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Artificial Intelligence in Dentistry - A Review

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Abstract

Artificial Intelligence (AI) is a breakthrough in the field of technology which is rapidly progressing and has captivated the minds of researchers across the globe. Ever since its discovery, dentistry has witnessed some of the exceptional achievements. Hence, this technology as the future of dentistry is abutting the implementation of its application. While, in no ways, AI can replace the role of the dentist, it is of prime importance to be aware of the possibilities to integrate this technology in the future of a gratifying and successful practice. The aim of this review is to analyse the role and applications of artificial intelligence in dentistry. The field of artificial intelligence has transformed medicine and dentistry in several ways. AI can only assist the clinician in performing the tasks efficiently, but in no way, the intellect of the human knowledge skill and treatment planning.

Keywords *: Artificial Intelligence, dentistry*

Introduction

Various technological advancements had occurred in the field of dentistry in the previous decade. In newer times, technologies are consistently developed and support the principles that attempt to mimic the human brain functioning to develop solutions. AI is defined as the study of intelligent agents, any device that perceives its environment and takes action that maximizes its chance of successfully achieving its goals. The term AI was coined within the 1950s and refers to the thought of building machines that are capable of performing tasks that are normally performed by humans. Computer based diagnosis is gaining momentum thanks to its ability to detect and diagnose lesions which can go unnoticed to the human eye, thereby paving way for holistic practice.[1]

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Artificial Intelligence :

Artificial Intelligence is usually called machine intelligence and is demonstrated by machine in contrast to the natural intelligence displayed by humans and other animals.[1] AI alternatively could also be stated as a topic handling computational models which will think and act rationally. AI research are often defined because the study of intelligent agents, any device that perceives its environment and takes action that maximize its chance of successfully achieving its goal.[2]

History dates back to as early as 400BC when Plato envisaged a basic model of brain function. Since then, the sector of science has witnessed various inventions with the arrival of technology for creating a model which will stimulate the functioning of the human brain [3]. The process of the constant search has given rise to what's referred to as Artificial Intelligence (AI), which may be a highly evolved system capable of mimicking functioning of the human brain.[4] This unexampled nature of the human brain has always made researchers and scientists inquisitive from time immemorial.

Artificial intelligence is defined as the field of science and engineering concerned with the computational understanding of what's commonly called intelligent

behaviour and with the creation of artifacts that exhibit such behaviours. Computer base diagnosis is gaining momentum thanks to its ability to detect and diagnose lesions which can go unnoticed to the human eye, thereby paving way for a holistic practice. The varied techniques of AI which are being applied in industry include Artificial Neural Networks (ANN) , which are being applied in dentistry include Genetic Algorithms (GA) and symbolic logic. Following its interception in 1959 when the primary computational trainable neural networks were developed, the sector of drugs and dentistry has witnessed innumerable research using AI.[5]

A machine learning prediction technique is an algorithm that estimates an unknown dependency between a group of given input variables and its output variables. When such dependency is observed, it can predict the longer term output by identifying the target function that best describes the behaviour governing the input-output patterns.[6] AI is capable of communicating with a video camera and can automatically detect the root canal orifices in all the teeth in the oral cavity. The Applications of Artificial Intelligence are abundant and more research has been directed towards maximizing benefits.

Applications of AI In Dentistry :

Caries Detection

Dental caries is one of the most common problem affecting people of all ages, it can be of nursing bottle or rampant caries affecting childrens, pit and fissure caries, smooth surface caries, root caries mostly seen in gediatric patients.[7,8] It can be defined as microbial disease of the calcified tissues of tooth, characterized by demineralization of the inorganic portions and destruction of organic structures. Acids produced by fermentation of carbohydrates such as sucrose, glucose, fructose, by the plaque bacteria such as streptococcus mutans leads to subsurface demineralization of the tooth enamel. The periods of disease activity vary greatly and it is influenced by various risk factors. Subsequent damage to dentin-pulp complex leads to painful conditions like acute/chronic pulpitis.[9,10]

Diagnostic aids refers to tools, procedures or technologies that are used in the determination of diagnosis.[11, 12,13,14] Dental caries is diagnosed by clinical methods and radiographic examination of teeth is usually by using intraoral periapical radiographs, bitewing radiographs, orthopantomography. Fermentable dietary carbohydrates are the key players in causation of caries. After intake of these sugars, the ph of dental plaque falls to 4.5 to 5 within 1 to 3 minutes and it takes another 10 to 30 minutes to return back to neutral ph. The critical ph of plaque is 5.5 and tooth demineralization starts if ph drops below this level. Caries producing bacteria readily use up the sugars and produce sticky polysaccharides called dextrans which helps in adhering the plaque firm to tooth surfaces and causes further acid production and tooth decay.[15,16,17,18] By using smart microchips, we can assess the patients food intake, diet activity and oral ph levels irrespective of whether it is a pediatric, adult or gediatic case. Thereby it helps in assessing the caries activity, helps in diagnosing initial or incipient caries cases, and accordingly we can manage the cases by alteration in diet patterns or preventing the tooth decay.[19,20,21]

Orthodontics :

AI helps in orthodontic diagnosis and treatment planning[22]. The data is fed into the system the set algorithms and AI software helps in predicting tooth movements and final outcomes of the treatment.[23]

Oral Medicine and Radiology:

Artificial Intelligence can be used as a useful modality in diagnosis and treatment of lesions of oral cavity and can be employed in screening and classifying suspicious altered mucosa undergoing premalignant and malignant changes.[24] Artificial Intelligence might accurately predict a genetic predisposition for oral cancer for a large population. The use of ANNs in the diagnosis subtypes of temporomandibular disorders has been studied by Bas Betal[5]

Correct diagnosis is the key to a successful clinical practice. In this regard, adequately trained neural networks can be a boon to diagnosticians, especially in conditions having multifactorial etiology. In head and neck imaging modalities, it can be integrated with imaging and cone-beam computed tomography to identify minute deviations from normalcy that could have gone unnoticed by the human eye. ANN is found to act as a second opinion to locate the minor apical foramen ,

thereby enhancing the accuracy location on radiographs, working length determination by radiographs [25]. It is also found that sufficient sensitivity, specificity and accuracy to be a model for vertical root fracture detection in digital photography and in diagnosing proximal dental caries[26].

Prosthodontics :

AI combined with designing softwares can help the dentist to design the best possible and aesthetic prosthesis considering a number of factors like facial measurements , anthropological calculation, ethnicity, and patient desire[27]. Another breakthrough in this field is the use of CAD CAM technology[28] which creates 2 and 3D models. Virtual Reality Stimulation (VRS) can be used to simulate facial profile during treatment.

Oral And Maxillofacial Surgery :

The tremendous utilization of artificial intelligence in oral and maxillofacial surgery is alongside the evolution of robotic surgery where the human body motion and human intelligence is stimulated. AI software programs have assisted the surgeon in planning surgeries with reduced operation time thereby preserving prior to the actual surgery with higher intra operative accuracy[29].

Forensic Odontology :

Dental age estimated is based on the sequence of tooth formation and eruption time.Stages of tooth formation can be observed radiographically. Radiographic methods of age estimation are commonly used due to availability of the pre and post treatment records and also the ease of availability of the data can be retrieved any time[30].

Periodontics:

Deep learning analysis using radiographs can assist in diagnosing and treatment planning of periodontal diseases by enabling the early detection of periodontal changes, bone loss, and changes in bone density.[31]

Pediatric Dentistry:

In pediatric dentistry, Artificial Intelligence have many potential applications which would change the behavioural pediatric practice in future. Also, with the help of larger datasets, machine learning algorithms will only become more sophisticated over time. AI is also gaining pace in the early orthodontic tooth movement with customized AI driven appliances which would have better acceptability by the new generation. AI enabled restorative dentistry with design computer-aided manufacturing technology is already established in adult dental practice and would emerge a boon to restorations and aesthetics. Pain control with AI enabled devices is the new, smarter way towards injection-free pedodontic practice The various 4D goggles, movies, animations and virtual reality-based games can be used as a behaviour modification aid effectively for pediatric patients.[32]

Dental Implants:

The dental technicians position the abutments already assembled on a 3D printed model, with the implant analogues inserted, and scan them with a desktop scanner. This shows obtaining the anatomy and relative position of the abutments, including the margin line. Although this is often possible, it's an additional step that forces the technician to print a model, with related costs and problems , but in particular to model the definitive zirconia restorations.

These additional steps can now be avoided by using AI. Artificial Intelligence is defined as the ability of a system to get information from external data and learn from them, which use those learnings to realize the objectives and goals through flexible adaptation. Machine learning, as a subset and foundation of AI, is the ability of computer systems to perform specific tasks to approximate human cognition, without using explicit instructions, counting on patterns and mathematical models. CAD software is often 'instructed' to save lots of the stereolithographic file of the individual abutment, modelled by the technician, during a specific folder, then to retrieve it automatically when needed. The dentist can capture a replacement of an intraoral impression of the abutment with the correct position, which are generally subgingival. The portion which is relative to the abutment, that can be recognised and eliminated.

Future Of Artificial Intelligence :

As technology continues to invariably the dental community stands on the precipice of an AI revolution that will forever change the way dentistry performed from both a clinical and practice management perspective. Already, several practice management products have

been introduced which incorporate AI, including a digital assistant that uses natural - languages processing to replace the traditional point and click interfaces and a learning based schedule optimizer.

Moreover, deep learning AI techniques will begin to increasingly impact clinical dentistry. These tools are able to spot abnormalities in images that even clinicians might overlook, while executing its findings in realtime to seamlessly integrate into any practice workflow. As deep learning systems continue to grow in intelligence, the tools will augment diagnostic accuracy. On the contrary, this rise of the machines will enable to perform at a higher level while essentially making the job much easier.

Challenges Of AI :

We see three reasons why dentistry has not fully adapted to AI technologies. Proper analysis of these reasons will help to make dental AI technologies better and facilitate their uptake in clinical care. First , medical and dental data are not as available and accessible as other data, due to data protection concerts and organisational hurdles. Data is often locked within segregated, individualized and limited interoperable systems. Datasets lack structure and are often relatively small, at least when compared with other datasets.[33] Second, processing data and measuring and validating results is often insufficiently replicable and robust in dental AI research. It remains unclear oftentimes used for both training and testing leading to data snooping bias. Third, the outcomes of AI in dentistry are often not readily applicable. The single information produced by most dental AI applications will only partially inform the required and complex decision- making clinical care[34].

Conclusion

The field of artificial intelligence has transformed medicine and dentistry in several ways. Though Artificial Intelligence systems are a greater asset in dentistry and dental education, the human biological system is complex and it is to be noted that these technological advancements are still the beginning of innovations and discoveries of mankind. Furthermore, AI can only assist the clinician in performing the tasks efficiently, but does not replace the intellect of the human knowledge, skill and treatment planning.

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