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Artificial Intelligence In Oral Imaging

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Abstract
The fourth revolution "Artificial intelligence" (AI) has paved the way for all fields of medicine. The field of Dentistry is also influenced by this trend. Though the usage of AI is used in all the fields of dentistry, its application is particularly fastidious in orofacial radiology with gaining a remarkable role in diagnosis, analysis of the image, and forensics. Apart from these, AI also improves radiographic image quality. In the near future, AI is anticipated to undergo further development and establish diagnosis by itself, and fabricate treatment plans. We clinicians must have thorough knowledge regarding the role of AI in this field. Hence, the present review aims to provide a comprehensive overview of the role of AI in oral radiology, and aims to help dental professionals to understand the new tool which will become a part of their routine work in their future days.

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I. Introduction:

The present era we live in is called the "era of science". There has been a marvelous evolution in science with the development of digital technologies and Innovations. Nonetheless, these cutting-edge technologies being implemented into everyday life by integrating the greater technology "Artificial intelligence (AI)" has made us stand on the brink of the Intelligent Age.

AI has remarkably blossomed and sustained it's application sweepingly in almost all medical fields, including dentistry. This technology mimics human intelligence to perform complex predictions and enable decision-making in dentistry.[1] In recent years, AI models have been under development and investigated for in many actions such as identification of pathologies, diagnosis, and treatment evaluation. However, the integration of AI particularly to oral radiographic diagnosis has produced more accurate and straightforward results which can assist physicians. [2,3]

History Of AI

The first discussion about AI started in 1950 when Alan Turing proposed that machines can also do the same thing as humans and we can construct machines that can solve problems and make decisions. Later, in 1955, in the Dartmouth Summer Research Project, the term "Artificial Intelligence" was proposed.[4]

Though developments occurred in the next 30 years. In the 1980s, two paths of AI; machine learning (ML) and deep learning (DL) systems were developed.[5] Since then, AI has largely been used in all industries.However, in 2012, a breakthrough occurred with the development of a graphics processing unit (GPU)-implemented DL network with eight layers. In the last decade, AI like Alexa, Siri, ChatGPT, Gemini etc have become a part of day-to-day life even for common man.[6]

What Is Artificial Intelligence?

AI is a sequence of computational operations designed to imitate the cognitive and behavior patterns of humans, in short can be described as non-human intelligence. ML and DL are prominent types of computational AI algorithms. [7] Thus, ML and DL systems can learn over time which is appropriately based on experience. These two systems contrast in nature. ML let's the computers learn by training while expert systems simulate the process of decision-making as done by human.[5,8, 9]

Artificial neural network (ANN) is a type of DL. It is an extremely popular algorithm due to its high performance. The structure of ANN is composed of many small units called neurons that communicate with each other and are arranged in layers. convolutional neural networks (CNNs), a type of ANN, uses a special neuron connection architecture. It utilized a mathematical operation, convolution, to process digital signals such as sound, image and video. In medical imaging, CNNs are the most preferred and commonly used DL.[10,11]

AI In Oral Imaging

In oral radiology, CNNs are the commonly used models, which aim for classification, detection and segmentation. The task Classification is done by segregating based on determination of presence or absence of a disease; eg. to identify the presence of malignancy, type of malignancy, caries. Al based Detection can identify and localize regions with lesions or certain anatomical structures. Segmentation has been used to segment various anatomical structures or lesions in images obtained using various modalities, including plain radiography, CT, MR, and ultrasound images. [11-14]

Diagnostics

In radiology, AI has an outstanding role in the identification of the abnormal or pathology. Literature provides evidence that a properly trained AI model has sufficient capacity to reach or sometimes may even surpass human performance and abilities. Therefore, with this evidence, the application of AI can be considered for day-to-day use by providing a 'first pass' analysis that can save the radiologist's interpretation time by highlighting potential pathology in the radiographic images. Several DL models have investigated for diagnosis of dental caries, periodontal disease, vertical root fracture, periapical pathosis, cysts and tumors of jaw bone, cephalometric analysis, osteoporosis and stability of dental implants.[15-24]

The CNN models can detect and identify anatomical structures and pathologies. Hung et al (2020) [16] performed a systematic literature review search to investigate the diagnostic performance of AI in oral radiology. Interestingly, all the 50 included studies focusing on AI applications provided exquisite results of the investigated AI models for their application in radiology.

Shahidi et al (2014)[17] designed a model software using MATLAB programming language that could automatically locate w craniofacial landmarks on CBCT images. For training purposes, 8 CBCT images were used, while 20 CBCT images for testing. Overall, the mean deviation was less than 4 mm, which was acceptable. Blum et al [18] reported that compared to the experts, AI was 95% faster and 2.12% superior in detection of craniofacial landmarks in CBCT. Compared to conventional lateral cephalogram, It is more time-consuming and requires adequate experience to position anatomical landmarks in sliced CBCT images. Integration of AI in cephalometric evaluation is faster, and accurate.[19,20]

For detection of dental caries in IOPA radiographs by CNN models, Lee et al [21] used 3000 IOPA images (2400 for validation and 600 for testing). The diagnostic accuracies of premolar and molar models ranged from 82.0% to 89.0%. Lin et al [22] reported that in their model assessed 53% of the localized CEJs which were within ~ 0.15 mm deviation and 90% has less than 0.44 mm deviation.

Hwang et al [23] reported that the gray level co-occurrence matrix (GLCM) can identify osteoporotic and non-osteoporotic areas based on the endosteal margin area with an accuracy of 96.25%. Kavitha et al [24] proposed a new model based on a hybrid genetic swarm fuzzy (GSF) classifier which could identify osteoporosis in women with an accuracy of 96.01%. Apart from these, model have also been created to classify and diagnose oral mucosal lesions, oral and maxillofacial cyst, identification of root canal and periapical pathologies, implant osseointegration. [24-27]

Forensics

Forensic dentistry is widely used for age estimation, sex determination, and identification of unknown people because human dentition follows a predictable developmental sequence. Although radiographic findings of dental structures, including teeth, play an important role in forensic science, it is very time-consuming work and measurements are affected by the subjective judgment of observers. Evaluating medical images for forensic procedures by AI can be advantageous. Accurate and faster procedures can be done with integration of AI in forensic odontology.

De Tobel et al [28] developed an automated method "Transfer Learning" as a type of CNN based DL approach to estimate the age based on the development of lower third molar on OPG. Interestingly, the authors observed that overall performance of the model was almost similar to those done by humans. Khanagar et al [29] in their Systematic review observed that AI technology has promising results in forensics and recently has been widely applied in forensicsbfor bite-marks identification, determination of gender, estimation of age estimation and in assessing and predicting the morphology of mandible, teeth and other related structures.

Other applications

Models have been developed to improve the quality of the radiographic images by removing common errors such as blurring, metal artifact, noise, etc. CNNs based models can improve the blurring of radiographic images. Also, architectures like CNN and GAN have been implemented in Image denoising and image deblocking of CBCT and CT images. These implications subsequently improve the quality of the image with low dose or patient exposure. In recent years, AI has been utilized in reducing metal artifacts in CBCT images. A programme called Metal artifact reduction (MAR) which uses DL has been investigated for its efficiency to recover and replace artifacts by interpolation.[15, 30, 31]

Considerations In Artificial Intelligence

The foremost concern is the cost of development and training of the model. It is quite expensive to develop an AI model that can provide automated interpretation. To improvise the accuracy, a large amount of learning data and training data sets is mandatory. These training datasets should have minimal error to establish a high accuracy. Any inadequacy in the process of AI learning can significantly cause fallout in the accuracy. Hence, during the Al model development is rather time consuming and requires lots of efforts from the development team members.

To create a model, a well-organized team of experts with extensive experience in AI is necessary; therefore, for development of models with high success rate, the experience and ability of the engineers plays a huge role. Though the results of artificial intelligence readings are highly accurate, they are not completely reliable. This is because the output results of the AI are completely influenced by the appropriate and valid selection of the dataset that could establish a proper adequate training. Nonetheless, a final decision of the interpretation and diagnosis by a skilled professional like radiologists is considered mandatory.

II. Conclusion

In dentistry, Radiographs are very essential and necessary to arrive at an accurate diagnosis and to ensure apt treatment. The integration of the artificial intelligence into this important field can be significantly better helpful to the clinician in faster and more accurate diagnosis. However, there still exists a dilemma regarding the reliability of the diagnosis of the model and the oral radiologist will contribute a noteworthy role in AI-related research.

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