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Review Article

Current state and trajectory of artificial intelligence in dentistry: A review

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ABSTRACT

Artificial intelligence to a limited extent is science and engineering engrossed with the study of intelligent behaviour using computers and performing tasks which usually assumed can only be performed by human beings as well as the design of products that display this action. It is making waves in dentistry as exponential amount of digital data is available, note worthy progress in hardware performance, as well as significant advancements in algorithmic and software approaches, the current abilities of this technology is unparalleled. Its applications are diversifying into domains that were exclusive to human specialist and include medical and dental imaging diagnostics, decision making assistance, digital medicine, drug discovery, wearable technology, medical surveillance, robotic and digital assistants. The aim of this review is to define artificial intelligence, its benefits in dental field and its potential risks to community.

1. Introduction

One of groundbreaking revolution in technology of new digital era is artificial intelligence. Spectacular development, expansion and growth have been found in field of artificial intelligence over brief period of time.[1] Many electronic devices have been launched which aide in recording data in a comprehensive manner and made it possible to easily use and analyse the data coming from those electronic devices by artificial intelligence. It is the replication of cognitive abilities of humans by computer systems and embraces reasoning, learning, processing and display of information.[2] For improving patient care, healthcare services & convenience to doctor's use of valuable and innovative technologies like artificial intelligence have been integrated into medicine and dentistry.[3] These fields have undergone a rapid digitalization process with digitized data acquisition, machine learning and computing infrastructure. Studies pertaining to this technology began in 1943, but the term "artificial intelligence" was coined by John McCarthy in 1956 at a conference in Dartmouth.[4] Deep learning technologies can be applied to the interpretation of medical images in a number of ways, including categorization, entity recognition and contextual segmentation. Artificial intelligence implies essential technologies including

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machine learning, artificial neural networks and deep learning.[5] Neural networks are neuromorphic networks that can be regarded as the pillars of deep learning procedures. There are different versions of neural networks among which the most important types of neural networks are artificial neural networks, convolution neural networks and generative adversarial networks. Artificial neural network encompasses a group of neurons and layers. This model is a basic model for deep learning, consisting of a minimum of three layers. The inputs are worked on the forward direction only. Input neurons retrieve features of input data from the input layer and transmit data to hidden layers and the data goes through all the hidden layers successively.

Eventually, the results are synopsized and displayed in the output layer. All the hidden layers in network can weigh the data obtained from pre-existing layers and make amendments before sending the data to the next layer. Each hidden layer acts as an input and output layer, allowing the artificial neural network to understand more complex features. Convolutional neural network is a type of deep learning model mainly used for image recognition and generation. The mean difference between both variations is that later consists of convolution layers, in addition to the pooling layer and the fully connected layer in the hidden layers. Convolution layers are used to generate feature maps of input data using convolution kernels. It is typically categorized into three types: artificial narrow intelligence, artificial general intelligence, and artificial super intelligence. In medicine and specifically in dentistry, an expanding amount of applications in this technology are in progress.[6]

2. Discussion

Artificial intelligence holds potential to transform oral health care by aiding in rectifying shortcomings that have been strongly censured in traditional dental care. It has varied applications in various branches of dentistry leading to improved clinical diagnosis and decision-making performance. The bright prospects of artificial intelligence in endodontic and restorative dentistry are for sure.[7] It is in budding stage and there is probability that revolution will come in restorative dentistry by end of this decennium.[8] Applications include detection of dental conditions such as dental caries, periapical lesions, atypical variations in root canal morphology, detection of apical foramina, post operative pain using root canal treatment and to minimize failures related to morphological difference while during root canal treatment.[9] It enhances diagnostic accuracy, improving treatment planning and predicting treatment outcomes. Failure of restorations can be analyzed by artificial intelligence factors such as the type of restoration, patient characteristics and oral health status.

Chemical stability, resistance to abrasion, and flexure strength in restorative dentistry also can be examined using artificial neural network.[10] Its application in oral surgery includes prediction of difficulty of extraction of mandibular third molars, facial swelling following impacted mandibular third molars extraction, relationship of teeth and adjacent vital structures & to predict facial morphology after orthognathic surgery.[11] Its application in oral radiology includes automatic detection of variety of benign and malignant lesions and conditions associated with teeth, jaws, maxillary sinus, salivary glands, temporomandibular joint through deep learning with higher sensitivity while doing radiographic interpretation.[12] Traumatized or cracked teeth is the third most common reason for tooth loss. Prompt diagnosis and care can salvage a cracked tooth and help in preserving it. However, cracked teeth often present with discontinuous symptoms, making their detection problematic. Conventional techniques, such as CBCT and intraoral radiographs, have low sensitivity and clarity where as models working on principle of artificial intelligence are capable of detecting, quantifying, and localizing cracked teeth using high-resolution. It also aids in determining the developmental stage of mandibular third molars, supernumerary roots on panoramic radiographs. Oral cancer is the sixth most common malignancy worldwide. Early recognition and intervention can lead to a better prognosis and a better survival rate. Artificial intelligence can aid in early diagnosis and decrease the mortality and morbidity associated with oral cancer and also distinguish leions through laser-induced autofluorescence spectra recordings. This novel technology can also help by recurring reminders for patients on tobacco or smoking cessation programs. From view point of oral pathology it is used to distinguish two tumors with similar radiologic appearance but different clinical properties.[13,14]

Its application in prosthodontics includes enhancement of design of dental implants through refining and improving the structural and material aspects for better longevity, for maximum fatigue fracture resistance and to minimize micro strain in the adjacent bone.[15] Artificial intelligence also helps in deciding correct locations for implant placement through intraoral scanners can directly import them in CAD software. It also enhances efficiency of scanning process to automatically remove excess soft tissues and flabby material.[16] In fixed prosthodontics intraoral scan is obtained for margin detection and it is modified through artificial intelligence. Best possible crowns can be obtained through digitization in form of computer-aided design/computer-aided manufacturing (CAD/CAM) along with artificial intelligence. It procures precise design for manufacturing of fixed and removable dental restorations and also predicts debonding based on die images. Classification of dental arches for fabrication of removable prosthodontics can be done by artificial intelligence. It is consistently a difficulty for the dental technician to set up denture teeth in edentulous patients

to meet both functional and aesthetic requirements.[17] A well balanced occlusion can be obtained through artificial intelligence by creating precise intermaxillary relations by precise teeth arrangement. It also helps in aesthetic of patient with precise shade matching. Artifical intelligence helps in improvising overall aesthetics of patient through 3D face scanning, availability of virtual fusions of 3D data. Its application in orthodontics includes convolutional neural network-based machine learning algorithm to see teeth extractions included in the orthodontic treatment plan, possibly localize reactive sites for a therapeutic approach to malocclusion and also used for the segmentation of the pharyngeal airways in obstructive sleep apnoea and non obstructive sleep apnoea patients.[18]

The predominant usage of neural networks in orthodontics is in diagnosis and treatment planning, automated anatomic analyses, growth and development appraisal and assessment of treatment effectiveness. Through this technology various automatic approaches to cephalometrics is clarified. It enhances the reliability and precision of the cephalometric analysis & helps in identification of landmarks. These systems garner notice with their high speed and exactitude.[19] It is worthy of remembrance that these systems have an acceptable variance and can show bias and the treatment process and results may differ from those previously simulated. Orthodontists should visualise these digital systems as a helping aid and should not dither to mediate where required.[20] Its application in periodontics includes distinguishing chronic periodontitis from aggressive periodontitis. Because of intricate disease development, no single clinical, microbiological, histopathological or genetic test or combination of them can distinguish these entities.[21] Papantanopoulos and colleagues employed artificial intelligence to discern between both forms of periodontitis in patients by using immunologic parameters, such as leukocytes, interleukins and IgG antibody titres.[22] It can be used for precise measurement of periodontal bone defects using cone beam computed tomography.[23] Artificial intelligence in forensic odontology involves evaluation, examination, management and dental evidence presentation for judicial proceedings, all in favour of justice interest. This field is associated with legal concern & has the ability to bring justice where dental remains are the only available evidence. Technology of artificial intelligence has proven to become milestone for providing information that is reliable in forensic sciences for decision-making.Its other merits include maintenance of records & insurance. It presents a novel approach for solving difficulties. It is more capable of managing data & handling information than humans.

It can also automate various administrative tasks, such as tracking referrals, appointment scheduling, billing, inventory management, streamlining practice operations, and reducing manual workloads. Disadvantages comprise of complexity of system, too much expenditure in setup, vigorous and appropriate training of operator is necessary. The outcomes of artificial intelligence in dentistry are not readily applicable and transparency of data is of great issue. Data snooping errors are found as system is frequently used both for training and testing.[24]

3. Conclusion

Application of artificial intelligence should be done in various fields up to maximal benefit of humanity. Improvisation in technological approaches should be reconnoitring more in depth & data harmonization for integration should be diligently pursued. Down the road there is possibility of clinical use of artificial intelligence, but primary exploration and fundamental investigation is required to overcome current limitations.

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5. Conflicts of Interest

There are no conflicts of interest.

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