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Artificial Intelligence - Step Towards New Evolutions In Dentistry - A Review

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Abstract

Artificial intelligence (AI) is a sub-science of information technology that made significant advances in medicine, and more and more artificial intelligence research is being done in dentistry. Dentists need to understand the basic concepts and be able to do this critically evaluate dental AI research. Machine learning (ML) is a subfield of artificial intelligence that most research on artificial intelligence in dentistry is devoted to the most productive area of ML research automatic dental image interpretation. Other areas include maintenance recommendations, predicting future illnesses and treatment outcomes. Research must also be standardized methods and use outcome indicators suitable for clinical use what concerns In addition to research challenges, this article discusses the ethical, legal and logistical aspects related to the implementation of clinical practice. This includes explainable artificial intelligence, model bias, privacy and security. Artificial intelligence in dentistry holds the promise of a new way to practice dentistry, the impact of AI on patient outcomes has yet to be determined.

Keywords: Artificial intelligence, dentistry, imaging, machine learning, neural networks, Dentronics

Introduction

Artificial intelligence is defined as capability of engineered system to acquire, process and apply knowledge and skills acquired through experience or education that are generally associated with human intelligence. John McCarthy coined the term AI in 1959.(1,11,12)AI is an emerging field in dentistry similar to the other fields. In dental clinic AI perform number of simple tasks with fewer errors, less staffing and greater precision than the human counterparts. Application of artificial intelligence includes high accuracy, sensitivity, specificity and precision in detection and classification of malocclusion in orthodontics. (3,13)

Dental restorations are automatically detected and classified on panoramic radiographs. AI also assists in the detection of dental and maxillofacial abnormalities like Periodontal diseases, Root caries, BRONG(Bisphosphonate related Osteonecrosis of the Jaw)- a Bony lesion i.e., associated with facial detection and dental extraction. Data analysis is done using the Machine learning field in AI.(3,13,14). In 1956 Machine learning was first mentioned by Arthur Samuel. He also defined it as a process that enables computers to learn without being explicitly programmed. At present outcome can be classified or predicted from an extensive databases are made possible by using the Machine learning which significantly improved with breakthrough of deep

learning in the later stages which process numerous algorithms effortlessly with Graphics processing units (GPUs) in the computer. (2).

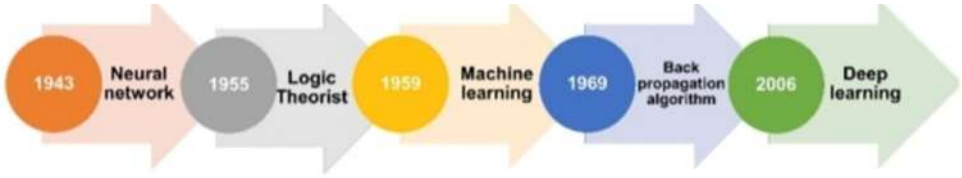

Figure 1. Important milestones in the advancement of AI.

Machine learning

Artificial intelligence has subset of machine learning, neural network, deep learning. Machine learning describes about the different methods for making use of large amount of data and also help to self improve our own experience(4). Transfer learning, reinforcement learning, object detection and speech recognition are some of the most specialized branches of machine learning(5).

Patient history, restorative and periodontal charts, results of diagnostic and laboratory tests, radiographs, extra oral and intraoral images are the different types of datasets used in dentistry(5). ML models are used for input of these data sets to generate outputs like image interpretation, diagnosis, treatment recommendations and future disease prediction(6).

There are two different ways by which machine learning algorithms can be trained – Supervised and Unsupervised.

1. Supervised learning is the relationship between input and output so that for the given test data input, output can be predicted.
2. Unsupervised learning: Data clustering and dimensionality reduction are the commonly used tasks and their main goal is to identify patterns by extracting the most relevant features from dataset(1)

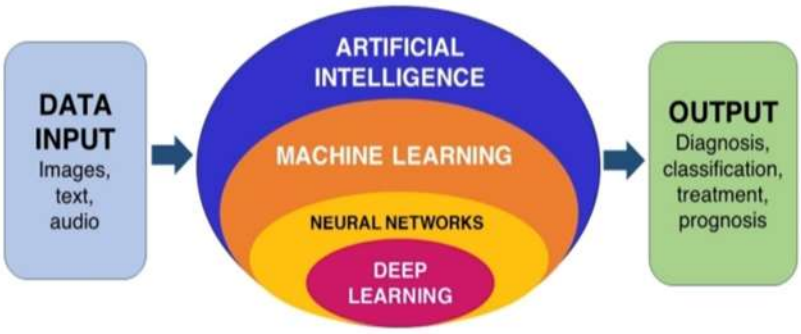

Figure 2. The working of AI in a schematic format.

Applications

Artificial intelligence and its applications evolves rapidly day by day in dentistry as it benefits clinicians with high quality patients care and simplifies complicated protocol with predictable outcomes. Electronic searching was carried out to understand the trends of AI which is done along with approaching individual companies to obtain the details of AI based services(9).

In Orthodontics,

Artificial Neural Network(ANN), Convolutional Neural Network(CNN), Support vector machine and regressive algorithms are the most commonly used algorithms in Orthodontics(9,38).

The two potential outcomes of AI in orthodontics are Treatment need assessment and outcome scoring. Based on Orthodontics related data, the Beyesian network attained a high level of agreement with orthodontist with diagnosis if orthodontic treatment need. Attractive scoring and apparent age estimation are achieved by CNNs by characterizing specific

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facial trails. In clinical trails, facial attractiveness is evaluated by decision on profile and frontal images which are compared between CNN technique and conventional rate groups(9,39).

Oral and Maxillofacial surgery,

In OMFS, the applications of digitalization with a special emphasis on the combination of implant and prosthodontics(5,40-44) or on the positive effects of cobot dentistry assisted surgery in head and neck cancer(5,45). Based on the concept of prosthetic driven implantology and CT scan analysis, computer assisted implant surgery is developed and have been reviewed(5,46). Advances towards fully automated are made by several authors generally but not to be adequate until today. The ability to identify cyst, benign tumor, oral cancer, lymph node metastasis have been experimentally investigated with the ML algorithms including SVM, ANN , RF and K- nearest neighbors(9).

1. Cone Beam Computed Tomography(CBCT) have handcrafted engineered features by which SVM was 94% accurate differentiating periapical cysts from keratocystic odontogenic tumors. (Yilmaz et al, 2017)(9).
2. To score the malignancy of cytology images derived from telemedicine platform CNN is utilized which showed high sensitivity in detecting oral malignant(93%) and high grade potential malignant(73%) lesions.(Sunny et al,2019)(9).
3. The head of the condyle was classified into two categories and tested by making 300 images. For the treatment of TMJ OA, AI is used to support clinicians with diagnosis and decision making(Lee et al, 2020)(3).

Outcome of tooth extraction is predicted with the help of CDS model through the electronic dental records. Models that integrates more medical information about the patient are required for highly accurate diagnosis(3).

Endodontics and Restorative dentistry,

There is increasing relevance for AI in endodontics. AI is useful in detecting the periapical lesions, root canal system anatomy evolution, root fractures , predicting the viability of dental pulp stem cells, determining the working length measurements and predicting the future if retreatment procedures are required. Orhan et al used CNN to detect periapical lesions on Cone Beam Computed Tomography images and their results were similar to those obtained by experienced dental practitioner. In Root canal treatment, dentists who are specialized in endodontics evolves using the magnification to ensure adequate view of root canal(9).

The idea of robotic system for assistance is published by Nelson et al which is also called as “Vending machine” was suppose to supply the root canal instruments during the treatment procedure in order to reduce the reflection from the operating site(5,47). In clinical study, DL method is used for the evolution of periapical lesions lesion , DL method assessed the CBCT segmentation and CNN detection(5,47,48)

The DL algorithm trained here in a limited CBCT environment showed excellent results in lesions detection accuracy. Convolution Neural Network (CNN) is used in restorative dentistry to predict the debonding of composite crowns using the 2D images captured from the 3D stereolithographic models. It also helps in deep learning with CNN which showed good performance in the dislodgement predictability of composite crowns through the 3D stereolithographic models(5,49-51).

Oral pathology,

Dental caries

Caries is the most common complaint in the world. Beforehand opinion is the key to caries- related conditions in cases. Cariodiagnosis is veritably high grounded on visual cues and X-ray data. This visual data can be in the form of machine literacy(ML) data input. Devito etal.(2008) constantly estimated the performance of Perceptron neural network in the opinion of sect bite radiation proximal caries and concluded that the individual enhancement was39.4(4,21). Lee etal.(2018) used 3000 periapical radiographs to estimate the performance of deep convolutional neural networks for dental caries discovery. High rigor of 89, 88 and 82 were observed in the premolar, molar and both premolar and molar regions(4,22).

Hung etal.(2019) conducted a study with a test and training set composed of data from the National Health and Nutrition Examination Survey. Grounded on the presence or absence of root caries supervising literacy styles were classified. Among the different

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ML styles used in their study, support vector machine(SVM) showed the stylish performance in root caries discovery(4,23).

Clinical image data from colorful sources have also been used in artificial intelligence models, which have produced excellent results in the opinion of dental caries. A 2019 study delved the use of convolutional neural networks(CNN) to descry dental caries in infrared photography. Speed and delicacy of caries discovery was increased by CNN. Cantu etal.(2020) used bite- sized X-ray images to estimate the performance of a deep literacy(DL) network. When the caries lesions were detected in them. A aggregate of 3,686X-ray images were used, of which 3,293 were used for training and 252 for test data. Park etal.(2021) tested ML vaticination models for early nonage caries discovery against traditional retrogression models. Data on 4195 children(aged 1 – 5 times) were attained from the Korean National Health and Nutrition Examination Survey(2007 – 2018) and anatomized. ML- grounded vaticination models were suitable to descry ECC, prognosticate high- threat groups and recommend treatment also to traditional vaticination models(4,24).

Oral cancer and cervical lymph nodule metastases,

Oral cancer is the most common malignancy in the world. Former exposure may be leading to better prognostic and better survival(4,25).

1. Artificial intelligence can support primitive opinion and degrade the mortality and morbidity associated with oral cancer. Nayak etal.(2005) used ANN to difference between normal, malignant and apicins using shaft amplification Diffuse recordings of auto fluorescence. This was compared to finite element analysis about the same things. The results displayed a sensitivity of98.3, a specificity of 100, and a sensitivity of, implying that this system may have effective real-time functions(4,26).
2. CNN was moreover operative than experts Diagnosis of cancerous precursors and cancerous lesions. The rendition of the CNN model can improves with larger data sets(4,27). Aubreville etal.(2017) used DL to detect oral cancer Was based on confocal axial endomicroscopy(CLE) images.
3. This system existed a joy and section 90(4,28). Shams etal.(2017) carried on a comparative study to predict oral cancer from achievable unpleasant oral lesions using a deep neural networks(DNN). DNN has been compared with the least homogenized support vector machines locales and multi-room observation. These findings were verified by Jeyraj etal.(2019).
4. CNN was used differentiate between cancerous and other tumors based on hyperspectral images. The results suggest that CNN can be used to determine the rest type and opinion about an image oral cancer without expert supervision(4,30).

A lot of research has been done recently in the field of oral cancer research. Many studies have successfully developed artificial intelligence models capable for predicting the status and urgency of oral cancer(4,31-35). Several studies own analogized deep knowledge(DL) with learned knowledge systems. Dialogues with different results. Ariji etal.(2014) evaluated the interpretation of DL detection of cervical node metastases using CT images. CT images of 137 positives histologically proven cervical lymph nodes and 314 antagonistic histological lymph nodes of 45 cases of oral measured cell melanoma were used. The results of the DL approach were compared between two conditioned radiologists. The DL network was just as accurate trained as radiologists(4,36). Experimenters have also used DL to delineate extranodal extension of cervical lymph node metastases. The performance of the DL system was significantly better to the radiologist, suggesting that it can be used as a unique identification too extranodal metastasis(4,37).

Neural networks and machine learning seem efficient Or better than conditioned radiologists and physicians caries, sinusitis, Periodontal problems and TMJ conditions. Cancer opinion with artificial intelligence models can curate distinct data courses for appraisal, problem estimation and referral experts(4).

Studies of premalignant lesions, lymph nodes, secretion of salivary glands, and scaled cellular melanoma shows encouraging results in terms of both individual and prognosis the value of artificial intelligence. This type of sweating can degrade early mortality and effective corrective actions. These

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platforms convey big data tools and helmets to analyze the data for accurate and cost-effectual extraction. In these models are all-important for the safe integration of these models into common clinical procedures To be perfect to attain ultimate treatment with special and observation. Too Non-control tissue is needed to refer these models to clinical practice(4).

Dental Ethics and Artificial Intelligence Research

In many ways, artificial intelligence raises a controversial question: how can embrace the promise of AI development as it embraces it potential moral challenges? One of them is creative risk the gap between research and clinical use and more undermines the trust of doctors and patients artificial intelligence devices of the future (Jobin et al. 2019). It's a matter of trust and may require further investigation by researchers potential risks associated with the technologies used their work. For example, the current range is high lit, which is rarely mentioned in AI dentistry research it involved ethics committee approval and was never referred to either guidelines related to the ethics of artificial intelligence.

This may be due to a possible lack of awareness of the subject. This situation can evolve in the short term as other sectors are already trying to do so find ways to use them responsibly. For example, a consortium radiology experts proposed more ethical rules should be created so that artificial intelligence can be used better in its fields (Geis Et al. 2019).(10)

Challenges and limitations

Explaining AI

Neural networks are considered a "black box" because of how they get there Prophecy is inexplicable even to their authors. This is due to inherent complexity Of an architecture that has hidden layers, no interpretable values, and is not n-linear relationships between layers and nodes(6,17). The consequence can be the risk of incorrect AI decisions important consequences for the patient, as shown by a neural network designed for prediction risk of death in patients with pneumonia misclassified as having a history of risk of asthma is lower than in the general population(6,15)The dentist can make mistakes however, a malfunctioning algorithm in one patient may cause discomfort for many patients. Therefore, it is necessary to ensure that AI decisions are explainable, transparent, reliable and repeatable(6,16)

Research methods

Current research methodology shows significant heterogeneity algorithm, dataset and performance evaluation. Lack of reporting standardization resulted in studies that may be weak, unique and inconclusive.59 recommendations and guidelines related to the reporting of ML studies were developed in however, there does not seem to be a general consensus on reporting Standards(6,18,19).It is recommended that guidelines and reporting standards be in place Developed for ML research tailored to dental needs. Reporting standards that emphasize transparency and reproducibility increase the "scientific value" of AI research. Health services that enable mandatory validation studies and clinical trials before receiving regulatory approval for clinical use contexts.(6,20)

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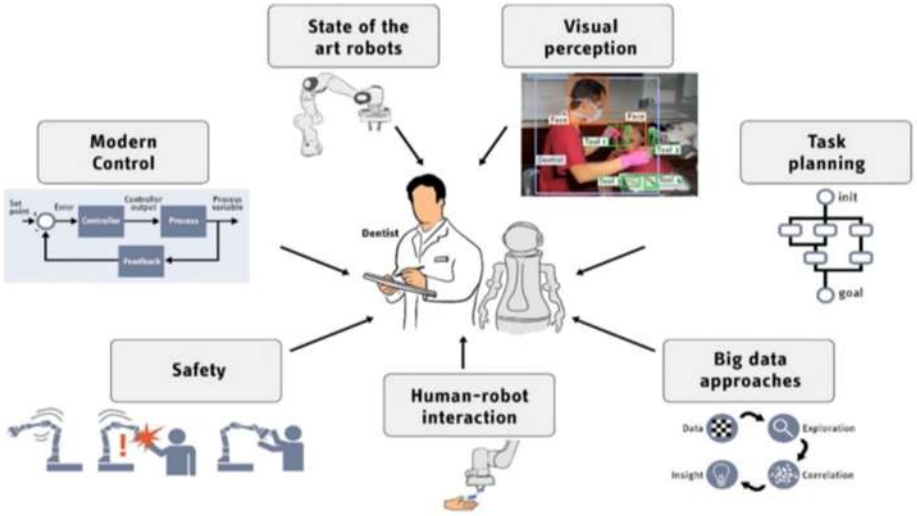

Fig. 1 – Vision of possible robots and artificial intelligence service network to support future dentistry.

Conclusion

AI systems that can hold inputs from a patient's electronic medical and dental records, Medical and dental imaging and genomic data, and behavioral, economic and social data factors. It has been suggested that patient outcomes can be bettered through the provision of artificial intelligence dentists advocating clinical decision making and dental effectiveness. Still, behind the success of artificial intelligence is its capability to absorb information quickly and well big data sets and give accurate results that are else not possible for a human do in the same volume. Accordingly far, the evidence for AI activity in the context of grand dental information is missing. Like all treatment decisions made by AI, AI is doubtful to replace dentists the system doesn't account human elements during opinions handle patient care. In addition, the success of dentistry largely depends on it to patient factors that demonstrate contact and advise patients on behavior. The fluctuations are skills that AI is unlikely to displace in dentistry. The unique chops of dentists and AI systems can work Synergistically to improve patient care. Currently artificial intelligence is more advanced in dentistry research and strategies to overcome implementation challenges the want for artificial intelligence systems is essential nowadays(6).

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