray imaging techniques to identify dental problems, abnormalities, and structural changes in teeth. Besides its role in diagnostics, dental imaging also shows promise in the field of biometrics. Analyzing human dental images can be intricate and timeconsuming due to the unique and irregular shapes of teeth, making the manual detection of dental issues particularly difficult. Therefore, automating dental image segmentation and analysis is becoming increasingly critical to achieve accurate diagnoses and improve treatment planning. This paper offers a comprehensive review of dental image segmentation and analysis, drawing from over 130 research studies across different dental imaging methods, including various types of X-rays, Computed Tomography (CT), and Cone Beam Computed Tomography (CBCT). The reviewed studies are grouped into three main approaches—image processing, machine learning, and deep learning—emphasizing their distinct advantages and limitations. This review explores advanced techniques in detail, focusing on imaging methods, pre-processing for image enhancement, performance evaluation metrics, and the datasets utilized.

[7]Tooth decay can occur multiple times throughout a person's life, but early detection significantly enhances the treatment process. In the medical field, advanced intelligent techniques are being widely adopted, especially for diagnostic purposes using panoramic radiographs. However, research on dental diseases is still constrained by the lack of a standardized dataset.

This study sought to bridge this gap by creating a comprehensive dataset of panoramic radiographs of teeth and jaws. A deep neural network algorithm was developed to classify teeth into four categories: healthy, decayed, root-canaled, and restored. To assess the effectiveness of the proposed method, the dataset was divided into five groups, and various evaluation metrics, such as confusion matrices and precision percentages, were applied to each group. The method achieved an average precision of 92

Furthermore, the performance of the trained network was compared with results from AlexNet and VGGNet16. Over a six-month period, two additional datasets were collected and carefully annotated by experts. A smart technique was also introduced to identify dental locations within the jaw, enhancing diagnostic accuracy. The final results demonstrated that the proposed network maintained high stability and offered a more effective approach to dental diagnosis.

[8] In recent times, dental diseases have become increasingly common due to dietary habits and excessive consumption of sugary foods, such as chocolates. This has created a need for a predictive model capable of detecting dental issues at an early stage. Dental image processing plays a crucial role in accurately identifying early signs of dental illness. One of the key research areas in this field is the segmentation of dental X-ray images for disease diagnosis.

In this approach, dental images are preprocessed using an adaptive method that adjusts brightness and contrast for consistency. Graph-cut segmentation is then utilized to separate the foreground from the background in dental X-ray images. For disease prediction, a Deep Convolutional Neural Network (CNN) is applied. Additionally, several segmentation techniques—such as Canny Edge Detection, Watershed, Thresholding, Active Contour, Sobel, and Otsu's Thresholding—are

explored and compared. The study shows that combining graph-cut segmentation with Deep CNN significantly improves accuracy, achieving an impressive success rate of 98 percentage.

[9] Radiographic imaging is widely used for assessing dental diseases and performing clinical evaluations. However, diagnosing dental conditions from radiographs can be difficult due to the slight mineral density variations in demineralized tooth and gum tissues. According to existing studies, dental abnormalities may remain undetectable on radiographs until demineralization exceeds 40percentage. Consequently, a dental practitioner's expertise plays a crucial role in accurately interpreting radiographic penetration depth through visual examination.

To mitigate this challenge, clinical diagnosis methods based on image processing have gained significant traction, advancing dentistry from conventional practices to modern digital techniques. This comprehensive literature review highlights the advancements in image processing-based digital dental diagnostics while identifying gaps in existing research.Thequality of the analyzed studies was evaluated using the Quality Assessment and Diagnostic Accuracy Tool-2 (QUADAS-2). From 178 articles published between 2012 and February 2023, 52 studies were chosen for review. Essential information such as image processing methods, dataset sizes, approach effectiveness, strengths and limitations, diagnosed conditions, imaging types, authors, and publication years was collected. Findings indicate that across these 52 studies, over 14 different image processing techniques were applied to various radiographic images, diagnosing one or multiple dental diseases with accuracy rates ranging from 64 percent to 93 percent. Many studies leveraged artificial intelligence (AI) for computer-aided diagnosis, with dental professionals labeling datasets and validating the proposed methods. While significant progress has been made in digital dental diagnostics, current techniques still fall short of clinically expected accuracy. There is a pressing need to refine existing methodologies and establish standardized public dental datasets to encourage further research and advancements in the fie.

[10]The identification of dental abnormalities aims to enhance clinical support by ensuring efficient diagnosis with reduced complexity and improved accuracy in detecting foreground objects. An automated system for predicting dental diseases incorporates a segmentation technique known as adaptive thresholding along with an unsupervised Support Vector Machine (SVM) classifier.

The proposed segmentation method, adaptive thresholding, extracts essential information from the dental input image, facilitating the feature extraction process. During feature extraction, the segmented region is analyzed to derive features related to color and texture, which are represented using histograms. In this graphical representation, the peak values of each bin (vertical lines between the X and Y axes) indicate the probability occurrences of extracted features. A combination of color and texture features is then utilized for classification using SVM.

SVM training involves reference samples to classify dental images as either normal or abnormal. This supervised learning model employs a Radial Basis Kernel Function to enhance classification accuracy. If an image is classified as abnormal, further analysis is conducted using SVM to determine the closest match with defective dental images. The final simulation results indicate that the proposed methodology outperforms previous approaches, offering improved classification accuracy and better detection of dental defects.

III. PROPOSED SOLUTION

Dental disease diagnosis using X-ray images is traditionally performed manually by dental professionals. This process is not only time-consuming but also susceptible to human error and subjectivity, leading to inconsistencies in diagnosis. Moreover, with the increasing volume of dental imaging data, there is a growing need for automated, accurate, and efficient diagnostic tools that can assist clinicians in identifying various dental conditions reliably.

To address the challenges of manual dental diagnosis, we propose the development of a MATLAB-based Graphical User Interface (GUI) tool designed to automate the classification of dental diseases from X-ray images. This intelligent

system integrates deep learning techniques with an intuitive user interface to support dental professionals and researchers in efficiently analyzing dental radiographs.

The core of the system is powered by the EfficientNetB0 model, astate-of-the-art convolutional neural network architecture known for its balance between accuracy and computational efficiency. The model is trained on a dataset of annotated dental X-ray images, where each image is associated with disease labels stored in a structured JSON format. This annotation format allows for flexible integration and easy modification of ground truth labels.

IV. KEY COMPONENTS OF SOLUTION

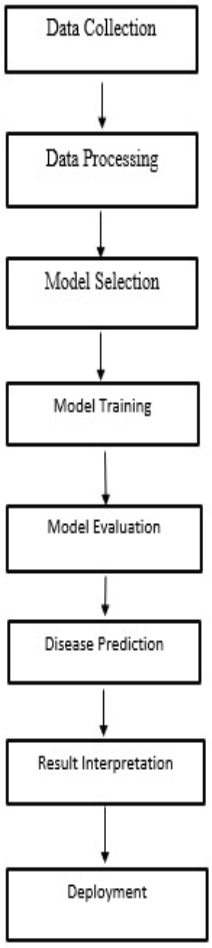

Fig. 1. Flow chart

1. EfficientNetB0astheBackboneforImage Classification EfficientNetB0 is a state-of-the-art convolutional neural network (CNN) used as the feature extractor in this project. It automatically learns rich features from dental Xray images, which are then used to classify different types of dental diseases. It offers a good balance between model size, accuracy, and performance, making it suitable for real-time or resource-constrained environments like a GUI.

2. Use of JSON-Based Annotations to Label TrainingData A JSON file is used to store metadata and labels for each training image. It contains fields such as:

- Image file name
- Disease label/class
- Any additional tags (e.g., bounding boxes if applicable) the main purpose is to organize and load training labels efficiently during the training phase, ensuring correct mapping between images and their corresponding disease annotations.

3. Data Preprocessing and Augmentation to Improve Model Accuracy How it's used: Preprocessing:

- Resize images to a fixed input size (e.g., 224x224)
- Normalize pixel values Augmentation:
- Rotate, flip, zoom, shift, or adjust brightness of images to generate more diverse training data

The purpose is to enhance model generalization and prevent overfitting by simulating variations found in real-world clinical images

4. Class Balancing to Ensure Fairness and AccuracyAcross All Disease Classes Techniques such as oversampling underrepresented classes or undersampling overrepresented classes are applied. The purpose is to avoid bias towards the most frequent disease classes and ensure that the model performs equally well across all types of diseases.

5. GUI to Make it User-Friendly for Dentists or Researchers A MATLAB-based graphical user interface allows users to interact with the system without needing to write code. Features in the GUI:

- Upload and view X-ray images
- Train the model using selected datasets
- Load trained models

- Predict and visualize disease from new X-ray images

Main purpose is to make the tool accessible and easy to use for non-technical users such as dentists and clinical researchers.

6. Training and Prediction Module Within the GUI The GUI includes buttons or tabs to:

- Initialize and train the model using EfficientNetB0 with the loaded JSON-annotated dataset
- Load a pre-trained model for quick testing
- Run predictions on newly uploaded X-ray images

Used to integrate model operations seamlessly into a single interface, allowing users to manage training and inference directly from the GUI.

7. Visualization of Results with Predicted Labels and Confidence Levels After prediction, the GUI displays:

- The predicted disease name.
-
- The confidence level or probability (e.g., “Periodontitis – 92.5%”)

Purpose is to provide clear, interpretable results that help cliniciansunderstand the model’s decision, adding transparency and aiding diagnosis.

V. RESULT

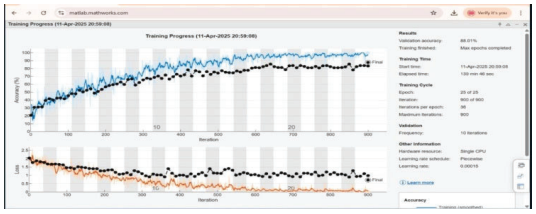

Fig. 2. Validation Accuracy

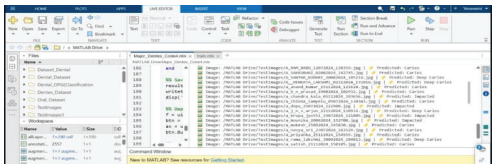

Fig. 3. Testing Predictions

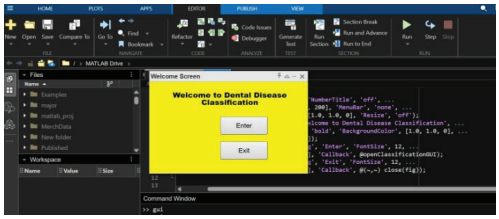

Fig. 4. Welcome screen of the dental classification GUI.

VI. CONCLUSION

This project successfully developed a machine learningbased system for classifying dental diseases using X-ray images, leveraging the EfficientNetB0 architecture. The model was trained on a dataset of annotated dental X-ray images, with careful attention given to data preprocessing, augmentation, and class balancing to ensure optimal performance.

The MATLAB GUI provides an intuitive interface for users, allowing them to easily upload and classify new Xray images, while displaying predictions along with their

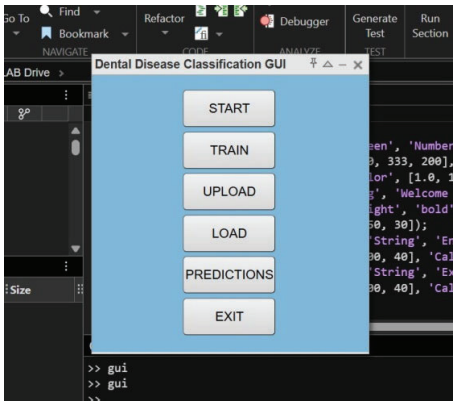

Fig. 5. Second screen of the dental classification GUI.

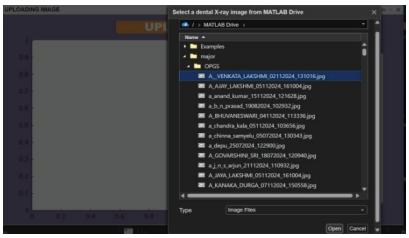

Fig. 6. Uploading required image for prediction.

respective confidence scores. The system utilizes a JSONbased annotation format, ensuring flexibility and scalability for future data integration and annotation.

By integrating state-of-the-art deep learning techniques with an accessible user interface, this project demonstrates the potential of AI in aiding dental professionals with disease diagnosis, potentially improving diagnostic accuracy and patient outcomes. Future work could involve further fine-tuning of the model, expanding the dataset to cover a wider variety of dental diseases, and integrating the system with medical databases or clinical platforms for real-world application.

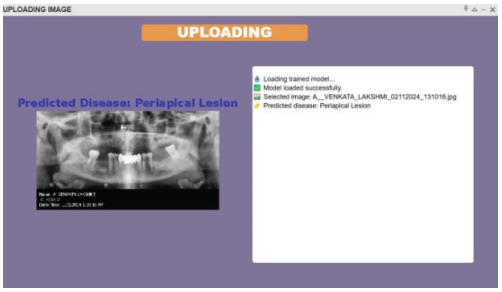

Fig. 7. Prediction of the Disease.

REFERENCES

[1] Rimi, IffatFirozy, et al. "Machine learning techniques for dental disease prediction." Iran Journal of Computer Science 5.3 (2022): 187-195.

[2] Alharbi, Mafawez T., and Mutiq M. Almutiq. "Prediction of dental implants using machine learning algorithms." Journal of Healthcare Engineering 2022.1 (2022): 7307675.

[3] Tuan, Tran Manh, Nguyen Thanh Duc, and Pham Van Hai. "Dental diagnosis from X-ray images using fuzzy rule-based systems." International Journal of Fuzzy System Applications (IJFSA) 6.1 (2017): 1-16.

[4] Ali, Ramzi Ben, RidhaEjbali, and Mourad Zaied. "Detection and classification of dental caries in x-ray images using deep neural networks." International conference on software engineering advances (ICSEA). 2016.

[5] Al Kheraif, Abdulaziz A., Ashraf A. Wahba, and H. Fouad. "Detection of dental diseases from radiographic 2d dental image using hybrid graph-cut technique and convolutional neural network." Measurement 146 (2019): 333-342.

[6] Kumar, Anuj, Harvendra Singh Bhadauria, and Annapurna Singh. "Descriptive analysis of dental X-ray images using various practical methods: A review." PeerJ Computer Science 7 (2021): e620.

[7] GhaznaviBidgoli, Seyyed Amirhossein, Arash Sharifi, and Mohammad Manthouri. "Automatic diagnosis of dental diseases using convolutional neural network and panoramic radiographic images." Computer Methods in Biomechanics and Biomedical Engineering: Imaging and Visualization 9.5 (2021): 447-455.

[8] Lakshmi, M. Muthu, and P. Chitra. "Tooth decay prediction and classification from X-ray images using deep CNN." 2020 International Conference on Communication and Signal Processing (ICCSP). IEEE, 2020.

[9] Chauhan, Rahulsinh B., et al. "An overview of image processing for dental diagnosis." Innovation and Emerging Technologies 10 (2023): 2330001.

[10] Prakash, M., U.Gowsika, and S. Sathiyapriya. "An identification of abnormalities in dental with support vector machine using image processing." Emerging Research in Computing, Information, Communication and Applications: ERCICA 2015, Volume 1. Springer India, 2015.

[11] Mahmoud, Nourelhoda M., et al. "Detecting dental problem related brain disease using intelligent bacterial optimized associative deep neural network." Cluster Computing 23 (2020): 1647-1657.

[12] Patil, Shashikant, Vaishali Kulkarni, and Archana Bhise. "Algorithmic analysis for dental caries detection using an adaptive neural network architecture." Heliyon 5.5 (2019).

[13] Vellappally, Sajith, et al. "IoT medical tooth mounted sensor for monitoring teeth and food level using bacterial optimization along with adaptive deep learning neural network." Measurement 135 (2019): 672-677.

[14] Arena, Paolo, et al. "Image processing for medical diagnosis using CNN." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 497.1 (2003): 174-178.

[15] Tzotsos, Angelos, and DemetreArgialas. "Support vector machine classification for object-based image analysis." Object-based image analysis: Spatial concepts for knowledge-driven remote sensing applications (2008): 663-677.