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Artificial Intelligence in Dentistry: A Literature Review

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ABSTRACT

Advancements in the field of technology has led to the development of newer application-based artificial intelligence (AI) technology that have been widely used in dental and medical sciences. AI-technology has been employed in a wide range of applications related to the diagnosis of oral diseases that have demonstrated phenomenal precision and accuracy in their performance. AI technology has influenced the healthcare field because of the need for accurate diagnosis and superior patient care. The present review aims to discuss the role of AI in various fields of dentistry and what the future holds for this upcoming technology.

Keywords: Applications; Artificial Intelligence; Dentistry; Neural Networks

Abbreviations: AI: Artificial Intelligence; NNs: Neural Networks; CNN: Convolutional Neural Networks; ANN: Artificial Neural Networks; ANI: Artificial Narrow Intelligence; AGI: Artificial General Intelligence; ASI: Artificial Super Intelligence; CBCT: Cone Beam Computed Tomography; 3D CNN: 3D Convolutional Neural Networks

Introduction

The term "artificial intelligence" was coined in 1956 at a conference in Dartmouth by John McCarthy. Machine learning, neural networks, and deep learning are subsets of artificial intelligence. Machines can learn through data to build algorithms and in this way, they can solve prediction problems without human help. Neural networks (NNs) use artificial neurons that are like human neural networks and mimic the human brain in a mathematical model. NNs can simulate human cognitive skills like problem solving and human thinking abilities to name a few, which includes both learning and decision making. Neural networks basically have three layers: input layer (where information enters the system), hidden layer (where data are processed), and output layer (where the system decides what to do) [1]. The most used types of neural networks are artificial neural networks (ANN), convolutional neural networks (CNN), and recurrent neural networks. Deep learning is a part of neural networks where the computer learns on its own how to process the data. Deep learning neural networks have between a few thousand and a few million neurons in the hidden layer [2,3].

AIs are commonly categorized into three types: artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial super intelligence (ASI). ANI, known as weak AI, possesses narrow abilities suitable for very specific tasks. These systems do not perform outside the single task for which they are designed [4]. For clinical purposes in dentistry (e.g., cone beam computed tomography (CBCT), 3D convolutional neural networks (3D CNN)) is more suitable for

more complex AI implementations. These are frequently applied even in interdisciplinary fields, such as forensic dentistry. AGI known as "strong" or "deep AI" is about as capable of solving problems as a human [5]. ASI will exceed human capabilities and will be able to learn and improve itself beyond our comprehension [4]. Artificial intelligence is also spreading in dentistry due to the technological advancements and digitization of dentistry. Dental second opinions can now be made by computers in many dental fields. NNs in dentistry can be used to make the process of diagnosis more accurate, rapid, and efficient. Fast development and new studies related to neural networks in dentistry were the reason to provide this narrative review. The aim of this study was to outline the different applications of neural networks in modern dentistry.

AI in Conservative Dentistry

Dental caries is the most common dental disease. For screening and diagnosis of dental caries, dental probes are most used. This is aided by observation of the texture and discoloration of tooth structure based on which one can determine whether the tooth is sound or not. Nevertheless, this method is very subjective and is based on the dentist's experience. In particular, the proximal surfaces may be problematic in dental examination [6]. Neural network use in conservative dentistry has developed quickly. Algorithms can be used to locate the edges of anatomical and pathological structures, which might be very similar to each other due to the image noise and low contrast [7]. In a study done by Geetha et al., an artificial neural network was used to determine whether there was caries or not in the 105 radiograph images. They extracted sixteen feature vectors from the segmented image, and these were the input nodes. There were two output nodes that consisted of caries or sound tooth. The accuracy of caries detection was 97.1%, and the false positive rate was 2.8%. This study indicates that neural networks may be much more precise in tooth decay detection than traditional dental examination [8].

AI in Endodontics

AI can be useful in detecting periapical lesions and root fractures, root canal system anatomy evaluation, predicting the viability of dental pulp stem cells, determining working length measurements, and predicting the success of retreatment procedures [9]. Apical periodontitis is an inflammatory process mainly caused by the bacterial infection of the root canal system. It may be detected through radiographic diagnostics and manifest as periapical translucencies that are also named periapical lesions. To reveal periapical translucencies, most are taken as periapical or panoramic radiographs and cone-beam computed tomographic images. Setzer et al. in their research used deep learning to detect periapical lesions on cone-beam computed tomographic (CBCT) images. The accuracy of finding the lesions was 93% [10]. AI technology has also proven to be very efficient in comparison to periapical radiographs in diagnosing vertical root fractures on CBCT images [11].

AI in Orthodontics

Artificial intelligence is spreading widely in the field of orthodontics. Li P et al. used an ANN in their study to predict whether patients need extractions or not in their treatment plan. Moreover, they took the anchorage patterns into consideration. The accuracy of the artificial neural network in the success of the treatment plan was 94.0% for extractions and 92.8% in the prediction of the use of maximum anchorage. These results indicate that ANN can be used by orthodontists to make more precise treatment plans [12]. In addition, ANN may help in the determination of the growth and development periods. In the research by Kök H et al., the cephalometric and hand-wrist radiographs were obtained from patients aged between eight and 17 years. The growth-development periods and gender were determined from the cervical vertebrae by using ANN and the accuracy value of the results was found to be 94.27% [13].

AI in Periodontics

Periodontitis is a widespread disease that concerns billions of people worldwide and if untreated, leads to tooth mobility and in severe cases, to tooth loss [1]. Krois et al. evaluated panoramic radiographs with the help of convolutional neural networks to detect periodontal bone loss in percentage of the tooth root length. The results were compared with the measures made by six experienced dentists. The CNN had higher accuracy (83%) and reliability than the dentists (80%) in detecting periodontal bone loss [14]. Peri-implant bone loss can be detected on dental periapical radiographs, but the difficulty is that the margins of bone around the implants are usually unclear, or the margins can overlap. For this reason, convolutional neural networks can assess the marginal bone level, top, and apex of implants on dental periapical radiographs. In the study by Jun-Young Cha et al., the bone loss percentage was calculated and classified by the automated system. This method can be used to assess the severity of peri-implantitis [15]. Assessment of the condition of teeth hard tissues, the level of oral hygiene, and the evaluation of psychophysiological features with the use of neural networks can effectively predict the risk of periodontal disease development in young people [16].

AI in Oral Surgery

Neural networks may be widely used in dental surgery. Extraction of the lower third molar is one of the most popular dental surgery procedures. The paresthesia of the nerve after mandible wisdom tooth extraction is quite a common complication [1]. In Byung Su Kim et al.'s work, convolutional neural networks were used to predict whether third molar extraction may lead to paresthesia of the inferior alveolar nerve. The panoramic images were used before the extraction and the anatomical relationship between the nerve canal and dental roots was used by the CNN to predict the occurrence of nerve paresthesia. However, the authors concluded that two dimensioned images as panoramic radiographs may lead to falser positive and false negative results [17]. Other applications for AI in maxillofacial surgery include

predicting results and planning orthognathic and craniofacial surgical procedures (i.e., after skeletal trauma) with the use of digital imaging, photographs, 3D photography and intraoral scans [18].

AI in Prosthodontics

Prosthodontics today make use of every aspect of digital dentistry. AI is used during the scanning process to automatically remove excess soft tissues and material [4]. Artificial intelligence can also be used to predict debonding of CAD/CAM restorations based on die images [19]. In removable prosthodontics, dental arches can be classified with the use of CNN [20]. AI can help with precise shade matching [21]. Various manufacturers provide software that uses AI to facilitate the smile-designing process [22].

Conclusion

Dentistry is a field of medicine where new technologies are developing very quickly. Nowadays, artificial intelligence and neural networks are mostly used to facilitate diagnosis, treatment planning, and prediction of the treatment results. artificial intelligence has developed very fast in recent years, and it may become an ordinary tool in modern dentistry soon. The advantages of this process are better efficiency, accuracy and precision, better monitoring, and time saving. More research is needed with the use of neural networks in dentistry to put them into daily practice and to facilitate the work of dentist.

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