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ARTIFICIAL INTELLIGENCE IN DENTISTRY: A MILESTONE

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ABSTRACT The concept of "artificial intelligence" (AI) refers to machines that are capable of executing human-like tasks. AI can also be defined as a field concerned with computational models that can reason and act intelligently. Perspicacious software for data computation has become a necessity as the amount of documented information and patient data has increased dramatically. The applicability, limitations, and potential future of AI-based dental diagnoses, treatment planning, and conduct are described in this concise narrative overview. AI has been used in a variety of ways, from processing of data and locating relevant information to using neural networks for diagnosis and the introduction of augmented reality and virtual reality in dental education.

AI-based apps will improve patient care by relieving the dental workforce of tedious routine duties, improving population health at lower costs, and eventually facilitating individualized, anticipatory, prophylactic, and collaborative dentistry.

The convergence of AI and digitization has ushered in a new age in dentistry, with tremendously promising future prospects.The applicability, limitations, and potential future of AI-based dental diagnoses, treatment planning, and conduct are described in this concise narrative overview.

KEYWORDS : Artificial intelligence, data computation, neural networks, digitization

INTRODUCTION

Artificial intelligence (AI) refers to the knowledge about the linguistic structure that is sent to the system, with the goal of providing a more intuitive and rapid response based on a learning algorithm that repeats patterns in updated data [1].

Machine learning (ML) is a subfield of AI which consists of growing discipline of computing algorithms that were developed to mimic the intelligence of living organisms by learning from their surroundings [2]. Machine learning, as a subfield of artificial intelligence, incorporates concepts from a variety of fields, including probability and statistics, evolutionary computation, psychology, control theory, and philosophy [3].

HISTORY OF ARTIFICIAL INTELLIGENCE:

For more than half a century after its inception as an academic study in the 1950s, artificial intelligence (AI) has remained a field of relative scientific mystery and limited practical relevance [413]. A generation of scientists, mathematicians, and philosophers had embraced the concept of artificial intelligence at the time (or AI). Allen Newell, Cliff Shaw, and Herbert Simon's, *Logic Theorist* was a programme developed by the Research and Development (RAND) Corporation to simulate human problem-solving abilities and is widely regarded as the first artificial intelligence programme [514].

ARTIFICIAL INTELLIGENCE IN DENTISTRY

In dentistry, AI is generally used to discriminate between lesions and normal structures, prioritise risk factors, and simulate and evaluate prospective outcomes using AI algorithms. AI is less susceptible to bias and better at judging probabilities and save time for the dentist by automation of processes.

Clinical Decision Support System

Clinical data, such as electronic health records, illness registries, patient surveys, and exchange of data, is growing substantially in number and quality. A computer using AI, considers all available data, making it possible to detect changes that are outside the scope of the professional's expertise and changes that are peculiar to a given patient, all within reasonable boundaries [64].

Artificial Neural Network

Artificial neural networks (ANNs) are a highly connected network of computer processors modelled after biological nervous systems [75]. These technologies allow oral health care experts from all over the world to communicate with each other [86] and in prioritising their patients' needs [98].

Augmented Reality and Virtual Reality

Virtual reality (VR) and augmented reality (AR), two modern simulation models, are increasingly being used to improve medical education[109].

VR gives users a 3D and dynamic representation of structures therefore, surgical procedures are the most common uses of VR [110]. The patient can try on a virtual prosthesis with the use of AI systems and augmented reality, which can be adjusted until the patient is pleased, and then the final prosthesis is constructed [121].Virtual reality and AI systems have been an effective tool for non-pharmacological treatment of pain [132].

HISTORY OF ARTIFICIAL INTELLIGENCE For more than half a century after its inception as an academic study in the 1950s, artificial intelligence (AI) has remained a field of relative scientific mystery and limited practical relevance. [13] A generation of scientists, mathematicians, and philosophers had embraced the concept of artificial intelligence at the time (or AI). Alan Turing, a young British polymath who investigated the mathematical possibilities of artificial intelligence, published a paper on Computing Machinery and Intelligence discussing how to build intelligent machines and test their intelligence. Five years later, the proof of concept was initialized through Allen Newell, Cliff Shaw, and Herbert Simon's, *Logic Theorist*. The Logic Theorist was a programme developed by the Research and Development (RAND) Corporation to simulate human problem-solving abilities. It was presented at the Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) led by John McCarthy and Marvin Minsky in 1956 and is widely regarded as the first artificial intelligence programme.

[ARTIFICIAL INTELLIGENCE IN DENTISTRY:

AI in healthcare is the use of the application to approximate human cognition in the analysis of complex medical data. Machine learning algorithms are capable of processing more data and detecting more patterns than humans. For general health care delivery, there are two forms of AI: physical and virtual. Sophisticated robots or automated robotic arms illustrate physical applications. Virtual components are software-based algorithms that assist clinicians in making clinical decisions. In dentistry, AI is generally used to discriminate between lesions and normal structures, prioritise risk factors, and simulate and evaluate prospective outcomes using AI algorithms. AI in dentistry is gaining popularity because it provides practitioners with high-quality patient care while also simplifying intricate processes by ensuring a predictable outcome. AI is less susceptible to bias and better at judging probabilities. AI applications save time for the dentist by automation of proce.

METHODOLOGY:

A comprehensive search of electronic data bases was used to identify and choose the literature for this paper like GOOGLE SCHOLAR, RESEARCH GATE and PUBMED published over the past decade from 2011 to 2021 by using keywords such as artificial intelligence, data computation, neural networks, digitization.

RESOURCES SELECTION:

To search the journals, full-length articles were collected and electronic searching was used. The papers were chosen in the first step based on their titles and abstracts, which were relevant to our study subject which yielded 117 articles. 26 articles were excluded due to redundancy. As a result, we were able to find 91 articles for the second step of the selection process.

The following criterion was then used.

CRITERIA FOR IDENTIFYING WHICH STUDIES TO INCLUDE IN THIS REVIEW :

INCLUSION CRITERIA.

1. The article must be about artificial intelligence (AI) and its use in dentistry.
2. Clinical and non-clinical trials.
3. To be quantified, there must be some predictability or observable results.

EXCLUSION CRITERIA

1. Where Full-text articles were not available or accessible.
2. The articles that are related to non-dental AI applications.

The number of articles was further decreased to 2137 after applying these criteria.

RESULTS:

AI IN ENDODONTICS

In a study, Johari et al. set out to create a probabilistic neural network that could detect vertical root fractures in intact and endodontically treated teeth using periapical and CBCT radiographs [14].

Saghiri et al aimed to test the accuracy of an ANN in a human cadaver model in order to simulate a clinical working length determination. Using the ANN, endodontists before extraction, and stereomicro scopically after extraction classified the file's placement in reference to the minor apical foramen as long, short, and exact. Friedman and Wilcoxon tests were used to compare the results [15].

The diagnostic performance of a deep learning system for classification of the root morphology of mandibular first molars on panoramic radiographs was investigated in study by Hiraiwa et al [16].

AI IN ORAL SURGERY

Zhang et al developed an AI model using an improved conjugate grads back propagation (BP) algorithm to predict facial swelling after extraction of impacted mandibular third molars[17]. The Neural Network Toolbox22 from MATLAB was utilised in the research [18].

Bas et al. used clinical signs and symptoms to determine the usage of ANNs for the prediction of two subgroups of temporomandibular joint (TMJ) internal derangements (IDs) and normal joints in their study[19].

AI IN ORTHODONTICS

Using lateral cephalometric radiographs, Xie et al. used an ANN model to determine whether extractions are necessary[20].

Jung et al. conducted research to develop an AI expert system for extraction diagnosis using neural network machine learning and to assess the model's performance.Using a back-propagation algorithm, 4 neural network machine learning models for extraction diagnosis were created and tested[21].

Thanathornwong [22] proposed an AI model based on bayesian network (BN) for determining the necessity for orthodontic treatment, which demonstrated high accuracy.

AI IN PERIODONTICS

Lee et al created a DCNN-based architecture with 16 convolution layers and 2 completely connected layers.Periapical radiography images were used to identify the best CNN algorithm and weights using a combination of pretrained deep CNN architecture and a self-trained network [23].

Also, to segment gingival disorders from oral images, Rana et al. introduced an autoencoder system with convolutional layers which differentiates between inflamed and healthy gingival [24].

Papantanopoulos and colleagues employed an ANN to differentiate between Aggressive periodontitis and Chronic periodontitis in patients [25]. To categorise periodontitis patients, they created MLP ANNs.In comparison to a goal probability value disclosed by KDE, they trained ANNs using cross entropy values (CE) of immunological markers of periodontitis patients.

AI IN ORAL MEDICINE

Recurrent apthous ulcer, that is diagnosed based on recurrence and the exclusion of other causes [26]. A study was conducted in which the architectural neural networks were optimised using ANN software that employed genetic algorithms.The neural networks were built and trained using input and output data.

A CNN algorithm was employed in one study to differentiate between ameloblastomas and keratocysticodontogenic tumours [27].

Also , Genetic Algorithms and ANN may also be used to estimate the size of unerupted canines or premolars and can be optimized to predict tooth surface loss.

AI IN RADIOLOGY

It may be used in conjunction with imaging technologies such as MRI and CBCT to detect minute deviations from normalcy that would otherwise go unobserved by the naked eye. This method may also be used to properly detect landmarks on radiographs for cephalometric diagnosis [28].

Wang et al contributed in the establishment of a bitewing radiograph dental anatomy data repository, the creation of a cephalometric radiograph anatomical anomaly classification data repository, and the design of objective quantitative evaluation for comparison and ranking of the algorithms[29].

Lee et al. have investigated DCNN for the identification of osteoporosis on panoramic radiographs utilising CAD system [30]. Single-column DCNN, single-column with data augmentation and multicolumn DCNN were used to analyse all panoramic radiographs.

The use of ANN to find the minor apical foramen improves the accuracy of working length estimation by radiography and the diagnosis of proximal dental caries. It also has enough sensitivity, selectivity, and reliability to be used as a model for detecting vertical root fractures in digital radiography [31].

AI IN DENTAL EDUCATION AND PATIENT MANAGEMENT

With the recent addition of AI to intelligent tutoring systems such as the Unified Medical Language System (UMLS), the level of feedback provided by the preclinical virtual patient has vastly improved [32].The dental chair has undergone a significant transformation from a traditional hydraulic chair to an electrical and fully automated dental chair controlled by sensors.The most recent is a voice command operated dental chair.

Virtual dental assistants based on AI are now available in market that can do a variety of simple operations in the dental clinic with higher precision.

Scheduling and managing regular appointments in accordance with the patients' and dentists' preferences. Notifying patients and dentists about dental screenings whenever genetic or lifestyle data shows a greater risk of dental disease.Notifying the dentist of any allergies the patient may have prior to each appointment. Informing the dentist about any relevant medical history .It also works by alerting the dental professional to the patient's behavioural details, such as cigarette or alcohol usage.When a dental emergency arises and the dental health care expert cannot be reached, emergency tele-assistance is provided [8].These methods are useful for forensic diagnostics also[33].

DISCUSSION:

AI IN ENDODONTICS

The probabilistic neural network can be employed as an appropriate model for detecting vertical root fractures on CBCT images of endodontically treated and intact teeth.The greatest accuracy,

sensitivity, and specificity values in the periapical radiographs were found to be 70.00 percent, 97.78 percent, and 67.7 percent, respectively. At a variance change range of 0.1 0.65, these values in the CBCT images were 96.6 percent, 93.3 percent, and 100 percent, respectively.

Furthermore in the following study the anatomic position of minor apical foramen was correctly determined 96% of the time by ANN. The diagnostic performance of a deep learning system for classification of the root morphology of mandibular first molars on panoramic radiographs found that on CBCT images, extra roots were found in 21.4 percent of distal roots.

AI IN ORAL SURGERY

ANN based on the enhanced conjugate grads BP algorithm displayed a high prediction accuracy, indicating that it can aid in the prediction of swelling following the extraction of impacted mandibular third molars.

The use of ANNs to diagnose TMJ ID subtypes could be a beneficial supplementary diagnostic method, for dental practitioners. The sensitivity and specificity of ANN in detecting unilateral anterior disc displacement with reduction were 80% and 95%, respectively, and without reduction were 69% and 91%, respectively.

AI IN ORTHODONTICS

The ANN used in this study was successful in detecting whether extraction or non-extraction treatment was better for malocclusion patients aged 11 to 15 years old, with an accuracy of 80%.The models displayed a 93% success rate in diagnosing extraction vs. nonextraction and an 84% success rate in diagnosing extraction patterns in detail.

AI IN PERIODONTICS

The accuracy of diagnosis of periodontally compromised teeth is 76.7–81% using the CNN method, while the accuracy of predicting the requirement for extraction is 73.4–82.8%. Premolars are more accurately diagnosed as PCTs than molars, indicating a difference in accuracy between the two types of teeth. This might be due to the fact that premolars typically have a single root, but molars often have two or three roots, resulting in a more complicated structure for a CNN to analyze.

Periodontitis pathophysiology is microorganism specific, ANNs may successfully categorise periodontitis patients into the AgP or CP classes based on their immune response profile.

AI IN ORAL MEDICINE

Prediction of occurrence of recurrent apthae includes gender, haemoglobin, serum vitamin B12 etc as factors related to recurrent aphthous ulceration and appropriate for use as input data to construct ANNs that predict recurrent aphthous ulceration.

The algorithm's specificity and accuracy of differentiating between ameloblastomas and keratocysticodontogenic tumours were 81.8% and 83.3% respectively, which were equivalent to clinical specialists' 81.1% and 83.2% .Moreover, there is a more substantial disparity in diagnostic time: professionals requires an average of 23.1 minutes to establish a diagnosis, whereas the CNN does the same in 38 seconds .

AI IN RADIOLOGY

The average classification accuracy using image rotation and intensity transformation enhanced training data is 88.8%.When compared to the results obtained without data augmentation, data augmentation improved classification accuracy by about 5%.The proposed tooth classification method could be useful for forensic identification by automating the filing of dental charts [34].

The DCNN-based CAD system (connectionist AI) is effective for diagnosing osteoporosis [35].

The position of the AF is accurately detected in 93% of the samples using false rejection and acceptation error techniques, according to ANN's analysis of images from radiographs (test samples) [36].

CONCLUSION:

AI is fast advancing, with applications in diagnosis, treatment, and prognosis prediction. Although there are challenges with data collecting, interpretation, and moral considerations that must be overcome, AI is seen as a valuable tool for dentists. AI can be user-friendly, transparent, reproducible, and unbiased with careful design and long-term clinical validation. With increasing skill in processing huge data, future AI development should continue to prioritise human interest as its primary objective.

REFERENCES

1. chwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res. 2020 Jul;99(7):769-774. doi: 10.1177/0022034520915714. Epub 2020 Apr 21. PMID: 32315260; PMCID: PMC7309354.
2. El Naqa, I., Ruan, D., Valdes, G., Dekker, A., McNutt, T., Ge, Y., Wu, Q. J., Oh, J. H., Thor, M., Smith, W., Rao, A., Fuller, C., Xiao, Y., Manion, F., Schipper, M., Mayo, C., Moran, J. M., & Ten Haken, R. (2018). Machine learning and modeling: Data, validation, communication challenges. Medical physics, 45(10), e834–e840. https://doi.org/10.1002/mp.12811
3. Mitchell TM. Machine Learning. New York, NY: McGraw-Hill; 1997. [Google Scholar]
4. Volume: 61 issue: 4, page(s): 5-14
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   Michael Haenlein1, Andreas Kaplan2
   1ESCP Europe Business School, Paris, France
   2ESCP Europe Business School, Berlin, Germany
   https://doi.org/10.1177%2F0008125619864925
5. https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/
6. Wasylewicz ATM, Scheepers-Hoeks AMJW. Clinical Decision Support Systems. 2018 Dec 22. In: Kubben P, Dumontier M, Dekker A, editors. Fundamentals of Clinical Data Science [Internet]. Cham (CH): Springer; 2019. Chapter 11. Available from: https://www.ncbi.nlm.nih.gov/books/NBK543516/ doi: 10.1007/978-3-319-99713-1_11
7. Steimann F. On the use and usefulness of fuzzy sets in medical AI. ArtifIntell Med. 2001 Jan-Mar;21(1-3):131-7. doi: 10.1016/s0933-3657(00)00077-4. PMID: 11154877.
8. Ramesh, A. N., Kambhampati, C., Monson, J. R. T., Drew, P. J.. Artificial intelligence in medicine. Annals of the Royal College of Surgeons of England, 2004, 86(5), 334–338. http://doi.org/10.1308/1478708042909
9. Kassianos, A.P., Emery, J.D., Murchie, P., Walter, F.M., Smartphone applications for melanoma detection by community, patient and generalist clinician users: a review. Br J Dermatol, 2015, 172: 1507–1518.
10. Khanna, Sunali&Dhaimade, Prita. (2018). Artificial Intelligence: Transforming Dentistry Today (Research Gate).
11. Sakakushev BE, Marinov BI, Stefanova PP, Kostianev SS, Georgiou EK. Striving for Better Medical Education: the Simulation Approach. Folia Med (Plovdiv). 2017 Jun 1;59(2):123-131. doi: 10.1515/folmed-2017-0039. PMID: 28704187.
12. PanteleimonPantelidis, AngelikiChorti, GeorgiosPaparoidamisIoannaPapagiouvanni, GeorgiosPaparoidamis, Christos Drosos, ThrasyvoulosPanagiotakopoulos, GeorgiosLales, MichailSideris.Virtual and Augmented Reality in Medical Education,2017,10.5772/intechopen.71963.
13. Buchanan JA. Experience with virtual reality-based technology in teaching restorative dental procedures. J Dent Educ; 2004, 68(12):1258-65.
14. Johari M, Esmaeili F, Andalib A, et al. Detection of vertical root fractures in intact and endodontically treated premolar teeth by designing a probabilistic neural network: an ex vivo study. DentomaxillofacRadiol 2017;46(2):20160107. DOI: 10.1259/dmfr.20160107.
15. Saghiri MA, Garcia-Godoy F, Gutmann JL, et al. The reliability of artificial neural network in locating minor apical foramen: a cadaver study. J Endod 2012;38(8):1130–1134. DOI: 10.1016/j.joen.2012. 05.004.
16. Hiraiwa T, Ariji Y, Fukuda M, Kise Y, Nakata K, Katsumata A, et al. A deep-learning artificial intelligence system for assessment of root morphology of the mandibular first molar on panoramic radiography. DentomaxillofacRadiol 2019; 48: 20180218.
17. Beale, M. H., Hagan, M. T. & Demuth, H. B. Neural Network Toolbox TM User' s Guide How to Contact MathWorks.: 406 (2015)
18. Zhang W, Li J, Li Z, et al. Predicting postoperative facial swelling following impacted mandibular third molars extraction by using artificial neural networks evaluation. Sci Rep 2018;8:12281.
19. Bas B, Ozgonenel O, Ozden B, Bekcioglu B, Bulut E, Kurt M. Use of artificial neural network in differentiation of subgroups of temporomandibular internal derangements: a preliminary study. J Oral Maxillofac Surg. 2012 Jan;70(1):51-9. doi: 10.1016/j.joms.2011.03.069. Epub 2011 Jul 29. PMID: 21802818.
20. Xie X, Wang L, Wang A. Artificial neural network modeling for deciding if extractions are necessary prior to orthodontic treatment. Angle Orthod 2010;80:262e6.
21. Jung SK, Kim TW. New approach for the diagnosis of extractions with neural network machine learning. Am J OrthodDentofacialOrthop 2016;149:127e33
22. Thanathornwong B. Bayesian-based decision support system for assessing the needs for orthodontic treatment. Healthc Inform Res 2018;24:22e8.
23. 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 Apr 30;48(2):114-123. doi: 10.5051/jpis.2018.48.2.114. PMID: 29770240; PMCID: PMC5944222.
24. Rana A, Yauney G, Wong LC, Gupta O, Muftu A, Shah P. Automated segmentation of gingival diseases from oral images. In: Proceedings from2017 IEEE Healthcare Innovations and Point of Care Technologies (HI-POCT); November 6-8, 2017. Bethesda, MD: IEEE; 2017. pp. 144-7. Available at: IEEE Xplore. [Cited September 23, 2018].
25. Papantonopoulos G, Takahashi K, Bountis T, Loos BG. Artificial neural networks for the diagnosis of aggressive periodontitis trained by immunologic parameters. PLoS One. 2014;9(3):e89757.
26. Tandon, D., &Rajawat, J. (2020). Present and future of artificial intelligence in dentistry. Journal of oral biology and craniofacial research, 10(4), 391–396. https://doi.org/10.1016/j.jobcr.2020.07.015.
27. Poedjiastoeti W, Suebnukarn S. Application of convolutional neural network in the diagnosis of jaw tumors. Healthc Inform Res. 2018;24(3):236-41.
28. Khanna S. Artificial intelligence: contemporary applications and future compass. Int Dent J. 2010;60:269–72.
29. Wang et al. published the first paper that employed DCNNs to diagnose and evaluate dental radiographs.
30. Chen YC, Hong DJ, Wu CW, Mupparapu M. The Use of Deep Convolutional Neural Networks in Biomedical Imaging: A Review. J OrofacSci 2019;11:3-10
31. Saghiri MA, Asgar K, Boukani KK, Lotfi M, Aghili H, Delvarani A, et al. A new approach for locating the minor apical foramen using an artificial neural network. IntEndontic J 2012;45:257-65.
32. Miki, Yuma &Muramatsu, Chisako& Hayashi, Tatsuro& Zhou, Xiangrong& Hara, Takeshi & Katsumata, Akitoshi & Fujita, Hiroshi. (2016). Classification of teeth in cone-beam CT using deep convolutional neural network. Computers in Biology and Medicine. 80. 10.1016/j.compbiomed.2016.11.003.

33. Lee JS, Adhikari S, Liu L, Jeong HG, Kim H, Yoon SJ. Osteoporosis detection in panoramic radiographs using a deep convolutional neural network-based computer-assisted diagnosis system: a preliminary study. DentomaxillofacRadiol. 2019;48(1):20170344. doi:10.1259/dmfr.20170344
34. Saghiri MA, Asgar K, Boukani KK, Lotfi M, Aghili H, Delvarani A, Karamifar K, Saghiri AM, Mehrvarzfar P, Garcia-Godoy F. A new approach for locating the minor apical foramen using an artificial neural network. IntEndod J. 2012 Mar;45(3):257-65. doi: 10.1111/j.1365-2591.2011.01970.x. Epub 2011 Oct 19. PMID: 22007705.
35. Khanna S S, Dhaimade AP. Artificial Intelligence: Transforming Dentistry Today. Indian J Basic Appl Med Res. 2017;6:161–7.
36. Sanjeev B. Khanagar, Ali Al-ehaideb, Prabhadevi C. Maganur, SatishVishwanathaiah, ShankargoudaPatil, Hosam A. Baeshen, Sachin C. Sarode, ShilpaBhandi, Developments, application, and performance of artificial intelligence in dentistry – A systematic review, Journal of Dental Sciences, Volume 16, Issue 1.