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MACHINE LEARNING IN GENERAL DENTISTRY AND ITS USE

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Abstract: AI is a powerful technology that can simulate human intelligence and perform complex tasks in various fields, including dentistry. One of the fields that can benefit from AI is endodontics, which deals with the diagnosis and treatment of the dental pulp and the surrounding tissues. AI models, such as convolutional neural networks and/or artificial neural networks, can be used for different purposes in endodontics, such as analyzing the root canal anatomy, predicting the survival of dental pulp stem cells, determining the working length, detecting root fractures and periapical lesions, and estimating the outcome of retreatment procedures. AI can also have potential applications in other aspects of endodontics, such as scheduling, patient management, drug interactions, prognostic diagnosis, and robotic endodontic surgery. AI has shown accuracy and precision in endodontics, especially in disease detection, assessment, and prediction. AI can help improve the quality and efficiency of endodontic diagnosis and treatment, which can lead to better endodontic outcomes. However, before implementing AI models in clinical practice, it is still necessary to further evaluate their cost-effectiveness, reliability, and feasibility.

Keywords: Electronic brain, deep learning artificial intelligence, convolutional neural networks (cnn), ai, cnn, ann, artificial neural network, applications of ai, artificial intelligence in dentistry, artificial intelligence.

Introduction and background

The brain, one of the most intriguing and complex organs in the human body, has always been a subject of curiosity and exploration for scientists and researchers. Despite many attempts, the scientific community has not been able to develop a perfect model that replicates the human brain [1]. For decades, scientists have been striving to advance the field of "artificial intelligence" (AI), which was first proposed by John McCarthy in 1956 as a branch of applied computer science [2] [3]. AI is sometimes also referred to as machine intelligence [2]. AI is considered to be the "fourth industrial revolution", as it uses computer technology to emulate cognitive processes, decision-making, and intelligent behavior that are similar to those of humans [3].

AI research in computer science involves the study of an intelligent agent, or any machine that perceives its environment and acts in a way that maximizes its chances of achieving its goals. The term "AI" is applied when the machine mimics cognitive functions, such as "learning and problem-solving", that humans often associate with other human minds [4]. AI techniques have shown great potential and ability in identifying relevant data patterns, leading to extensive experiments with them as clinical trial tools, especially to assist in decision-making for prognosis and prediction, as well as each stage of diagnosis and subsequent treatment [4]. AI has proven to enhance accuracy, efficiency, and precision at a level comparable to medical experts in a faster and cheaper way [3].

Artificial intelligence is already affecting our daily lives through various software tools for office and practice management. We can also interact with devices, applications, languages, and environments using intelligent conversational user interfaces powered by artificial intelligence, such as Siri and Alexa [4]. In health care, both virtual and physical forms of artificial intelligence

are relevant. The virtual form involves mathematical calculations for medication dosage, diagnosis and prognosis, appointment scheduling, drug interactions, electronic health records, and imaging. The physical form includes rehabilitation, telepresence, robotic assistance in surgery, and companion robots for elderly care [3].

Most dental applications use supervised learning, where the training data consists of many samples with different features or attributes (such as patient photos, gender, age, number of cavities, etc.) and a ground truth label (e.g., whether the patient had a previous endodontic visit or not) [3]. Artificial neural networks (ANNs) are algorithms that mimic the biological system of neurons and their connections that are involved in "learning". They help the algorithm to understand the relationship between the features and the ground truth [3].

Artificial intelligence (AI) is a powerful tool that can help solve various clinical problems and improve the efficiency and quality of medical and dental services [3]. The dental field has not yet fully adopted AI applications, but some areas have already benefited from its use, such as robotic surgery, image analysis, caries detection, radiology and pathology, and electronic records management [3]. Endodontics is one of the dental specialties that has seen an increase in AI research, which requires endodontists to update their knowledge and skills [3]. This review aims to present the current literature on the use of AI in different dental domains, with a focus on endodontics, for diagnosis, clinical decision making and prognosis prediction, as well as to identify any existing challenges or limitations in the implementation of AI.

Review

Artificial intelligence, a major invention that imitates human cognitive capabilities, has attracted the interest of researchers worldwide [5]. The key element of artificial intelligence technology is a neural network that mimics the structure and function of human brains, which can also emulate human reasoning. This type of brain architecture consists of densely connected neurons, which mainly operate as a data processing system to solve a specific problem [6]. It is a fast-growing technology that enables machines to perform tasks that were previously exclusive to humans [7]. Lately, it has been applied to dentistry, which has led to remarkable outcomes [5]. AI is an effective method for analyzing clinical dental data [8]. AI innovations suggest potential benefits for health care, such as lower postoperative complications, improved quality of life, better decision-making, and much fewer unnecessary procedures [7]. One of the most fascinating aspects of artificial intelligence (AI) is its capacity of a computer to demonstrate its own intellect through the resolution of issues using data [9]. AI relies on various methods and techniques to achieve this goal, such as machine learning, neural networks and deep learning. Machine learning is a branch of AI that involves methods used to predict results out of a data set. Making it easier for machines to acquire data already available and resolve problems without human intervention is the goal [9]. Neural networks are another technique that use artificial neurons and compute signals which execute similarly to that of the human brain [9]. Deep learning is a subset of machine learning that has numerous computational layers that create a network of neurons that identifies patterns on its own thereby improving detection [5]. Data science is a related field that involves a process of analysis of data and extraction of information from the analyzed data [10]. Data science often uses big data, which refers to analyses a huge amount of data that is steadily expanding in the right direction over years to give consumers correct information [11]. These concepts are essential for understanding the current and future developments of AI and its applications. AI, or Machine Intelligence, is a type of technology that mimics the way machines work. It follows the basic machine structure of Input, Processing, and Output [13]. In the field of dentistry, the input data can be of different types, such as sound data (handpiece noises), text

data (medical or treatment records, experimental parameters), or image data (spectral or radiographic images, photos). The input data is then processed by neural networks, which are complex mathematical models that can learn from data. The output of the neural networks is a result that can be useful for dental practice. For example, the result can be a diagnosis, a treatment plan, or a disease prediction. AI can analyze clinical signs, perform cephalometric analysis, or detect lesions based on voxel differences to make a diagnosis. AI can also suggest a treatment plan based on the input data by identifying the normal structures, simulating and evaluating the outcomes, converting the sound data, or linking data acquisition and CAD/CAM. Moreover, AI can predict the disease or its prognosis by analyzing genes, ranking risk factors, or forecasting outcomes.

Applications of artificial intelligence in endodontics.

Endodontics is a field that can benefit from the advances of artificial intelligence (AI) [14]. AI can help endodontists to plan and execute treatments, as well as to diagnose diseases and monitor their outcomes [15]. AI can also detect and analyze small differences in images that may be missed by the human eye, which can indicate endodontic problems or changes [16]. AI-based networks can work at the pixel level to identify variations that may be relevant for endodontic diagnosis and prognosis [16].

Periapical Lesions detection.

Periapical lesions are a common dental problem that can affect the health and function of the teeth and surrounding tissues. They are usually caused by apical periodontitis, an inflammatory condition of the root apex that results from bacterial infection [17]. About 75% of radiolucent jaw lesions are attributed to apical periodontitis [17]. Early detection and treatment of periapical lesions are important to prevent further complications and damage to the oral structures [18]. The most commonly used 2-dimensional imaging techniques for diagnosing periapical lesions are intraoral periapical (IOPA) and orthopantomogram (OPG) radiographs [3]. However, these methods have limitations in accurately depicting the 3-dimensional anatomy of the lesions and their relationship with adjacent structures [19]. Cone-beam computed tomography (CBCT) is a 3-dimensional imaging modality that can overcome these limitations and provide more reliable information about the presence, location, and size of periapical lesions [3]. A meta-analysis showed that CBCT had a higher accuracy score (0.96) than conventional IOPA (0.73) and digital IOPA (0.72) for detecting periapical lesions [20].

Root Fractures Detection

Vertical root fractures (VRFs) are a serious dental problem that can result in tooth loss or surgical intervention. They account for 2% to 5% of all crown/root fractures Diagnosing VRFs can be difficult, as they may not show clear signs or symptoms. Therefore, advanced imaging techniques such as cone beam computed tomography (CBCT) and radiographs are essential for detecting VRFs and avoiding unnecessary treatments [3]. Several studies have explored the use of machine learning methods, such as convolutional neural networks (CNNs), to enhance the accuracy and efficiency of VRF detection.

In Dental Education

AI-based intelligent tutoring systems have made great progress since their inception in the 1980s. They can create realistic scenarios that simulate clinical practice on patients and reduce the risks associated with training on a live patient. AI is widely used in dental education for this purpose. The virtual patient feedback to the students is greatly enhanced by these systems. The interactive interface provides high-quality learning environments by enabling students to evaluate their work and compare it to the optimal solution. Several studies on the effectiveness of these systems have demonstrated that students achieve a higher level of skill competency with these systems than with traditional simulator units.

For Diagnosis, Treatment, and Prognosis

Artificial intelligence can play a helpful role in diagnosing and treating diseases of the oral cavity, as well as detecting and classifying suspicious changes in the mucosa that may indicate premalignant or malignant conditions. Artificial intelligence can capture subtle differences at the pixel level that may escape human vision. Artificial intelligence may also be able to predict the genetic risk of oral cancer in a large population [1]. An AI-based machine learning system can be a valuable tool for assessing dental prognosis in relation to the treatment plan. A comprehensive treatment plan should be carefully evaluated to determine the long-term oral health and function of a tooth.

In Oral and Maxillofacial Surgery

The most prominent application of artificial intelligence in oral surgery is the development of robotic surgery, which mimics human body movement and intelligence. Robotic surgery can perform procedures such as dental implant, tumor and foreign body removal, biopsies, and temporomandibular joint (TMJ) surgery with image guidance. Comparative studies of oral implant surgery show significantly higher accuracy compared to the freehand technique, regardless of the surgeon's experience level. Moreover, there was no noticeable difference between experienced surgeons and trainees. Generally, shorter operation time, higher intraoperative precision, and safer manipulation around sensitive structures have been reported. Image guidance can also enable more complete surgical resection, potentially reducing the need for revision surgeries [1]. AI has transformed the field of surgery, enabling robotic surgeons to perform semi-automated operations under the guidance of a trained surgeon.

AI has revolutionized the field of forensic odontology, which is the application of dental science to legal investigations. AI can help forensic odontologists to estimate the age and sex of living or deceased individuals, based on their dental features. AI can also assist in comparing and matching bite marks left on victims or objects with the dentition of suspects.

Impact of artificial intelligence on dentists

AI has generated a lot of discussion about how it can transform dentistry, but there are still doubts about whether it will ever fully replace dentists. Dentistry that is done by machines and without human interaction is not clinical care. Machines cannot offer clinical judgment, subtle perception, or compassion, which are vital for providing personalized healthcare and professionalism. The most captivating aspect of human-to-human communication cannot be easily encoded into computer language [13].

The AI models we have developed show great potential for various dental applications, but they still need to be validated with external data from different sources and settings. We also want to explore how AI can help us detect lesions that are too subtle for human eyes to see [21].

Conclusions.

In conclusion, artificial intelligence technology has shown great potential in endodontics, especially in diagnosis, treatment planning, and outcome evaluation. However, AI cannot replace the human factor in dentistry, as it lacks the ability to form complex associations, make ethical judgments, and empathize with patients. Therefore, dentists should use AI as a supportive tool that enhances their clinical skills and improves their patient care.

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