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Unlocking new horizons with Artificial Intelligence in Dentistry

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ABSTRACT :

Since the beginning of recorded history, the human brain has been one of the most intriguing structures for scientists and engineers. Over the centuries, newer technologies have been developed based on principles that seek to mimic their functioning, but the creation of a machine that can think and behave like a human remains an unattainable fantasy. The term “artificial intelligence” (AI) refers to the idea of machines being capable of performing human tasks. Several branches of dentistry are increasingly relying on artificial intelligence (AI) tools. The literature usually focuses on AI models. These AI models have been used to detect and diagnose a wide range of conditions, including, but not limited to, dental caries, vertical root fractures, apical lesions, diseases of the salivary glands, maxillary sinusitis, maxillofacial cysts, cervical lymph node metastasis, osteoporosis, cancerous lesions, alveolar bone loss, the need for orthodontic extractions or treatments, cephalometric analysis, age and gender determination, and more. Creative interprofessional collaboration between medical professionals, scientists, and engineers is the cornerstone of AI advancement in dentistry. These advancements will also enable the transmission of vast amounts of health-related data between patients, academics, and healthcare professionals, as well as the provision of insights that improve patient care. This review describes some current and future applications of AI in dentistry.

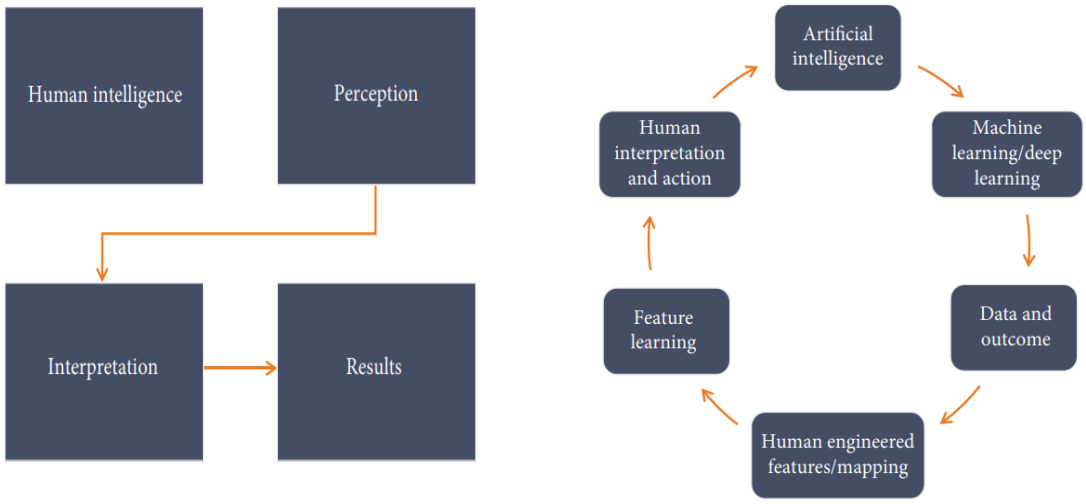
Keywords – Artificial Intelligence, Dentistry, Health, Human

Introduction and Background:

Artificial intelligence (AI) is a fast-moving technology that enables machines to perform tasks previously exclusive to humans.[1]According to “Barr and Feigenbaum,” AI is the part of computer science concerned with designing an intelligent computer system that exhibits characteristics we associate with intelligence in human behavior-understanding language, learning, reasoning, problem solving, and many more.[2]
IN 1956 the term "artificial intelligence" was coined by John McCarthy, a computer scientist, during the Dartmouth Conference, where he and other researchers discussed the potential of creating machines that could simulate human intelligence.[3] Over a period of time, newer technologies have been developed, but the creation of a machine that can think and function like a human remains an unattainable fantasy, which is now referred to as "artificial intelligence" (AI).[4] AI is a discipline of computer science and engineering that concentrates on the computational comprehension of what is commonly referred to as intelligent behavior and the development of intelligent artifacts. The human brain is a unique structure made up of networks of interconnected neurons that transmit signals throughout the entire body.[5] Early AI research focused on solving mathematical and logical problems. To mimic human problem solving abilities researchers had developed algorithms and symbolic reasoning approaches.AI research shifted toward neural networks and machine learning in the late 1980s and 1990s. In the 2000s and early 2010s, the availability of vast amounts of data and advancements in computing power led to the emergence of deep learning.[6]

How Artificial Intelligence works?

A subgroup of AI which enhances automated learning ability without being distinctly programmed is Machine learning. Its primary goal is to allow automated learning without human arbitration,with the present set of observations AI can models predict future events.[7] “deep learning,” is a popular field in machine learning where multilayered (deep) neural networks are used to learn hierarchical features in the data. The process of data (e.g., images) and corresponding labels (e.g., “carious tooth,” or “specific area on an image where a caries lesion is present”) being repetitively passed through the neural network during training, with the model parameters being iteratively adjusted to improve the model’s accuracy refers to as Deep learning.[2] The AI modalities: machine learning, deep learning, cognitive computing, computer vision (recognizes the content in photos and videos), and natural language processing (to both analyze and generate human speech with the help of machines), are promising and practiced in dentistry.[8]



Natural intelligence is characterized by perception, interpretation and biological response. In contrast, computer intelligence does so far not replace human responses, but largely supports human interpretation and action.[10] Figure 1

Throughout the past seven decades AI and its applications have been seen as both a blessing and a curse. There have been multiple instances in which technological advancements have fallen short of expectations during this time,. However, the past ten years represent the golden age of artificial intelligence.Readers cannot tell the difference between human- and machine-written text because the current state-of-the-art artificial intelligence-based natural language modeling has become so convincing. The second innovation is facial-recognition systems. The impact of AI-based technology on many facets of society, including healthcare and politics, has reached a tipping point. One of these fields is dentistry.[10,11] in oral and dental care AI's potential for increased effectiveness, safety, and efficiency is promising because it will enable better care to be provided to more people in less time.[12]

Within the field of dentistry artificial intelligence is playing a pivotal role in the modernization of conventional practices. To enhance the efficiency of diagnostics and data administration within the field of dentistry Artificial intelligence technologies are frequently employed in the development of automated software programs. Primarily, clinical decision support systems serve as tools that aid and direct professionals in making improved decisions.[13] These methods have been utilized to enhance the accuracy of diagnoses, aid in the development of treatment plans, and facilitate the predictions of prognoses. The increasing demand for these systems can be attributed to their efficacy in delivering explanations and logical reasoning.[14]

Uses of AI in dentistry

In Patient care

In health care Artificial intelligence is used to record medical reviews, interpret radiological images, and make clinical diagnoses and treatment plans. To analyze large volumes of data, identify patterns, and make accurate predictions AI technology uses algorithms and machine learning techniques. By leveraging AI, dentists can enhance diagnosis, treatment planning, patient care, and practice management.[15]

In treatment planning

To recommend treatment strategies that align with best practices and evidence-based clinical guidelines AI algorithms leverage extensive datasets and clinical research. AI systems can stay up-to-date with the latest developments in dentistry, ensuring that the guidance provided aligns with the most current knowledge. AI can assist dental professionals in making informed and evidence-based decisions by drawing on this wealth of data and research,. This enhances the quality of care and reduces the chances of outdated or suboptimal treatment approaches.[16]

In Patient assistance and engagement

By providing personalized support and enhancing the overall dental experience AI technology has transformed patient care in dentistry. AI-powered chatbots and virtual assistants offer patients 24/7 access to information, appointment scheduling, and guidance. Patients feel more involved in their oral health journey by providing interactive and personalized information. Patient satisfaction is enhanced by the convenience and accessibility offered by AI technology.Patients can access information, schedule appointments, and receive support at their preferred time and location, increasing convenience and reducing barriers to care. Additionally, the proactive nature of AI-driven reminders and notifications ensures that patients stay on track with their oral health care, leading to better treatment outcomes. [17,18]

In Patient Education

To educate patients about dental conditions, treatments, and preventive care AI can generate informative and easily understandable educational materials, such as videos, articles, and interactive presentations. This content can be tailored to each patient's specific needs and preferences, ensuring that they have access to accurate and personalized information. AI empowers patients to make informed decisions about their oral health and encourages them to maintain good dental hygiene proactively by delivering educational content. Informed patients are more likely to comply with treatment recommendations and adopt preventive measures, leading to better oral health outcomes.[19]

In Oral Radiology

With the help of AI dental images are enhanced by improving the clarity and visibility of details. Even in challenging cases dental professionals can use AI for image enhancement to identify potential dental issues more effectively. Enhanced images can reveal finer details, aiding in the early detection and diagnosis of dental conditions.[20]AI can assist in automating various aspects of the radiographic process. This includes capturing images, positioning

X-ray equipment, and ensuring image quality. Automation reduces the workload on dental staff and minimizes the potential for human error.[21] AI-powered image analysis can help identify and quantify dental caries (tooth decay), periodontal diseases, bone loss, and anatomical abnormalities. In the detection of oral tumors, cysts, and other pathological conditions automated image analysis can also assist.[22]

By analyzing CBCT scans AI can aid in treatment planning for dental implants and provide dentists with virtual treatment plans, optimizing the placement position and angulation for optimal outcomes. For example, AI algorithms can aid in the identification of dental anomalies such as impacted teeth, supernumerary teeth, or developmental abnormalities.AI algorithms can flag any deviations and alert dentists to potential issues by comparing patient data with established norms and patterns. Abnormalities in the temporomandibular joint (TMJ) and the surrounding structures can be detected by AI algorithms. AI algorithms can identify signs of TMJ disorders, such as joint degeneration, osteoarthritis, or disc displacement by analyzing radiographs and clinical data. This enables early intervention and appropriate treatment planning.[23,24]

In Oral Cancer screening

In the early detection of oral cancer AI tools play a significant role. AI can help identify potential signs of oral cancer by analyzing images of oral lesions, including tissue discolorations or irregularities. For improving the chances of successful treatment and potentially saving lives early detection is critical. AI-based oral cancer screening tools can be valuable to routine dental check-ups, providing an extra layer of vigilance in monitoring patients oral health.[25]

In Prosthodontics

By integrating with design software and taking into account factors such as facial dimensions, anthropological calculations, ethnicity, and patient preferences AI can assist dentists in designing aesthetically appealing and functional prostheses. AI is also instrumental in detecting bone types and cortical thickness for precise positioning of implants using surgical guide.[26]

In Periodontology

To aid in the diagnosis and classification of periodontal diseases AI algorithms can analyze various diagnostic data, such as clinical parameters, radiographs, and intraoral images. By learning from large datasets, AI models can identify patterns and indicators of periodontal disease severity, enabling early detection and personalized treatment planning.[27]

In Oral Surgery

To generate virtual surgical simulations AI-based surgical planning tools can utilize patient-specific data. Surgeons can virtually plan complex procedures, such as orthognathic surgery or tumor resection, by simulating various scenarios and assessing the potential outcomes. AI algorithms can assist in surgical simulation, providing insights into the optimal surgical approach, implant positioning, and reconstruction techniques, leading to improved surgical precision and patient safety.[28,29]

In Conservative Dentistry and Endodontics

AI-powered software helps in the detection and segmentation of root canals within radiographic images enabling endodontists accurately locate and analyze complex root canal systems. Automated canal detection can save time, enhance efficiency, and improve the precision of root canal treatment. By considering factors such as canal morphology, anatomy, and mechanical properties AI algorithms can analyze and optimize endodontic instrumentation techniques, such as rotary or reciprocating file systems.[30]

CariScreen AI is an AI system developed by dentists and engineers that assists in the detection and diagnosis of dental caries (tooth decay). To analyze dental images system AI uses advanced algorithms and provide dentists with accurate and efficient assessments of tooth decay risk. Dental clinics have reported a significant improvement in the early detection of caries by implementing CariScreen AI leading to timely interventions and better oral health outcomes for patients.[16]

In Orthodontics

AI algorithms can learn to identify and categorize different types of malocclusions, helping orthodontists in treatment planning and determining appropriate treatment modalities by training on large datasets. AI-powered software can simulate the progression and outcome of orthodontic treatment by generating virtual 3D models of patients' dentition. By analyzing dental models and predicting optimal bracket positions based on individual tooth anatomy AI algorithms can automate the process of bracket placement.[31,32]

AI frees up time for dental professionals to focus on patient interaction and quality care by streamlining administrative tasks, such as appointment reminders and follow-ups which leads to improved patient satisfaction and enhanced overall dental experiences. Moreover, AI has the potential to significantly enhance practice efficiency. This data-driven approach helps dentists make evidence-based decisions, optimize workflows, and reduce errors.[16]

Conclusion :

Although there is a discussion about how AI can change dentistry, questions remain about whether it will ever completely replace dentists.Clinical intuition, intangible perception, or empathy cannot be provided by machines, which are essential for providing individualized healthcare and professionalism. Human-to-human communication which is the most fascinating aspect cannot be easily translated into computer language. Despite possible misunderstandings and concerns about patient privacy, artificial intelligence will continue to be involved with dentistry on a broad scale. This is due to the importance of precise treatment techniques and efficient health-related data exchange in dentistry. The next decade will prove if this time the expectations for tangible AI applications are met by actual outcomes or if once again an AI-winter buries hopes and excitement. Particular in healthcare, the stakes are high. There is reasonable concern about data protection and data security and about handing over critical medical decisions to computers. However, AI has the potential to revolutionize healthcare and dentistry.Dentistry and, specifically, dental research, has a role to ensure that AI will make dental care better, at lower costs, to the benefit of patients, providers, and the wider society.

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