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ARTIFICIAL INTELLIGENCE IN DENTISTRY: AN OVERVIEW

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ABSTRACT

Different applications of artificial intelligence (AI) have been made in the medical field. It is a field that combines engineering and science and is concerned with the perception of intelligent behavior and the development of replicable artefacts. Technology has been the biggest innovation across all industries, and dental care is no exception. Artificial intelligence can be used to screen for and categorise suspicious changed oral mucosa that is undergoing premalignant and malignant alterations, as well as diagnose and treat lesions of the oral cavity. This field has a lot of potential for straightforward diagnosis, effective treatment, and satisfactory results.

KEYWORDS: Artificial Intelligence, Artificial Neural Networks, Deep learning, Machine Learning, Robotics.

INTRODUCTION

John McCarthy (1956), initially used the term "artificial intelligence" (AI) to describe machines that can mimic human knowledge and behaviour.[1] Subsets of artificial intelligence are Machine learning, neural networks, and deep learning.[2] AI can help with the creation of algorithms that can learn from the data presented and anticipate the future.[3] Deep learning and machine learning are the two categories. While deep learning learns and maps features in a single step, making it more resourceful for managing complex amounts of data than machine learning, which requires human professionals to first design the data systems before they can be processed for computing algorithms.[4]

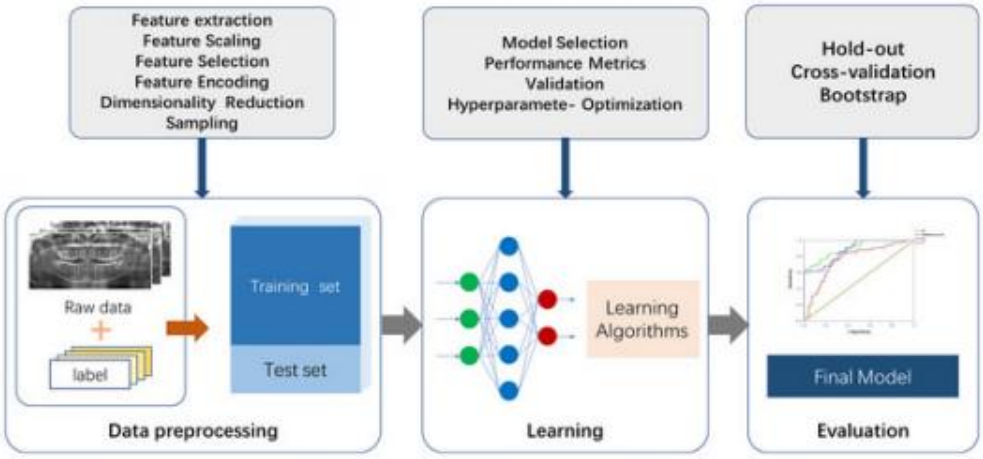

Fig. 1: Machine learning technique to get final model using image processing.

"Neural Networks (NNs)" is one of the key aspects of AI that imitate the human brain by using artificial neurons in a mathematical non-linear model that are comparable to those found in human neural networks. NNs are capable of simulating human cognitive abilities including problem-solving and human thinking, which includes learning and decision-making. In their simplest form, neural networks are composed of three layers: the input layer (where data enter the system), the hidden layer (where the data are processed), and the output layer (where the system decides what to do). The outline of any input to an output can be generated by NNs given a set of mathematical models.[2]

Artificial Neural Networks (ANN)

The ability of these systems to resolve issues that are too complicated for conventional approaches to handle is their greatest strength. They are helpful in many

branches of medical science, including disease diagnosis, biomedical identification, image analysis, and data analysis.[17] The clinical support systems are also actively developing in dental practise.

In a study by Kim et al., artificial neural networks were utilised to create a model that can anticipate toothaches based on the correlation between toothaches and daily brushing frequency, time, use of dental floss, pattern of toothbrush replacement, scaling, and other parameters including food and activity.[18]

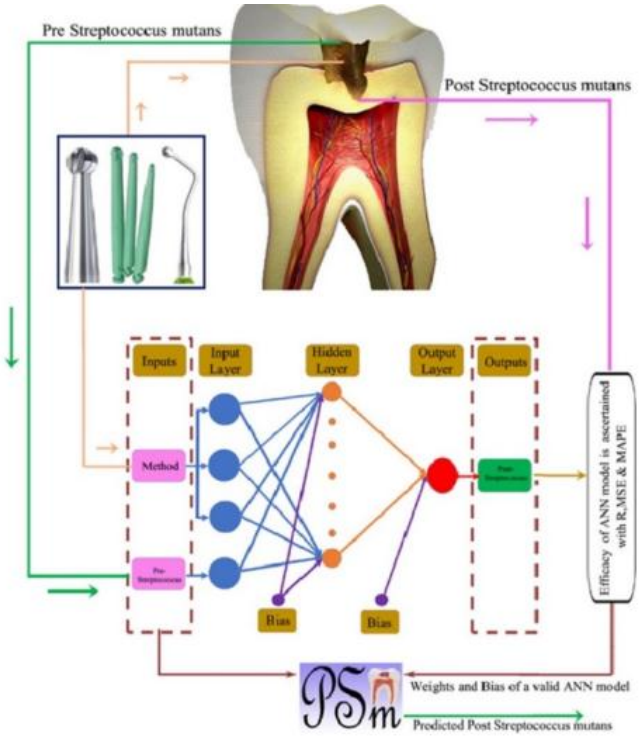

Fig. 2: ANN model to predict post-Streptococcus mutans to treat caries excavation.[20]

Convolutional neural network (CNN)

Convolutional neural networks (CNNs) are mostly used to analyse vast and complicated images. In research, CNNs are being used for dental imaging diagnosis. They are extremely well adapted to the task of image classification and are the most-used algorithm for image recognition.[20] Later, more rigorous, replicable, and comparable procedures should be used to demonstrate their utility, safety, and generalizability. It can be utilized for classifying dental arches and designing removable partial dentures.[19]

AI has several applications in dental and medical science, from collecting patient histories to processing data to ultimately pulling information for diagnosis from the data. AI purpose is to reduce human effort and help us make more informed decisions.[5]

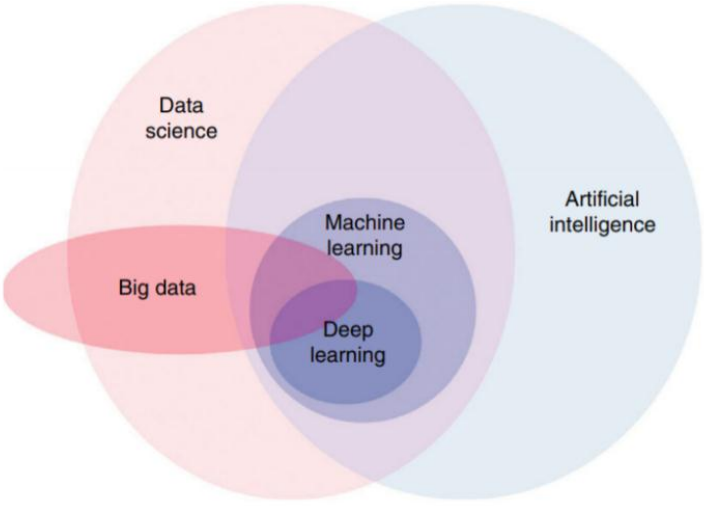

Fig. 3: Key elements of artificial intelligence systems.

AI Applications in Dentistry

Neural networks may be extensively used in dental surgery in a variety of settings, including orthognathic procedures, modifications to the bones, post-extraction problems, and implantology treatments. Because of the necessity for extreme precision and precise planning, implantology is a field that is evolving especially quickly, and the application of neural networks may be highly beneficial in daily practice. Additionally, neural networks could be able to forecast some surgical treatment issues and help prevent some of them.[2]

AI has been used to improve image interpretation in dental **radiology**. Digital radiographs can be calculated using the algorithms through input layer, hidden layer, and output layer to detect caries. Dental radiographs can be interpreted by the software with machine learning algorithms.[1]

In **restorative dentistry**, neural networks might be helpful in planning the selection of the dental treatment and cavity preparation technique. Algorithms can be used to locate the edges of anatomical and pathological structures.[2] In endodontics, working length determination and minor apical foramen can be determined along with vertical root fracture using AI. Saghiri et al. utilized the artificial intelligence based system of neural network and reported 96% accuracy in working length determination when compared to professional endodontists.[6]

In **orthodontics**, development of design software has greatly aided orthodontists in creating the best aesthetics for patients while taking into account all the relevant factors, including patient preferences and anthropological calculations.[4] An AI based orthodontics monitoring service has also been introduced, this service allows patients to scan their teeth through their phones and a unique tool, and the scans can be analyzed and monitored by orthodontists to confirm the status of orthodontic treatment.[1]

In **prosthodontics**, the use of computer aided technology for precise fit of prosthesis is another breakthrough of AI in dentistry.[7] They are not only faster and more accurate but also lab procedures are eliminated, greatly reducing the human mistakes. Additionally, before designing the prosthesis, this programme aids in anticipating tooth movement and the outcome of treatment.[4] Smile design has been a useful tool for team communication and patient motivation. Currently there are around 15 smile design software available for clinicians, all of these software rely on the input and preference of the clinician to design the shape and alignment of the future smile. Once the required patient data (photos) are uploaded, the AI engine searches and proposes natural shapes of teeth and alignment.[1]

In **periodontics**, based on immune response profile, artificial neural networks can be utilised to classify the patients into those who have chronic and severe periodontal disease.[4] Support vector machine models were applied for differentiation between aggressive and chronic periodontitis with the examination of subgingival plaque to identify different microbial profiles.[1]

In **dental surgery**, extraction of the lower third molar is one of the most popular dental surgery procedure. The paresthesia of the nerve after mandible wisdom tooth extraction is quite a common complication. The panoramic images were used before the extraction and the anatomical relationship between the nerve canal and dental roots was used by the convolutional neural network to predict the occurrence of nerve paresthesia.[2]

Robotics is a domain in artificial intelligence that deals with the study of creating intelligent and efficient robots. Robots offer surgeons easier operational access and flexible working settings. The most progressive innovation based on artificial intelligence is the application of Bio-printing, where cells are generated in thin layers producing living tissue and organs can be constructed using this technology.[14] This emerging application can be utilized for reconstructing the oral tissues; both hard and soft tissue. Nin˜o-Sandoval et al. used artificial intelligence based model for predicting the morphology of mandible and demonstrated that this framework may be the key for facial reconstruction in later years.[15]

In **forensic dentistry**, the demand to identify the age from the medical image is high. The assistance of AI has improved forensic work, increasing efficiency. Patil et al. used artificial neural networks for gender determination and proved this model to be a great tool for gender prediction and thus, this application can also be used in the field of forensic sciences for promising outcomes. Artificial intelligence has its applications extending to Forensic dentistry.[16]

Impact of AI on the Global Health: Role of AI in Public Health Dentistry

Artificial intelligence (AI) has proved a cutting-edge technology in detecting, diagnostics, and treating oral diseases. Topol.[8] suggested that deep learning, a subset of artificial neural network-based machine learning, has enabled impressive performance consistent with trained practitioners' interpretation of x-ray images, photos, symptoms, and habits.[8]

Numerous forms of machine learning or signal processing are predominantly applied, frequently in synergy with other methods, principally signal-to-process. It is reported that there are four AI-driven health interventions, classified in separate categories: (1) diagnostics, (2) patient mortality risk assessment, (3) disease outbreak prediction and surveillance, and (4) health policy and planning. However, most of the literature of global research into the AI-governed intervention in the domain of global health does not account for diverse ethical, administrative, or practical

considerations required for large-scale use of AI in the realm of global health.

Nina S. and Brian W. (2020) suggest that AI-driven no matter how specific a particular setting for intervention is, there is a growing need to develop thorough methodological guidelines that will define the scope, the function, and the goals of an AI approach to the global health-care system, taking into consideration all ethical limitations and concerns that might further direct the research agenda in the field.[9]

Generally, three application domains are related to AI-based health-care interventions in oral public health. The first one encompasses AI-driven tools used on smartphones or portables. Operated by nonspecialist community health workers (CHWs), based on off-site locations, these typically address traditional oral diseases. As reported by Hosny and Aerts (2019), CHWs may follow AI recommendations to triage patients and identify those requiring immediate treatment.[10]

This category of application involves the diagnostics of oral and labial cancer based on photographic images and peripheral blood samples. The advent of pocket diagnostic hardware (ultrasound probes and microscopes) also promises rapid improvements in this domain. Ubiquitous smartphones will allow patients to use AI to design their nutrition and daily routines.

The technology will also enable symptoms self-assessment and cover the advisory aspect during pregnancy or recovery phases, eventually allowing patients to monitor their health, thus facilitating the operation of the health system.

Future of AI in Dentistry

Despite their potential, AI technologies are yet to have a significant impact in medical practice. Convolutional neural networks (CNNs) in dentistry are presently being developed.[11] The management and sharing of clinical data are major challenges in the implementation of AI systems in health care. Personal data from patients are necessary for initial training of AI algorithms, as well as ongoing training, validation and improvement. To integrate AI into clinical operations, systems must be adapted to protect patient confidentiality and privacy.[12] Thus, before considering broader distribution, personal data will have to be anonymized.[13] Even with the ability to take these precautions, there is skepticism in the health care community about secure data sharing.

Limitation

Using AI to solve problems requires the algorithm to be comprehensive with multiple applications to solve a single question. Like the nature of data mining, AI might only reflect the results subjectively with associations, not with causality. Direct interpretation will not be provided with AI; a misinterpretation might occur with the misconduct of the algorithms. AI programs still need to be developed in collaborations that involve experienced clinicians and expert computer engineers to minimize potential risks of AI.[2]

CONCLUSION

New medical technology is advancing incredibly swiftly in the realm of dentistry. In dental radiology today, artificial intelligence and neural networks are mostly utilised to speed up diagnostics, plan treatments, and predict treatment outcomes. Genetics, psychology, microbiology, and many other fields are utilised by neural networks in dentistry. Research in dentistry is especially susceptible to this change because it plays a key role in ensuring that artificial intelligence will improve dental care. Artificial intelligence can undoubtedly aid in the delivery of improved healthcare to patients, but it cannot in any way take the place of human knowledge, skills, and capacity of judgement.

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