ARTIFICIAL INTELLIGENCE IN DENTISTRY

Abstract

Artificial intelligence (AI) is used when a computer imitates the analytical skills of the human brain, such as learning and problem-solving. The advancement of AI has an impact on robotic dental assistance, radiographic diagnosis, caries detection, histopathology and electronic recordkeeping. Ai is used in different fields of dentistry to detect aggressive tumours, to quickly depict the interdependence between the nasal bone and facial landmark, to measure the amount and direction of hard and soft tissue movements in three dimensions before orthognathic surgery, to discover periodontal bone loss on panoramic dental radiographs, oral health surveillance and many other. It is one of the most promising fields to lighten the burden of dentists and increase the accuracy in diagnosis, planning, and illness prognosis.

Keywords: Artificial Intelligence, Dentistry, Machine Learning, Deep Learning.

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I. INTRODUCTION

Researchers have been intrigued by one of the most fascinating components of the human body, the brain. For many years, they have been working tirelessly to advance "artificial intelligence" (AI). The term "AI" is used when a computer imitates the analytical skills of the human brain, such as learning and problem-solving. AI can revolutionize the field of medicine and dentistry. It has been shown to improve accuracy, efficacy and precision to the same level as medical specialists more quickly and economically. Applications of AI in dentistry are still uncommon. However, the advancement of these technologies has an impact on robotic dental assistance, radiographic diagnosis, caries detection, histopathology and electronic recordkeeping.

II. HISTORY

1. **1950:** The British mathematician Alan Turing, one of the founders of artificial intelligence.

2. **1957:** John McCarthy developed a functional programming language- LISP (List Processing Language) for artificial intelligence.

3. **1965- 1970:** The goal of building intelligent machines simply by uploading data did not succeed during this age, which is why it is regarded as a "dark period" for AI.

4. **1970- 1975:** Artificial intelligence achieved huge success in the field of disease diagnosis.

5. **1975-1980:** A new idea came up that artificial intelligence can be advanced by using other fields of research like psychology.

6. **1976:** One of the first examples that showed the possibilities of applying AI in medicine was the development of a glaucoma consultation program using the CASNET model at Rutgers University in Las Vegas, Nevada.

7. **1980's:** Large-scale initiatives with useful applications started utilizing artificial intelligence.

8. **1986:** University of Massachusetts released a decision support system, DXplain. This programme creates a differential diagnosis based on the inputted symptoms. When it was first released, DXplain could provide details on about 500 ailments.

9. **1990's:** Researchers designed computer models of human teeth using computer-aided modelling (CAM). These innovations led to the concept of building 3D models of dental crowns based on an individual's preferences simply by examining their remaining teeth.

10. **1997:** Gary Kasparov, the reigning world champion, was defeated by Deep Blue- a skilled chess-playing expert system.

11. **2007:** For the first time, machine learning was used to analyse dental radiographs for the diagnosis of dental caries. Computers were able to read radiographs and identify anomalies in teeth more quickly than human experts after training on sufficient datasets.

12. **2017:** In a Go game, Google's deep learning algorithm Alpha Go defeated Jie Ke, the top-ranked player in the world.

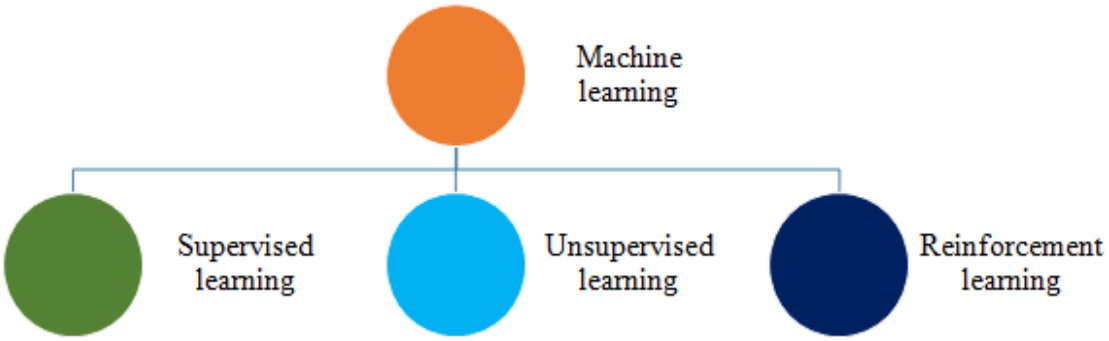
13. **2022:** A text-generation model called Chat GPT (Chat Generative Pre-trained Transformer) was introduced by Open AI. It can produce responses that resemble those of a human based on text input.

III. ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence (AI) is concerned with the design and implementation of computer systems capable of solving problems that usually require the ability of human beings. Typically, they cannot be resolved using traditional algorithmic techniques.

IV. MACHINE LEARNING

Machine learning (ML) is a branch of artificial intelligence that focuses on creating algorithms that let computers learn on their own based on data and prior knowledge.



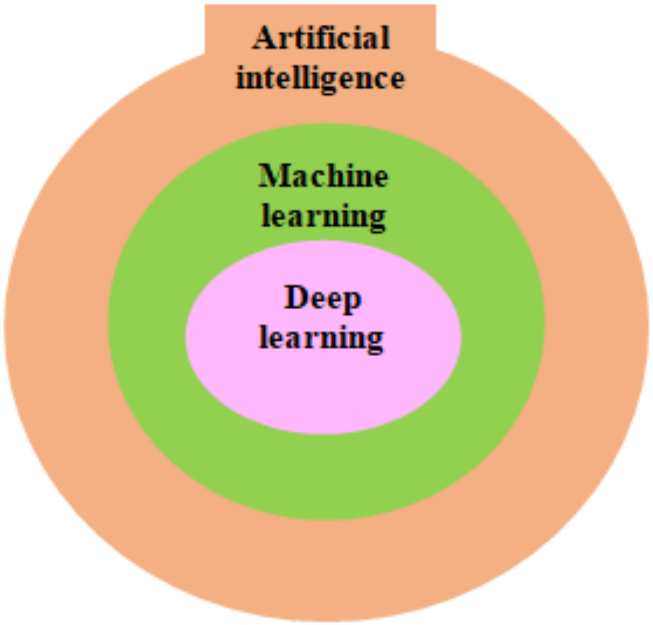
1. **Supervised learning:** A sort of machine learning system known as supervised learning predicts the outcome after being trained on a sample of labeled data that is given to the system.

2. **Unsupervised learning:** Machine learning occurs unsupervised or in the absence of any human supervision.

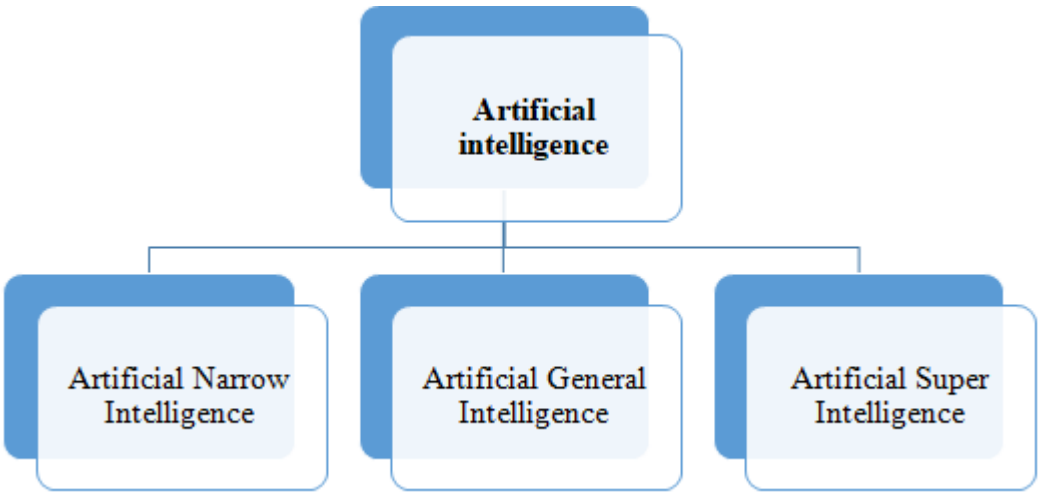
3. **Reinforcement learning:** It is a feedback-based learning system that mechanically learns from this feedback and enhances its functionality.

V. DEEP LEARNING

It is a subgroup of ML, referred to as a special learning machine. To find and gain insights from the data, deep learning uses a variety of model layers. For eg: ‘Convolutional Neural Networks’ that can easily capture 3D frames or image



VI. TYPES OF ARTIFICIAL INTELLIGENCE



1. **Artificial Narrow Intelligence:** It is set up to perform particular tasks like voice assistant speech recognition, car driving, or facial recognition. Narrow artificial intelligence models imitate human behaviour based on a restricted set of factors, constraints and circumstances.
   Eg: Chatbot, Siri by Apple, Alexa by Amazon

2. **Artificial General Intelligence:** The main feature of this AI is characterized by flexible thinking and reasoning that is human-like. It is a notion that will likely be developed within quantum computing.
   Eg: The K computer, created by Fujitsu, is regarded as one of the world's fastest supercomputers

3. **Artificial Super Intelligence:** This type of AI suppresses human capacity. It is based on science fiction.
   Eg: Search engine algorithms like Rankbrain from Google, a multitude of face and biometric recognition solutions

Based on functionalities

1. **Reactive Machines:** Reactive machines are type 1 AI that have no memory. It merely employs a single predefined logic and does not take previous experience into account.
   Eg: Deep Blue, the IBM chess program

2. **Limited Memory:** Limited memory is the type 2 AI system. It has a meager memory and primarily retrieves information from events and facts.

3. **Theory of Mind:** The use of this social intelligence is to comprehend emotions. It makes predictions about how people will act. The ability to read human emotions is built into computers.

4. **Self-awareness:** The system functions automatically whenever action is required because all the preset data has been recorded.

VII. APPLICATION OF ARTIFICIAL INTELLIGENCE IN DENTISTRY

1. Oral Medicine and Radiology

- **Artificial neural networks (ANN):** Artificial neural networks (ANN) are a type of AI technology that has been widely utilized to determine how aggressively tumours are acting. It is made up of a perceptron, which replicates how neurons function. The multilayer perceptron (MLP) is the one that is most frequently used. The MLP has proven to be a reliable tool for investigating the prognostic value of oral cancer biomarkers.

- **Clinical Decision Support System (CDSS):** Clinical decision support systems analyze patient data and make choices on the diagnosis, prevention, and treatment of orofacial illnesses based on innate clinical knowledge. Applications for CDSS can work independently or with other devices like radiography systems, order entry systems, or electronic dental records.

- **Probabilistic and General Regression Neural Network:** The following decisions benefit from using these models:
  - To identify the kind of cancer in patients based on case history recording, intra-oral and extra-oral examination
  - To forecast patient survival following appropriate care and follow-ups

- **Dynamic Bayesian Networks:** Time-series gene expression data gathered at the follow-up study of patients are taken into account by the dynamic Bayesian networks. Based on the information, one can speculate on the causal linkages between the genes, as well as infer the related Dynamic Bayesian Networks.

The objectives of this programme are to:

- Evaluate patients' chances of having their oral cancer return
- Disseminate crucial knowledge about the basic mechanisms that underlie the disease.

2. Oral and maxillofacial surgery

- **Rhinoplasty:** Artificial neural networks are a key component of machine learning models because of their ability to quickly depict the interdependence between the nasal bone and facial landmark. Artificial neural network-based fracture prediction is crucial for early detection and carefully thought-out surgery. Several machine learning methods have been applied to anticipate nasal issues, including random forests, support vector machines, and back-propagation neural networks (BPNNs) for recognizing nasal bones.

- **Orthognathic Surgeries:** To ascertain the quantity and direction of surgical interventions, it can be helpful to measure the amount and direction of hard and soft tissue movements in three dimensions before orthognathic surgery. It is especially helpful for treating individuals with cleft-related abnormalities and scar tissue. AI may be used to quickly analyse digital cephalometric data, detect precise landmarks, and make therapeutic decisions.

3. Orthodontics

- **Cephalometric:** Artificial intelligence-based cephalograms are taking the place of manual landmark identification and tracing by reducing errors and saving time.

- **Facial Proportions:** To comprehend the standards of beauty and duplicate aesthetically "beautiful" proportions, surgeons and orthodontists use measurements of "perfect" face proportions. AI apps execute optical facial recognition while simulating more complicated cognitive functions, such as the analysis and interpretation of facial data.

- **Extraction:** For malocclusion patients between the ages of 11 and 15, a decision-making expert system was developed to decide whether extraction is required or not. Error backward propagation learning is a technique used by ANN to lessen the risk of error. An accuracy rate of about 80% was achieved using this method.

- **Management of Impacted Canine:** The best orthodontic and periodontal outcomes for impacted canines require comprehensive treatment care. The degree of difficulty and the distance the canine is from the neighbouring teeth determine how long the therapy will last. The Bayesian Network adopts a middle ground between statistics and artificial intelligence.

- **Temporomandibular Joint Disease:** One of the most popular examination techniques for determining bone abnormalities in the TMJ is the orthopantomogram (OPG), and CBCT may be utilised to confirm the diagnosis if necessary. In addition

to this, an AI system was created and trained to recognize TMJ osteoarthritis on an orthopantomogram to solve this issue. In addition to this, an AI system was created and trained to recognize TMJ osteoarthritis on an orthopantomogram.

4. Paediatric and Preventive Dentistry

- **Dental plaque:** A ground breaking investigation is being conducted to identify primary teeth that have been damaged by plaque using AI model-based deep learning approaches. AI systems (CNN framework) model performed at clinically acceptable levels when compared to a paediatric dentist with training.

- **Toolkits Designed by Machine Learning:** To create oral health assessment toolkits that could accurately predict the Children's Oral Health Status Index (COHSI) and Referral for Treatment Needs (RFT), a research team looked at machine learning. Dentists, parents, and even kids may use the findings of the machine learning-based toolkit to assess a patient's oral health and determine whether they require dental care.

- **Mesiodens and Supernumerary Tooth Identification:** With the use of a single deep learning model, artificial intelligence can diagnose mesiodens. The detection of extra teeth may benefit greatly from convolutional neural networks. A deep learning model to find mesiodens might aid physicians with less clinical expertise in making quicker and more accurate diagnoses. For eg: Squeeze net, ResNet 18.

- **Early Childhood Caries:** Different genes and gene polymorphisms have been identified by researchers as the cause of dental lesions in patients, however genetic variables related to the disease are rarely included in most studies. For physicians to implement prevention methods throughout a child's early years of life and for parents to instil healthier eating habits, single nucleotide polymorphisms for dental caries risk prediction could be a very helpful tool. To predict the presence of dental caries based on polymorphisms, the researchers used artificial neural networks in their study.

- **Pit and Fissure Sealants:** Dental sealants act as a primary prevention barrier against dental caries. Therefore, it seems like the most sensible course of action to fine-tune the convolutional neural network (CNN) to recognize dental sealants. A deep learning-based CNN was created to recognize these sealants and proved to have great diagnostic accuracy.

- **Deciduous and Young Permanent Tooth identification:** For object recognition, convolutional neural network, one of the most well-liked deep learning models, is frequently employed. Single-stage detectors (YOLO algorithm) and two-stage detectors (R-CNN) are the two main categories of object detection techniques. Two-stage detectors were used in certain studies, which led to good object detection outcomes. Even while two-stage detectors require more time and processing power than one-stage detectors, they are frequently more accurate.

5. **Prosthodontics**

- **Computer-aided design/computer-aided manufacturing (CAD/CAM):** CAD/CAM, which stands for "computer-aided design/computer-aided manufacturing," is used to create both permanent and removable dental prosthetics. In fixed prosthodontics, margin detection was completed using AI after an intraoral scan. Using data from numerous real crowns, this technique can produce the best crown design for several situations.

- **Dental Implant:** The ideal dental implant treatment plan combines CBCT and intraoral scanning. Implant dentistry's usage of AI offers the chance to combine the two and create next-generation prostheses. AI can be used in many different therapeutic methods and has several advantages. Convolutional neural networks (CNNs) based on AI were used to categorize implants using panoramic and periapical radiography. According to the study's findings, the AI-CNN system is almost as good at classifying implant procedures as humans are. Incorrect placement, subpar cementation, occlusion, and interproximal repair are examples of potential error-causing factors.

- **Maxillofacial Prostheses:** The artificial eye has already been used by twelve individuals with vision difficulties. These AI-powered devices can improve vision without requiring surgery. Dental professionals can construct the most attractive prosthesis for patients with the use of AI and specific designing tools, taking into account anthropological calculations and face proportions. For people who are blind or have visual impairments, there are smart reading glasses available. It is a cutting-edge voice-activated device that can be mounted on practically any set of glasses.

6. **Oral and Maxillofacial Pathology:** Fuzzy cognitive maps (FCM), a novel tool for grading oral cancers, were created. The model achieved excellent accuracy for low-grade and high-grade tumours, demonstrating its potential as an important tool in the effective diagnosis and grading of oral tumours. This novel strategy may enhance patient outcomes and lower the morbidity and mortality rates related to oral cancers.

7. **Endodontics**

- **Root Morphology:** Conventional radiography is still routinely used and plays a significant role in diagnosing and planning therapy for root canal pathology. Its limitations include superimposition and distortion of bone and dental structures. The root canal morphology was accurately assessed by the AI's deep learning algorithm. The categorization of photographs by the DL system may help inexperienced practitioners better understand them for diagnostic purposes.

- **Working Length Determination:** The working length must be accurately determined for root canal treatment. The apical foramen can now be found with contemporary technologies like CBCT and electronic apex locators. The ANN diagnosis method results in an improved radiographic working length determination and helps to improve diagnosis. Additionally, ANNs are applied as a decision-making system in a

wide range of therapeutic situations and their accuracy in locating the apical foramen varied from 93%–95%.

8. Periodontics

- **Periodontal Training Simulator:** A periodontal dental simulator using haptics aids in the development of the abilities needed to recognize and treat periodontal disorders. You can "touch" a haptic device that displays 3D views of the upper and lower teeth as well as the gingiva. The haptic input that results simulates how a dental operator's hand feels when utilizing instruments in a clinical setting.

- **Halitosis:** Artificial olfaction is a non-invasive method for evaluating the whole range of volatile chemicals inhaled. It is made up of several sensors that work together to analyze the composition of exhaled air before processing it for a pattern recognition application. The subject's halitosis is classified as extra-oral or oral using a decision tree classifier, the latter of which can also be linked to several systemic disorders.

- **Bone loss:** AI is used to discover periodontal bone loss on panoramic dental radiographs. The results demonstrated that the trained AI software has at least a dentist-like discriminating capacity to evaluate periodontal bone loss on panoramic radiographs despite the restricted dataset of radiographic image segments.

9. Public health dentistry

- **Surveillance:** For a long time, public health monitoring data streams have been utilised to examine trends and threats. AI approaches, particularly those based on machine learning, have been used to uncover patterns, spot abnormalities, and distinguish patterns. Strong temporal and spatial components are usually present in these data streams, demanding study in conjunction with other social, economic, and environmental data. AI opens the door to the use of a range of novel or underutilised data sources for public health surveillance, particularly ones that were not initially or intentionally designed to address epidemiological concerns.

VIII. ADVANTAGES OF AI

- It is easy to use
- The machines may be reconfigured to operate for extended periods without growing weary or bored.
- Precision in diagnosis
- The uniformity of practice
- Reduces time

IX. DISADVANTAGES OF AI

- The mechanism's intricacy
- The expense of the setup

X. CONCLUSION

New technologies are developed and applied rapidly in the field of dentistry. AI is one of the most promising fields since it has qualities like great efficiency and accuracy if unbiased training data is used and an algorithm is properly trained. Dental professionals can use artificial intelligence as an additional tool to lighten their burden and increase the accuracy in diagnosis, planning, and illness prognosis.

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