Review Article

Smartening Up with Artificial Intelligence in Dentistry: A Review

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ABSTRACT

Artificial intelligence is gaining popularity around the world as a high-impact, game-changing breakthrough in the field of intelligence innovation. It is used in a variety of fields, ranging from automation to dentistry. It is a lifeline for dentistry, especially in the field of prosthodontics, as it aids in the creation of functional maxillofacial appliances and the design of prostheses. It also aids in the recording, diagnosis, treatment planning, and patient management processes, allowing oral health care professionals to work smarter rather than harder. This paper discusses the prosthodontic issues and obstacles that come with total denture construction. It also emphasises advancements in digital technology in prosthodontics, artificial intelligence in dentistry in general, and methods that have been implemented to improve the oral health-care system.

Keywords: Artificial intelligence, implant prostheses, machine learning, maxillofacial appliances.

Artificial intelligence [AI] is a branch of science and engineering concerned with the computational under-standing of what is often referred to as intelligent behaviour, as well as the production of artefacts that demonstrate such behaviour [1]. It's essentially a field of computer science that focuses on the creation of intelligent machines that work and respond in the same way that humans do. The biological brain system and its ability to learn by example inspired artificial neural networks. To aid in fast diagnosis and treatment planning, a large amount of data can be gathered and computed to build an AI [2].

In terms of the number of hours worked machine can put in without becoming exhausted, machines have a little advantage over humans [2,3]. Human intellect and mind, on the other hand, require a respite before performing competing tasks. In the realm of dentistry, AI is steadily making roads in areas including as imaging, orthodontic therapy, restorative and prosthetic dentistry, endodontics and implantology, the most recent addition, a voice command dental chair that requires no physical input from the clinician [4]. AI envisions intelligent systems capable of experiencing their own surroundings and devising strategies to improve their chances of success [5]. AI programming languages are the most important instruments for deciphering symbolic data. With the advent of data processing, cloud computing and the availability of huge amounts of data collected, AI in general and in dentistry in particular began to gain attraction [6].

HISTORY

Alan Turing, an important theoretician and visionary, proved in 1936 that a universal calculator, known as the Turing machine, is possible. According to Turing, such a machine can solve any problem as long as it can be

represented and solved by an algorithm [7,8]. The design of "The logic theorist" by Newell and Simon in 1955 can be called the first program in the development of artificial intelligence. In 1965, John McCarthy created the term "Artificial Intelligence. John McCarthy is regarded as the "Father of Artificial Intelligence" [9]. He was a mathematician. AI refers to a machine's ability to mimic human knowledge and behaviour.

Machine learning is a branch of AI that was originally discussed in 1959 by Arthur Samuel, who defined “The process by which a computer learns without have been programmed” which isn't meant to take the position of a dental health care professional, but it can be used to generate a second, more educated opinion based on statistical decision-making and prediction [10].

STRONG AND WEAK AI

Machine Competencies are mainly Strong AI and Weak AI. Strong AI refers to a system that, through unnatural software development and artificial hardware, mimics human intellect. The important elements are reasoning ability, puzzle solving, decision making, planning, learning, and communication, which refer to a machine's ability to execute human activities and copy or recreate human behaviour efficiently. Weak AI is a concept that aims to improve the cognitive behaviour and judgmental capacity of computer systems in order to make them inherent in those computer systems, denying the unreasonable reduction and attempting to reproduce human intelligence, which is predicted and planned by strong intelligence [6].

IMPORTANT ASPECTS OF AI

1. MACHINE LEARNING

Machine learning (ML) is a discipline of computer science that develops algorithms based on data. It is one of the sections in AI that provides knowledge to computer systems through data and observations without having to programme them [11]. This allows a computer to correctly generalise a setting by tuning or adjusting the variables within the algorithm to receive the endurance between the input and output [12].

Machine learning is classified into four learning areas [12,13]:

a) Supervised learning: The machine has a tracking data set that a human expert has correctly labelled.
b) Unsupervised learning: The machine does not use a tracer data set, but instead tries to take the data and sort it into clusters or groups without the assistance of a human.
c) Semi-supervised learning: Because it is difficult to supervise every dataset, machine learning accuracy can be enhanced by combining a big amount of unlabelled data with a small amount of labelled data.
d) Reinforced learning: According to Hal Varian, reinforced learning is a type of sequential experimentation in which a computer tries to attain a goal while engaging with a dynamic external environment.

2. NEURAL NETWORKS

The creation of artificial neural networks is focused on the structure of the human brain or biological brain, and they can identify patterns similar to the human brain, organise data, and learn. This entails a network of highly interconnected computer processors that can learn from previous examples, evaluate non-linear data, handle imprecise data, and generalise, allowing the model to be applied to independent data, making it a very appealing analytical tool in the field of medicine [5]. The most important advantage of artificial neural networks is that they solve problems that are too complex for conventional techniques to solve and also those that do not have an algorithmic solution that can be solved with the help of an algorithmic solution [6].

3. DEEP LEARNING

Deep learning is a sort of machine learning that analyses input data using a network with multiple computational layers [10].

DENTAL EDUCATION

The field of intelligent tutoring systems has come a long way from its inception in the 1980s. Both of these methods, augmented reality and virtual reality, are frequently utilised in dental education to generate scenarios that imitate clinical work on patients while removing all of the hazards associated with teaching on a live patient. The quality of feedback provided by the preclinical virtual patient has greatly improved since artificial intelligence

was recently incorporated into intelligent tutoring systems such as the Unified Medical Language System (UMLS). Students can evaluate their work and compare it to the ideal in the interactive interphase, resulting in high-quality training environments [1].

APPLICATION IN VARIOUS FIELDS OF DENTISTRY

1. ORAL MEDICINE AND RADIOLOGY

Oral cavity lesions can be diagnosed and treated in a variety of ways. AI was used to screen and classify suspected changed mucosa undergoing premalignant and malignant alterations [14]. Oral cancer genetic predisposition in a big population could be discovered [15]. AI can be used to properly predict ANNs (Artificial Neural Networks) can help dentists diagnose subtypes of temporomandibular disorders, predict factors linked to the occurrence of recurrent aphthous ulcers, and predict the occurrence of BRONJ (Bisphosphonate-related osteoradionecrosis of the jaw) associated with dental extraction in patients taking bisphosphonates for the treatment of osteoporosis [16]. Clinicians' understanding of the form changes that occur in patients with TMJ osteoarthritis will increase as a result of this research [5]. The Mobile Mouth Screening Anywhere (MeMoSA) app can take images of the oral cavity that may be interpreted remotely by doctors [17]. In the last 20 years, image identification utilising AI systems has progressed from science fiction to reality in the radiology profession. Because of its unique ability to learn, AI has a significant advantage in head and neck imaging, and it can be combined with other imaging modalities such as CBCT and MRI to detect minute deviations from normality that would have gone unnoticed by the human eye. On panoramic radiographs and Waters' radiographs, illustrations showing the precise location of landmarks on radiographs aid in the detection of vertical root fractures, cephalometric analysis, diagnosis of maxillary sinusitis, and the detection of Sjogren syndrome on CT. In terms of cost, this could result in significantly better patient care [2].

2. PEDIATRIC DENTISTRY

AI has a wide range of possible applications that could transform behavioural paediatric treatment in the future. In terms of time and aesthetics, AI enabled restorative dentistry with computer aided design and production would be a benefit to paediatric restorations. The sizes of unerupted premolars and canines can be predicted using ANN throughout the mixed dentition stage [18]. The new, wiser technique to avoid injections in pedodontics is to use AI-enabled pain control devices. For paediatric patients, various 4D goggles, movies, animations, and virtual reality-based games might be used as a behaviour modification aid [2].

3. PERIODONTICS

Deep learning analysis of radiographs can aid in the early detection of periodontal alterations, bone loss, and changes in bone density, as well as the detection of peri-implantitis, which can aid in the diagnosis and treatment planning of periodontal disorders [19]. This aids in early intervention. Based on their immune response profile, ANN (Artificial Neural Network) may also be utilised to accurately classify patients into two groups: aggressive periodontitis and chronic periodontitis [2].

4. ENDODONTICS

The most common periapical lesions visible on radiographs are granulomas, abscesses, and cysts, however some may go unreported because pictures are noisy or have low contrast. AI can reliably find tooth areas prone to caries and complex periapical pathoses, define the boundaries of lesions with more precision, and differentiate them [20]. With the use of the Logicon Caries Detector, proximal caries can be detected and characterised. AI can assist in analysing the life span of various restorative materials and selecting them wisely for appropriate instances, as well as correctly detecting the minor apical foramen (AF), hence improving working length accuracy [2,21].

5. COMMUNITY HEALTH

The investigation of the relationship between prevention and treatment strategies in the realm of public health, as well as analytics of patient outcomes, should be the primary goal of AI in dentistry. Diagnostic suggestions, therapy protocols, biological pharmacy, personalised medicine, patient monitoring, and even foresight of epidemiological disease expansion from a global viewpoint have all been established using artificial intelligence [22].

Machine-learning models are more useful than statistical models for predicting the DMFT index and caries risk in 12-year-old children, and they can be used to predict the DMFT score as well as the life-long mean index of carious teeth, extracted teeth, and/or filled permanent teeth independently [23]. "Denta Mitra" is a mobile app that uses artificial intelligence (AI) to track oral health. It allows users to monitor their dental health using an AI-based scanner in the app, measures and reminds them about oral hygiene on a regular basis, and connects them with nearby dentists, book appointments, and virtually consult dentists.AI can also demonstrate its competence in a crisis or epidemic situation [24]. The medical sector is looking for innovative tools to monitor and control the spread of the COVID19 (Coronavirus) pandemic in today's global health crisis. It can quickly follow the virus transmission, identify high-risk patients, and aid in the real-time control of the illness.

6. ORTHODONTICS

Using intraoral scanners and camera to analyse radiographs and photos, diagnosis and treatment planning can be combined. This eliminates the need for patient impressions as well as multiple laboratory stages, and the results are typically far more precise than human perception. Algorithms and statistical analysis can be used to anticipate tooth movement and treatment outcome [12].

7. PATIENT MANAGEMENT

Virtual dental assistants powered by artificial intelligence can execute a variety of duties in the dental clinic with more precision, fewer errors, and less manpower than humans. It can be used to schedule visits, track insurance and paperwork, and aid clinical diagnosis and treatment planning [2]. It is extremely helpful in informing the dentist about the patient's medical history, as well as behaviours such as smoking and drunkenness. In the event of a dental emergency, the patient has the option of receiving emergency tele assistance, especially if the dentist is unavailable. As a result, a detailed virtual database of the patient can be produced, which will help the patient receive the best therapy possible [10].

8. PROSTHODONTICS

AI paired with design software can help dentists create the most functional and attractive prosthesis possible, taking-into account a variety of parameters such as facial measurements, anthropological calculations, ethnicity, and patient preference [5]. To recreate the facial profiles after treatment, virtual reality simulation (VRS) technologies can be used. This allows the dentist to design the aesthetics quickly and serves as a motivator for the patient. Various aspects such as anthropological calculations, facial measurements, ethnicity, and patient preferences have been incorporated by a design assistant, RaPiD, for use in prosthodontics in order to produce appropriate aesthetic prosthesis for the patient. RaPiD unifies computer-aided design, knowledge-based systems, and databases through the use of a logic-based representation [9]. The procedure of obtaining a final dental restoration through fine milling of ready ceramic blocks is known as CAD/CAM application in dentistry. It's used to make inlays, onlays, crowns, and bridges, among other things. The CAD/CAM technique entails the creation of two- and three-dimensional models, as well as their materialisation using numerically controlled mechanics. It has taken the place of the time-consuming and difficult process of traditional casting, lowering the human error component in the finished prosthesis [10]. The bionic eye (figure 1), which was developed in the United States, has already been tested on a dozen patients who have lost their vision. These artificial intelligence-assisted devices can assist people in achieving vision without the need for surgery [6].

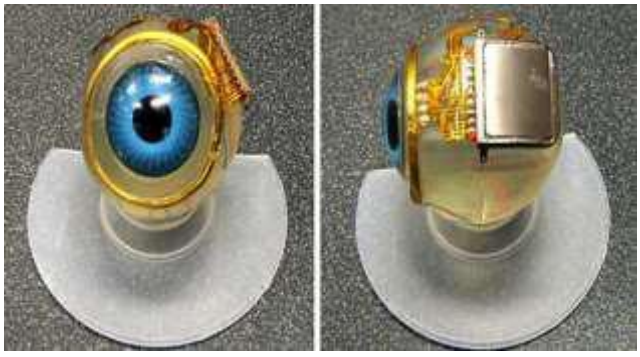

Figure 1: Bionic eye which is used to achieve vision with out surgery

AI in the field of implantology has the capability to unite the two and produce unborn prostheses. Researchers from the Finnish Centre for Artificial Intelligence (FCAI), the University Hospital of Tampere, Planmeca (figure 2) and the Alan Turing Institute have suggested a new model to rightly and automatically determine the exact position of the mandibular conduit for dental implant procedures [10].

Figure 2: Planmeca which is used to determine exact position of implant

Implant systems can be discovered from panoramic radiography pictures using deep learning-based object detection. Artificial olfaction is important in robotics because it mimics the human olfactory structure, which can recognize distinct smells and is used in a variety of applications, including environmental monitoring, disease detection, public security, agricultural production, and food processing. To recreate the facial profiles after treatment, virtual reality simulation (VRS) technologies can be used. This allows the dentist to design the aesthetics quickly and serves as a motivator for the patient [12].

LIMITATIONS AND CONCERNS

When using AI to address problems, the algorithm must be able to work with multiple applications in order to answer a single question. AI will not provide direct interpretation; however, a misinterpretation may occur due to algorithmic malfeasance [2]. To reduce the hazards associated with AI, programmes must be created in partnership with competent physicians and expert computer engineers. Several issues with IBM Watson have been discovered, indicating that AI applications in healthcare are still in their infancy and require significant improvement. If the diagnostic work becomes overly reliant on the AI system, liability will become a concern. When analysing information offered by AI, clinicians should constantly be vigilant and careful. Another worry is HIPAA (Health Insurance Portability and Accountability Act of 1996) compliance when using AI to protect medical information. Machine learning, for the most part, requires data for training. To avoid breaking HIPAA requirements, the exchange of training sets and the application of models should be done with prudence [25].

FUTURE OF AI

Radiologists should be conversant with AI terminology and hierarchy. Health informatics, computer science, and statistics courses should be included in the curriculum of radiology programs [26]. The radiologist should receive training in logic, statistics, and data science, as well as other genomes and biometrics-related knowledge. Radiologists should be aware of the difficulties in preparing training datasets for supervised learning.

CONCLUSION

AI has made significant advances in engineering and medicine, but it lacks a subjective sense of human empathy and moral judgement. In dentistry, intelligent systems are useful for obtaining a speedy diagnosis and treatment plan for difficult disorders. Artificial intelligence's clinical uses are endless, and the field is still in its early stages, with active research ongoing. Both in conventional dentistry and maxillofacial radiography, these technologies have a bright future. While it is true that medical research is in the best interests of human health, caution must be given to avoid making assumptions based on technology, as this may cause us to overlook fundamental human intuition and normal biological outliers in the complex human body. AI is expanding its footprint in clinical systems ranging from databases to intraoperative video analysis.

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