

Artificial Intelligence in Dentistry

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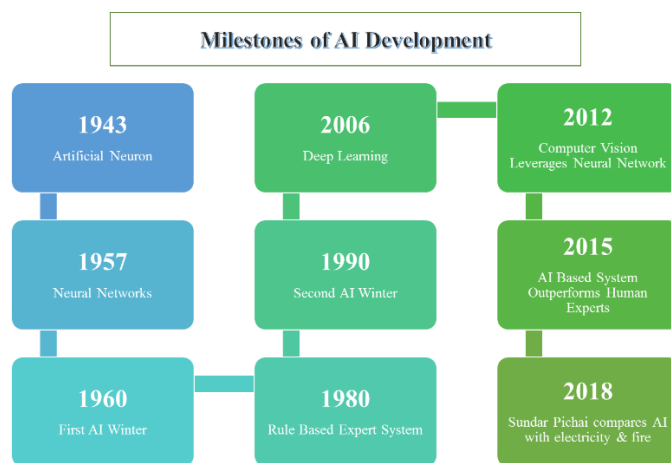
Abstract

Field of AI has experienced spectacular development in the last two decades. With recent trends in the data acquisition and machine learning AI thought to serve as a greater trend in dentistry. It is a fast-evolving technology that enables robots to perform the tasks which were previously exclusive to humans. AI is helpful in-patient diagnosis of diseases and prediction of treatment outcomes. AI decreases the post-operative outcomes and complications, decreases follow ups, increases accuracy, increases care, identifies abnormalities, improves dental education.

Keywords: AI (Artificial intelligence), ai (assisted intelligence), applications of AI, CNN (conventional neural network), DL (deep learning), ML (machine learning),

Introduction

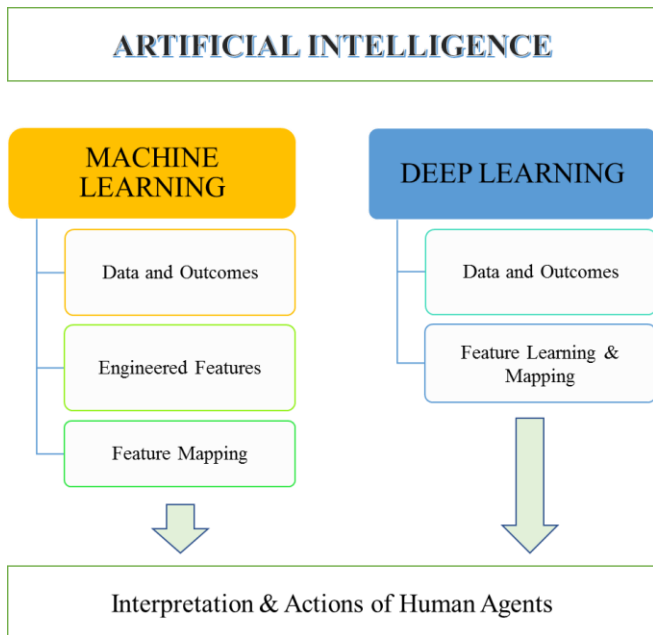
The term AI (artificial intelligence) was first introduced by John Mc Carthy in 1956. Many called this machine intelligence and also 4th generation revolution. AI is the idea of machines which have an ability to perform most of the human tasks. In a recent international dental show, AI was topic on everyone’s lips. Everyone called it revolutionary. AI uses neural networks for computing signals similar to that of human brain.



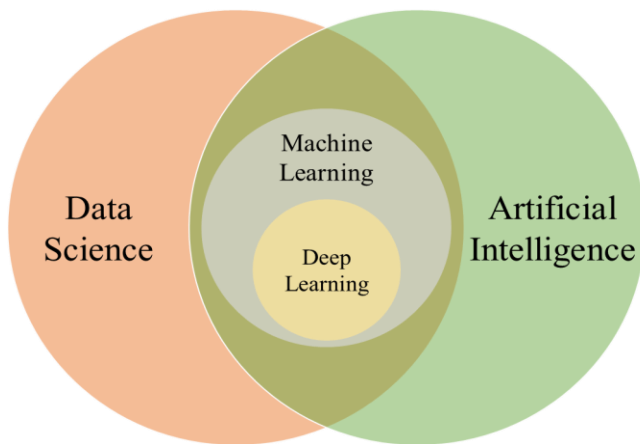
Dentistry has come a long way from the primitive dental drills to the advanced dental implants and this trend has evolved so fast in the recent few years. As a part of technology AI has become a driving force in many areas of work. Then the question arises why not in healthcare particularly in dental health care? It has potentially revolutionized in many aspects of dental fields. AI seems to be a science fiction movie, which slowly got evolved and has become an integral part of our day to day lives. In recent times Chat GPT, a form of AI where it got completely integrated into human lives and modified in various ways. Chat GPT is a simple example of AI which proves how it works and helps to resolve complex tasks.

The main difference between natural intelligence versus artificial intelligence lies in the way it processes the data. Natural intelligence processes data through a set of events, where the information is first perceived later the process of integration occurs which further leads to the generation of response.

(Perception → interpretation → response)



AI processes data through a set of events which include: (Machine learning → data & outcome → engineering features → mapping → interpretation)



The main area where AI lacks is the process of data generation without applying a biological response. This is the way by which natural intelligence and AI differ. Explained AI is a combination of visualization,

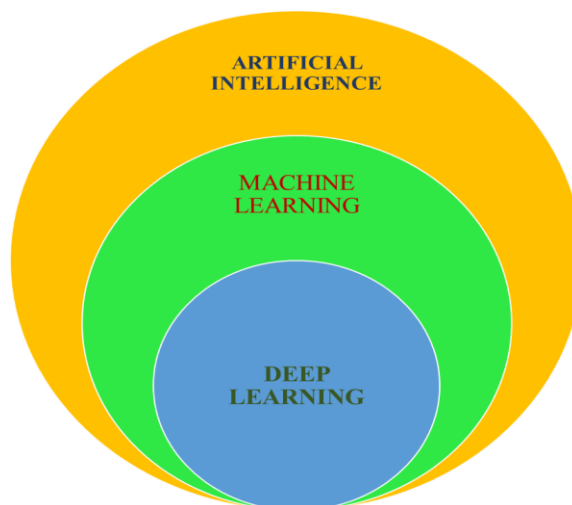
interpretation, explanation of the logic. In 2018 Naylor found that diagnostic imaging is central in many healthcare fields especially AI where it increases the effectiveness of care by decreasing its costs. Israni and Verghese in 2019 introduced the robotic assistance which operated 24/7 for humanizing care via voice, speech, text recognition and decreases the time for the doctors to keep records. Topol in 2019 designed a technology for keeping the data of the records, where the patient's visit and go but their data and the diseases are acquired over years in the system. Schwendicke et al in 2019 mentioned that AI is entering in the field of dentistry predominantly for the purpose of dental imaging.

What is AI?

AI is a branch of computer science which is associated with intelligence entities. It is a sequence of operations with codes to perform a particular task. Nowadays, in medicine people tend to use machine learning as a part of AI.

AI has 2 parts, which includes

1. Machine learning
2. Deep learning



Machine learning: Without any pre knowledge, the system identifies all the abnormalities without any patient assistance. In this process machine learning algorithm gains experience via exposure to different examples and

they setup and identify patterns by applying the algorithms that avail it.

For example, if a mother shows several pictures of dog to a child, the child identifies the dog over the span by himself once a new pattern of dog is found.

Deep learning: A subbranch of machine learning, where this is nothing but stacking of various patterns to create a deep and far more powerful system. For example: The child recognizes certain patterns and shapes such as eye, ear that avail it and larger components like the heads, legs and defines the whole dog by clubbing various smaller and larger components together.

AI operates in two phases:

1. Training
2. Testing

Input → processing → output



Why hasn't AI yet come into practice???

The main limitations of AI lie in its limited data availability, accessibility, structure, comprehensions. Other area where AI lacks behind is lacking in methodological rigors and standards in the development process. AI also is impractical in terms of values and following of the ethics.

Artificial intelligence (AI) versus assisted intelligence (ai), as dentists we need AI to assist dentists to enhance their performance, improve in decision making and streamlining the process. ADA released a new white paper No.1106 for dentistry whether it overviews the artificial intelligence and augmented intelligence and their uses in dentistry. AI is evolving so much that in near future it may replace the need for doctors, this is not we need. Ashley Byrne, assistant director at Byrnes

Dental lab pointed a gap in AI and ai. Dentistry needs both AI and ai but the uses of these have to be carefully monitored. Assisted intelligence emphasizes the collaboration between AI and human intelligence, it recognizes that human possess unique cognitive skills where AI currently lacks.

Applications of AI in health care field

1. Diagnosis and treatment plan
2. Image analysis and interpretation
3. Predictive analysis
4. Virtual Reality stimulations for patient education
5. Patient communication

1. Diagnosis and treatment plan

AI algorithm analyses patient records and assist dentists in the diagnosis and treatment plan. All the radiographic images particularly the periapical images, orthopantomogram, CT scans, MRI helps AI in diagnosing the alveolar bone levels, peri radicular and peri apical images, tumours, cysts.

2. Image analysis and interpretation

AI can analyze and interpret the various abnormalities and helps in formulating a treatment plan. Various peri apical and peri radicular anomalies, alveolar bone abnormalities, cysts, tumours are diagnosed by AI.

3. Predictive analysis

AI analyses the patient's dental records and also identifies and predicts the diseases and effective interpretation and prevention can be formulated.

4. Virtual Reality for patient education

AI provides patient an immersive and interactive experience to understand various procedures and this can help patients to decrease the anxiety levels during procedures and increase the effectiveness of the dental treatment and also improves education.

5. Patient Communication

AI assisted chatbots and voice assistants provides the patients 24/7 about the information of dental care, post-operative care, post-operative queries, appointments and also decreases the wait times.

Benefits of AI

1. Increases the accuracy and efficiency in diagnosis and treatment plan:

AI identifies even the smallest changes in the dental radiographs and are helpful in even preventing all the minor changes that occur in the oral cavity and further reduces the major complications that effect it.

Robots can assist in performing few minor procedures which include the dental cleaning, polishing, restorations and help dentists to concentrate more in other major issues and more complex tasks. Smile-bot is a digital assistant currently used by a few dentists in the dental practices.

2. Increased patient satisfaction:

AI helps in accurate diagnosis and treatment plan where it improves the efficiency and has a long term treatment goals and also all patients are immensely satisfied. The treatment protocol and plan they make are patient appropriate and even patient education and predictive analysis make AI have an immense effect over the patient satisfaction.

3. Cost Effectiveness:

Having AI decreases the usage of invasive procedures as well as complicated ones where the dental diseases are diagnosed in an early stage and the effectiveness is improved and also it replaces the effectiveness of frequent follow up visits.

In future era AI in dentistry looks promising:

1. Improved diagnosis
2. Predictive analysis
3. Treatment plan

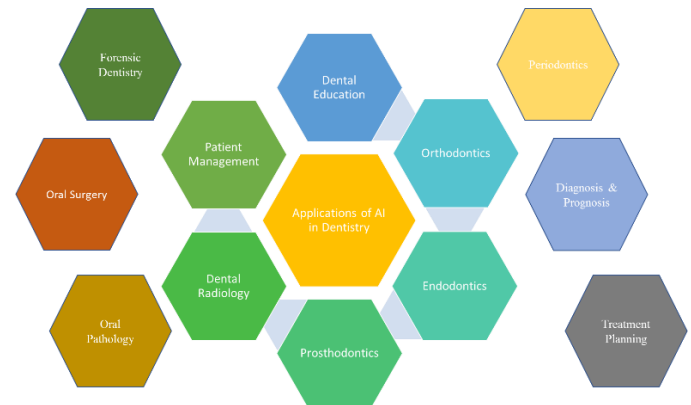
4. Virtual Reality & Augmented Reality

5. Digital impression scanning

6. Improved patient assistance

Applications of AI in dentistry

In June collection of journals of California dental association, it provides latest advances in AI technology and potential impact on dentistry. The following are the applications of AI in dentistry mainly in the fields of :



1. Radiology

Applications of AI in the field of dental radiology include formulation of a 3 D view for the diagnosis of various anomalies. A precision of 95.8% - 99.45% in detecting and identifying a tooth. Carious lesions from the periapical radiographs and alveolar bone loss, cysts, tumors are identified from the radiographs. Dental X rai pro is an AI based program that helps dentists to analyze radiographs more accurately and with a great consistency.

2. Orthodontics

Application of AI in the field of Orthodontics helps in decision making and treatment planning for the need of tooth extraction before orthodontic treatment and helps in corrections of various malocclusions. 3-D imaging technology and cloud-based system has used AI in orthodontics.

3. Periodontics

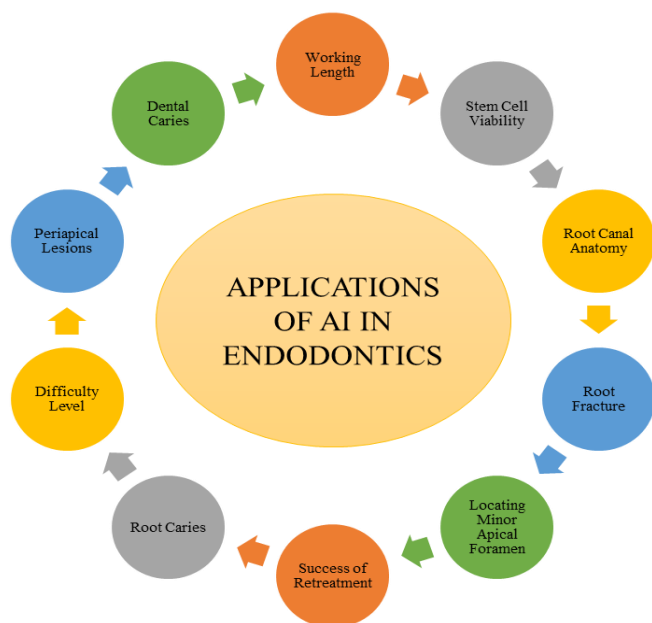
AAPD in 1999 has recognized two forms of periodontitis, which includes chronic and aggressive

periodontitis. Difficulties raised to discriminate the two forms, AI identifies the parameters like leukocytes, interleukins, Immunoglobulins (Ig) and Antibody (Ab) titers, which shown an accuracy of 90-98% in classifying patients as chronic or aggressive periodontitis. CD4-CD8+ T cells triate, neutrophils count, eosinophils count determines the differences between the chronic and aggressive periodontitis. Despite the advances, no improvement is made to correctly identify the diagnosis and prognosis of periodontally compromised tooth (PCT). Lee and coworkers used deep AI algorithm to diagnose the periodontally compromised tooth, which showed 76.7-81.0% while an accuracy of extraction was 73.4-82.8%. Due to the complex anatomy of the molars when compared to any other tooth, the deep AI 's accuracy to identify periodontally compromised tooth (PCT) currently lacks. Lee et al based-on bone loss he formulated a deep learning network to identify periodontally compromised molar.

4. Endodontics

The applications of AI in the field of endodontics have shown very promising results for its usage in near future.

The applications include:



a. Root Fracture

Fukuda et al designed a tool for identifying the vertical root fracture. Clinically for the determination of vertical tooth fracture is highly difficult, but with the help of periapical radiographs makes it convenient for the determination of root fractures. The application of AI in determination of root fractures would make the dentists work easier.

b. Working Length Determination

Saghiri et al used a model of human cadaver to replicate a setting for working length determination. The accuracy that he obtained in these tests showed promising for its usage in future purposes.

c. Root Anatomy

Lahoud et al showed a 3-D tooth segmentation using CNN (conventional neural network) approach. All the complex structures of the maxillary molars and mandibular molar roots can be easily visualized using this technique.

d. Retreatment Predictions

Campo et al designed a technology for the prediction of non-surgical retreatment of root canal with risks and benefits.

e. Periapical Lesions

Mol et al and Carmody et al designed a model for determination of the periapical lesions. Endres et al created a DL algorithm for identification of various periapical pathologies. Flores et al created a technology that could differentiate the granuloma versus cyst using CBCT. Poswar et al reported different gene expression for a periapical cyst versus granuloma. Lin et al designed two models where the first model determines the alveolar bone levels identification and, in another model, where it determines the quantity of the amount of bone loss. CNN (conventional neural networks) uses a specific neuron connection architecture and mathematical operation to

process digital signals. As the molar is a very complex structure, the success of endodontics completely relies on CBCT (cone beam conventional tomography), but this is more radiation risk to patients. So, CNN has an increased accuracy of 86.9%, the main limitation of CNN is to identify those images that are segmented manually and consumes more time. The size of the obtained images is also to a smaller area of concentrate.

5. Oral Pathology

The application of AI in Oral Pathology helps in the diagnosis of precancerous and cancerous lesions. It develops an accuracy of about 80-83.3% and specificity of about 78-81.8%. The differential diagnosis of ameloblastoma and OKC has an accuracy rate of 83.3%.

6. Oral Surgery

The applications of AI in the field of oral surgery would be useful and helpful for assisting the dentists work best if they were able to diagnose the temporomandibular disorders, implants, tumors. Various technologies have come forward for the determination of these anomalies and have shown a promising future.

7. Prosthodontics

AI in the field of prosthodontics is helping dentists out basically during impression procedures, implants, dental scanning. Rapid (dental assistant) was introduced which carries out a few functions which include anthropological calculations, face dimensions, ethnicity and patient preferences.

8. Forensic Odontology

AI in the field of forensic odontology determines the biological age of the patient, gender, differentiates individuals between whether they are healthy or diseased, bitemarks study.

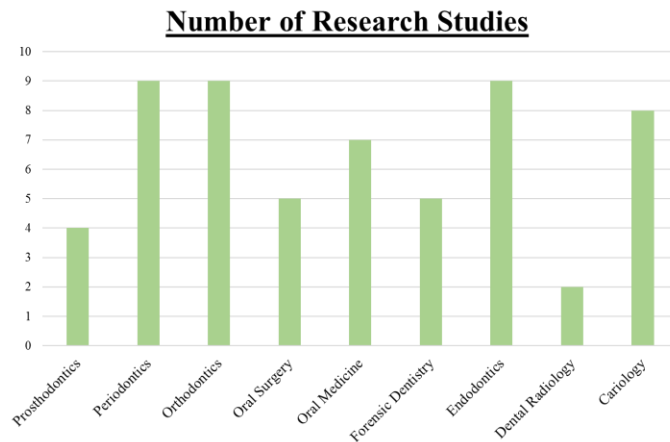
9. A new antibiotic was identified by researchers in Massachusetts institute of technology, they used a machine- learning model that trained to assess

whether a chemical compound would inhibit growth of Acinetobacter basmannii.

10. Diagoncat is a 3D x-ray group helpful for implant surgical guide.
11. Promaton, relu, orca are a few examples of 3 D xray groups.
12. Pearl, V7 labs, overjet (for detection of caries, periodontal bone loss)
13. Ray Cloud software helpful of night guard design.

Applications of artificial intelligence	
Patient education	Ai helps in formulating a 3d image useful for better patient education
Diagnosis	Ai helps in diagnosis of various cysts, caries, tumors, bone loss in their early stages (early diagnosis)
Prognosis	Ai helps and assists in the formulation of prognosis of the disease and assists dentists in formulation of a better treatment plan
Treatment plan	Ai assists dentists in providing a treatment plan according to the disease and even gives patients various probable treatment options that can be obtained
Dental radiology	Ai assists dentists in visualizing of all the 3d views so that even the initial defects are not overlooked, and a better diagnosis and treatment plan are made. It helps in visualizing of various cysts, tumors, alveolar bone defects and levels, caries.

Orthodontics	Ai assists dentists in diagnosing the malocclusions both skeletal and the dental and provides a better treatment plan.
Periodontics	Ai helps dentists in their clinical practice where it identifies chronic, aggressive periodontitis and decides the prognosis of a periodontally compromised tooth in a better way.
Endodontics	ai in the field of endodontics helps in diagnosing determining of root fracture, working length determination, root anatomy, retreatment predictions, viability of stem cells of pulpal tissue, periapical lesions.
Oral pathology	Ai helps in diagnosing the precancerous and cancerous lesions in early stages.
Oral surgery	Ai diagnoses various temporomandibular disorders, cysts, tumors, implants and helps in making a better treatment plan.
Prosthodontics	Ai helps during the cases of impression making, scans the whole mouth, anthropological measurements, face dimensions,
Forensic odontology	Ai determines the biological age of the patient, gender, differentiates individuals between whether they are healthy or diseased, bitemarks study.



Challenges of AI

AI is ideal in simple aspects of dentistry like scaling, polishing, filling but AI in the implant placements processes a great challenge since in these areas the experience of a clinician should not be underestimated. In April, Italy became the first western country to block Chat GPT, for priority concerns violation. AI could replace one fourth of the work tasks in united states and Europe but may also mean replace new jobs and a productivity boom and increase the annual global value by 1%.

1. Patient confidentiality and privacy protection
2. Safety issues
3. Schwendicke et al in 2019 mentioned that processing of the data and measuring and validating of the results is replicable and robust insufficiently.
4. Gianfrancesco et al in 2018 and England and Cheng in 2019 mentioned that data is used for both training and testing which leads to data snooping bias.
5. Maddox et al in 2019 stated that AI and its applications will only be partially inform the required and complex decision making in clinical care.

Later many dental researchers started addressing these limitations and challenges faced by AI to potentiate its applications by developing standards such as

- Concepts and terminology

- Data principles (Wilkinson et al)
- Sample size estimation(El Naga et al)
- Metrics
- Performing and testing
- Risk management
- Value and trust worthiness

AI in near future may assist in addressing the weakness harshly criticized in conventional dental care (Watt et al).

Conclusion

AI has got a various application in the field of dentistry and it has got a potential to transform the field of dentistry by having more modified advances years yet to come. By using AI dentists can provide a more accurate diagnosis and a better treatment plan so as to improve the oral health of all the individuals. The coming decades ahead will meet all the applications of AI and assists in addressing the weakness that is criticized in the dental care. AI is used as a tool to assist dentists in carrying out more useful tasks and enhances the patient dentist relationship and communication. By addressing all the challenges of AI this can be used as a tool in near future. This is an important factor and a tool to assist dentist but should not replace dentists.

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