Turning science fiction into reality using artificial intelligence: A boon to dentistry.

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Abstract

One of the areas of contemporary research that is quickly acquiring worldwide recognition as a result of digitalization is artificial intelligence (AI). Medical and dental field are also not left behind in this digitisation era. They are using AI to reduce the work load and to improve clinical diagnosis so that the clinician can provide better treatment planning and predict the prognosis of a disease. AI is used in the field of dentistry and can be applied to all its specialities including prosthodontics. In prosthodontics they are helpful in designing the prosthesis, implant planning and placement and in fabrication of maxillofacial prostheses.

Keywords: Artificial intelligence, dentistry, prosthodontics, maxillofacial appliances, implant.

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Introduction

The continuous research in science and technology has made our daily life very easy with development of different applications and devices like google assistant, Alexa, Siri, cortana, Tesla etc. Artificial intelligence is the foundation for each of these applications. Artificial intelligence in layman terms can be associated with robotics.

AI is a wide ranging branch of computer science which is focused on understanding and building intelligent entities, such as software programs or smart machines.[1] It is mainly described as series of operations which is designed and constructed to perform job commonly associated with human intelligence.[2]

AI basically means the simulation of human intelligence processes by machine mainly characterized by ability to reason or learn from past experiences like human. Earlier which was assumed just as a science fiction in now becoming reality in modern world having different applications in medical field . Dentistry is such a branch of medical field which needs lot of assistance and manpower. This AI can make life of a dentist very easy with different applications in various branches of dentistry and can be believed to be a boon to dentistry.

In 1955, a mathematician called John McCarthy created the word artificial intelligence. [3] He used such term to refer to a device possessing an ability to emulate human behavior and intelligence.[4] Because of his huge contribution in the field of AI, he is regarded as inventor of artificial intelligence.

John McCarthy arranged an eminent Dartmouth conference in 1956, on the research design related to artificial intelligence and it was this time that AI was appreciated as an important discipline of computer science. A considerable research work on AI was done between a period of 1950s to 1970s.[5]

Richard Bellman, a mathematician published a book on artificial intelligence in 1978. AI according to him includes automating a number of processes that are often related with human cognitive abilities including learning, making decisions and solving problems.[6] The main objective was to design a device which will learn itself by processing of data and by doing so can solve the problems on their own by mimicking human cognitive skills.

Aspects of AI

The aspects of artificial AI include the following:

Machine learning is an important subset of AI. It is usually determined by algorithms to anticipate results based on input dataset. Its main aim is to assist machines so that it can learn from input data and provide solutions without any human aid. This is similar to a learning process of child where an adult teaches a child to identify a dog by showing different images of it. Eventually the child learns the process involved in identifying a dog by using its cognitive skills.

- Neural networks is also known as artificial neural networks [ANNs]. It consists of series of algorithms to evaluate the signals through artificial neurons. The aim is to design a neural network which will work similar to human nervous system.

- Deep learning is considered as subdivision of machine learning. It consists of neural network with three or more layer for analysing the input dataset. Deep learning has a main aim of creating a neural network system with improved features which will automatically detect data to be selected.

Convolutional neural networks (CNNs) is otherwise known as deep learning, is a variant of artificial neural network, used widely for identification and classification of object or image. Using CNN, deep learning thus recognizes objects in an image.

Application of artificial intelligence in dentistry

AI does not intend to replace the person involved in providing dental and oral health care rather it is considered as a way to develop a second well informed view based on numerical analysis and forecasting.

AI plays a pivotal role in enhancing diagnostic accuracy and revolutionizing dental health care. AI presently serves wide variety of purposes in dental field ranging from identification of typical and atypical anatomical features, diagnosing various disorder, forecasting treatment outcomes, assisting in dental laboratory procedures and so on.

Application of AI in various field of dentistry are as follows:

Oral and maxillofacial radiology and diagnosis

CNNs have promising potential to identify and detect anatomical structures such as teeth and its adjacent structures.

AI technology may be utilised to detect and identify dental caries.

According to Lee et al. investigation, CNNs based on deep learning has demonstrated exceptional performance in detecting dental caries on periapical dental radiographs.[7]

Ariji et al. conducted a study where he used deep learning classification to find how well CT images could diagnose cervical lymph node metastases that had extra nodal extensions. This study has shown superior performance using deep learning in diagnosis with accuracy of 84% in comparison to trained radiologists. [8]

The performance of AI in early detection and diagnosis of asymptomatic osteoporosis utilising panoramic dental radiographs was evaluated by Lee et al. and it demonstrated

encouraging findings. This detection of osteoporosis was supported by competent oral radiologists.[9]

Orthodontics

Diagnosis and treatment planning are the key factor to consider before predicting successful orthodontic treatment. AI can help to make clinical decisions in treatment planning procedure including the need to decide whether to extract teeth before treatment or not and can be used to make decision before orthognathic surgery.

AI was used in a study conducted by Xie et al. to decide whether tooth extraction is necessary to treat malocclusion before commencing any orthodontic treatment.[10] Clinical trail in this study had accuracy of 80% in deciding whether extractions is necessary in treating malocclusions.

Choi et al. conducted a study where artificial intelligence was used to determine whether the particular case needs surgery or not using the lateral cephalometric dental radiographs. His study proved to be very effective in diagnosing the surgery or non -surgery case with an accuracy of 96%. This study has shown favourable results, therefore can be utilised in the proper diagnosis and establish a course of action for orthognathic surgery. [11

Endodontics

To reduce the treatment failure due to atypical variation in morphology of root canal, CBCT is used now a days by endodontics. But due to higher radiation dose compare to conventional radiation it is not used systematically.[12]

However, AI can be used to overcome this problem.

Saghiri et al. conducted a study where artificial neural network (ANN) system was used to determine the working length .This study had an accuracy of 96% which is much more in comparison to professional endodontists. [13]

Saghiri et al. in other study used AI to locate minor apical foramen, and it showed an accuracy of 93% in locating minor apical foramen.[14]

In endodontics, vertical root fractures can be determined with the help of AI. Johari et al. conducted a study where probabilistic neural network (PNN) was employed to diagnose and find vertical root fractures. With an accuracy of 96.6%, this PNN algorithm has shown to be quite effective. [15][16]

Periodontics

Periodontal disease is one of the commonly occurring dental diseases affecting humans. It is well known fact in literature that periodontal disease can leads to early loss of teeth.AI technology may be used in the diagnosis of periodontal diseases.

Lee et al., conducted a study where periodontally compromised teeth were identified and predicted utilising a computer-aided detection system. A deep convolutional neural network (CNN) method was used in the investigation, and the results showed a 78.9 % accuracy rate.[17]

On panoramic dental radiographs Krois et al. reported using CNNs to find periodontal bone loss (PBL). The study's findings were consistent with those of professional perspectives. This method has proved to be helpful in reducing the dentist time spent on diagnostic and treatment planning. [18]

Oral pathology

Early detection of various oral carcinomas can significantly increase the prognosis of a disease. Therefore, AI can be used as an adjunct in detection of oral cancerous and precancerous lesion. To diagnose head and neck cancerous lesions CNN has proved to be an effective tool having a specificity of 78–81.8% and accuracy of 80–83.3% while the experienced specialists diagnosis had a specificity of 83.2% and accuracy of 82.9%.

CNN has also proved to have great potential for detecting tumours tissues in radiographs and in tissue sample. [19] [20]

Prosthodontics application

CAD-CAM

AI can be used with cad cam system to aid in prosthesis designing and manufacturing. AI has considerable advantage of using the ability to assess and learn from the millions of doctor-approved crowns in the database, with cases added to the cloud on a regular basis. Esthetics are often evaluated by measuring the potentially enormous number of dental anatomy information available.

Implant therapy

Before placement of implant , identification of exact anatomical landmark adjacent to region of implant placement is very important .For this we mostly use CBCT image in treatment planning phase.

The introduction of AI in implantology field has the potential to exactly locate the anatomical landmark to avoid any injuries to important structures such as nerve and vessels. A new model was proposed by researchers at the Finnish Center for Artificial Intelligence (FCAI), the University Hospital of Tampere, Planmeca and the Alan Turing Institute to accurately identify the location of the mandibular canal for dental implant placement.[21]

In the market there is availability of vast range of implant systems with versatile designs. Therefore, to identify exact dental implant systems after implant failure is difficult especially in patients without proper records. Radiographic method of identification is one of the mean to identify implant but others characteristics namely connection type, diameter and length might be difficult to identify. So to cope up with this problem AI can be used to develop a database where information about all available implant systems can be kept. [22] This will help to solve several queries with respect to the implant being identified.

Maxillofacial prosthesis

Colour matching is a problem in extra oral prosthesis .AI can be used to know the exact shade matching with patient's existing tissue. So, the prosthesis will have a colour similar to surrounding tissue.

AI is also used in the eye prosthesis with the help of bionic eye. Patients with vision impairments have already benefited from this bionic eye. These technologies, can help patients achieve vision without requiring surgery. A digital camera is fitted on specialised glasses in this bionic eye device, allowing the user to read text or recognise faces. A microchip interprets the information captured by the camera and translates it into audio, which is then delivered to the visually impaired person's ears via a small headset.**[16]**

Conclusion

The conventional components of dentistry are being modernized by AI. It is now being utilised to design various applications and software programs which are supposed to enhance the diagnostic accuracy of a dentist and at the same time help them in predicting the proper treatment outcome and can also assist them in maintaining patients record.

This will reduce the clinician work load and support the clinician in performing the tasks professionally, but in no way swaps the intellect of the human knowledge, skill and treatment planning.

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