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Artificial intelligence in the field of dentistry

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Abstract
Humans have resurrected intelligence in order to make better decisions and relieve themselves of a massive workload. Artificial intelligence, or AI, is a computer program's ability to learn complex patterns by training it to perform acts that imitate human learning and problem-solving abilities. While artificial intelligence is still a young field, it has made significant progress in the fields of medicine and dentistry. As a result, dentists must be mindful of the possible consequences for a profitable clinical practice in the future. Any AI application in dentistry should show tangible value by enhancing access to and quality of care, increasing service efficiency and safety, inspiring and enabling patients, promoting medical research, or increasing sustainability, for example. Individual privacy, privileges, and autonomy must be prioritised; a transition from centralised to distributed learning may help with this while also enhancing scalability and robustness. Dental education would need to go hand-in-hand with the implementation of clinical AI technologies, promoting digital literacy among the potential dental workforce. The culmination of artificial intelligence along with digitization has seen a new era in the field of dentistry and its future aspects appear extremely promising.

Keywords: artificial intelligence, neural networks, decision-making, diagnostic systems, informatics, deep learning, machine learning, dentistry

Introduction
The evolution of ‘Artificial Intelligence' is the product of years of constant effort and hard work by researchers. The term was coined in 1950 to describe the concept of designing machines that can perform tasks that would usually be performed by humans. It's often referred to as "machine intelligence." Algorithms are used in Machine Learning (ML), a subfield of AI, to perform tasks by learning patterns from data. Machine learning involves adjusting parameters related to the underlying technique, such as the number of neurons and layers in a neural network; population size, mutation rate, and crossing over rate in genetic algorithms, and so on [1]. Genetic algorithms, Artificial Neural Networks (ANN), and Fuzzy logic are examples of machine learning models that can learn and inspect data to perform different functions. ANN is the most common model among these. The artificial neuron, which is a mathematical model system inspired by the human neuron, is one of the most important components of any ANN. A network capable of solving specific tasks like image classification (e.g., radiographic image showing a decayed tooth) is created by assembling artificial neurons and connecting the layers of these artificial neurons using several mathematical operations [2]. AI is a branch of machine learning. Artificial neural networks (ANNs) with complex multilayers are referred to as deep learning. Deep learning and neural networks (NNs) such as feedforward NNs and feed backward NNs differ in their characteristics [3]. Deep learning has a more complex way of linking layers, as well as a higher number of neurons than other networks to communicate complex models, more computing power to train, and automated feature extraction [4].

Artificial Neural Networks
Artificial neural networks (ANNs) are a highly connected network of computer processors modelled after biological nervous systems [5]. These systems enable dental health care professionals from all over the world to communicate with one another [6]. Patients may enter their symptoms and be informed of the most likely diagnosis of their disease using their personal smart devices. There are now smartphone apps that assist patients in identifying malignant melanomas by contrasting the patient's images with a large interphase of images of lesions from all over the world [7]. Self-examination of suspected oral cancerous lesions may be done using a method similar to this. This technology enables patients to obtain an expert opinion as soon as possible, while also assisting dental health care professionals in

prioritising appointments as needed.

Clinical Decision Support System (CDSS)

The CDSS is made up of a network between a complex (medical) knowledge base and an inferencing system, which is typically a collection of rules derived by experts from evidence-based medicine and applied by medical logic modules written in a language like Arden syntax [8]. Any computer system designed to assist healthcare practitioners in making clinical decisions by handling clinical data or medical information is referred to as a CDSS [9].

The Inference Engine (IE) is the central component of any such scheme, providing information about the patient from which conclusions about specific conditions can be drawn. The knowledge base and tools developed to promote the acquisition and elicitation of this knowledge reflect the knowledge used by IE. Another system that is used to predict genetic disorders and susceptibility to the same is a genetic algorithm (GA),which is a search heuristic that mimics the process of natural evolution [10]. The most time-consuming aspect of this phase up until the last decade was entering organised data into the system, but with the advent of speech recognition and artificial intelligence systems' ability to recognise and extract information from scanned paperwork, this process has been streamlined [11]. The interactive interphase is also included, which is intended to help health care professionals absorb large quantities of knowledge faster than human assistants while also bridging the gap between the doctor and the patient.

Fuzzy logic

Lotfi Zadeh coined the word fuzzy logic. Fuzzy logic is a machine learning technique that is both versatile and simple to use. The four major components of the Fuzzy Logic system are as follows:

1) The Basse Rule
2) Uncertainty
3) Engine of Inference
4) Defuzzification

The aim of fuzzy logic is to mimic human reasoning abilities that function with ambiguous words. To aid dental practitioners in making decisions, Mago *et al*. created a fuzzy logic based expert system that recognises imprecise values of dental sign-symptoms associated with mobile teeth [12]. Oral and dental diseases affect people of all ages, but often people neglect them. The fear of going to the dentist or the cost of care is the cause. Ambara and colleagues devised a fuzzy logic-based expert system that is both time and cost effective, and can be conducted without the use of any tools, reducing the patient's fear [13]. A collection of rules in the fuzzy logic scheme corresponds to pre-bleaching shades in the well-known Vita commercial shade guide.

Application of AI in dentistry

AI has primarily been used in dentistry to improve the accuracy and efficiency of diagnosis, which is critical in obtaining the best outcomes from procedures while still providing superior patient care. Dentists must apply all of their training and experience to diagnose and choose the best treatment choice. They must also foresee the prognosis, which necessitates precise clinical decision-making abilities. Dentists, on the other hand, don't always have enough experience to make the best professional decision in a short amount of time. They may use AI applications as a guide to help them make better decisions and perform better.

Dental Education

In dental education, there has been a significant improvement in the quality of input provided by the preclinical virtual patient, thanks to the recent introduction of artificial intelligence in intelligent tutoring systems like the Unified Medical Language System (UMLS).

Artificial Intelligence in Patient Management

Artificial Intelligence-based virtual dental assistants can perform a variety of tasks in dental clinics with less error and greater precision. It may be necessary to schedule a patient's appointment in the clinic, obtain the patient's medical and dental records, manage insurance, and assist the dental surgeon in proper diagnosis and care planning. It also works by alerting the dental professional to the patient's habitual information, such as tobacco or alcohol usage, as well as the patient's medical history. This creates a virtual database for each patient, which aids the dentist in disease diagnosis and care. It will also be useful for patient follow-up and online emergency medical advice.

Pain Assessment

In a study by Xiao-Su Hu *et al*, an artificial neutral network (3-layer NN) achieved an optimal classification accuracy of 80.37 percent for pain and no pain discrimination [14].

Oral Cancer

It's worth noting that neural networks are being used to process photographs of oral cancer lesions for early detection and diagnosis during dental hygiene appointments. Early detection is critical for oral cancer survival, so the clinician must conduct an oral cancer test during each recall visit. If premalignant or potentially malignant lesions are detected early enough, malignant changes can be avoided entirely or, at the very least, the chances of treatment success are increased [15].

Mobile applications for image capture of oral lesions for remote diagnosis have been created to aid in early diagnosis. Similarly, deep learning would be used for the device to distinguish between pictures with and without signs of oral cancer, which is being incorporated into these applications [16].

In reality, the algorithm will be able to categorise various oral lesions into one of three groups: benign, malignant, or potentially malignant [17]. The use of AI in early detection of oral lesions could theoretically improve care quality by allowing patients to receive the right treatment at the right time.

Detection of Tooth Decay

According to Jaroslav Bláha, a group of dentists found just about half as many caries cases in X-rays as AI. He was also able to demonstrate that AI can detect orthodontic landmarks on X-rays better than humans. AI systems are now outperforming humans in certain situations. Even if AI is just as good as humans in terms of efficiency, its speed is still significantly faster today [18]. AI systems will play an increasingly important role in dentistry in the future, simply because they save time and money.

Dental decay and periodontal disease

Dental caries is usually discovered by a clinical examination of the teeth and a review of dental radiographs. Though radiograph analysis provides initial objective evaluations, tactile sensation is also used to evaluate tooth morphology, restoration margins, interproximal encounters, incipient decay, and persistent decay. Diagnostic abilities can also differ depending on the dental provider's level of practise. In these situations, AI approaches may be beneficial because they have been shown to provide a more effective diagnostic process when combined with clinical assessment.

Using image recognition, classification, and segmentation, AI may enhance dental efficiency. CNNs, for example, can detect dental decay by learning the position and morphology of carious lesions on radiographs, making them useful for decay diagnosis [19].

Several AI investigational devices have been approved for use in dentistry and are currently on the market. Dental software is now available that can build a network of nodes and links that can collect and implement learning based on real-world data. It emulates the structure and learning mechanism of a human brain [20]. This app uses a cloud-based algorithm to detect areas of dental decay on digital radiographs and automatically highlights them [21]. Essentially, it uses CNN image detection to predict caries and can be easily incorporated into current workflows. Furthermore, CNN techniques may include image recognition and segmentation, which can be used as a supplement to radiographs to detect periodontal disease. CNNs can detect edges and capture patterns in periodontally damaged teeth (PCT) images. Through their multiple convolutional and hidden layers, deep CNN algorithms can learn hierarchical feature representations and capture regional patterns from PCT images [22].

Artificial intelligence in Radiology

It can be used in conjunction with imaging systems such as MRI and CBCT (cone beam computed tomography) to detect minute deviations from normalcy that would otherwise go unnoticed by the naked eye. This technique can also be used to precisely identify landmarks on radiographs for cephalometric diagnosis [23]. If an ML algorithm is trained by analysing thousands of such images that have been labelled as normal or abnormal, it can detect a lymph node in a head and neck image as normal or abnormal [24].

The use of ANN as a second opinion in locating the minor apical foramen has been discovered to improve the precision of working length determination by radiographs and the diagnosis of proximal dental caries. It also has enough sensitivity, specificity, and precision to be used as a model for vertical root fracture detection in digital radiography [25].

Lee *et al*. [26] recently investigated DCNN for the identification of osteoporosis on panoramic radiographs using a computed-assisted diagnosis (CAD) method. When the DCNN CAD method was compared to the work of an experienced oral and maxillofacial radiologist, the findings showed a high level of agreement.

Artificial intelligence and restorative/prosthetic dentistry

A dentist must consider many considerations when providing a perfect prosthesis to a patient, including anthropological calculations, facial dimensions, aesthetics, and patient preferences. Another example of Artificial Intelligence in dentistry is the use of computer-aided technology for precise prosthesis fitting [27]. In dentistry, CAD/CAM-based devices are often used to achieve extremely precise finished dental restorations. Inlays, onlays, crowns, and bridges are also built using AI-based systems. This device has replaced the traditional form of prosthesis casting, saving time and reducing errors [28].

Forensic Odontology

Age estimation is a crucial feature of forensic odontology that has been used for a variety of purposes over the years. In the recent past, there has been a lot of research into estimating human age using facial pictures [29].

However, there is a scarcity of data on the use of artificial intelligence in dental age determination. The sequence of tooth formation and eruption time is used to calculate dental age. The stages of tooth formation can be seen on a radiograph. Methods of radiography because of the abundance of pre- and post-treatment information, as well as the ease with which data can be collected at any time, age estimation is widely used. There are many programming neural networks that can train computers to automatically estimate the age with the advent of artificial intelligence.

Oral and Maxillofacial Surgery:

The widespread use of artificial intelligence in oral and maxillofacial surgery is paralleled by the advancement of robotic surgery, which simulates human body motion and intelligence [30]. AI software systems have aided surgeons in preparing operations with reduced operating time, while still maintaining critical structures to the smallest detail prior to the actual procedure, resulting in higher intraoperative precision [31]. One AI software system has assisted surgeons in reducing operating time while retaining vital structures to the smallest detail prior to the actual procedure, resulting in higher intraoperative precision [32]. Another ingenious application of AI is bio printing, in which organs and living tissues can be formulated in successive thin layers of cells that can be used in the future to regenerate oral hard and soft tissues that have been lost due to pathological or unintentional causes [33].

Periodontics

Deep learning analysis of radiographs can help with periodontal disease diagnosis and treatment preparation by allowing for the early detection of periodontal changes, bone loss, and changes in bone density. Peri-implantitis detection may also aid in early intervention in implantology [34].

Temporomandibular joint disorders (TMD):

1. Use of magnetic resonance imaging to determine the prognosis of TMD.
2. Use of screening questions to aid in treatment of TMD.
3. Identification of subgroups of internal derangement of the temporomandibular joint.

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Conclusions

Artificial intelligence employs a wide range of strategies, and it is only in its early stages. The current research has offered sufficient proof of its efficacy. There is a widespread belief that artificial intelligence will eventually replace doctors, which is why they have been hesitant to embrace it. In reality, incorporating these approaches will not only improve the efficiency of specialists, but it will also aid in improved patient care. Although developments in AI such as neural networking, natural language processing, image recognition, and speech recognition have revolutionised medicine and dentistry in many ways, they still have a range of drawbacks and challenges to overcome. One of them is the high cost of initial capital equipment. It's important to remember that artificial intelligence was created by humans, so it'll never be able to enslave them in new circumstances unless it's been educated to do so.

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