International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 05 Issue 09 September 2022
DOI: 10.47191/ijcsrr/V5-i9-18, Impact Factor: 5.995
IJCSRR @ 2022
www.ijcsrr.org

Artificial Intelligence - Future trend in Oral Diagnosis and Radiology

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ABSTRACT: Artificial intelligence in the medical field has gained an immense boost after successful trials in various fields. Artificial intelligence is computer science that is able to replicate human behavior. After its use in medical science, its use has been done in dentistry also. Artificial intelligence is adding new dimensions to dentistry. It has been used in the diagnosis of vital structures, anatomy, etc. This article reviewed the uses of artificial intelligence in the field of oral diagnosis.

KEYWORDS: Anatomy, Oral diagnosis, Vital.

INTRODUCTION

Artificial intelligence is a generic term that refers to carrying out human tasks using machinery and technology. "Barr and Feigenbaum" define AI as the area of computer science that deals with creating a smart computer system that demonstrates traits associated with intelligence in human behavior, such as language comprehension, learning, reasoning, problem-solving, and many more. [1] Machine learning and its related topics, including deep learning, cognitive computing, natural language processing, robotics, expert systems, and fuzzy logic, are subcategories of artificial intelligence (AI). Machine learning is a branch of artificial intelligence that improves automated learning without being explicitly programmed. Its main objective is to enable automated learning without human judgment. AI models use the current set of observations to forecast future events. [2]

Studies on artificial intelligence for the diagnosis of a wide range of disorders, including dental caries, periodontal disease, osteosclerosis, odontogenic cysts and tumours, and diseases of the maxillary sinus or temporomandibular joints, have been done in the field of OMF radiology. White at UCLA created an early form of artificial intelligence in the 1990s. The system he created was called "ORAD" in 1995. The ORAD II version of this system offers differential diagnosis for OMF disorders. [3] A user of the system can input the clinical and radiographic characteristics of a patient, and the system will subsequently offer a list of differential diagnoses. This system represents a pioneering effort in the use of artificial intelligence in diagnostic procedures.

To get the intended outcomes from artificial intelligence research, many elements need to be taken into account. First, a proper augmentation method is required to increase the volume of data because the creation of automatic interpretation systems utilising artificial intelligence requires a big number of data. Additionally, training data sets should be highly accurate and consistent, with little to no error. Otherwise, the artificial intelligence system's learning process won't be acceptable. Therefore, participation in these activities by OMF radiologists with the necessary experience is crucial. In the discipline of dentistry, radiographic imaging is particularly helpful for both making diagnoses and ensuring that treatment is done correctly. Radiographic images are statistically examined as part of treatment planning in implant, orthodontic, and oral surgery. In these sectors, artificial intelligence is quite useful. OMF radiologists continue to play a significant role in the research into artificial intelligence because they are experts who comprehend the fundamentals of radiographic imaging and have the skills to read radiographs and interpret them in terms of various diseases. OMF radiology is also one of the most promising areas for the advancement of dentistry.

The role of the radiologist as a diagnostician, which essentially entails two processes: radiographic assessment followed by interpretation, has drawn increased attention due to advancements in both radiology and AI. [4]

The ability to physically identify a picture and the perceptual ability to use object detection to distinguish between normal and abnormal are both included.

[5] It is difficult because the human perception of stimuli can occasionally overlook observations that lead to inaccuracies. Radiologist carelessness results in missed and delayed detection, which could have a negative impact on patient health.

The application of AI to radiology is said to enable not only more accurate image processing but also simpler and less expensive image retrieval in the new era of automated imaging repositories and electronic health record systems. The vast majority of current AI applications in radiology by far use the artificial neural network (ANN), which is both the most popular and effective technique.

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ANNs have advanced to become the most well-known AI system in modern medicine. [6,7] These computer frameworks simulate how the human brain functions. Among these are networks of closely coupled computer units that mimic the behavior of neurons, carry out simultaneous data processing operations, and incorporate intricate weighted links.
Many of the benefits that have made ANNs the most popular type of AI in radiology can be attributed to them. Through supervised learning, which compares the expected results, ANNs can be "used."It can also learn through unsupervised learning, in which the interpretation of and correlation with the input data change the weighting of their interactions.[7,8]
In spite of human advice, ANN will develop and expand on a case-by-case basis, providing increasingly more precise diagnoses over time through unsupervised learning. As a result, the ANN may extrapolate knowledge from straightforward situations in order to handle more complex ones. [7]
An algorithm specific to oral radiology might be developed to help detect and suggest the best course of action.
With a focus on patient data from digital scans and radiographs, AI is gradually advancing in the field of dental radiography. AI can be used to process more knowledge for quicker diagnosis and improved healthcare administration. [9]

Good clinical practice is based on the effective evaluation. In this context, appropriately trained neural networks may be useful for diagnosis, especially in illnesses with complex aetiology.
The neural network distinguishes and divides the main anatomical regions using radiological (X-rays, panoramic, and lateral cephalogram) pictures (jaws, teeth, etc).
By identifying (normal look, filling, crown, root canal, implant, periapical pathosis, etc.) and providing a likely range of diagnosis, this distinguishes between various diseases and illnesses.

Automated analysis using AI - From the huge number of available radiographs, the clinical expert analyses and prepares a specific dataset for the training set. An skilled physician or oral radiologist manually annotates the training data, and then the AI software is taught using those datasets to build an adaptive dataset. The testing dataset assesses the accuracy of the adaptive data set (a fresh set of radiographs not evaluated previously). Consequently, AI aids in the automated analysis of dental radiographs.
For automated teeth detection, Tuzoff et al. (2019) discovered a sensitivity of 0.9941 and a precision of 0.9945, but for tooth numbering, the sensitivity and specificity were 0.9893 & 0.9994, respectively.[10]

AI in Anatomic landmark detection
Convolutional neural networks (CNN) enable precise edge recognition, and edge-based, region-based, and knowledge-based methods are used to locate cephalometric landmarks. It can be used to find landmarks that are hard to see with the unaided eye because to low contrast, overlapping, or poor quality. Using knowledge-based algorithms and pixel-by-pixel elaboration, CNN aids in more precise anatomical detection. [11] As a result, automated analysis of dental radiographs allows for the precise delineation of landmarks. It can also be used in conjunction with CT and MRI to identify abnormalities from the norm in images that could otherwise go unreported. [12]

AI in dental caries detection - Using a series of bitewing radiographs, AI assists in identifying interproximal caries. For the identification of dental caries in bitewing, periapical, and panoramic radiographs, a pre-trained deep learning network can be used. [13] According to Lee et al. (2018), within 3000 dental radiographs, dental caries in premolars, molars, and both premolars and molars may be accurately identified in 89 percent, 88 percent, and 82 percent of cases, respectively. [14]

AI in periapical pathologies detection – A clinician's eye may occasionally miss periapical pathologies such as periapical cysts, granulomas, and abscesses, but AI can assist in their diagnosis. AI can provide proper detection by precisely locating the lesions' boundaries. With the right therapies, these technologies will aid in the early diagnosis of peri-implantitis in the future. [12]

AI in detection of bone loss - Radiologists will be helped by ANN to lessen cognitive bias and diagnostic efforts and further improve the periodontal pathology diagnosis accuracy. In the radiographic identification of periodontal bone loss, Koris et al. (2019) discovered that neural networks performed better in terms of diagnostic performance, with an accuracy of 81 percent, than individual physicians, who demonstrated an accuracy of 76 percent (P=0.067). [15]

AI in detection of oral cancer – AI can aid in the early detection of oral cancers. The prognosis for head and neck cancer may be improved thanks to ANN's assistance in detecting cervical lymph node metastases. Kim et al. (2019) discovered that deep learning

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enhanced cancer survival prediction, assisted professionals in deciding on better treatment options, and helped cut down on pointless treatment regimens. Int J Med Health Sci. Oct 2020, Vol 9; Issue 4 discovered that the accuracy of the training and testing sets was 81 and 78.1 percent, respectively. [16] The application of CNN improved the diagnosis of cervical lymph node metastases, according to Ariji et al. (2019). An accuracy of 78.2 percent, a sensitivity of 75.4%, and a specificity of 81.0 percent were achieved using a CNN image classification system as equivalent to those of skilled radiologists. [17]

According to C Park et al.'s[18] investigation of an artificial neural network system used to assess cervical lymph node metastasis of oral squamous cell carcinoma on MR images, the artificial neural network system was found to be more beneficial than any individual MR imaging criterion. In their investigation, the observer determined and entered into the system the imaging characteristics of lymph node metastases. For the identification of dental caries, periodontal disease, vertical root fracture, periapical pathosis, and cysts and tumors of the jaw bone, studies have looked into the use of deep learning. [19] Recently, Chang et al. [20] created an artificial intelligence system that integrated a deep learning architecture and the traditional method to automatically stage periodontitis on dental panoramic radiographs. In the automatic diagnosis of periodontal bone loss and staging of periodontitis according to the degree of alveolar bone loss, the computer-assisted diagnosis (CAD) approach has shown high accuracy and outstanding dependability. The fact that the learning process requires updated data based on precise readings from OMF radiologists is crucial for artificial intelligence investigations. However, because there are variations in observers' levels of expertise and experience, the diagnosis accuracy of dental caries depends on the observers' capacity. Therefore, the quality of the annotation data determines how effective artificial intelligence systems are overall. To get accurate results, researchers looking into artificial intelligence-based automatic readings must require fine-grained data, such as readings from qualified OMF radiologists.

Radiographic analysis: Dental image analysis utilizing AI has been used for a variety of tasks, including the evaluation of bone quality (osteoporosis), the evaluation of bone age using hand-wrist radiographs, and the localization of cephalometric landmarks. [21,22] In the dentistry industry, CNN-based deep learning systems have been deployed, and a system that combined 2D and 3D CBCT pictures were created. [21] Both CBCT and panoramic pictures have been used to detect and categorize teeth using deep learning. [23,24] By automatically populating digital patient records when teeth are identified using such methods, automated CAD outputs can assist dentists in making clinical choices and shorten charting times. [23,25]

Using panoramic radiographs to diagnose osteopenia and osteoporosis can help and the degree of erosion of the mandibular lower cortex as well as the reduction in mandibular cortical width (MCW) were used to assess osteoporosis in postmenopausal females. [26,27] The diagnosis of osteoporosis was carried out using artificial intelligence research using MCW and mandibular cortical erosion findings of panoramic radiography. [28,29]The clinical application of artificial intelligence models to diagnose osteopenia and osteoporosis is anticipated.

A study on a deep neural network for categorizing dental implant systems was conducted by Sukegawa et al[30]. The evaluation of five deep CNN modes led researchers to the conclusion that the well-calibrated VGG16 produced the best classification outcomes for dental implant systems. Several artificial intelligence models have been employed in cephalometric investigations. Early automated cephalometric analysis techniques were too inaccurate for clinical usage. [31] New algorithms were then created in order to increase accuracy. Researchers have been actively investigating 3D cephalometric landmark analysis utilizing CBCT images in recent years, [32,33] and they have discovered that the mid-sagittal plane landmarks are more reliable than the bilateral landmarks. [34]

Forensic dentistry: Because human dentition develops in a predictable order, forensic dentistry is frequently utilized for age estimation, sex determination, and person identification. Studies have looked into the information that can be gleaned from dental radiography of the teeth or the nearby bony structures. An automated dental identification method built on individual CNNs was introduced by Nassar and Ammar[35]. They employed bitewing and periapical pictures. For the purpose of recognizing teeth, Zhang et al. [36] introduced a label tree with a cascade network in 2018. They found that this method outperformed a single network by a wide margin. Teeth or their supporting structures in the oral cavity undergo developmental and degenerative changes over time, which can be used to estimate age. Instead of sectioning or extracting teeth to examine their structure, dental radiology-based technologies are advantageous because they are precise, non-invasive, and can be applied to both living and deceased people. Automated age estimation often entails a number of steps, such as picture pre-processing, segmentation, feature extraction, and classification, although the results might be influenced by observers. Deep learning algorithms, in contrast, don't need these extra steps, hence they have drawn greater interest than other artificial intelligence algorithms in autonomous techniques.

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Artificial intelligence is a promising method for solving the problem and enabling objective decision-making. Although artificial intelligence has mainly been studied for age estimation, future innovations in other domains will be highly useful.

CONCLUSION

AI appears to have a bright future as a tool that could "change the game" in oral radiology. An issue that has caused unease among the radiological communities worldwide as some radiological practitioners question whether AI can replace the requirement for qualified radiologists has emerged as a result of this unheard-of technological advancement in the field of radiological study.
As a result, AI software proved to be a competent second reader, while it was still limited by some significant, albeit modified, false positives. Future AI technologies may be able to rely on algorithms that are much more trustworthy and efficient, handle recall issues and high false positives, find anomalies in any imaging modality and even identify odd and difficult situations that would otherwise go unnoticed.

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Cite this Article: Dr. Debanti Giri, Dr. Piyush Dongre (2022). Artificial Intelligence - Future trend in Oral Diagnosis and Radiology. International Journal of Current Science Research and Review, 5(9), 3405-3409