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A GLANCE ON THE INSIGHTS OF ARTIFICIAL INTELLIGENCE IN DENTISTRY: WHAT A DENTIST SHOULD KNOW

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ABSTRACT

Objective: Nowadays, dental technologies are developing fast and the improvements in dental materials and their applications are varying. Thus dentist should follow these advances and apply the verified ones to get their benefits, provide better oral care in less time and achieve patients' satisfaction. Artificial intelligence (AI) uses are spreading in daily life and its application in health field and dentistry is growing exponentially that in the near future every dental health care provider should know about it and if not getting benefit of it in his work, he will be running out of time. In this manuscript, some AI vocabularies and concepts will be addressed in a glance and have knowledge about some dental studies in AI tools applications in dentistry. The importance of the current emerging AI tools that they are applied in identification and classifications, diagnosis and aid in treatment planning to suggest the best possible treatment options to the patients. It is promising to enable the dental practitioner to provide better care to more patients in less time.

KEYWORDS: Digital dentistry, AI diagnostic tools, AI tool RPD designing, Clinical decision support system, doctor-engineering

INTRODUCTION

Artificial intelligence (AI) expresses the capacity of machines and technology to implement tasks that requires human intervention where simulate the intelligent behavior and critical thinking comparable to that of human.[1,2] This technology has the ability to learn and employ knowledge to achieve certain tasks in different fields for example language comprehension, learning, reasoning and problem-solving.[3]

AI systems can distinguish and respond to proceedings, phenomena and objects in a way similar to human intelligence.[4] It comprises developing and training machines by input of data in order to accomplish decision-making and problem solving, imitating the human brain.[5] Thus the

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effective employment of AI tools can considerably improve patients' care and facilitate optimizing daily workflow.[6,7]

As AI keeps permeating all aspects of daily life, it has become gradually essential to understand how it is perceived and employed.[8] It is important to acquaint oneself with different fundamental techniques to arise a comprehensive understanding of AI such as machine learning and deep learning algorithms and neural networks.

Machine learning (ML) is a segment of AI that comprises the application of utilizing statistical models and algorithms to predict outcomes from data. ML considered a significant revolution from using procedural languages only to advance computer applications. ML techniques created AI that disclosed that not all information should be fed to computer by laborious technical steps but could be taught to learn, conclude, detect patterns in given data and process by itself. It evidenced that technology could produce knowledge.[9] The objective of ML is to allow machines to attain knowledge from input data to independently tackle problems with no need of human involvement.

Algorithms, using ML techniques, can generate a mathematical model from given data, permitting them to do tasks that have not been obviously taught to perform. To achieve this, ML is frequently used to predict outcomes or classify cases depending on entered data. In supervised learning techniques, the required data is labeled to train the created model, next the algorithms determine the relationships between labeled outcome data and entered data like patient characteristics or medical images, as in Bayesian networks, support vector machines and linear regression. On the other hand, unsupervised learning methods don't label training data, as in clustering strategies or principal component analysis. [10]

Neural networks (NNs) are commonly identified as a kind of ML model that have revealed superior performance comparable to conventional ML techniques, especially when working with complex data formats like photography or language. They are techniques that perform signal computation by using artificial neurons. Their primary objective is to create computational models simulating daily activities of the human brain.[11]

NNs can perform transformation to the fed data input e.g. a radiographic picture of a decaying tooth into a certain output as "decayed tooth" assuming a number of mathematical restrictions. Through adequate data entry and processing power, NNs can be taught to accurately reveal the principal statistical structures inherent in the data set. To train NN, it is frequently provided with data points accompanied by detailed labels (used for classification tasks afterwards) or numerical outputs (used for regression tasks afterwards).[12] The weights of the model that denote the inter-connections between the neurons, are made optimum by a repeatable process in order to decrease the prediction inaccuracy and errors. By feeding new data point over a trained NN, it tends to predict the outcome of formerly undetected data.[13] In addition as model training advances, the degree of links between functional units is achieved to reduce task inaccuracy.[10]

Deep learning (DL) is a primary element of ML that to examine and analyze the input data uses a multi-layered cognitive matrix inside a deep neural network. There are three main DL methods: deep neural networks, recurrent neural networks and convolutional neural networks (CNNs). The objective of DL is building a neural network with automatic pattern recognition to enhance the process of feature identification.[9,14] Deep learning, unlike traditional ML methods, can learn simultaneously by automatically extracting the required features from raw data symbols in place of learning with rules. In addition, its prediction accuracy can increase according to the data size. DL is characteristically very powerful and fits for radiology and medical imaging. [10]

Examples of recent innovations in medical ML that follow this approach, convolutional neural networks (CNNs) that are applied in image

recognition and recurrent neural networks (RNNs) that are applied in predictive modeling tasks.[10] DL algorithms employs multiple layers thus can manage significant volumes of complex or highly dimensional data and the quality of the data used, as the number and quality of images and their explanation by expert, are very imperative compared to other AI algorithms. That is why DL has grew more interest in the literature for making diagnosis of common global diseases because obtaining quality data is easy.[15]

DL reliability can be increased by sharing additional experts thus overcome the limitations of having just one expert to create reference data sets. In addition, experts create an open-access standardized test data set for every type of dental image separately that allow the implementation of DL algorithms to be evaluated and compared reliably. [15] Furthermore, using segmentation and object identification as pre-processing tools applied on the raw data first, then classification is performed to overcome the problems of dental images and overlapping. Taking into consideration that in case small changes occur in the data input, manual review is required as this change can lead to different classification results thus affects the accuracy. [16]

Natural language processing (NLP) attempts to recognize entities mutual within texts and books, disclose relationships between the data of these entities, then specify meaningful answers to challenging inquiries. For prescription of drugs, NLP purposes to make pick up practical clinical entities out of texts automated. Clinical characteristics NLP-derived can be used in diverse circumstances, like clinical monitoring and as an input element in further modeling technique.[17]

"Computer vision" describes the automatic interpretation- analysis of photos and movies, and manages how viewers collect knowledge and learn new data input from images and films.[17] Currently, image information is evaluated in a potent approach, principally in computer vision. Thus AI isn't a distant concept any more and accessible to be used in practical clinical applications.[16]

"Clinical decision support system" is any computer program, which deals with medical data or medical knowledge required to interpret these dataset thus is proposed for assisting healthcare professional in clinical decision- making.[18]

To summarize, AI functions on two levels; the first involves training, where data are used to train and set the parameters and second is the testing level, where AI performs the nominated task of decision making or problem solving based on the training data that are mostly from the pool of collected data of interest.[19] when variety of the original images that are accurately labeled are collected, may be sufficient to train a well-performed model.

Currently several tools based on AI are engaged to streamline and automate dental practices that were labor-intensive previously. These technologies provide valuable services, including enhanced accuracy in diagnosis, prediction of diseases, and recommendation of appropriate treatment plans, to simplify the workload of the dental practitioner. AI is widely used in different dental disciplines like in caries detection, periapical lesion identification, oral cancer diagnosis, in endodontic treatment aid to determine working length determination, determination of root morphology and impacted teeth and its relation to surrounding anatomic structures, gender determination in forensic odontology, pediatric dentistry and implant dentistry in most of them is used for identification, diagnosis and proposing treatment plans.

Studies showed that AI helps dental healthcare providers in diagnosis and treatment planning by providing consistent explanations that assist in scientific assessment. [12,19,20] It is expected that AI will keep expanding as more precise imaging methods used and advances in data processing algorithms.

Among the tasks that already apply AI in the clinics and medical facilities; online scheduling of appointment, online check-in, digitizating medical

records, follow up appointments reminder calls in addition to drug dosage algorithms and warnings of adverse effects in case prescribing multi-drug combination.

Most of the literature spotlights on artificial intelligence models and comparing their application and accuracy, where AI models were applied in detecting and diagnose of a wide variation of dental and oral conditions. In a study stated that when CNN algorithms were used in dental caries detection and diagnosis on periapical radiographs, the efficiency of AI technology was revealed.[21] Another study used the AI models in analyzing panoramic radiographs to detect signs of maxillary sinusitis and their diagnostic performance were satisfactory.[22]

Others compared the diagnostic performance of the AI model versus the human observer taking the experts data input report as a baseline for the evaluation like in Pauwels et al.[23] study in recognition of periapical lesions in periapical radiographs. Though, the identification of structures is depending on the experience of the observers and expertise. Consequently, the AI model learning about the fed structures will be based on the knowledge of the human observer as he label the image input.

In the detection and diagnosis of osteoporosis, studies when compared deep CNN with the rates of detection completed by experienced oral radiologists, in the CAD system performance was significantly higher while in diagnosis of osteoporosis in dental panoramic radiograph using deep CNN showed comparable success.[24,25]

Upon collecting a large number of disease-related imaging data input, the model learned the differences between normal imaging features and diseased imaging features following continuous learning and training. DL can accurately identify and categorize each the disease-state and regular soft and hard tissue structures; such as impacted teeth, dental caries, bone loss, periodontal disease. In addition can automatically extract features in unlearned images. Using this classification model, DL has high prospective in the diagnosis and treatment of tumors and in the assessment for orthognathic surgery. [16] Accordingly AI can aid dentists to spot anomalies, provide a supportive second opinion, and reduce the possibility of human error. Further more early detection allows the dentists to promptly intervene, and improve patient's outcomes.[26]

Prediction of the predisposing or related factors can be enhanced by operating AI rather than merely depending on clinical inspiration from experienced doctors or extensive work of case screening. When predicting disease incidence, stochastic forest survival model and support vector machine SVM model are ML models that chiefly developed relying on the risk factors for example family history, sex, age and lifestyle. Supplementary, probability analyses are accompanied operating a statistical algorithm. However using AI aimed at disease prediction demands additional clinical patient information and is more complex than in diagnosis of disease. [16] Further more, while ML models can accurately recognize disorders in evaluated images, and create assumptions depending on the provided electronic records of the patient, it is the healthcare provider's plans for therapy that finally will decide the impact on clinical outcomes. [27]

In prosthodontics, computer-aided machines help dentists as in the designing and construction of the prostheses using CAD/CAM. AI models have revealed the ability to provide a reliable diagnostic tool used in fixed prosthodontics in tooth shade selection revealing enhanced shade matching than when using conventional visual selection, automated restoration design and in mapping the preparation of the finish line where without any manual interaction can mark the margins. In optimizing the casting manufacturing by reducing the porosity of cast metal and decreasing the time of manufacturing and in predicting patient's facial changes after removable prosthesis insertion.[28]

In designing RPD, as in Chen et al.[29] study, used Knowledge-Based System (applying ontology and

case based reasoning [CBR]) to develop a clinical decision support system model where the Input is the patient's oral conditions and the instantiation process makes transformation to the findings of oral examination into structured terms, relationships between them and situations represented by terms stored in ontology database and processed by CBR tool and the final output is RPD design in the form of text format.

AI tool was also trained by entering a database of implant images that was utilized afterwards in identification and classification the implants. This is clinically relevant when the data of the implant system can't be recovered or isn't available and the dentist needs to provide maintenance to the implant, its superstructure or restoration. AI model has been employed to deal with the problem to identify and classify implant systems, and studies have reported the improved accuracy of AI compared to trained dental professionals. [30,31]

The mentioned applications show how blending AI technologies in different dental could produce a variety of unique options. In addition when used as an instructional tool, AI provides the chance to support less experienced undergraduate students for their professional development. AI supplements the inherent intelligence of healthcare providers by using complex computing and implication to provide insights, letting the model to learn and acquire knowledge and enable dentists to make choices.

Still AI research and its applications are in the initial phases of progress especially in dentistry. It requires large data sets, digitization of health-related data and training integration to proceed progressively. Issues as data privacy and ethics matters need to be handled appropriately, beside further studies are required to promote its development and evaluate their clinical performance.

Several universities have begun creating cutting-edge medical programs, comprising a doctor-engineering, to meet the demand and teach the future medical practitioners the challenges presented by AI in medicine. Those "Augmented doctors" will benefit from using clinical expertise beside the digital abilities to solve contemporary problems in medicine, manage the digital transition, contribute in the development of digital strategies in medical organizations, and lead for research and innovation. [32]

As well as the established traditional medical education, new programs concerning digital medicine and targeting the graduated physicians and dentists, these are required to qualify them, in order to cope with the future through digital transformation initiatives.

The overview of AI-powered tools is enthusiastically predictable and its future is optimistic especially in accomplishing repetitive tasks or managing enormous amounts of data in classification purposes, AI systems dominate. [13] And as the technical problems related to AI are addressed to be resolved, new significance will be created.

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