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Artificial Intelligence in Oral Cancer and Temporomandibular Joint Disorder: Review Article

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Summary

Artificial intelligence (AI) is an evolving discipline encompassed within computer science, with the objective of creating intelligent computers that possess the capacity to execute tasks that have conventionally relied on human cognitive capabilities. The establishment of the concept of intelligent behaviour in computers, commonly referred to as the 'Turing test,' can be attributed to Alan Turing in the year 1950. Academics have conducted comprehensive investigations into the potential applications of artificial intelligence (AI) in the field of healthcare since the mid-20th century.

Presently, Artificial intelligence (AI) is widely acknowledged for its utilization of novel principles to address intricate challenges. With the continuous progression of technology, the prospect of computers attaining intelligence comparable to that of humans becomes increasingly plausible. Machine learning (ML), which is a subfield of artificial intelligence (AI), encompasses the process of training algorithms using extensive datasets in order to identify patterns and generate predictions. Deep learning (DL), a subfield of machine learning (ML), leverages extensive datasets and iterative algorithms to address intricate real-world problems. Artificial neural networks (ANNs) form the basis of AI, with input, hidden, and output layers. Deep learning involves ANNs with at least two hidden layers. Convolutional neural networks (CNNs) are a type of ANN optimized for automatic feature extraction through local connections, shared weights, pooling, and preferred analysis.

Artificial intelligence emergence in healthcare offers opportunities to train computers to attain advanced intelligence, improving diagnostic aids and reducing errors in clinical practice. In the specialized field of oral medicine, AI could enhance patient care by aiding in diagnosis, management, and treatment of oral conditions, including complex medical needs.

Overall, AI's growth in various domains, particularly healthcare, demonstrates its potential to revolutionize industries and contribute to societal advancements. As technology continues to evolve, the possibilities for AI implementation are boundless, leading to significant positive impacts on human life and well-being.

Introduction

The subject of computer science comprises a wide range of disciplines, one of which is artificial intelligence (AI). The AI is concerned with the creation of intelligent robots that are capable of doing activities that typically require human cognitive abilities [1].

Alan Turing, a prominent figure in the field of computer science and artificial intelligence, played an important part in its establishment during the year 1950, Turing established the concept of intelligent behavior

in a computer as the capacity to attain cognitive proficiency at a level comparable to that of a human being. This notion subsequently gained popularity and came to be known as the 'Turing test' [2]. Since the mid-20th century, scholars have extensively investigated the potential uses of intelligent techniques across various domains within the field of health care [3,4].

Currently, artificial intelligence (AI) is widely recognized as a discipline that employs innovative concepts and solutions to address complex problems. With the ongoing advancements in electronic speed, capacity, and software programming, it is conceivable that computers could potentially attain a level of intelligence comparable to that of humans in the future [5].

Machine learning (ML), a branch of artificial intelligence (AI), involves the process of training computer algorithms to make predictions or judgment, the process entails the training of algorithms on extensive datasets to recognize patterns and correlation based on past experiences. Machine learning can be categorized into two main types: supervised learning where the computer is provided with outcome data, and unsupervised learning where no outcome data is given.

Deep Learning (DL) is a distinct subfield within the broader domain of Machine Learning (ML), characterized by its utilization of large-scale datasets and algorithms that possess the ability to learn and improve their performance iteratively. The utilization of an iterative process facilitates the enhancement of accuracy levels in deep learning models through increased exposure to data. As a result, deep learning models demonstrate notable efficacy in tackling complex, practical challenges and exhibit the capacity to acquire knowledge and adjust to unfamiliar situations (refer to Figure 1).

Artificial Neural Networks (ANNs) consist of 3 fundamental components: (1) an input layer, (2) a "hidden layer" comprising multiple nodes that perform weighted multiplication of the input and incorporate a bias value, and (3) an output layer responsible for transmitting the weighted sum of the hidden layer nodes to an activation function, thereby facilitating prediction. These components are visually represented in figures (2) and (3).

Deep learning is referring that there are at least two hidden layers in a network.

Convolutional neural networks (CNNs) are a type of artificial neural networks (ANNs) that consist of multiple layers of neurons, including convolutional layers, which have been optimized for the function of automatic feature extraction [6,7]. They possess the capability to utilize local connections, shared weights, pooling, and preferred analysis [8].

The emergence of artificial intelligence (AI) in the healthcare sector has opened up possibilities for training computers to attain advanced levels of intelligence. The enhancement of patient healthcare can be achieved through the utilization of improved diagnostic aids and possessing the capacity to mitigate errors in routine clinical practice [9].

Oral medicine is a distinct branch of dentistry that focuses on the identification and treatment of medical conditions that impact the oral cavity, jaws, and salivary glands. Furthermore, the objective is to provide medical care to individuals who have intricate medical requirements [10].

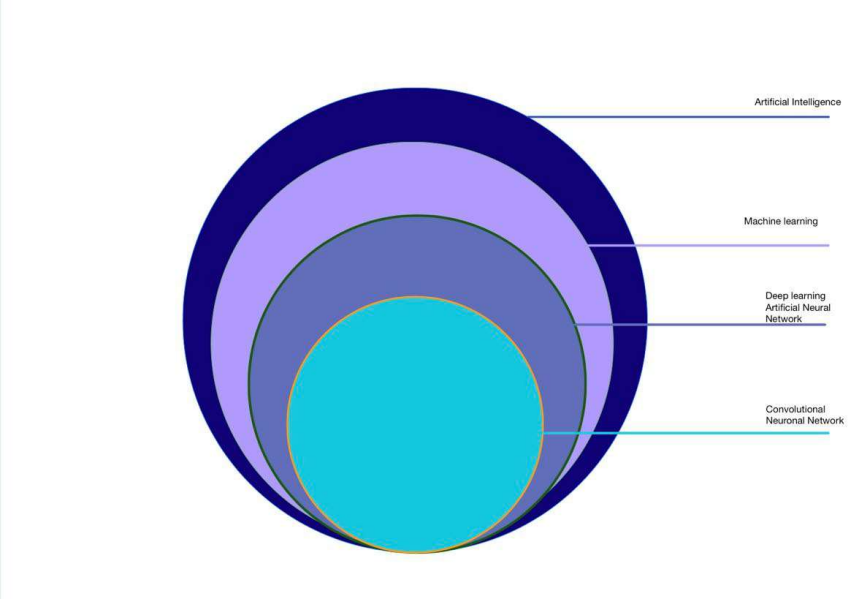

Figure 1: Artificial Intelligence subtypes

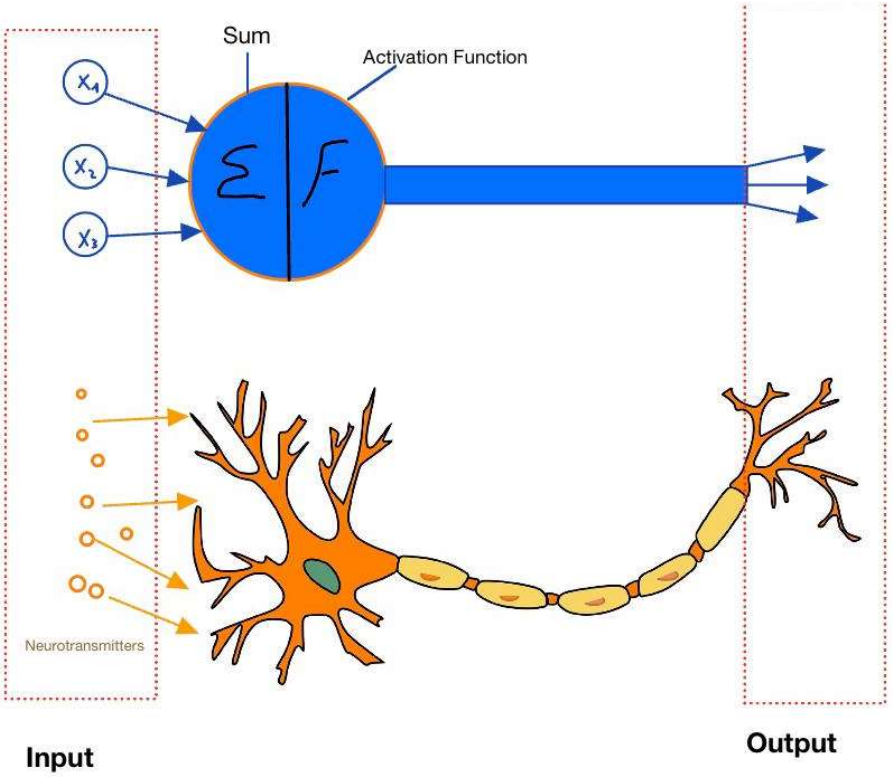

Figure 2: artificial neuronal network and biological neuron.

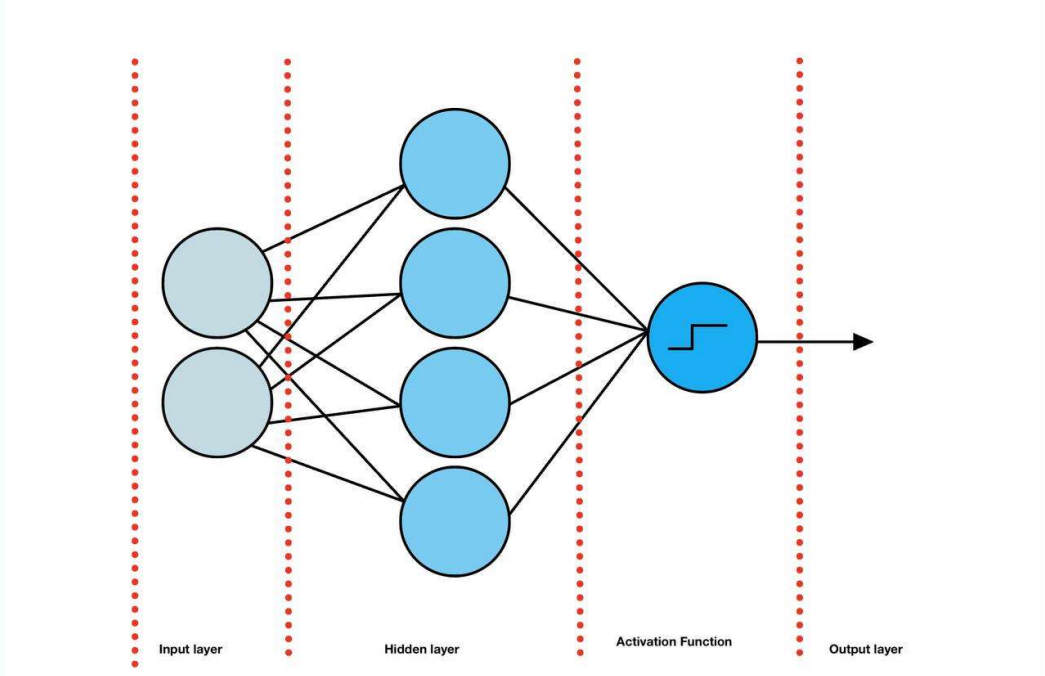

Figure 3: an example of Artificial neuronal network with one hidden layer.

Artificial Intelligence in Oral cancerous and precancerous lesions

Oral cancer accounts for roughly 4% of all malignant tumours and is the most common form of head and neck cancer [11]. The timely identification of oral cancer is often delayed, resulting in an unfavorable prognosis. Based on the information provided in the available reports, it has been observed that the timely identification of a medical issue is correlated with a higher 5-year survival rate of 83%. Nevertheless, when there is a delay in diagnosing the condition and metastasis occurs, the percentage of survival decreases to less than 30% [12].

Early detection and diagnosis of oral neoplasm results in better survival rates and better prognosis [11].

Oral premalignant disorders, referred to as oral potentially cancerous disorders, encompass a collection of conditions that have been formally delineated by the World Health Organisation (WHO) in the year 2017. These conditions manifest clinically and pose a potential risk for progressing into malignant tumours within the oral cavity. The aforementioned risk can be observed in either identifiable precursor lesions or in mucosa that appears clinically normal [13].

In recent years, there has been an increasing amount of research indicating that the application of AI has demonstrated comparable or even better performance to human professionals in detecting abnormal lesions in different organ imagery [14,15,16,17].

In a study conducted in 2005 in India, researchers employed artificial neural networks (ANN) to differentiate between normal, premalignant, and tissue samples based on laser-induced autofluorescence spectra recordings. A comparison was made between this and a principal component analysis of the identical issues. The findings indicate that the methods employed exhibit a high level of accuracy, with a specificity of 100% and a sensitivity of 96.5%. These results suggest that the methods hold significant promise for real-time applications [18].

Jeyraj et al. (2019) developed a deep learning algorithm based on partitioned convolution neural network (CNN) of automatic cancer diagnostic system to distinguish between cancerous and non-cancerous tissues based

on hyperspectral medical images of oral cancer case studies, the study determined that the employed processing algorithm effectively distinguished between cancerous and benign tumors. Over the single phase of training, this proposed deep convolutional neural network (CNN) demonstrated the ability to achieve accurate classification.

The study determined that the deep learning algorithm can be readily implemented on a basic workbench to create an automated medical image classification algorithm of oral cancer, even without the need for expert supervision [19].

In a retrospective study that included 255 patients with SCC, kim et al. (2019) , found that the utilization of deep learning algorithms for survival prediction has the potential to enhance the accuracy of predictions and provide valuable guidance to clinicians, which can aid in the selection of treatment options that optimize patient survival outcomes, while also helping to prevent the administration of unnecessary treatments [20].

According to a recent meta-analysis comprising 14 studies, it was determined that Artificial Intelligence (AI) exhibits advantageous diagnostic capabilities, characterised by a heightened sensitivity rate, in the context of oral cancer detection. Furthermore, it is anticipated that the diagnostic accuracy will further improve due to advancements in image acquisition devices and the integration of various artificial intelligence algorithms [21].

Artificial Intelligence in temporomandibular disorders

Temporomandibular disorders (TMD) include a range of musculoskeletal and neuromuscular conditions that impact the temporomandibular joint (TMJ) [22,23].

The diagnosis of temporomandibular disorder (TMD) relies on the evaluation of the patient's clinical history and the performance of a clinical examination [23]. However, accurately detecting and classifying TMD can present difficulties. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is a diagnostic protocol that is extensively employed in clinical practice. It necessitates a specific level of training and involves a significant investment of time and resources [24].

A study utilized two convolutional neural networks (CNNs) to accurately identify and differentiate the mandibular condyle, articular eminence, and temporomandibular joint (TMJ) disc in magnetic resonance imaging (MRI) pictures. The study conducted determined that convolutional neural network (CNN)-based segmentation models can be considered a reliable tool for assisting skilled personnel in accurately identifying important anatomical components for magnetic resonance imaging (MRI) of the temporomandibular joint (TMJ) [25].

A recent study has determined the viability of implementing an artificial intelligence (AI)-based system [26].

An other investigation was conducted to create an artificial intelligence (AI) algorithm, which was subsequently evaluated against the diagnostic abilities of seasoned professionals. The study revealed that AI has the capability to interpret orthopantomograms (OPGs) for the purpose of diagnosing Temporomandibular Joint Osteoarthritis (TMJOA) with a sensitivity level comparable to that of specialists [27].

A recent study developed a ML model that utilized a combined model, based on cephalogram data and clinical parameters (age, gender, limited mouth opening, crepitus, etc.), was developed and validated for the purpose of screening for degenerative joint disease (DJD), and suggested that, the model used has the potential to improve the precision of DJD screening and enhance the efficacy of decision-making in dental clinics [28].

The findings of a meta-analysis comprising 17 articles regarding the automated diagnosis of masticatory muscle disorders, TMJ osteoarthrosis, internal derangement, and disc perforation suggest that the utilization of Artificial Intelligence (AI) algorithms in the diagnosis of temporomandibular disorders (TMD) holds promise

as an effective decision support tool for healthcare professionals. In conjunction with medical diagnostic images, the inclusion of diverse input data types, such as electronic medical records (EMR), biomarkers, and radiomics features, has the potential to enhance the diagnostic precision of temporomandibular disorders (TMDs), Nevertheless, the study also concluded that the studies included in the analysis exhibited significant potential for bias. And suggested that the level of certainty in the evidence was deemed to be very low in the included studies, recommended that future research be conducted with a higher level of quality [29].

Recently, another meta-analysis study that include 20 papers found that Deep learning models demonstrated comparable diagnostic accuracy to clinicians in diagnosing osteoarthritis based on 2D and 3D radiographs. However, these models exhibited suboptimal performance in detecting disc disorders when applied to MRI datasets [30].

Conclusion:

The dental healthcare sector experiences rapid development and adoption of new technologies. The AI is regarded as one of the most promising fields due to its notable attributes, including high levels of accuracy and efficiency. However, it is important to note that these advantages can only be achieved if the AI system is trained using unbiased data and the algorithm is appropriately developed and refined, with these new technologies we expect their future usage to be as primary screening tools for different pathologies and diseases, helping in quicker and more efficient referrals to specialists and more specialized centers. There is a huge potential for AI that could use different parameters for each patient providing the best treatment plan on individual level, however, The successful navigation of ethical, legal, and technical challenges is imperative for the future. By actively acknowledging and confronting these mentioned issues, it is feasible to harness the full potential of artificial intelligence (AI) in order to optimize oral health outcomes and fundamentally transform the course of dental treatment.

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