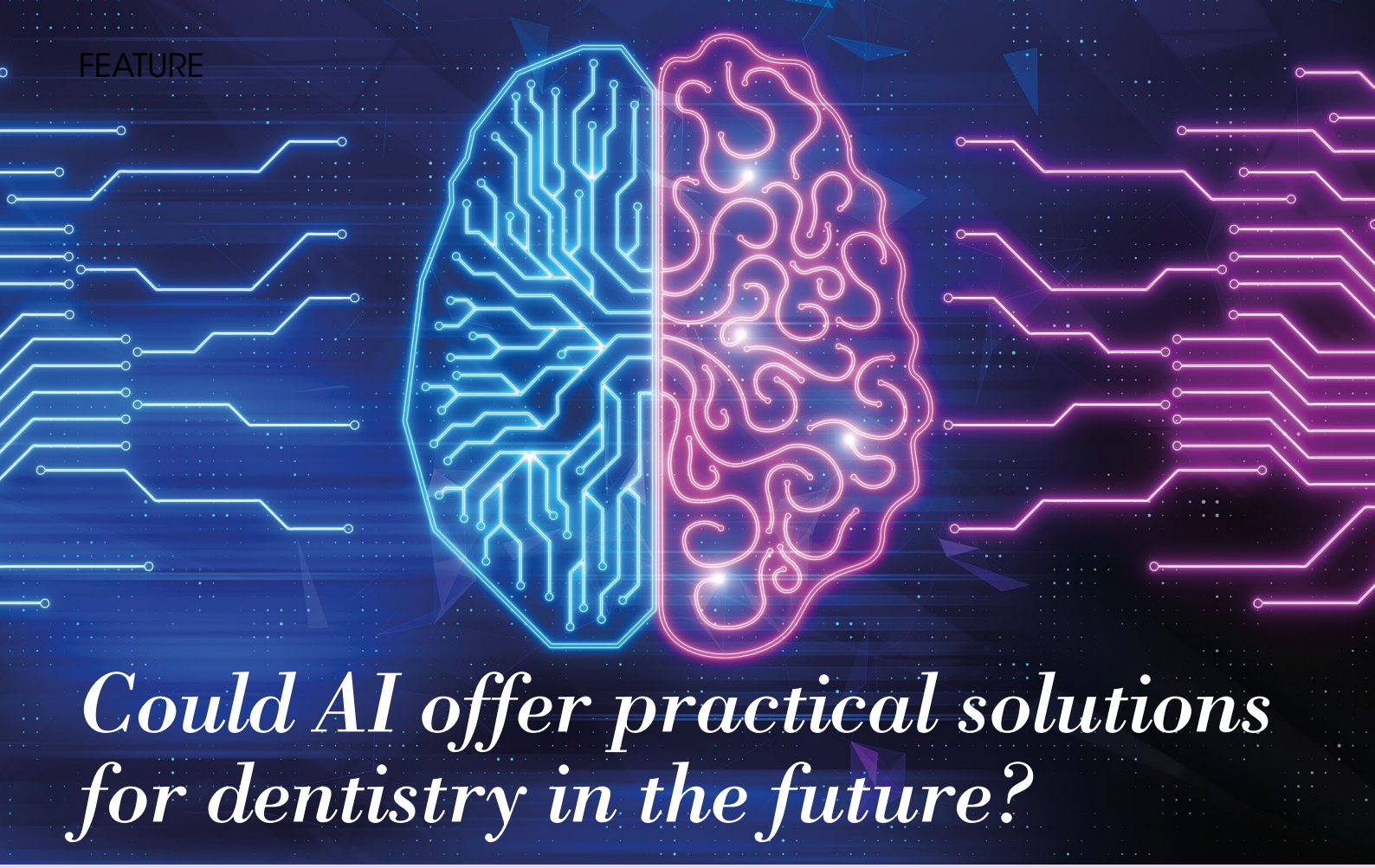

Could AI offer practical solutions for dentistry in the future?

Dr **Fahad Umer**[1] provides an overview of Artificial Intelligence (AI) and how it might be applied in dentistry.

What is AI?

An innovation that significantly alters the way consumers think and businesses operate is recognised as a disruptive technology. Cars, telephones, computers and the internet are some recent examples of disruptive technologies. Artificial Intelligence (AI) is making a quick progression up the ranks from future technology to disruptive technology.

We are surrounded by AI in our daily lives. AI through our phones has become an integral part of our everyday routine. Social media leverages AI algorithms to enhance our online experiences and recommend customised content and ads. Likewise, other technologies such as smart assistants (Siri, Alexa), self-driving cars, phone cameras, and spam filters also utilise AI algorithms for their functions.

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ML and DL

AI is an umbrella term that describes a computer algorithm that can perform cognitive functions such as learning and problem solving, thus mimicking human intelligence. Machine Learning (ML) and Deep Learning (DL) are further subcategories of AI sometimes mistakenly used interchangeably, which is not correct. Therefore, there is a need to better understand the differences between them. ML quite simply put is specialised statistical algorithms that learn patterns from provided data and make predictions on unseen data. DL is an evolved complex version of ML that is modelled on the human brain (Fig. 1).

At its core, DL is made up of an elementary unit called artificial neurons (perceptron) which when stacked sequentially in three layers (input, hidden, and output) are referred to as Artificial Neural Network (ANN). The term 'Deep Learning' describes an ANN in which there is an input layer and output layer and more than one hidden layer (Fig. 2).

Recent AI research is more focused on DL as opposed to ML; this is because DL offers many distinct advantages. DL algorithms can learn features and recognise patterns on their own whereas in ML these have to be manually inputted by subject experts - an expensive and labour-intensive exercise. Furthermore, when an ML algorithm makes an inaccurate prediction a subject expert needs to make adjustments to improve it. In DL the algorithm can measure its accuracy and thus automatically adjust and improve upon itself at the next iteration. Due to these attributes, DL can achieve incredibly high accuracy values, making it more useful in handling real-life scenarios.

DL is being leveraged in computer vision (ability to recognise and identify images), natural language processing (ability to understand and contextualise words), and audio signal processing (speech recognition). The most significant uptake of AI in dentistry is through computer vision

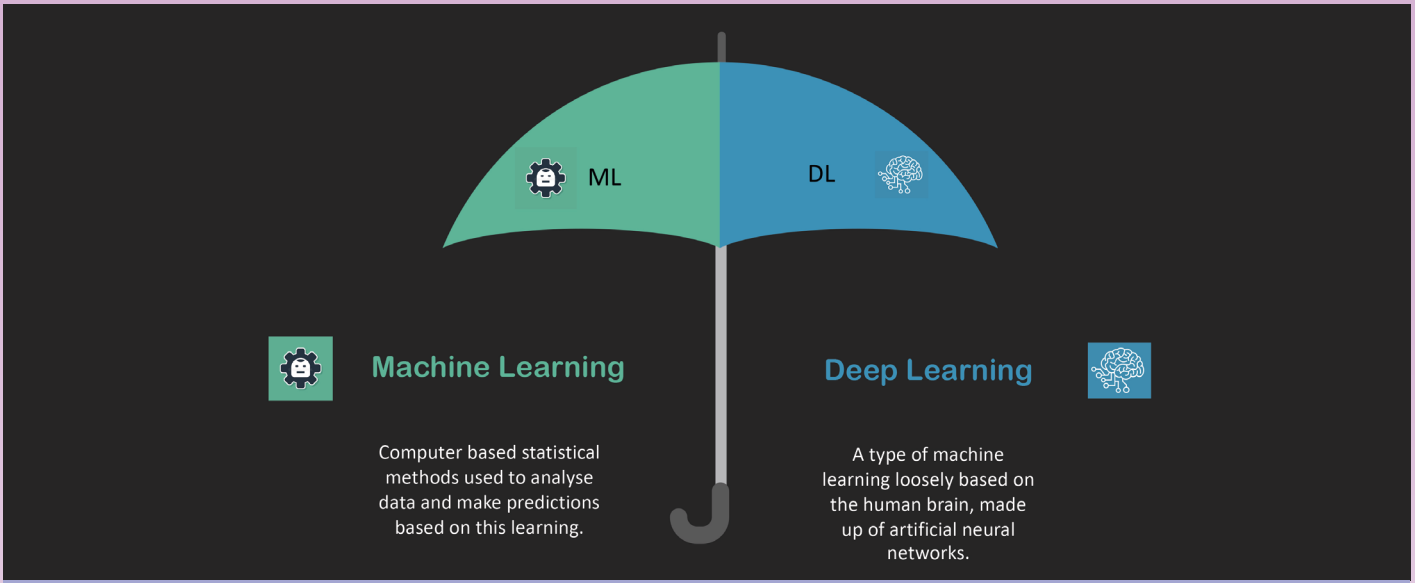

Fig. 1 Artificial Intelligence is an umbrella term that describes a computer algorithm that can perform cognitive functions, mimicking human intelligence

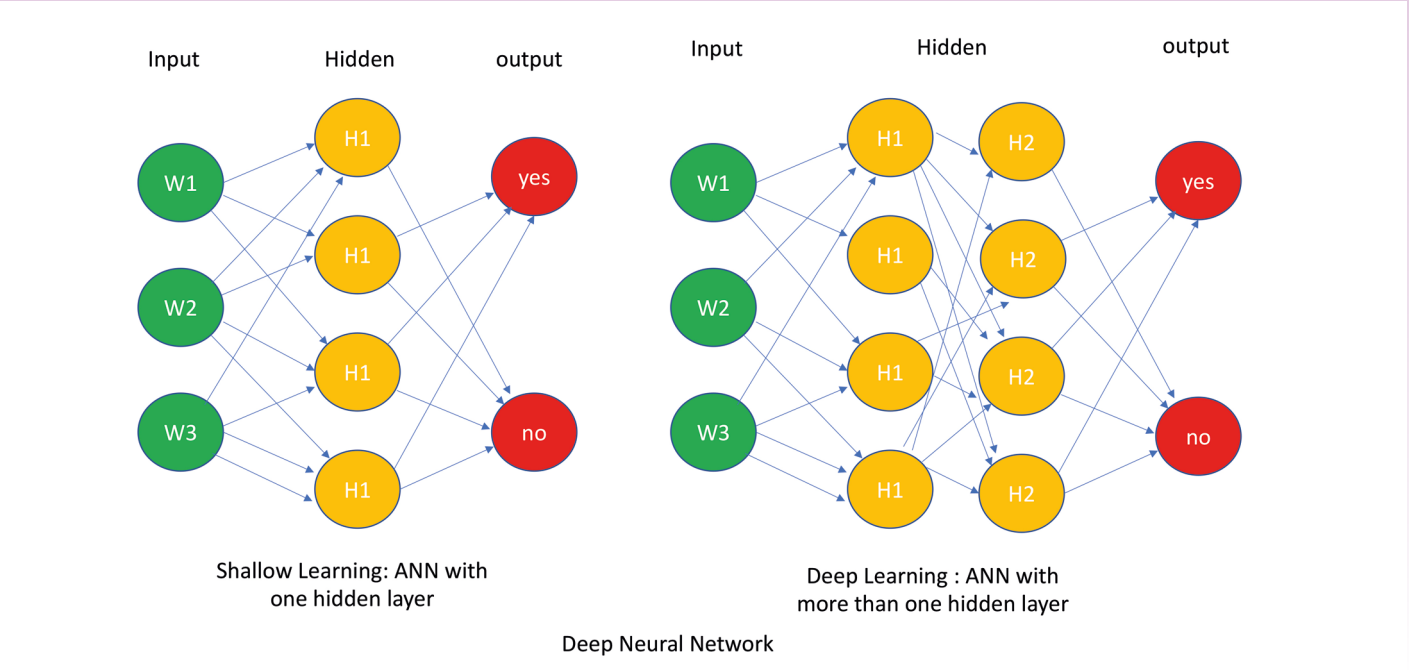

Fig. 2 The layers of the Artifical Neural Network (ANN)

utilising Convolution Neural Network (CNN) as a special type of DL method for image processing.

A CNN is an advanced ANN in which a specialised layer known as the convolutional layer is added to the algorithm. This convolutional layer acts like a sliding window that looks for specific features such as borders, shapes, edges, and colours in an image to simplify complex images into a feature map for more efficient computing.

'While the algorithm does well in teeth recognition its performance gets affected by artifacts, pathology, impacted teeth, and different varieties of dental implants.'

Clinical applications of AI in dentistry

Despite being accepted in other industries AI has not become a part of routine medical and dental practice. In dentistry, research on AI has only emerged in recent years.

Some examples are discussed below.

Automated charting

Several ML and DL algorithms are being tested to automate dental charting on

radiographs. Orthopantomogram (OPG) is the most common radiograph being used for dental charting. But researchers have found it to be a challenging task. This is because there is a lot of overlapping anatomy (zygoma, sinuses) on the OPG that confuses the algorithm. While the algorithm does well in teeth recognition its performance gets affected by artifacts, pathology, impacted teeth, and different varieties of dental implants.

Endodontics

In endodontics, ML models have been tested for working length determination and have shown acceptable performance. Further CNN-based DL models are being researched for diagnostically challenging tasks such as root fracture detection and early periapical lesion detection most have shown promising results.

Orthodontics

In orthodontics, diagnosis and planning are the most important steps before initiating treatment. AI is being developed to plan extraction *versus* non-extraction treatment. The orthodontist usually makes these decisions based on information from radiographs, pretreatment photographs, and study models. So, it was not surprising to note that the AI being tested did not perform very well as the decision of extraction *versus* non-extraction based on radiographs only.

Oral cancer

Correct and early detection of oral cancers is essential for favourable patient outcomes. AI has shown a lot of promise in this field of study. Researchers have shown the good diagnostic potential of DL models in detecting cancers both radiographically and histologically. Furthermore, AI has been shown to diagnose lesions faster than human experts.

'It must be mentioned that dentists do not solely rely on dental radiographs for caries detection and therefore a limitation of automated caries detection is not including patient history and clinical examination.'

Caries detection

Research is ongoing for the detection of occlusal and proximal caries on periapical (PA) and bitewing (BW) radiographs. Both ML and DL models have been employed for caries detection. It must be mentioned that dentists do not solely rely on dental radiographs for caries detection and therefore a limitation of automated caries detection is not including patient history and clinical examination.

Periodontology

Algorithms are being developed to diagnose treatment plans and predict the prognosis of periodontally involved teeth. First attempts at this endeavour are not very promising as the algorithms are able to make more accurate predictions for single-rooted teeth as opposed to multirooted teeth.

Limitations

AI, especially deep learning, is data-intensive; to be accurate the algorithm needs to be trained on large volumes of annotated data. This has created a market for large datasets and given rise to complex ethical concerns. Who owns this data: the patient or healthcare provider? This is a question that needs answering. Patients' consent must be sought before utilising their radiographs for AI development. There are significant concerns that patient data may be used by the healthcare industry and insurance companies unethically for targeted advertisement and making decisions on premiums.

Additionally, if a diagnostic disagreement arises between the dentist and the AI technology, how will this be resolved? Likewise, who will be accountable for any adverse event which may arise through an erroneous diagnosis by AI technology?

The current scientific literature on AI-related dental research is irregularly reported with high heterogeneity. The dental AI models at a closer look are overfitted with questionable generalisability. A mechanism must be set up to regulate transparent AI research and control the quality of AI software.

Conclusion

AI has the potential to improve diagnostic accuracy and efficiency. In dentistry, however, AI is at a nascent stage. Recently with the advent of DL, interest in AI-related research and development has increased. Work is being done in almost all dental specialties with promising results; however, current AI technology is task-specific, lacks generalisability, and is far from being a reliable adjunct for dental professionals. With time, however, it is hoped that the encouraging preliminary results will further blossom into practical solutions in which the AI and health care providers can work synergistically for enhanced patient care.

Useful resources

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