

# Early Detection of Dental Plaque Using Convolution Neural Networks: A Technological Approach for Oral Health Improvement

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*Abstract- Nowadays dental or oral diseases are very common diseases and there's half of the world's population suffers from it because of several reasons like illiteracy rate, unhygienic or poverty, etc. They are most commonly seen in age groups of 5-6, 12, and 35-41 years. Therefore, to reduce the risk factor for oral disease it's important to have control over it at an early stage. The World Health Organization (WHO) had performed a survey to determine the presence of oral disease and over 6% of the population is facing problems related to it. In today's century there is different technology available like Deep Learning, Machine Learning and Artificial intelligence (AI) these human technologies are nowadays, a helping hand in medical science fields because of these algorithms, treatment and detection of not only oral diseases but any kind of disease can be done efficiently. However, in this paper to detect dental plaque we have used different natural photos collected by the clinics and by applying a convolution neural network we have classified it into cavity or non-cavity. Thus, this study uses the Convolution Neural Network (CNN) algorithm, this mode requires very little Pte-process data compared to the deep learning algorithm. This paper documents the extensive datasets of dental plaque gathered from different sources and the training, testing, and Validation procedure of the detector. An important part of this training is the detection and localization of dental bacterial plaque (DBP), which is the main cause of the most common oral diseases (caries and periodontal disease). The result of all the process will come that we can easily detect dental plaque with the help of this algorithm and show its accuracy. This paper*

*attempts to review the current body of evidence regarding the role of dental plaque.*

*Indexed Terms- Dental Plaque Detection, CNN, Image Processing.*

## I. INTRODUCTION

Dental plaque is essentially a sticky film of bacterium that perpetually keeps forming on teeth it's acidic in nature and it will destroy teeth enamel and it will cause several oral diseases like periodontal disease, cavities, trauma gums, tooth loss, etc. Everybody has dental diseases to some or the other extent so, if your teeth feel a fuzzy feeling after you run your tongue over them then that's plaque. However, the identification of plaque is troublesome for youngsters and their folks as a result of the tooth and plaque typically look alike, particularly once the plaque is gifted in restricted amounts. All now, plaque is usually detected by clinicians either directly exploitation associate in nursing mortal or with the assistance of a revealing resolution and is quantified exploitation indices supported by the world of tooth coated or the plaque thickness. However, these assessment strategies area unit inconvenient and time intense, particularly once youngsters don't seem to be cooperative in addition, revealing agents will stain oral membrane and therefore the lips, though briefly, that could be a major esthetic issue. Laser-induced car visible radiation chemical analysis and digital imaging analysis exploitation the HIS color area have additionally been delineated within the literature, however the value of kit and standardization of the techniques area unit major drawbacks within the

popularization of such strategies. Thus, there's a necessity to develop a cheap and convenient technique to objectively discover and quantify plaque.

Here, we have a tendency to gift a pioneering study that uses networks for the detection of plaque supported by an information set of primary teeth. In addition, we have a tendency to appraise the diagnostic performance of Associate in Nursing AI system exploitation deep learning in police investigation plaque on the first tooth surface.

## II. LITERATURE REVIEW

Until now, there has been no analysis in the field of medicine using AI to find bacterial plaque. This study tried to seek out good and straightforward ways to diag nose bacterial plaque and use the results to teach kids about oral hygiene compliance for a more robust life. The investigation presented was aimed at studying micro-ecological phenomena during and after microbial penetration of the gap between restoration and tooth substance and to verify our theory on the "micro biosphere in the marginal gap after filling. ." Eighty-two teeth filled with different restorative materials were investigated using a combination of methods including light microscopy, transmission electron microscopy, and scanning electron microscopy Rover G, Belladonna FG, Bortoluzzi EA, De-Deus G, Silva EJ, Teixeira CS. Influence of access cavity design on root canal detection, instrumentation efficacy, and fracture resistance assessed in maxillary molars. *Journal of Endodontics*. 2017 Oct 1;43(10):1657-62. [1].

The mouth cavity is considered to be home to several hundred distinct types of bacteria. Among these, periodontal disease-associated bacteria adhere to and colonize the sub-gingival pocket, forming a bio film (dentalplaque) Saygili G, Uysal B, Omar B, Ertas ET, Ertas H. Evaluation of the relationship between endodontic access cavity types and secondary mesiobuccal canal detection. *BMC oral health*. 2018 Dec; 18:1-6., Butt MA, Kazanskiy NL, Khonina SN. Label-free detection of ambient refractive index based on plasmonic Bragg gratings embedded resonator cavity sensor. *Journal of Modern Optics*. 2019 Nov 11;66(19):1920-5. [2, 3]. Removing bio

film from various areas of the oral cavity is crucial to oral disease prevention and is achieved through regular personal and professional removal [4].

These disclosing agents are extremely useful because they (a) determine the user's level of oral hygiene;(b) spread knowledge of the importance of bio film eradication; and (c) provide personalized instructions and incentives for better oral hygiene; (d) facilitate user self-assessment; (e) measure oral hygiene effectiveness; (f) evaluate prevention and training programs for better oral hygiene; and (g) enables studies on bio film identification. Additionally, they play a crucial role in the execution of preventive dental programs, which is especially beneficial for kids of schoolage. One's grasp of the many theoretical concepts and medical phrases linked with them is facilitated by the live vision of the colorful surfaces of the children's teeth and tongues who participate in these programs. The dynamic display of vibrant hues on the dental and lingual surfaces of the young participants enhances comprehension of diverse theoretical principles and medical terminology linked to these initiatives. Bhan A, Vyas G, Mishra S, Pandey P. Detection and grading severity of caries in dental X-ray images. In2016 International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE) 2016 Sep 22 (pp. 375-378). IEEE.[5].

During this study, we tended to take photos of the labial surface of teeth, and an AI model was trained to spot accumulated bacterial plaque. Safeguarding and promoting oral health contribute decisively to maintaining overall health and wellness and should thus be prioritized and improved Connert T, Krug R, Eggmann F, Emsermann I, ElAyouti A, Weiger R, Kühl S, Krastl G. Guided endodontics versus conventional access cavity preparation: a comparative study on substance loss using 3-dimensional– printed teeth. *Journal of endodontics*. 2019 Mar 1;45(3):327-31.[6].

The most common locations of biofilm are those in which access to and management of oral hygiene tools is difficult. Also, biofilm is located where the tongue and saliva's natural self-cleaning process does not work effectively for a variety of reasons Muresan MP, Barbura AR, Nedevschi S. Teeth detection and

dental problem classification in panoramic X-ray images using deep learning and image processing techniques. In 2020 IEEE 16th International Conference on Intelligent Computer Communication and Processing (ICCP) 2020 Sep 3 (pp. 457-463). IEEE. [7]. Future studies can additionally train and check the detection potency of the AI model by exploitation of tooth photos taken at totally different angles. In the gift study, the AI model wasn't inferior to that of the medical specialty medical practitioner, even once the medical practitioner checked out the photos that were taken by a camera with a high resolution Bhan A, Goyal A, Chauhan N, Wang CW. Feature line profile based automatic detection of dental caries in bitewing radiography. In 2016 International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE) 2016 Sep 22 (pp. 635-640). IEEE. [8]. The level of oral hygiene education and the usage of the proper equipment for a cleaner mouth directly affect the surface area of biofilm detection spots (toothbrush, toothpaste, tongue scrapers, floss, etc.) Silva EJ, Pinto KP, Ferreira CM, Belladonna FG, De-Deus G, Dummer PM, Versiani MA. Current status on minimal access cavity preparations: a critical analysis and a proposal for a universal nomenclature. International endodontic journal. 2020 Dec;53(12):1618-35. [9].

The study was conducted within the framework of a national preventive action program in schools based on the guidelines of good clinical practice (GCP), defined as the international ethical standard of scientific quality for the design, conduct, performance, documentation, analysis, and reporting of clinical trials Germain D, Mondejar-Fernandez J, Meunier FJ. The detection of weakly developed plicidentine in teleost teeth using 3D tomography. Cybium. 2016 Jan 31;40(1):7582. [10]. Detection of dental plaque is important for the doctors, the victims, and the researchers Lo Giudice A, Leonardi R, Ronsivalle V, Allegrini S, Lagravère M, Marzo G, Isola G. Evaluation of pulp cavity/chamber changes after tooth-borne and bone-borne rapid maxillary expansions: a CBCT study using surface-based superimposition and deviation analysis. Clinical oral investigations. 2021 Apr;25(4):2237-47. [11]. So, to overcome this problem, this paper proposed a solution for getting the results of dental plaque

without human intervention using the CNN algorithm Braun A, Guiraud LM, Frankenberger R. Histological validation of ICDAS II and radiological assessment of occlusal carious lesions in permanent teeth. Odontology. 2017 Jan;105(1):46-53.[12]. The AI system was trained with 886 dental photos; further coaching with additional dental photos might improve the performance of the AI model. Our study presents a unique AI model for the detection of bacterial plaque on primary teeth. What is more, the intraoral camera we tend to use is cheap for many families, so it might be doable for oldsters to observe their children's oral hygiene habits with the assistance of the AI model in everyday life.

### III. PROBLEM STATEMENTS

- i. Current approaches for early detection of dental plaque are limited, often relying on traditional visual examination methods, leading to delayed identification and intervention.
- ii. The reliance on subjective assessments by dental professionals hinders the accuracy and consistency of plaque detection, highlighting the need for a more objective and standardized approach.
- iii. Lack of accessible and user-friendly tools for regular monitoring of oral health at home creates a barrier to timely identification of emerging dental plaque, especially in individuals without regular access to dental care.
- iv. Delayed detection and intervention in dental plaque may contribute to the progression of oral health issues, leading to more severe conditions and complications, emphasizing the urgency for improved early detection methods.
- v. The lack of standardized diagnostic criteria for early detection of dental plaque creates challenges in comparing and replicating research findings. Establishing universally accepted criteria is vital for the credibility and adoption of technological solutions in oral health improvement.

IV. METHODOLOGY

In this study, the dataset utilized for clinical augmentation comprises visually representative images of both cavity and non-cavity conditions. The dataset consists of 74 images dedicated to training, with 45 images specifically designated for plaque training. The testing set comprises 10 images featuring plaque conditions. All images in the dataset were in .jpg format.

For image preprocessing in Python, the ImageDataGenerator from the Keras.preprocessing.image module was employed. During training, 20% of the images were reserved for validation, and random horizontal flips were applied. Additionally, a random zoom range of 0.2 was incorporated to enhance the model's robustness.

A Sequential model with 10 layers was constructed for the study. The training dataset was utilized with a learning rate of 0.001, and the training process involved 20 epochs.

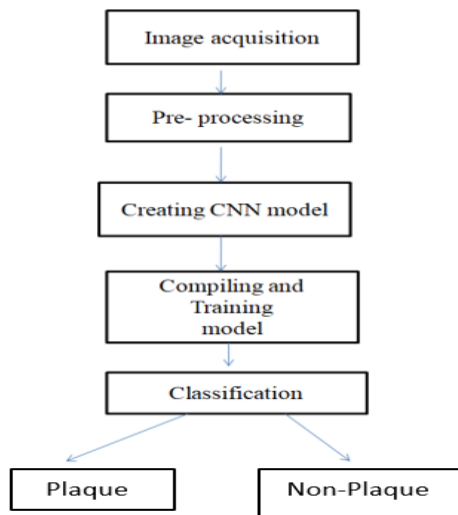


Fig.1 Flowchart of steps

V. ALGORITHM

Deep Learning that has emerged as a good tool for analyzing massive information – uses advanced algorithms and artificial neural networks to coach machines/computers so they'll learn from expertise, classify and acknowledge data/images similar to a personality's brain will inside Deep Learning, a

Convolution Neural Network or CNN may be a sort of artificial neural network, that is wide used for image/object recognition and classification. Deep learning so acknowledges objects in a picture by employing a CNN. CNNs are enjoying a significant role in various functions like image process issues, pc vision tasks like localization and segmentation, yet as speech recognition in linguistic communication process. As CNNs are enjoying a big role in these invasive and rising areas, they're highly regarded in Deep Learning.

The various deep learning strategies use information to coach neural network algorithms to try to a range of machine learning tasks, like the classification of various categories of objects. Convolution neural networks are deep learning algorithms that are terribly powerful for the analysis of pictures. This text can notify you the way to construct, train and appraise convolution neural networks. You may conjointly learn the way to boost their ability to find out from information and the way to interpret the results of the coaching. Deep Learning has varied applications like image process, linguistic communication process, etc. It's conjointly utilized in bioscience, Media & recreation, Autonomous Cars, etc. CNN may be a specialized quite neural network for process information that features an illustrious, grid-like topology, like time-series (1D grid), image information (2D grid), etc. CNN may be a supervised deep learning algorithm; it's utilized in varied fields like speech reorganization, image retrieval and face reorganization and particularly in bioscience.

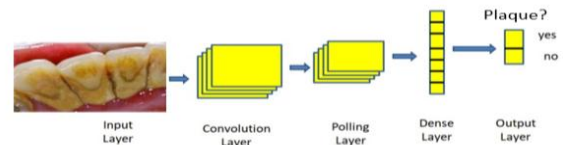


Fig.1 Illustration of the proposed Convolution Neural Network(CNN)

Convolution layer: The input is convoluted by convolutionary layers and transfers its result to the consequent layer. For its receptive region, every convolutionary nerve cell processes information solely. Though, it's doable to use utterly connected feed-forward neural networks to find out options in addition to classifying information, applying this design to photographs isn't realistic. A convolution

layer ought to have three things: dimension and height of convolution kernel, variety of input and output channels, and depth of input filters.

**Pooling Layer:** To outline the underlying computation, convolutionary networks will have native or international pooling layers. By group action the outputs of nerve cell clusters on one layer into one nerve cell on a consequent layer, the pooling layers minimize the information measurements. Native pooling blends skinny, sometimes a pair of x a pair of clusters. International pooling works on all of the convolution layer's neurons. Additionally, a goop or a mean may be calculated by pooling.

Any nerve cell in one layer is absolute to each nerve cell in another layer by utterly connected layers. It's similar to the standard multi-layer neural network (MLP) in theory. By adding a specific operation to the input values coming back from the receptive field within the previous layer, every nerve cell in an exceedingly in a very neural network computes an output price. A vector of weights and a bias verify and operate that is applied to the input values. Learning progresses by creating repetitious changes to those biases and weights in an exceedingly neural network. **Dropout Layer:** As mentioned on top of, CNN is at risk of overfitting thanks to its totally connected nature. To unravel this issue, dropout is employed drops the nodes with a chance of 1-p at the coaching stage. This can be to validate the operating of the model while not some connections. **Flatten Layer:** To input it to the consequent layer, flattening transforms the information into a 1-dimensional sequence. To make one long operate vector, we have a tendency to flatten the output of the convolution layers. And it's associated with the ultimate model of classification, referred to as a totally connected layer.

**VI. Result**

When a cavity is badly diagnosed, the lesion could eventually invade the enamel, dentin, and pulp tissue, resulting in loss of tooth performance. Fast and precise detection and diagnosis are very important for implementing applicable interference and treatment of cavities. Radiography and intraoral pictures are thought to play a significant role in detective work dental caries; however, studies have shown that 20%

of suspicious areas are erroneously diagnosed as cavity mistreatment this technique; thus, diagnosing via radiography alone while not Associate in Nursing objective assessment is inaccurate. Distinguishing tooth decay with a deep convolution neural network-based detector permits the operator to tell apart changes within the location and morphological options of cavity lesions. Deep learning algorithms have broader and more profound layers and are regularly being developed, remarkably enhancing their exactitude in detective work and segmenting objects. Within the case of classification of cavity and non-carries, our CNN model was created with binary cross entropy loss with a learning rate of zero.001. However, the accuracy is multiplied by increasing the dataset pictures. We tend to test the model by standardization hyperparameters and achieved the most accuracy of 85.58%.

Epochs	Accuracy	ValidationAccuracy
Epoch1/15	0.5556	0.4
Epoch2/15	0.4286	0.538
Epoch3/15	0.7778	0.461
Epoch4/15	0.5714	0.538
Epoch5/15	0.4444	0.538
Epoch6/15	0.5714	0.769
Epoch7/15	0.8571	0.9231
Epoch8/15	0.7778	0.5577
Epoch9/15	0.7778	0.6250
Epoch10/150	0.6667	0.4519
Epoch11/150	0.5556	0.5481
Epoch12/150	0.8889	0.7019
Epoch13/150	0.7143	0.5385
Epoch14/150	0.8571	0.769
Epoch15/150	0.7778	0.8558

Table1. Result depicting accuracy gained by Supervised Learning model



Fig.3 Model of accuracy using RM Soptimize

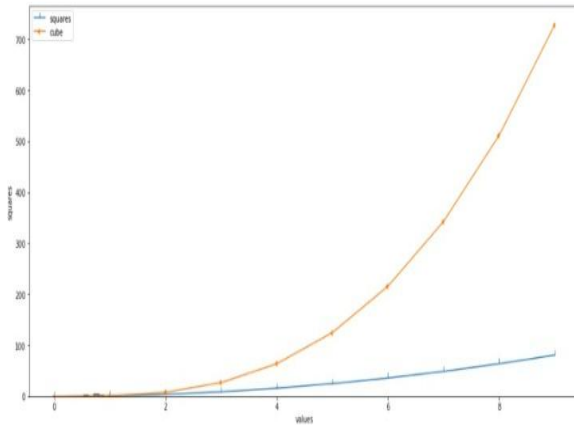


Fig.4 Accuracy Graph

### CONCLUSION

With the progress of technology, bioscience will take a lift within the designation and treatment of diseases. Clinical applications of deep learning convolution neural networks within the dental field have shown vital accuracy in sleuthing and designation caries, and these models hold promise in supporting dental practitioners to boost patient outcomes. With facilitate of image sweetening techniques, several medical pictures are often corrected and may facilitate doctors to diagnose or notice the malady expeditiously. With facilitate of Machine learning and AI algorithms several complete machine-controlled processes area unit created that area unit serving to doctors in specialized areas. This paper presents that, that a mobile application can be created that users/patients can use to photo the caries and may get a result concerning the standing of a difficulty, meantime with increase in dataset, the accuracy of the model can increase.

The training process consisted of 15 epochs for the model, revealing fluctuations in accuracy throughout. Notably, a significant increase in validation accuracy from 0.4 in the first epoch to 0.9231 in the seventh epoch was observed. However, subsequent epochs displayed varying levels of accuracy, with epochs 6 and 14 showing relatively high accuracy and validation accuracy. Nonetheless, in the final epoch (Epoch 15), despite maintaining a high training accuracy of 0.7778, there was a decline in validation accuracy (0.8558 vs. 0.769), indicating a potential

overfitting scenario. In conclusion, the model demonstrated promising performance in certain epochs, but careful consideration and optimization may be required to address potential overfitting and further enhance generalization to new data.

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