ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 5, Issue – 3, May - 2022, Page No. : 609 - 615

Artificial intelligence in dentistry- A glimpse into the future

[1]Dr. Rohini Dua, Department of Pediatric & Preventive Dentistry, National Dental College & Hospital, Dera Bassi, S.A.S Nagar, Punjab.

[2]Dr. Gurneet Aujla, Department of Pediatric & Preventive Dentistry, National Dental College & Hospital, Dera Bassi, S.A.S Nagar, Punjab.

Corresponding Author: Dr. Gurneet Aujla, Department of Pediatric & Preventive Dentistry, National Dental College & Hospital, Dera Bassi, S.A.S Nagar, Punjab.

Citation of this Article: Dr. Rohini Dua, Dr. Gurneet Aujla, "Artificial intelligence in dentistry- A glimpse into the future", IJDSIR- May - 2022, Vol. – 5, Issue - 3, P. No. 609 – 615.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

A plethora of advancements in the field of technology during the last few decades have integrated these technological advancements into our day-to-day life. Constant effort and hard work of researchers for several years has resulted in the evolution of "Artificial Intelligence". With the potential to train a computer program to achieve highly intelligent capabilities, artificial intelligence began emerging in the healthcare field. Every field has opted for artificial intelligence with huge enthusiasm and so the field of dental science is no exception. From the basic step of taking a patient's history to data processing and then extracting the information from the data for diagnosis, artificial intelligence has many applications. While in no case artificial intelligence can replace the role of a dental surgeon but it is important to be acquainted with the scope to amalgamate this advancement of technology in the future for the betterment of dental practice.

Keywords: Artificial Intelligence, Deep Learning, Neural networks, Dentistry

Introduction

Ever since the field of science has originated, researchers and technologists have been busy solving the complexity of the human brain. A plethora of advancements in the field of technology during the last few decades have integrated these technological advancements into our day-to-day life. Gaming, language processing, robotics, and image identification are examples of non-medical applications of Artificial Intelligence technologies.

Constant effort and hard work of researchers for several years has resulted in the evolution of 'Artificial Intelligence' (AI), a term coined in 1950 by John McCarthy. He is widely recognized as the 'Father of Artificial Intelligence'. He chose this term to explain the potential of machines to perform tasks that can fall in the range of "intelligent" activities.

In the year 1956, John McCarthy organized the Dartmouth conference, where the research project to be carried out for the development of artificial intelligence was formally introduced. The 1950s to 1970s was marked as a very crucial period, wherein extensive research was done on AI.

Artificial intelligence (AI) is defined as "a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behaviour, and with the creation of artefacts that exhibit such behaviour". AI refers to the idea of designing machines that are capable of performing tasks that are

normally done by humans. It is at times called machine intelligence.

With the potential to train a computer program to achieve highly intelligent capabilities, artificial intelligence began emerging in the healthcare field.

Artificial intelligence (AI) is playing an increasingly important role in healthcare, including dentistry. Its software platforms are currently being developed or implemented for use in many targeted healthcare applications, including medical diagnostics, patient monitoring, and learning healthcare systems.

AI is being used in various disciplines such as medical diagnosis, exchange market, control of robots, law, science, or entertainment. Some most commonly used forms of artificial intelligence are Alexa and Siri. These platforms have brought about a remarkable development in the day-to-day lives of the people by acting as virtual assistants. They can carry out their function simply by voice recognition and command.

Discussion

- **Machine learning** is part of AI, which depends on algorithms to predict outcomes based on a dataset. Its purpose is to facilitate machines to learn from data so they can resolve issues without human input.

Machine learning was first mentioned by Arthur Samuels in 1959. He defined it as a process that enables computers to learn without being explicitly programmed.

- **Neural networks (NN)** are a set of algorithms that compute signals via artificial neurons. They were invented keeping the structure of the brain as its basis and it can imitate the human brain. The main constituent of any NN is the artificial neuron, which is a mathematical non-linear model was inspired by the human neuron. By stacking artificial neurons and connecting those layers using mathematical operations, a network is engineered that aims to solve a specific task.
- **Deep learning** is a component of machine learning that utilizes the network with different computational layers in a deep neural network to analyse the input data. The purpose of deep learning is to construct a neural network that automatically identifies patterns to improve feature detection. Deep learning is also known as convolutional neural networks (CNN). They collect features from the abstracted layer of filters and are primarily used to process large and complex images.

A. Artificial intelligence in dentistry

AI approaches have a huge capacity to distinguish and analyse the injuries of the oral cavity which may normally go unseen by the natural eye, thus making its way into dental practice. It has been used in dentistry mainly to make the process of diagnosis more accurate and efficient, which is of utmost importance in achieving the best results in the treatment provided along with superior quality patient care.

Principles

The various principles of AI which are being applied in dentistry include artificial neural networks (ANN), genetic algorithms (GA), and fuzzy logic.

Artificial Neural Networks (ANN)

Artificial Neural Networks were developed keeping the construction of the brain as its premise and it can mimic human brains. In 1951**,** Minsky and Dean Edmunds fostered the stochastic neural analogy reinforcement calculator, which is perceived as the absolute first neural organization in its formative history. They can solve problems that are too complex to be solved by conventional methods.

An investigation done by Kim et al. (2009) utilized an Artificial neural network to construct a model that can anticipate toothache based on the relationship between toothache and everyday tooth brushing recurrence, tooth brushing time, use of dental floss, frequency of toothbrush replacement, undergoing scaling and different elements like eating regimen and exercise.

Another research done by Nieri et al in 2010, utilized Bayesian network analysis to recognize connections between different components influencing the diagnosis and the final treatment result of affected maxillary canines. In this investigation, all the pre-treatment and post-treatment information of the patients was assembled along with patient-related factors to recognize links between these factors. The examination induced that Artificial knowledge could be utilized in dentistry to help dental experts.

Genetic Algorithms (GA)

It is inspired by Darwin's theory of Natural Selection. It includes approaches such as mutation, inheritance, selection, and crossover to search for a better option for the problem. They work on the process of finding the best solution out of multiple best solutions, "BEST OF BEST". It is based on problem-solving rather than the concept of analytical relationships of conventional methods.

Łodygowski T and colleagues in 2009, utilized a Genetic Algorithm for streamlining a dental implant system to diminish the issue of mechanical crack and to give long haul solidarity to the implant.

Another study by Li H et al. in 2015, used a genetic algorithm in conjunction with a backpropagation neural network to improve tooth colour matching, which is one of the greatest challenges in prosthetic dentistry.

A recent study by Tripathi et al (2019) reported on the genetic algorithm-based approach to detecting dental caries in its early stages to avoid the severity of tooth decay.

Fuzzy Logic

The term fuzzy logic was coined by Lotfi Zadeh, which means the things which are not clear or vague. The idea behind fuzzy logic is to mimic the ability of human thinking that works with not-so-clear-cut terms.

Mago et al in 2011, developed an expert system based on fuzzy logic that accepts imprecise values for signs and symptoms associated with mobile teeth to help dentists make decisions.

Herrera and colleagues in 2010, used a fuzzy logic-based system that predicted the colour change after teeth were bleached based on the tooth's initial chrome values.

B. Applications of artificial intelligence in dentistry

Clinical Decision Support Systems (CDSS)

In the past few years, AI-assisted data analysis and learning tools have been used widely in research with patient electronic health records (EHRs). These records were previously kept on paper within hospitals but now exist electronically on secure computer servers.

The clinical decision support system is defined as, any computer program that has been designed to help health professionals in making clinical decisions and also deals with the medical data or with the knowledge of medicine necessary for interpreting such data.

CDSS can link EHRs with other sources of data, such as biomedical research databases, genome sequencing databanks, pathology laboratories, insurance claims, and pharmacovigilance surveillance systems. AI-assisted analysis of all this big data can generate clinically relevant information in real-time for health professionals, health systems administrators, and policymakers.

Currently, the interactive interphase with voice controls is being designed to assist the health care professional to work more efficiently with a time-saving and cost-effective clinical dental practice.

Orthodontics

In recent times, by analysing the radiographs and photographs, AI helps in orthodontic diagnosis, planning treatment, and monitoring the progression of treatment. With the advent of intraoral scanners and cameras making of dental impressions are being replaced by digital impressions. The above data is fed into the system, the set algorithms and AI software helps in predicting tooth movements and the outcome of the treatment.

A study based on the cellular neural networks was aimed to evaluate the accuracy in locating the cephalometric landmarks on cephalometric radiographs, the results of this study were encouraging and the model demonstrated good results. (Leonardi R, 2009)

AI-based technology has been applied for determining the stages of the growth and development by cervical vertebrae, a study reported that the Artificial Neural Network-based model demonstrated a mean accuracy of 77.02% in determining the stages of the growth and development of cervical vertebrae. (Ko¨k H, 2019)

Another study designed for predicting the need for orthodontic treatment proved to be effective and demonstrated promising results with a high degree of accuracy in predicting the need for orthodontic treatment. (Thanathornwong B, 2018)

Oral And Maxillofacial Radiology and Diagnostics

Zhang et al (2018) reported the use of AI-based convolutional neural networks (CNNs) and evaluated effective teeth recognition. The model demonstrated a high precision of 95.8%.

Chen et al. (2019) applied the CNNs to detect the teeth number in intraoral periapical films and then to identify the tooth. The model demonstrated very high precision. The results indicated that AI technologies make it convenient

for clinicians to do their job. They do not have to enter the details manually. Using these automated systems dentists can enter their dental charts digitally, resulting in higher efficiency.

AI technology in the detection of dental caries has demonstrated excellent results which were reflected in the study done by Lee et al. (2018) who reported applying CNN algorithms for detection and diagnosis of dental caries on periapical radiographs.

The result of the application demonstrated considerably good performance.

Ekert et al. (2019) were successful in detecting apical lesions when they applied CNNs to detect apical lesions (ALs) on panoramic dental radiographs.

Oral And Maxillofacial Surgery

As per WHO (February 2020), every year there are around 657,000 new cases detected of cancers of the oral cavity and pharynx, and is also a reason for 330,000 deaths.

AI technology has been used for detecting cancers. Aubreville et al. (2017), showed extremely positive and promising results when employed CNNs for an automatic approach for diagnosing Oral Squamous Cell Carcinoma was used with confocal laser

endomicroscopy images. The study indicated that the AI model will be helpful for early diagnosis.

Zhang et al. (2018) used an artificial intelligence model based on ANN for predicting the postoperative facial swelling following the extraction of impacted mandibular 3rd molars.

Periodontics

It is a known fact that periodontal disease is one of the main reasons for the early loss of teeth. Various studies have been done to ascertain AI technology application to diagnose and predict periodontal diseases.

Lee et al. (2018) reported the use of a CAD system, based on a deep convolutional neural network (CNN) algorithm for diagnosing and predicting the teeth that are compromised with periodontal health. The outcome was quite acceptable with a mean predictive accuracy of 78.9%.

Yauney et al. (2019), used an AI-based system based on CNNs for correlating poor periodontal health with systemic health outcomes and reported that, AI can be used for automated diagnoses and can also be useful for screenings for other diseases.

Krois et al. (2019) used CNNs to detect periodontal bone loss (PBL) on panoramic dental radiographs.

Treatment Outcome Assessment in Cleft Patients

Raphael Patcas et al (2019) evaluated the facial attractiveness of treated cleft patients and controls by artificial intelligence (AI) and compared these results with panel ratings performed by laypeople, orthodontists, and oral surgeons. They concluded that AI-based scoring requires further perfection and refinement to differentiate cleft features of the face that negatively influence the human perception of attractiveness.

Endodontics: Saghiri et al. (2012) used an artificial neural network (ANN) system in determining the working length and showed exceptional accuracy of 96% which is higher than the accuracy compared to professional endodontists.

In endodontics, AI is used to diagnose vertical root fractures. A study employed by Johari et al. (2017) used a probabilistic neural network (PNN) for the diagnosis of vertical root fractures. This PNN system displayed excellent performance with an accuracy of 96.6%.

These assessments indicate that AI-based models are incredibly effective when it comes to the detection of vertical root fractures on CBCT images and panoramic radiographs.

Prosthodontics

AI combined with designing software can aid the dentist to design the best possible and aesthetic prostheses considering several factors like facial measurements, anthropological calculations, ethnicity, and patient desire.

AI plays a major role in identifying the type of bone, cortical thickness for making precise surgical guides for placing implants (Vera V, 2013)

The use of CAD/CAM technology which creates 2D and 3D models has replaced the time-consuming and laborious process of conventional casting thereby reducing human errors. Furthermore, AI-based systems are used to design inlays, Onlays, crowns, and bridges.

Dental Education System

Clinical dentistry is an essential part of dentistry for learning the skills, to enhance patient care. Traditionally, pre-clinical operative training for dental students was a combination of theoretical teaching and practical learning. Recently artificial intelligence has been incorporated into tutoring intelligent education systems and training in dentistry. (Feeney L, 2008)

These technologies can create a virtual reality that enables simulation of the practical procedures in three

dimensions that enable simulation and allow the assessment of clinical and surgical techniques. (Pohlenz P, 2010)

The practice sessions can be done several times till the skill set is expertised by students over the subject before the actual handling of real clinical cases, reducing the risk of iatrogenic damage.

Pediatric Dentistry

Wenzhe You et al (2020) developed an AI model which showed clinically acceptable performance in detecting dental plaque on primary teeth compared with an experienced Pediatric dentist.

Conclusion

In conclusion, Artificial Intelligence is not a myth but our future in dentistry. Its applications in every area are growing day by day. While in no way it can replace the role of the dentist as a dental practice is not only about the diagnosis of disease, but it also includes correlation with various clinical findings and provides treatment to the patient.

Due to the need for precision and instant information exchange in Dentistry, AI will continue to connect with the dental profession in every aspect. In the future, we expect that dental clinics will establish an AI-Comprehensive Care System.

AI can assist the clinician in performing the tasks efficiently, but in no way replace the intellect of the human knowledge, skill, and treatment planning.

References

1. Boreak, Nezar. "Effectiveness of Artificial Intelligence Applications Designed for Endodontic Diagnosis, Decision-making, and Prediction of Prognosis: A Systematic Review." The Journal of Contemporary Dental Practice 21, no. 8 (2020): 926-934.

2. Chen, Yo-wei, Kyle Stanley, and Wael Att. "Artificial intelligence in dentistry: Current applications and future perspectives." Quintessence Int 51, no. 3 (2020): 248-57.

3. Comendador, Benilda Eleonor V., Bien Michael B. Francisco, Jefferson S. Medenilla, and Sharleen Mae. "Pharma Bot: a pediatric generic medicine consultant chatbot." Journal of Automation and Control Engineering 3, no. 2 (2015).

4. Hung M, Park J, Hon ES, Bounsanga J, Moazzami S, Ruiz-Negrón B, Wang D. Artificial intelligence in dentistry: Harnessing big data to predict oral cancer survival. World J Clin Oncol 2020; 11(11): 918-934

5. Katne, Tejaswi, Alekhya Kanaparthi, Srikanth Go Toor, Srikar Muppirala, Rama Raju Devaraju, and Ramlal Gantala. "Artificial intelligence: demystifying dentistry–the future and beyond." Int J Contemp Med Surg Radiol 4, no. 4 (2019): D6-D9.

6. Khanagar, Sanjeev B., Ali Al-Ehaideb, Prabhadevi C. Maganur, Satish Vishwanathaiah, Shankar gouda Patil, Hosam A. Baes hen, Sachin C. Sarode, and Shilpa Bhandi. "Developments, application, and performance of artificial intelligence in dentistry–a systematic review." Journal of dental sciences 16, no. 1 (2021): 508-522.

7. Khan agar, Sanjeev B., Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankar gouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode. "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of dental sciences 16, no. 1 (2021): 482-492.

8. Khanna, Sunali S., and Prita A. Dhaimade. "Artificial intelligence: transforming dentistry

today." Indian J Basic Appl Med Res 6, no. 3 (2017): 161-167.

9. Kissos, Limor, Limor Goldner, Moshe But man, Niv Eliyahu, and Rachel Lev-Wiesel. "Can artificial intelligence achieve human-level performance? A pilot study of childhood sexual abuse detection in self-figure drawings." Child Abuse & Neglect 109 (2020): 104755.

10. Kissos, Limor, Limor Goldner, Moshe but man, Niv Eliyahu, and Rachel Lev-Wiesel. "Can artificial intelligence achieve human-level performance? A pilot study of childhood sexual abuse detection in self-figure drawings." Child Abuse & Neglect 109 (2020): 104755.

11. Lysaght, Tamra, Hannah Yee fen Lim, Vicki Xafis, and Kee Yuan Ngiam. "AI-assisted decision-making in healthcare." Asian Bioethics Review 11, no. 3 (2019): 299-314.

12. Oh, Sang-Yeob, Supratip Ghose, Kyung Yong Chung, Joong-Kyung Ryu, and Jung-Soo Han. "Recent trends in convergence-based smart healthcare service." Technology and Health Care 22, no. 3 (2014): 303-307.

13. Park, Jae Hyun, Leah Rogowski, Janet H. Kim, Sumayah Al Shami, and Scott EI Howell. "Tele dentistry platforms for orthodontics." Journal of Clinical Pediatric Dentistry 45, no. 1 (2021): 48-53.

14. Patcas, Raphael, Radu Timofte, Anna Volokitin, Eirikur Agustsson, Theodore Eliades, Martina Eichenberger, and Michael Marc Bornstein. "Facial attractiveness of cleft patients: a direct comparison between artificial-intelligence-based scoring and conventional rater groups." European journal of orthodontics 41, no. 4 (2019): 428-433.

15. Schwendicke, Fet al, W. Samek, and J. Krois. "Artificial intelligence in dentistry: chances and challenges." Journal of dental research 99, no. 7 (2020): 769-774.

16. Tandon, Divya, Jyotika Rajawat, and Monisha Banerjee. "Present and future of artificial intelligence in dentistry." Journal of Oral Biology and Craniofacial Research 10, no. 4 (2020): 391-396.

17. Yatabe, Marilia, Juan Carlos Prieto, Martin Styner, Hongtu Zhu, Antonio Carlos Ruellas, Beatriz Paniagua, Francois Budin et al. "3D superimposition of craniofacial imaging—The utility of multicentre collaborations." Orthodontics & craniofacial research 22 (2019): 213-220.

18. You, Wenzhe, Aimin Hao, Shuai Li, Yong Wang, and Bin Xia. "Deep learning-based dental plaque detection on primary teeth: a comparison with clinical assessments." BMC Oral Health 20 (2020): 1-7.