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Review Of Artificial Intelligence Techniques For Dental Implants Using Radiographic Images

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Abstract: Replacement of missing teeth is possible via dental implants for decades. Dental implant surgery can provide an alternative to dentures or bridgework when natural tooth roots are lacking. Implants are a long-term tooth recovery alternative that can be used to restore missing teeth and bone supports that have deteriorated due to periodontal disease. It is crucial to use the right imaging techniques for implants and to interpret the results correctly. To assess the quantity and condition of the bone at the implant site without surgery, radiography is the only available method. the efficacy of an artificial intelligence (AI) system for designing dental implants. Recent years have seen notable advancements in dentistry thanks to artificial intelligence (AI). The goal of this systematic review is to highlight developments in all applications commonly used in dentistry and their efficacy in terms of treatment clinical judgment, and treatment prognosis prediction. Most published research focuses on artificial intelligence AI models use CNNs and ANNs to detect and diagnose dental caries, Periapical periodontitis, maxillary rhinosinusitis, maxillofacial follicle, lymph nodes of the neck, osteoporosis, Malignant tumors, predicting orthodontic extractions, vertical root rupture determining the need for orthodontic treatments, salivary gland syndrome, Craniometry analysis, and establishing age and gender. AI systems have shown great potential for implant identification, excellence analysis, and structural analysis are all possible.

***Keywords*- Dental Implant, Radiographic Images, AI, CNN, Deep learning.**

I. INTRODUCTION

Over the past few decades, implant dentistry has advanced to the point that it is now a crucial component of contemporary dental care. Dental implant therapy was only available to edentulous patients up until the late 1980s [1]. It was carried out by a group of qualified dentists at certain universities or specialist dentistry centers. Dental implants were later used by people who had partial dentures as an implant material, design, and component technology advancements. The replacement of missing teeth is a popular dental treatment it supports treatment methods for a variety of implants, like a tooth, teeth, or complete edentulous jaw replacements that have been established [2]. With the help of a panoramic dental radiograph the whole mouth's worth of teeth is visible. Moreover, it displays the jaws and the skull, providing the dentist with a full picture of the patient's issues. Practitioners utilize panoramic dental radiography to see issues that are difficult to see or that are in the buccal cavity [3]. The dentist manually interprets the radiography, identifying each tooth and the current issue as necessary. Nevertheless, unclear X-ray radiography might cause issues during analysis and result in incorrect interpretation. To determine the best treatment for patients, many study results have shown that AI is greatly benefiting the health sector by detecting symptoms and getting the most effective health services. both the patients and the service provider need a new innovative method for dentistry to serve them [4].

II. LITERATURE SURVEY

Dental Implant: Dental implants are used to replace missing teeth for several years. Dentists have successfully altered the way lost teeth are replaced. Such as implant surgery, which entails several procedures to provide effective support for new teeth and a bone healing time for its treatment, which can take months [5]. Implant surgery can provide an alternative to dentures and bridgework when natural tooth roots are lacking. Long-term tooth recovery can be used to restore missing teeth and bone supports that have deteriorated due to periodontal disease [6]. To place a dental implant post, a decayed or dead tooth must be extracted. Bone grafts and bone augmentation are used in the preparation. The gum is removed, and the stud or post is drilled into the jawbone. The fresh tooth root will be attached to the implant after it has been completely integrated. Integration of implant material with surrounding tissue is key to success [7]. Dental implants can replace an entire row of missing teeth and have a natural tooth appear and feel like one of your own; they are preferred over dentures. For effective dental implants, dentists are more inclined to observe patients who have implant-retained or implant-supported restorations. regular dental visits and meticulous oral health are required which results in a higher success rate and lasting a lifetime [8].

Dental Implant Evaluation: People have used dental implants to regain full, comfortable facial aesthetics and masticatory function.1600–1800: Dental implants have been around since 3000 B.C. and were first described by Maggiolo J. in 1809 and Scholl in 1905 [9,10]. In 1900-1950: Cobalt-chromium-molybdenum alloy and subperiosteal implants were developed in 1937-1940 but did not become common until 1948. 1980–2000: The Brand mark regimen and in Clinical Dentistry at Toronto Conference on Osseointegration led to a surge in implant research in the late 1980s and early 1990s. Dr David Scharf published data when implants are placed in an operating room under aseptic conditions in 1993, it shows that implants can have a similar success rate. This enhances the standard practice of inserting dental implants in the office rather than in an expensive hospital operating room. 2000–2016: The best way to replace teeth is with dental implants. [11,12]. The stress distribution is predicted using manufacturing technology and computer-aided design. Soft tissue response and osseointegration are enhanced with zirconia implants. To replace teeth Dental implants are preferable to bridges, dentures, and conventional crowns. These are frequently painful and may cause changes in the way a person eats or speaks [13,14]. Dental implants have a natural appearance and feel, perform similarly to natural teeth, and last longer than traditional tooth replacement techniques. Dental implant systems recover chewing ability, cosmetic appearance, bone loss prevention, health preservation, and overall quality of life [15,16].

Types of Dental Implants: Dental implant designs include subperiosteal, end osseous forms, blade forms, and ramus frames, Screw-shaped end osseous dental implants are placed in the mandible or maxilla. Endosteal implants: Endosteal implants, which are the most popular dental implants and require a healthy jawbone and create a stronghold. Endosteal dental implants are performed to replace the missing tooth root. They are typically screw-shaped and inserted in either the mandible or maxilla. Subperiosteal implants: Subperiosteal implants, which lie on top of the bone beneath the gum rather than being fixed in the jawbone, are an alternative to Endosteal Implants. The patient either lacks sufficient jawbone for an implant or they are unwilling to have extensive oral surgery. Zygomatic implants: Zygomatic implants are the most complicated type of dental implant and should only be done if needed and encase do not have enough jawbone [17,18].

Artificial Intelligence in Dental Implant

AI mimics human intelligence through thought, deep learning, and adaptation. AI has grown exponentially in all fields since then. To imitate human intelligence, AI allows machines and computers to refer to serious technologies. The study of intelligent agents that recognize their surroundings and achieve maximum chances of success is known as artificial intelligence (AI). AI techniques are being used in industry, such as artificial neural networks (ANN) and Al. It has become important in healthcare, including the analysis of a wide range of patient information and the human logic simulation that perform a few tasks [19,20]. Different types of tasks can be accomplished by different types of AI. AI is a broad term with weak and strong variants. Reinforcement machine learning, computer vision, data mining, and natural language processing are all examples of today's AI. Strong AI is a multi-task algorithm capable of making decisions in multiple fields, but research is cautious due to ethical issues and potential dangers [20]. AI has been used in healthcare and medicine since the 1950s to improve diagnoses. Artificial Intelligence (AI) is being used in healthcare with promising outcomes. Precision medicine is the most common use of machine learning in healthcare [21]. AI is being used in medicine for reading radiological images and classifying diseases. Artificial intelligence has found applications in healthcare, such as human biology and dental implants. AI can be used to generate implant surgery plans for dental diagnostics. In implant dentistry, artificial intelligence (AI) models are used for success prediction, implant type recognition, and, and design optimization [22,23].

Applications of AI in Dentistry: -AI can be used to generate implant surgery plans for dental diagnostics. In implant dentistry, AI models are used for success prediction, implant type recognition, and design optimization [24]. Artificial intelligence algorithms can be used to diagnose diseases. AI can help identify dental implants, optimize designs and predict implant survival. Dentists typically make diagnoses using visual and tactile examinations in addition to radiographic examinations. Detecting early-stage lesions can lead to more complicated treatment, such as crowns, root canal therapy, or implants. Dental radiography and Explorer are reliable diagnostic tools, but screening and diagnosis are dependent on the experience of the dentist [25]. Orthodontics: AI aids in orthodontic diagnosis by predicting treatment outcomes and tooth movements. Prosthodontics: Prosthodontics combines facial measurements, ethnicity, anthropological calculation, and patient desire to design the best prosthesis [26,27,28]. Periodontics: Deep learning analysis can help with dental disease diagnosis and treatment by detecting periodontal changes, bone density, and bone loss [29].

III. ALGORITHM

Different Methods using CNN Techniques are illustrated below:

Prajapati et al., (2017) [30] described the VGG16 pre-trained model with Transfer learning with an accuracy of 88.46% inductive transfer learning with the VGG16 model enhances best accuracy.

Lee et al., (2018) [31] describe the GoogLeNet Inception v3 network, pre-trained models. In the molar and premolar regions, the predicted results have an accuracy of 89%, 88%, and 82%, respectively. Deep Convolutional Neural Network algorithms are expected to be one of the better and most efficient methods for identifying and treating dental caries.

Chen et al., (2021) [32 R-CNN Customized and Smaller disease lesions might not serve as indicators for a more rapid R-CNN with a precision of 0.5. and recall of 0.6.

Zhang et al., (2022) [33] CNN customized for multitasking Precision of 0.951, recall of 0.955, and an F-score is 0.953. The approach gives reliable and thorough diagnostic support to dentists.

Moran et al., (2020) [34] ResNet and an Inception model that have been pre-trained Precision of 0.762, specificity of 0.711, recall of 0.923, and negatively predictive of 0.902 In the health context, the researched CNN model can aid in the identification of periodontal bone disease. degradation all through periapical assessments.

Convolutional Neural Networks (CNN): In the new area of medical research rapidly emerging (CNNs) Deep convolutional neural networks (DCNNs) have given rise to impressive results in radiology and pathology diagnosis and prediction [35]. A CNN is a type of data processing algorithm in which each artificial neuron is an automaton that collects, processes, and conveys with the other node or neurons in a convolution layers activity, like how the striate cortex of animals interprets information. Nodes of neurons that are coupled to one another and arranged into layers according to mathematical calculations make up CNNs. From the first (input) layer to the last (output), the information (the image) is filtered at each layer. As a result, the first layer will determine the image's general

shape, the second layer will determine its edges, and the third layer will determine its angles, points, structure, and so on until the final layer makes a prediction about the identity of the image [36]. Image categorization and partition, Object Recognition, Video scrutiny, Natural Language Processing (NLP), and Voice Recognition are a few of the fascinating application areas of CNN. Deep CNN uses many feature extraction phases to automatically discover portrayals from the data, which contributes to its strong learning capabilities [36]. Refer to Figure 1.

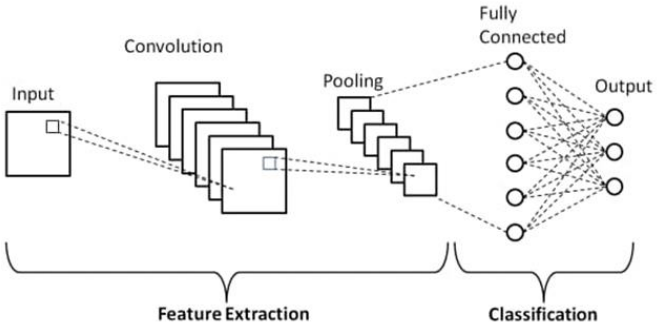

Figure 1: CNN Architecture

Current medical research in the area of dental disease detection with ANN is quite busy. The initial research published in the literature used ANN based on radiographs as an option for radioactive material caries (RRC) recognition, trying to predict RRC lesions with a 99.2% prediction performance [36,37]. This method indicates how more investigation on RRC detection and prediction could improve dental care for those with neck and head cancer (HNC). In their work, Li et al. [38] created a segmented structure for identifying areas with five common gum problems. The MobileNetV2, with Exception and DeepLabv3+ network serving as the mainstay, forms the foundation of the suggested semantic segmentation architecture. By adopting the recommended segmentation methods, most of the gum soreness regions can be accurately classified into 4 or 5 categories. Based on the proposed segmentation methods, the majority of the gum inflamed area may be appropriately separated into categories. The diagnostic method recommended in [39] includes statistical feature extraction, Laplacian over Gaussian Filter, morphological operations, window-based dynamic threshold, and backward-propagation neural network (BPNN).

Machine Learning Algorithms: The term "artificial intelligence" covers a wide range of subjects. AI is thought to include machine learning (ML) algorithms as a subfield. Support Vector Machine, K-means, AdaBoost, random forest, Bayesian network, and logistic regression are a few ML methods. The ML methods AdaBoost, random forest, and Bayesian network will all be reviewed. Also, the research has created an "enhanced AdaBoost algorithm," a new AdaBoost method [40,41]. Decision trees with a level of one are most frequently employed for weak learners. Decision stumps is another name for these decision trees. Because random forest offers many advantages over other machine learning algorithms and has been used extensively in analysis and regression, it is employed in a wide range of applications [39].

IV. METHODOLOGY

In this methodology, we recommend a deep learning method for assisting dentists in accurately diagnosing patients using panoramic dental CBCT images. The following examples highlight the paper's primary contributions:

1. To learn the semantic segmentation CNN, we manually annotate orthopantomographic radiographs.

2. Using a Convolutional neural network, we significantly split the panoramic radiographic into 2 categories that represent empty and non-empty teeth.

3. Used a variety of image processing techniques to identify and classify every tooth or cluster of teeth depending on the problem as well as the dental issue that is causing it.

4. We analyzed the proposed solution and compare it with other CNNs developed for the same purpose.

5. Applied a refining procedure to remove minor inconsistencies.

The proposed research shares out with the use cases of a CNN for identification, and dental implant detection. One of the popular applications of image processing is to identify the face in the image. Our system is a vital tool for suggesting implants based on empty tooth. Manually, it is much hard to detect and identify the implants. This system will help manual prediction to fritter away time and cost. [44]. It has the advantage of accurately identifying the empty tooth and suggesting implants. From the results observed in the studied research papers, we can conclude that CNN provides remarkable accuracy in recognizing the implants for different cases [45]. Based on the proposed research we have identified the stages of the dental implant system as per shown in Figure 2.

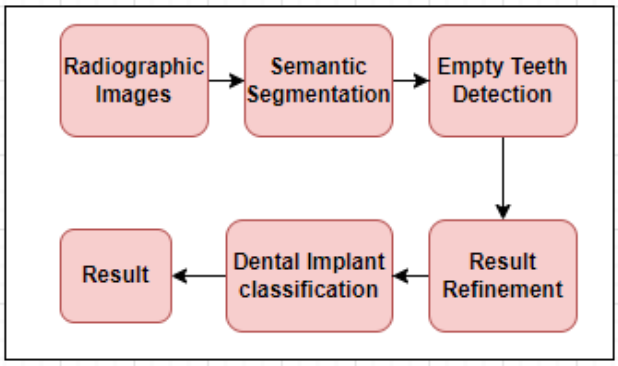

Figure 2. Stages of the dental implant system.

V. Future Scope

According to the findings of this study, AI models such as VGGNet-19, GoogleNet Inception-v3, as well as automatically generated DCNN structures have shown promising results in detecting and classifying fractured dental implants, with the automated Deep CNN infrastructure outperforming the others using only periapical radiographic X-ray images. More potential and clinical proofs, however, are required to define the viability of just using DCNN models in dental practice. The study also discovered that AI models created to identify implant type had an accuracy rate of between 93.8% and 98%, so even though models used to forecast osseointegration of implant success using various data inputs had an accuracy ranging from 62.4% to 80.5%. Furthermore, investigating learning methods could be critical steps toward enhancing AI models for restorative dentistry. Data set standardization and benchmarking may aid in the development of AI models as unambiguous data interpretation is critical in dental diagnosis. The future of dental research should centre on precision medicine, patient-centred results, and the integration of dental and general wellness of health. Dental research should have a societal impact, not just producing scientific papers, but research that can truly change clinical protocols.

VI. Research Gap

According to our findings, smaller or wider diameter implants have a higher failure rate, whereas longer implants have a greater rate of success. Success also depends on the operator's expertise and the height and quality of the available bones. As a result, meticulous case selection and the absence of systemic diseases contribute to an increase in implant survival rates. Additional long-term clinical studies are needed to assess the impact of various risk factors and implant diameter length on the success of diverse demographics. AI models are still in their infancy, despite their potential to distinguish between different types of implants, prediction of implant victory using patient peril factors, and enhance implant draft designs. Al models' utility and dependability should be confirmed before recommending them for clinical use, as their application in implant dentistry is explored significantly. The most advanced application of Artificial Intelligence in implant dentistry, according to the reviewed research, is implanted type detection using radiographic images. whose overall accuracy lies between 93.8% and 98% . The accuracy of the Al models employed in the studies to forecast implant or osteointegration effectiveness varied between 62.4% to 80.5% .

VII. Conclusion

The results of this systematic study led to the below conclusion: The proposed research deals with the methods of various technologies like CNN, ANN, and DCNN Machine learning models and techniques for predicting dental implant detection. The most effective application of image processing is to identify the objects in the image. The article reviews various vital tools for suggesting implants. Manually, it is much hard to detect and identify the implants. To minimize the time and cost consumed during manual prediction it helps us to compare the probability of getting accurate results based on various research and their achieved success rate. It has the advantage of accurately identifying the empty tooth and suggesting implants. From the results observed in the studied research papers, we can conclude that Convolution Neural Network results in remarkable accuracy in identifying the implants for different cases.

VIII. References

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