



Artificial Intelligence Driven Orthodontics: A Review

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Abstract

In this ever-evolving world, artificial intelligence (AI) has brought revolution in the field of Orthodontics. AI not only enhances human intelligence, but also increases the precision. With constant studies and discoveries in AI, Orthodontic diagnosis and treatment planning has been improving. AI not only solves a wide variety of clinical problems and improves diagnosis, clinical decision-making and error prediction, but also reduces chairside time and avoids various additional steps of traditional methods. It can provide accurate and precise high-quality treatment. Therefore, this article focuses on what AI has to offer us.

Keywords: Artificial Intelligence, Artificial Neural Network, Convolutional Neural Network, Deep Learning, Machine Learning, Orthodontics.

Introduction

Mathematician John McCarthy coined the term artificial intelligence in 1955 and is widely regarded as the father of artificial intelligence. He chose the term to describe the machine's ability to perform tasks that might fall into the realm of "intelligent" work.[1] Artificial intelligence is the ability of machines to have their own form of intelligence. AI enables machines to learn from data and solve problems on their own.[2]

Machine learning (ML) is the key to AI. It relies on algorithms to predict outcomes based on datasets and is influenced by many research areas. The aim is to make it easier for machines to learn from data so that they can solve problems without human intervention. Some of the most commonly used ML techniques include Support Vector Machines (SVM), Logistic Regression (LR), and Naïve Bayesian

classifiers, decision trees (DT), random forests (RF), extreme learning machines (ELM), fuzzy k-nearest neighbors (FKNN), convolutional neural networks (CNN). [3,4]

Neural networks are set of algorithms that compute signals by artificial neurons that try to mimic human neurons. Deep learning is an integral part of ML that analyses input data using networks with different computational layers of deep neural networks. The goal is to build a neural network that can automatically recognize patterns. [3,4] Big data refers to large data sets and/or combinations of all. Available data points from multiple sources are used to recognize patterns that inform custom experiences for different people.[5]

Convolutional Neural Networks (CNNs) are increasingly used in medical imaging. Most commonly used to identify, segment, or classify anatomical structures. Deep

learning has also recently been used to learn and classify geometric features.[6] Machine learning approaches, or algorithms trained to recognize patterns in large amounts of data, are ideal for facilitating data-driven decision-making.[7]

Over the past few decades, our profession has undergone major changes. The introduction of new and more aesthetic options in orthodontic treatment, the move to fully digital workflows, the emergence of temporary fixation devices, and new imaging technologies provide a new focus for both patients and professionals.[5] The use of artificial intelligence (AI) in orthodontics has made the diagnostic process more exact and efficient. This knowledge is fundamental for predicting treatment prognosis.

However, the addition of this AI knowledge does not change the fact that healthcare professionals are leveraging their own knowledge gained through specialized training. AI applications help clinicians make better decisions and improve performance. AI results are highly accurate and therefore, human error can be prevented in some cases.[8] Orthodontic treatment is usually a time-consuming procedure and using ML technology can solve this problem.[9] Therefore, this review article aims to study about artificial intelligence and its influence in the field of orthodontics.

Discussion

Artificial Intelligence has been expanding its territory in healthcare field. With constant evolution, the utility of Artificial Intelligence in the field of Orthodontics is widely increasing.

AI and Studying Growth and Development-
As reported by Flores-mir et al, the timing of pubertal development determines growth

rate and primarily estimates an individual's residual growth and development potential.[10] These are usually determined by the application. With the help of radiographs of the wrist, cephalometric analysis and maturation stages of the cervical spine. AI technology is also used for discrimination Growth and development by cervical stages. Kok H et al used an artificial intelligence algorithm to show that his average accuracy of determining growth and development by cervical spine stage was 77.02% when applied to cephalometric radiographs. [11]

AI and Cephalometric analyses-

Various studies are being conducted to demonstrate AI Techniques and their applications in identification of cephalometric landmarks. Park et al compared the efficiency and accuracy of state-of-the-art deep learning algorithms to automatically identify cephalometric landmarks using cephalometric radiographs. [12] The results showed that the system was highly accurate in calculating landmarks. Studies conducted by Kunz et al and Hwang et al showed excellent accuracy in identifying landmarks. [13,14] They trained human inspectors using specialized artificial intelligence (AI) and deep learning algorithms, respectively, automatic identification systems. Yu et al showed excellent results in automated skeleton classification using lateral cephalometry based on AI models. The results of the above studies show that these systems have proven viable option to repeatedly identify multiple cephalometric landmarks. [15]

AI and orthodontic extraction-

AI technology was applied to determine whether tooth extraction was necessary before orthodontic treatment. In a study by

Xie et al, Artificial Neural Network (ANN) model was applied to determine if extraction was necessary using lateral cephalometric radiographs. The results were very promising. [16] Jung et al demonstrated 92 percent accuracy using an AI expert system to determine extraction of permanent teeth using lateral cephalometric radiographs. [17] The results of both studies suggests that the AI mode was effective and accurate in predicting extraction needs. These models can be used as decision support in clinical practice. High accuracy was noted in his study by Thanathornwong, who proposed an AI model based on a Bayesian network (BN) to assess the need for orthodontic treatment.[18]

AI and Surgical Orthodontics-

Orthognathic surgery is the most critical step for the patient. [18] Arnet et al noted that inaccurate diagnosis may lead to serious problems and compromised facial esthetics of the patient. This shows importance of accurate diagnosis for patient's problem. AI technology strives to make the dentist's work highly accurate and precise. [19]

Choi et al reported a new artificial intelligence model to determine surgical/non-operative cases based on lateral cephalometric radiographs. He has shown that the system is highly effective in diagnosing surgical/non-surgical cases. This model has shown promising results and can be applied to the diagnosis of orthognathic surgical case. [20] Recently, AI has shown to have great potential in mandibular prediction and face reconstruction. [21]

AI and Orthodontic retention-

AI can help monitor retention, manufacturing a wide variety of retainer materials and a digital workflow for designing individual retainers. AI-based

Dental Monitoring software (Paris, France) was introduced to monitor mid – treatment follow ups, retention protocols, including factors such as stability, retainer adjustment issues, and maintenance of oral hygiene. The software uses intraoral photographs taken with the patient's smartphone and helps patient to follow instructions for retainer use. [22-24] Advances in digital technology have made it possible to manufacture retainers using digital workflows. Individual nickel-titanium retainers can be digitally planned based on intraoral scans of the teeth. It is then precision manufactured using a Computer-Aided Design and Computer- Aided Manufacturing (CAD-CAM), process to ensure a snug fit to the palatal and lingual surfaces of the tooth. [25] A clear plastic retainer have been created using a 3D printed model created from an intraoral scan. They are as accurate as retainers made with traditional impressions. [26,27]

After going through all the utilities, the undeniable fact is, artificial intelligence can enhance human intelligence but can't replace it.

Conclusion

AI has revolutionized oral health and orthodontic treatment by addressing the weaknesses of conventional diagnostic and treatment planning methods. AI-based algorithms help orthodontists make better diagnoses and treatment plans, and helps create custom orthodontic appliances with precision.

AI not only solves a wide variety of clinical problems and improves diagnosis, clinical decision-making and error prediction, but also reduces chairside time and avoids various additional steps of traditional methods. AI can play an important role in

expanding the reach of orthodontic state-of-the-art technology and assisting practitioners to deliver healthcare in the 21st century.

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