Review Article

Artificial intelligence in conservative dentistry and endodontics: A game-changer

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Abstract

Artificial intelligence (AI) technology has mostly been used by dental practitioners to diagnose problems, plan treatments, make clinical judgments, and predict outcomes. In endodontics, convolutional neural networks and artificial neural networks, two types of (AI) models, have been used to study the anatomy of the root canal system, measure the length of root canal, identify periapical pathology and root fractures, prediction of success of retreatment procedures, and dental pulp stem cells viability. The goal of this review is to assess AI's role in conservative dentistry and endodontics.

Keywords: Artificial intelligence; artificial neural networks; convolutional neural networks; deep learning; machine learning

INTRODUCTION

Artificial intelligence (AI), a branch of applied computer science, was initially introduced by Rajaraman and JohnMcCarthy in 1956.[1] It imitates intellectual behavior, critical thought, and decision-making that are characteristic of humans using computer technology. AI has been shown to boost productivity, precision, and accuracy to the same level as medical professionals while doing so more swiftly and cheaply. Dental science has joined the many disciplines that have enthusiastically embraced AI. AI is used in a variety of ways in the medical and dentistry field, including the collection of patient histories, data processing, and information extraction for diagnosis. In the sphere of health care, AI might be virtual or physical, for example., robotics. The virtual type includes all the mathematical formulas used in electronic medical records, imaging, appointment scheduling, drug dosing algorithms, and drug interactions. Examples of physical attributes include assistance by robots in surgery, telepresence, rehabilitation, and socially assistive robots used in elderly care.

TYPES OF ARTIFICIAL INTELLIGENCE

Type I

Narrow artificial intelligence

It is also known as weak AI. It is a subset of AI that has the intelligence to complete particular jobs.[2] It can fail in unexpected ways if it exceeds its bounds. For example., image recognition, disease mapping, and prediction tools [Figure 1].

General artificial intelligence

Any intellectual task can be completed as efficiently as by a human. It does not employ replication or simulation and

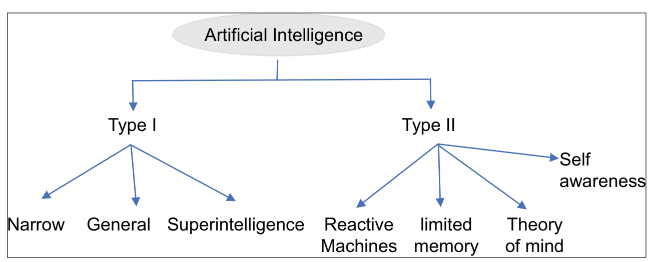

Figure 1: Types of artificial intelligence

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instead trains machines to completely comprehend humans using the theory of mind.[3] Fujitsu's K, one of the fastest supercomputers, is one of the most noteworthy attempts to create strong AI.

Artificial superintelligence

It is a level of system intelligence, in which computers are able to outperform humans in any task due to their cognitive capabilities.[4] Strong AI is capable to think, provide reasons, solve puzzles, make decisions, plan, learn, and communicate on its own, among other essential abilities.

Type II

Reactive machines

These machines only intend to perform a small number of specific tasks; they consistently respond in the same way to the same inputs.[5] It can only react to the current situation; it cannot form memories or use acquired knowledge to influence future assessments [Figure 2].

Limited memory

It can keep track of prior information and forecasts, looking to the past for cues as to what might happen next, for example., virtual voice assistance and self-driving cars.

Theory of mind

It refers to the idea that a person experiences different emotions and feelings that have a complete impact on their behavior.[6] Future AI systems will need to learn to comprehend the sentiments and thoughts that both humans and AI objects have. These AI systems in nearby future will need to be able to modify their behavior to be able to interact with us. For example., Sophia (World's famous robot-human look-alike) is just a simple example of this technology as it cannot have the interpretation of human emotions but have a conversation with them.

Self-awareness

It is when machines are capable of understanding both their own emotions and mental states as well as those of others.[7] AI that is self-aware will have human-level consciousness, equivalent human intelligence, and the same needs, desires, and emotions as people when that goal is reached. Basic example is chat generative pretrained transformer.

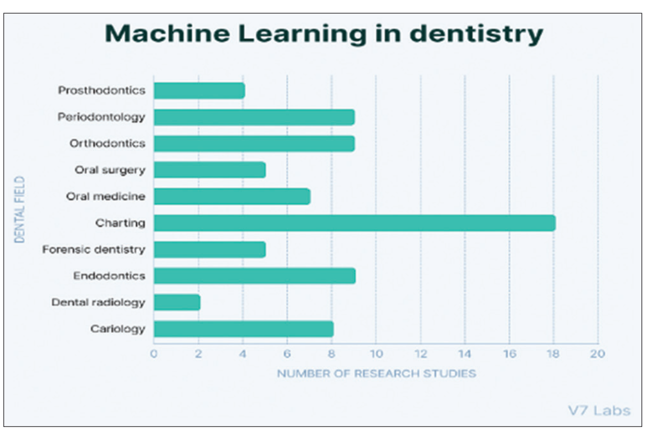

Figure 2: Range of ML research in several dentistry fields

WORKING OF ARTIFICIAL INTELLIGENCE

AI uses sophisticated algorithms, quick, repeated processing, and vast volumes of data to enable software to learn patterns automatically and work accordingly. Three basic functions on which AI works:[8]

- Learning
- Thinking
- Self-correction.

To understand the working of AI, we should have basic knowledge of its subdomains i.e.,

- Machine learning (ML)
- Deep learning (DL).

Machine learning

It emphasizes to use the data and algorithms to imitate human learning skills and gradually improve accuracy.

Source: https://www.v7labs.com/blog/ai-in-dentistry.

It is further divided into four types:

1. Supervised ML
2. Unsupervised ML
3. Semi-supervised ML
4. Reinforcement learning.

Process of machine learning

Input data → Data analysis → Data training → Result prediction → Evaluate and store.

Supervised learning

Using labeled datasets, it develops algorithms that accurately do data identification or forecast results [Figure 3].[9]

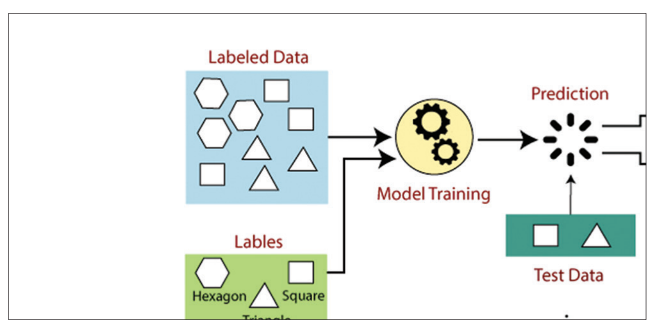

Figure 3: Diagramatic representation of supervised learning[19]

Source: Javatpoint

Applications of supervised learning:
1. Medical diagnosis
2. Speech recognition
3. Spam detection
4. Fraud detection
5. Image segmentation.

Unsupervised machine learning
It does not require supervision. Without any human oversight, the system generates output predictions after training on an unlabeled dataset.[10] The foremost goal of the unsupervised learning approach is organizing and classifying the unsorted dataset into groups on the basis of their shared characteristics, differences, and patterns.

Applications of unsupervised ML:
1. Anomaly detection
2. Utilized to detect plagiarism and copyright in text data for scholarly articles using document network analysis.

Semisupervised machine learning
It is a form of ML between supervised and unsupervised.[11] For example., image classification and text classification

Applications of semisupervised ML:
1. Speech analysis
2. Protein sequence classification.

Deep learning
The neural networks try to replicate the functioning of the human brain, by allowing the machine to "learn" from large volumes of datasets.[12]

It is based somewhat on how human neurons interact with one another in the brain to interpret information. Each succeeding nodal layer is engaged when it receives the signal from its adjacent neurons, just as how the electrical signals go between the cells of living things.

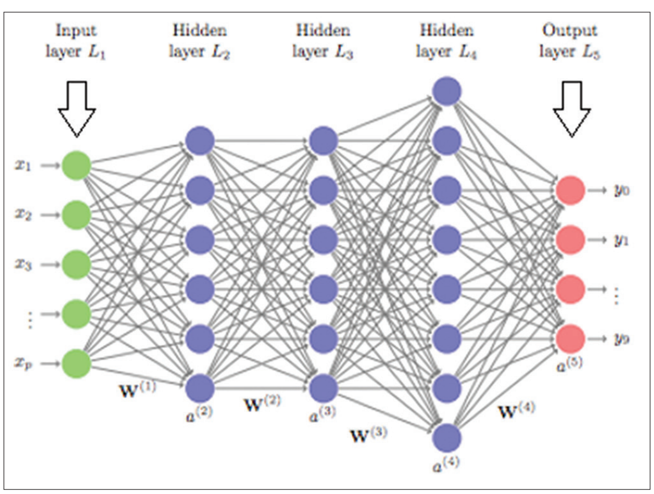

Figure 4: An illustration of a deep learning neural network

The foundation of DL models, artificial neural networks (ANNs), allow every single layer to be given a specific transformational task, and that input/information may go through multiple layers to optimize and refine the final outcome [Figure 4].

Recurrent neural networks (RNNs), a new variation of neural networks, perform better than simple neural networks when dealing with sequential data.

The main difference between RNN, convolutional neural network (CNN), and ANN is complex problems can be solved with the aid of ANNs. Computer vision-related issues are best resolved by CNNs. Natural language processing is a strength of RNNs.

Source: University of Cincinnati.

ROLE OF ARTIFICIAL INTELLIGENCE IN CONSERVATIVE DENTISTRY:

- Caries detection
- Vertical tooth fracture
- Detection of tooth preparation margins
- Prediction of restoration failure.

Caries detection
According to research, even seasoned dentists struggle to correctly identify proximal caries on radiographs. The chances to begin minimally invasive dentistry are also lost if early lesions are ignored.

In the study conducted by Estai *et al*., 2468 bitewing radiographs were examined by three dentists to determine if proximal caries were present or absent.[13] The CNNs were then trained using this dataset. The approach showed better results and more accuracy than prior studies using a multi-step approach, one CNN to identify regions of interest in locations that are likely to develop caries, and another to identify caries inside the region of interest. Before such algorithms may be employed as independent diagnostic tools, more research with larger datasets is required.

Vertical tooth fracture
The CNN learning model has potential for spotting vertical root fracture (VRFs) on panoramic pictures.

Detection of tooth preparation margins
Preparation margins are automatically oriented, scored, and marked using AI before being sent to the laboratory for crown design.[14]

ROLE OF ARTIFICIAL INTELLIGENCE IN ENDODONTICS

Root morphology

The DL system could be useful in diagnosing, and it categorizes photos that might help novice doctors understand images. It was shown that the DL algorithm helps in evaluating root canal morphology and their three-dimensional changes following instrumentation.[15]

Working length verification and locating the apical foramen

The ML and ANN diagnosis method results in an improved radiographic working length determination and helps to improve diagnosis. In addition, ANNs are employed as a decision-making system in a variety of health-care settings.

Retreatment prediction

The combination of ML and case-based reasoning approach takes into account data from areas including achievement, memory, and analytical probabilities.

Detection of periapical lesions

DL segmentation in combination with CNN and ML resulted in high accuracy in detecting a periapical pathology on cone-beam computed tomography (CBCT) images. Meta-analysis showed CBCT having 0.96, Intraoral periapical (IOPA) images having 0.73, and radiovisiography having 0.72 accuracy for periapical pathology detection.[16,17]

Detection of periapical cyst or granuloma

Using AI, the gene expression was examined to differentiate a cyst and a granuloma. It uses ML and ANN.[18]

Viability of dental pulp stem cells prediction

After a variety of regenerative regimens and challenges with bacterial infection, the neuro-fuzzy inference system predicted cell viability.

Detection of vertical root fracture

Using ML, CNN, and probabilistic neural networks, it may be useful in identifying root fractures. Promising and ongoing research is being done in this field.

Miscellaneous

- Setting up a patient's appointment at the clinic
- Getting the patient's complete medical and dental history
- Assisting the dentist in making an accurate diagnosis and treatment plan
- Aftercare and online emergency medical advice
- By reducing the amount of time spent on assessments and enabling semiautomated records, it reduces the dentist's chair-side time.

CONSERVATIVE DENTISTRY

- CNNs and DL are useful in detecting caries and provide the classification of deep fissures and close interproximal contacts
- Finish line location of prepared tooth
- Prediction of the unsuccessful restoration
- It facilitates the quicker and less-erroneous fabrication of inlays, onlays, crowns, and bridges
- Helps to create an effective treatment plan for the patient by enabling the previsualization of new smile designs before the procedure.

Limitations

To find suitable systematic algorithms for varied scenarios, further tests are required. It cannot quickly adapt to new imaging programs or computers. More experiments are required to find the most suitable analytic algorithms for different situations. Both the initial training of AI algorithms and the continuing validation and improvement of those algorithms require personal data from patients. AI must be integrated into medical practice, however, the system must be changed to protect personal information and confidentiality. Using data that has been wrongly categorized may produce subpar results. The use of AI in health care may still be in its infancy and come with a number of demanding conditions. Despite having the ability to do so, the health-care industry is still hesitant about secure data transmission.

CONCLUSION

Even though numerous studies have shown that AI may be employed in dentistry. AI has been viewed as a helpful tool by a variety of professionals and dentists. Future clinical applications of AI techniques might be feasible, but overcoming current limitations will require more fundamental research.

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Conflicts of interest

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