ARTIFICIAL INTELLIGENCE: THE FUTURE OF DENTISTRY

Abstract

Artificial intelligence (AI) has emerged as an innovative technology with the prospective to reform various sectors, including healthcare. In dentistry, AI has gained considerable importance due to its ability to increase and develop dental practice. AI algorithms, powered by machine learning and deep learning techniques, can evaluate vast number of dental data, like radiographs, clinical photographs, and patient documents. By obtaining this data, AI can play a vital role in the detection and diagnosis of dental problems like Dental caries, periodontal diseases, and oral cancers with high accuracy and efficiency. In addition, AI can help in treatment planning by means of virtual simulations, predicting treatment outcomes, and optimizing the selection of appropriate dental materials and prosthetics. Furthermore, AI-powered chatbots and virtual assistants play a vital role to improve patient communication, appointment, and education. These intellectual systems can offer modified oral health recommendations, respond patients' queries, and suggest guidance on post-treatment care. Even though AI has many advantages in dentistry, challenges such as data privacy, regulatory compliance, and ethical considerations need to be addressed.

Keywords: Artificial Intelligence, Machine learning, deep learning, caries, periodontal diseases, oral cancers.

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I. INTRODUCTION

Artificial Intelligence is a breakthrough in the field of technology that is revolutionizing a range of industries, and dentistry is no exception. Artificial intelligence in a simpler terms means, the simulation of human intelligence by machines like computers. The term AI was first coined by **John McCarthy in 1955**, in Dartmouth Summer Research Project on Artificial Intelligence along with other researchers like Minsky, Nathaniel Rochester, and Claude Shannon. According to John McCarthy, it is defined as "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable" [1]. It can be also defined as "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision making, and translation between languages" [2]. AI has been widely utilized in medicine and dentistry; designed for imaging modalities, decision making, digital medicine, discovery of drugs, robotic and virtual assistants. Thus, AI can be considered as a relevant tool to aid dentists and medical professionals decrease their workload.

AI has the ability to do data analyzing, pattern identification, and to create informed predictions, thus it can improve diagnosis, treatment planning, patient communication & preventive care in dentistry.

II. HISTORY

The field of AI emerged in the 1950s with the work of pioneers like Alan Turing, John McCarthy, and Marvin Minsky.

Alan Turing in 1950 proposed the idea of a model's intelligence titled "**Computing Machinery and Intelligence**," [3] He developed **Turing test** to know whether computers can imitate human intelligence. John McCarthy first used the term artificial intelligence in 1956. [4]

III. TYPES

AI has been categorized as

- Weak AI
- Strong AI [5]

Weak AI is designed to perform virtual abilities like thinking, talking, moving if they are trained in that manner. Examples include SIRI, Alexa, and image recognition system. [5]
Strong AI can perform or surpass human level intelligence [6]

Sub Fields of AI:
AI include many sub fields like

- Machine learning
- Neural network
- Vision recognition
- Robotics

- Speech processing
- Natural language processing[7]

IV. NEURAL NETWORK

Neural network which has been designed similar to our human brain, can replicate human thoughts. It consists of layers of simple processing units; called neurons and this make up is similar to that of our brain architecture, which primarily serves as a data processing system to address a specific concern [8].

V. MACHINE LEARNING (ML):

It concentrates on creating models and algorithms that let computers learn and make judgments or predictions without being explicitly programmed. Instead of being so, with specific instructions machine learning learns from and adapt to data. For machine learning to be used effectively, a large number of data sets are necessary [9]. Data can be entered in any format, including text, audio, clinical images, radiographs, patient symptoms information, and audio of voice, murmurs, bruits, auscultation, or percussive sounds [10]. Deep learning is a branch of machine learning that analyzes input data using several computational layers in a deep neural network. In deep learning, a neural network with more than three layers, including input and output, is referred to be "deep.". Deep learning aims to build a neural network that recognizes patterns automatically to enhance feature detection [11]. There are many types in deep learning models, widely used are Convolutional neural network (CNN) which can progress feature of a neural network since it can provide accurate data than multilayer neuron network and also superior to humans. Best examples of CNN include Google lens and Google translators ML can be broadly categorized into supervised, unsupervised and reinforcement learning. Through a learning process, an Artificial Neural Network (ANN) is created for a specific application, such as pattern recognition or data classification, and utilized to increase the model's predictive accuracy.
Example of machine learning:

- Face detection in mobile camera
- Speech recognition
- Face recognition

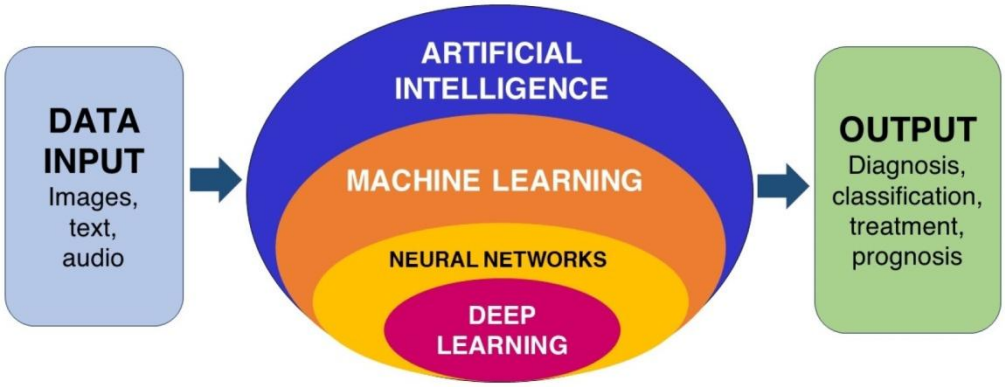

Figure 1: Functioning of AI [10]

VI. AI IN DENTISTRY

Artificial intelligence is transforming dentistry, empowering dental professionals to provide more accurate diagnoses, personalized treatment plans, and preventive care strategies. With advancements in diagnostics, treatment planning, virtual assistants, and predictive analytics, AI is revolutionizing oral healthcare, leading to improved patient outcomes and enhanced overall oral health.

1. **Oral Pathology:** Artificial intelligence can be applied in oral pathology by means of whole slide imaging in order to scan large number of tissue sections by getting beyond manual method limitations such inter-observer bias, incorrect diagnoses, prohibitive time requirements, etc[12]. Das et al. (2015) proposed an AI method called automated segmentation method so that Keratinization and keratin pearl can be ruled out from histopathological digital images [13]. The Mobile Mouth Screening Anywhere (MeMoSA) app is now working on a project that uses deep learning to distinguish between hundreds of photographs that show oral cancer symptoms and those that do not [14].

2. **Pediatric Dentistry:** Pain control with AI enabled devices is the novel idea towards injection-free pedodontic practice. AI can also be applied in the education process for students as well as patients. In behavior management of pediatric patients, various 4D spectacles in the form of videos, animations and virtual games can be used[15].

3. **Periodontics:** In 2018, Lee et al. created a deep convolutional neural network (CNN)-based computer assisted detection system (CAD) for the identification and prediction of periodontally damaged teeth [16]. Yauney et al. used an AI algorithm based on CNNs for automated diagnosis and systemic health screenings, and they found a correlation between weak periodontal state and systemic health outcomes[17]. Deep learning analysis with the use of radiographs can help in the diagnoses and treatment plan of periodontal diseases by the early detection of periodontal alterations like loss of bone and bone density changes and detection of peri-implantitis. This aids in early implantology intervention. With the aid of immunologic factors, artificial neural networks (ANN) can assist in identifying aggressive and chronic periodontitis in patients. [11].

4. **Prosthetic Dentistry:** In the branch of prosthetics, AI might be considered as an impending tool in various aspects. Deep CNN model can be a useful aid in classifying implant systems with nearly equal or better accuracy when compared with humans [18]. Takahashi et al developed an AI model with the help of CNN for classification of dental arches to assist in the fabrication of dentures [19].

5. **Orthodontics:** AI in orthodontics can be used to identify various anatomical/pathological structures and marking of reference points in Ceph analysis and thus it helps in complex decision-making in treatment planning. The accuracy of AI for automated ceph analysis based on widely-used orthodontic parameters was examined by Kunz et al. in 2020. AI algorithms could influence the extraction decision, surgical intervention in Orthognathic Surgery [20].

6. **Oral medicine and radiology:** Artificial neural networks (ANN) can be used in radiology to analyze plain radiographs, ultrasonography, CT, magnetic resonance imaging (MRI), cone beam CT (CBCT), and radioisotope images. When developed by a qualified radiologist, a machine learning algorithm can detect dentoalveolar pathology by examining thousands of images that have been classified as normal or abnormal[21].

7. **Endodontics:** Convolutional neural networks and artificial neural networks have been used in a variety of endodontic applications, including studying root canal anatomy, spotting periapical lesions and root fractures, determining working length, predicting the viability of pulpal stem cells, and forecasting the results of retreatment procedures[22]. In order to determine whether there were carious lesions in the 105 radiographs, Geetha et al. employed an artificial neural network . They came to the conclusion that neural networks can be more precise in caries diagnosis than traditional dental inspection[23].

8. **Challenges of AI Use in Dentistry:**

- Medical and Dental data cannot be easily accessible and available
- Appropriate training is necessary
- The utilization of data for testing and training purposes can result in "data snooping bias." [24].

In conclusion, AI holds great promise in dentistry, offering opportunities for improved diagnostics, treatment planning, and patient care. By harnessing the power of AI, dental professionals can enhance their decision-making capabilities, optimize treatment outcomes, and deliver personalized and efficient dental services. However, continued research, development, and collaboration are essential to overcome the challenges and fully unlock the potential of AI in the dental field.

REFERENCES

[1] John McCarthy. (Nov 12, 2007). http://www-formal.stanford.edu/jmc/
[2] Stevenson A. Oxford Dictionary of English. USA: Oxford University Press (2010).
[3] Muthukrishnan, N., Maleki, F., Ovens, K., Reinhold, C., Forghani, B., & Forghani, R. (2020). Brief history of artificial intelligence. Neuroimaging Clinics of North America, 30(4), 393–399.
[4] Kaul, V., Enslin, S., & Gross, S. A. (2020). History of artificial intelligence in medicine. Gastrointestinal Endoscopy, 92(4), 807–812.
[5] Rupali, M., & Amit, P. (2017). A review paper on General concepts of "Artificial Intelligence and Machine Learning." International Advanced Research Journal in Science, Engineering and Technology, 4(4), 79–82.
[6] Ding, H., Wu, J., Zhao, W., Matinlinna, J. P., Burrow, M. F., & Tsoi, J. K. H. (2023). Artificial intelligence in dentistry—A review. Frontiers in Dental Medicine, 4.
[7] Vijipriya, Ashok, J., & Suppiah. (2016). A review on significance of sub fields in artificial intelligence. International Journal of Latest Trends in Engineering and Technology, 6(3).
[8] Agrawal, P., & Nikhade, P. (2022). Artificial intelligence in dentistry: past, present, and future. Cureus. https://doi.org/10.7759/cureus.27405.
[9] Sah, S. (2020). Machine Learning: A Review of Learning Types. Preprints.
[10] Patil, S.; Albogami, S.; Hosmani, J.; Mujoo, S.; Kamil, M.A.; Mansour, M.A.; Abdul, H.N.; Bhandi, S.; Ahmed, S.S.S.J. Artificial Intelligence in the Diagnosis of Oral Diseases: Applications and Pitfalls. *Diagnostics* **2022**, *12*, 1029.
[11] Sachdeva, S., Mani, A., Vora, H., Saluja, H., Mani, S., & Manka, N. (2021). Artificial intelligence in periodontics – A dip in the future. Journal of Cellular Biotechnology, 7(2), 119–124.

[12] Uppala D, Smyrna O, Lavanya L, Gadam, Kumar TV. Systematic analysis of artificial intelligence in pathology Oral Maxillofacial Pathol J 2023;14(1): page no. 142-144
[13] Samuelson MI, Chen SJ, Boukhar SA, Schnieders EM, Walhof ML, Bellizzi AM, Robinson RA, Rajan K D A. Rapid Validation of Whole-Slide Imaging for Primary Histopathology Diagnosis. Am J Clin Pathol. 2021 Apr 26; 155(5):638-648.
[14] Andrea Park. Researchers Training AI Mobile App to Detect Early Signs of Oral Cancer. https://oralcancernews.org/wp/researcherstraining-ai-mobile-app-to-detect-early-signs-of-oral-cancer/.
[15] Baliga MS. Artificial intelligence – The next frontier in pediatric dentistry. J Indian Soc Pedod Prev Dent 2019; 37:315.
[16] Lee JH, Kim DH, Jeong SN, Choi SH. Diagnosis and prediction of periodontally compromised teeth using a deep learning-based convolutional neural network algorithm. J Periodontal Implant Sci. 2018; 48(2):114-23.
[17] Yauney G, Rana A, Wong LC, Javia P, Muftu A, Shah P. Automated Process Incorporating Machine Learning Segmentation and Correlation of Oral Diseases with Systemic Health. Annu Int Conf IEEE Eng Med Biol Soc. 2019; 2019:3387-93
[18] Pareek M, Kaushik B. Artificial intelligence in prosthodontics: a scoping review on current applications and future possibilities. Int J Adv Med 2022; 9:367-70.
[19] Takahashi T, Nozaki K, Gonda T, Ikebe K. A system for designing removable partial den-tures using artificial intelligence. Part 1. Classification of partially edentulous arches using aconvolutional neural network. J Prosthodont Res. 2021; 65(1):115- 8.
[20] Kunz, F.; StellzigEisenhauer, A.; Boldt, J. Applications of Artificial Intelligence in Orthodontics—An Overview and Perspective Based on the Current State of the Art. *Appl. Sci.* **2023**, *13*, 3850. 21. Oral med
[21] Singh Parihar AP. Artificial intelligence in oral medicine and radiology. J Indian Acad Oral Med Radiol 2019; 31:285.
[22] Aminoshariae, A., Kulild, J., & Nagendrababu, V. (2021). Artificial intelligence in Endodontics: current applications and future directions. *Journal of Endodontics*, *47*(9), 1352 1357.
[23] Geetha, V.; Aprameya, K.S.; Hinduja, D.M. Dental caries diagnosis in digital radiographs using back-propagation neural network. *Health Inf. Sci. Syst.* **2020**, *8*, 1–14
[24] Banerjee M. Artificial Intelligence in Dentistry: A Ray of Hope. CODS J Dent 2021;13(2):58–60

