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Review Article

Enhancing dental care through artificial intelligence: A comprehensive overview

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ABSTRACT

Artificial intelligence (AI) in dentistry is poised to alter a number of aspects of the industry, marking a paradigm shift of profound significance. Dental diagnostic procedures are being streamlined and optimized with the use of artificial intelligence technologies. Machine learning algorithms have demonstrated exceptional competence in the early identification of dental disorders, including cavities, periodontal diseases, and structural abnormalities in teeth, thanks to their extensive training on large datasets of dental pictures. These developments make it easier to intervene quickly, which enhances patient outcomes and lessens the strain on healthcare systems.

Furthermore, tailored care and AI-driven treatment planning have become important areas of innovation. AI algorithms assist in the creation of customized treatment plans by analysing patient data, including genetic predispositions and medical histories. The application of AI extends beyond diagnostics and treatment planning to optimize administrative tasks within dental practices. Automated appointment scheduling, billing processes, and electronic health record management systems powered by AI technologies contribute to increased operational efficiency, allowing dental professionals to focus more on patient care.

Combining human knowledge with AI skills has the potential to completely change the dental care industry by offering more precise diagnosis, individualized treatment plans, and enhanced patient experiences all around. As AI develops, its application to dentistry serves as a shining example of advancement, bringing about a new era in oral healthcare marked by increased accessibility, efficiency, and precision.

1. Introduction

Infections of the teeth are common worldwide. Approximately 3.5 billion individuals worldwide suffer from dental illnesses, primarily from untreated caries, severe periodontal disease, edentulism, and severe tooth loss (with just one to nine remaining teeth), according to the 2017 Global Burden of Disease research.[1] Dental problems, particularly those that go untreated, can lead to infections, pain, limited mouth opening, and even potentially fatal conditions that have a major negative impact on a patient's quality of life, ability to work and be productive, and ability to participate in social activities.[2] Radiographs and clinical examination are frequently used in conjunction to diagnose dental conditions.[3] Dentists face difficulties in rapidly and accurately interpreting radiographs because of the intricate anatomy and evolving illnesses.[4]

It has been demonstrated that artificial intelligence (AI) greatly improves the accuracy and efficiency of work flow in the medical imaging industry.[5] Dental photos are now frequently digitalized and readily converted into computer language.[6] As a result, the use of AI in the auxiliary diagnosis of dental conditions is encouraging.[7,8]

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The term artificial intelligence (AI) refers to a branch of science and engineering that focuses on creating artefact's that display intelligent behaviour and computationally analysing what is typically referred to be intelligent behaviour. John McCarthy originally used the term "artificial intelligence" in 1956. Artificial intelligence technology has expanded to include a wide range of applications in domains such as robotics, natural language processing, expert systems, game play, theorem-proving, image reputation, and telephony. In the past ten years, technology has also completely transformed the fields of medicine and dentistry. Examples include online appointment scheduling, online check-ins at medical facilities, digitization of medical records, calls to remind patients about follow-up appointments and immunization dates for children and pregnant women, drug dosage algorithms, warnings about potential side effects when prescribing multiple medications, and much more.

The substantial expansion of clinical databases and the expanding usage of information technologies in healthcare need the adaptation of traditional facts analyses to a new computational paradigm. Artificial intelligence algorithms-based methods have been widely applied in the biomedical sciences. With the introduction of data computing, cloud computing capabilities, and the availability of large amounts of data collecting, artificial intelligence (AI) in general and in dentistry or medicine in particular started to gain traction. It is now established that AI is a potent and, in certain cases, more effective tool for accurately diagnosing a wide range of medical disorders.[9]

1.1. Application of AI in Dental Practice

The integration of Artificial Intelligence (AI) into dentistry has emerged as a transformative force, revolutionizing various aspects of patient care, diagnostics, and practice management. This comprehensive overview explores the multifaceted role of AI in dentistry, delving into its applications in diagnostic imaging, caries detection, periodontal disease assessment, treatment planning, patient engagement through virtual simulations, and operational efficiency. While AI presents significant opportunities for enhanced precision and efficiency in oral healthcare, it also brings forth challenges, such as data privacy and ethical considerations. The synthesis of human expertise with AI capabilities holds the promise of reshaping the landscape of dentistry, ensuring more accurate diagnostics, personalized treatments, and improved overall patient experiences.

2. AI IN Diagnosis

Since early identification and diagnosis significantly improves prognosis, oral illness diagnosis and detection are essential in dentistry. Certain lesions in the mouth may be precancerous or cancerous in nature, thus it is important to get a proper diagnosis and treat the patient accordingly.[10] Artificial intelligence has a lot to offer in the diagnosis and treatment of cancers and other oral disorders. The screening and categorization of mucosa undergoing premalignant and malignant changes is also made possible by this state-of-the-art technology. It can identify minuscule departures from the norm that the human eye might overlook when paired with other imaging modalities such as CBCT and MRI.[11] The use of Convolutional Neural Networks (CNN) in the diagnosis of head and neck cancer lesions has proven to be quite beneficial. It offers a great deal of potential for finding tumours on radiographs or in tissue samples. The Artificial Neural Networks (ANN) may also help in creating a treatment regimen by identifying and classifying individuals who are at high risk of developing oral cancer or pre-cancer.[12]

3. AI in Risk Assessment

It was shown that automated risk assessment outperformed even the judgment of highly experienced senior dental professionals when it came to assessing the danger of dental disease. Risk assessment comprises determining the factors that raise the risk in a given scenario and estimating the degree to which those factors contribute to the illness's development. Evidence from two separate investigations by Persson et al. shows that risk assessments based on the professional opinions of periodontists and dentists differ too much to be useful in clinical periodontal decision-making.[13]

Dental Medicine International Inc. of Mount Vernon, Washington, in the United States developed the Periodontal Risk Calculator (PRC), a computerized tool that estimates periodontal degeneration and assesses risk. The method evaluates certain elements as potential risk factors for periodontitis based on algorithms that assign relative weights to the several recognized risks that enhance susceptibility to the disease. It uses a risk assessment tool that rates risks from 1 to 5 and generates treatment recommendations to help patients and clinicians adopt a risk-reduction-based healthcare approach. In order to calculate risk, nine factors are considered: the patient's age; smoking history; diabetes diagnosis; history of periodontal surgery; pocket depths; furcation involvements; restorations or calculus below the gingival margin; bone height; and vertical bone loss. A database including information on people who have periodontitis was used to validate the predictive algorithm. A risk score for periodontal degeneration is derived from these characteristics and can range from one to five for each individual.[14]

4. AI in Treatment

Among the most significant applications of AI in oral and maxillofacial surgery is the development of robotic surgery. By simulating human body movement and intelligence,

robotic surgery lets surgeons plan surgeries with shorter operating periods and greater intraoperative precision, all the while protecting critical neighbouring structures down to the last detail prior to the actual surgery. AI is crucial in determining the type of bone and cortical thickness to create accurate surgical guides for pacemaker implants. A further development in this area is the use of CADCAM technology, which replaces the time-consuming and tedious process of conventional casting and produces 2D and 3D models, thereby eliminating human error.AI-based systems are also used to create crowns, bridges, inlays, and onlays. [11]

Rapid uses a logic-based representation as a unifying framework to integrate databases, knowledge-based systems, and computer-aided design. Cone-beam computed tomography (CBCT) has become the gold standard for maximizing the therapeutic outcomes of endodontic therapy and minimizing treatment failures brought on by morphological variance. AI gadgets make paediatric injection-free practice more beneficial. The AI-assisted aligners promise to provide exact treatment execution, help with progress tracking, and reduce treatment times and appointment scheduling. [15]

5. AI in Public Health Surveillance

The process of identifying, characterizing, monitoring, and reacting to disease outbreaks, other health risks (like radiation exposure, bioterrorism, contaminated food or water supplies), and other population-related health trends (like malnourishment, periodontal disease, or oral cancer) is known as public health surveillance. [16]

These surveillances take place at the local, state, federal, and international levels. To accomplish a prompt, targeted, and efficient reaction to emergent health events, it is frequently necessary to integrate multiple institutions (e.g., hospitals, pharmacies, and public, state, and political health organizations). Our work focuses on the potential benefits of artificial intelligence and machine learning for public health, specifically in terms of early, automated detection of emerging outbreaks and other health-related phenomena. The detection of outbreaks has significantly improved over the last ten years thanks to advancements in detection performance measuring metrics, integration of numerous data streams, and analysis of temporary and local data, among other things.

This change in public data analysis will necessitate a corresponding change in functional diagnostic systems' methods, which include data mining, artificial intelligence, and machine learning approaches to find relevant patterns in vast amounts of data and support public health decision-making. Experts will heavily rely on tools and systems that process large amounts of complex, highly-dimensional data using scalable algorithms, machine learning techniques to further improve system performance from user feedback, and advanced statistical methods to accurately distinguish associated ineffective patterns. [17]

6. Limitation of AI

The most significant challenging circumstances in the application of AI structures in healthcare are those involving the control and sharing of clinical records. Patient personal records are crucial for continuing education, validation, and advancement of AI algorithms, as well as for their initial training. Additionally, the advancement of AI will facilitate the sharing of data between institutions and nations. In order to include AI into scientific activities, systems must be modified to safeguard the privacy and confidentiality of impacted individuals. Consequently, personal records will be anonymised before being considered for wider circulation.

The healthcare network is hesitant to share data, even if they are able to take those safety measures. Safety issues are also linked to AI architecture. The precision of the annotations and labelling of the educational dataset heavily influences the quality of the final results predictions made by AI systems. Bad things can happen when information is not properly labelled. Consequently, the resulting AI systems' effectiveness is limited. Furthermore, healthcare professionals want to have a thorough comprehension of the judgments and forecasts generated by an AI tool, along with the ability to challenge them.

7. Conclusion

The field of dentistry has entered a new period marked by the height of artificial intelligence and digitization, and its prospects for the future are quite bright. Therefore, learning more about ourselves is one reason to study. Creating intelligent beings in addition to identifying them is another goal. However, artificial intelligence is still in its infancy and will never be able to match human intelligence and expertise.

Even at this early stage, AI has developed a great deal of enormous and astounding goods. It is obvious that computer systems that possess intelligence comparable to or greater than that of humans could have a significant impact on our daily lives and the future of society. While there is undoubtedly room for improvement when it comes to incorporating AI into dentistry, it will never fully replace a dentist's role in clinical practice, which entails providing individualized patient care in addition to making diagnoses. A dentist must make the final decision because dentistry is a multidisciplinary field, even if AI can assist in many ways.

"Artificial intelligence is one of the most profound things we're working on as humanity. It's more profound than fire or electricity." - Sundar Pichai.

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9. Conflict of Interest

None.

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