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Artificial intelligence in radiology – towards new horizon

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Abstract

The interest in artificial intelligence (AI) has ballooned within radiology in the past few years primarily due to notable successes of deep learning. With the advances brought by deep learning, AI has the potential to recognize and localize complex patterns from different radiological imaging modalities, many of which even achieve comparable performance to human decision-making in recent applications.

Artificial Intelligence (AI) is a revolution in the area of technology that is seeing fast progress. AI has been at the center of discussion among radiologists. Common fiction has always depicted the farfetched risks of AI but the element of truth is that AI has the potential to revolutionize the way we work in the twenty first century. Since its formation, dentistry has seen some of its impressive accomplishments.

Dentistry has progressed in leaps and bounds over the past few years. New technological advances and diagnostic aids have paved the way for the revolutionization of conventional dental treatment. 'Artificial intelligence', which is a highly evolved system capable of mimicking functioning of the human brain is one such breakthrough whose potential has recently been tapped into.

The applications of AI in dental sciences include diagnosis, differential diagnosis, imaging and management of head and neck diseases, dental emergencies as well as other specialties of dentistry. This overview of AI aims to provide an insight into the

various techniques and applications of artificial intelligence in the field of oral medicine and radiology.

Keywords: Artificial Intelligence, Oral Medicine, Radiology,

Introduction

One of the most promising areas of health innovation is the application of artificial intelligence (AI) in medical imaging, including, but not limited to, image processing and interpretation [1]. Indeed, AI may find multiple applications, from image acquisition and processing to aided reporting, follow-up planning, data storage, data mining, and many others. Due to this wide range of applications, AI is expected to massively impact the radiologist's daily life.

Computers have revolutionized the field of diagnostic and quantitative imaging and are imperative in radiology workflow nowadays. Early milestones of computer technology include imaging acquisition inventions, such as computerized tomography (CT), nuclear medicine, and magnetic resonance imaging (MRI), and the developments of digitized picture archiving and communication systems (PACSs). Significant advances in "intelligent" image analysis have been achieved in recent years with the booming of artificial intelligence (AI) technology due to the emergence of deep learning. [2,3,4]

AI is basically divided into Machine learning (ML) and Deep Learning associated with convoluted neural networks. (CNN). Machine learning concerns 'the question of how to construct computer programs that automatically improve with experience'. [3] Deep learning is a class of machine learning 'concerned with algorithms inspired by the structure and function of the brain. Innovation has grown by leaps and bounds in the field of medicine and dentistry in the most recent decade. AI patterns, especially those utilized in deep learning, have discovered a striking purpose in image recognition. Specifically, AI algorithms exceed expectations at consequently recognizing complex imaging data, furthermore giving a quantitative assessment of the imaging features. [5,6,7]

Machine Learning

Machine learning is a component of artificial intelligence (AI) that teaches computers to think in the same way as humans do: to learn and develop from past experiences. This operates through data discovery, pattern recognition and requires minimal human involvement. The machine learning can automate almost any task that can be completed with a data-defined pattern or collection of rules. [8,9]

Deep Learning

Deep learning was motivated by the hugely equal design found in brain and its sources can be followed to Frank Rosenblatt's perceptron.[10,11] Deep learning algorithms create a layered, separate levels system of learning and data representation, where more important level highlights are labelled in terms of lower (less conceptual)highlights.[6] The advanced learning architecture of the deep learning algorithm is inspired by artificial intelligence imitating the complex, layered learning process in the human brain of the primary sensorial areas of the neo-cortex, there by extricating highlights and thoughts from the rudimentary understanding.

Applications of artificial intelligence in dentistry

- Regularizing appointments according to the convenience of the patients and dentists.
- Foreshadowing the patients and dentists about check-ups whenever any genetic or lifestyle information indicates increased susceptibility to dental diseases.
- Managing the paperwork and insurance.

- Supporting the clinical diagnosis and treatment planning.
- Portending the dentist before every appointment about any allergies that the patient may have
- Making the dental healthcare provider vigilant about any relevant medical history
- Setting up regular reminders for patients who are on tobacco or smoking cessation programs.
- Providing emergency tele-assistance in cases of dental emergencies when the dental health care professional cannot be contacted.

Techniques of ai applied in oral medicine and radiology

- Artificial neural networks (ANN)
- Clinical Decision Support System (CDSS)
- Principal Component Analysis (PCA)
- Data Mining technique
- Fuzzy Logic
- Belief Merging
- Genetic Algorithms (GA)
- Probabilistic and General Regression Neural Network
- Dynamic Bayesian Networks
- Atlas based techniques
- Deep Learning (DL)
- Machine Learning (ML)[11]

Artificial intelligence in oral radiology

Advances in both radiology and AI have set a more noteworthy investigation on the capacity of the radiologist as a diagnostician, which basically involves two procedures: radiographic assessment followed by interpretation.[12] It is challenging, as human perception of stimuli will sometimes miss observations as cause errors. Radiologist negligence contributes to missing and prolonged detection, which may lead to poor health outcomes.[13]

With the new era of automated imaging repositories and electronic health record systems, the usage of AI with radiology is asserted to enable not only more accurate, but also easier and cheaper image processing. The artificial neural network (ANN) is by far the most common and efficient method utilized by most existing AI applications in radiology. ANNs have ascended to turn into the most famous AI system in present day medicine. [14,15]

These Computer frameworks mimics the role of a human brain. These include networks of tightly integrated computational systems that take on the position of neurons, conduct concurrent data processing functions, and combines complex weighted links. The information base of the device encodes the weighting of each relation, and each ' neuron ' uses this weighting, guided by statistical logic, to determine whether to activate other ' neurons ' along with the line. [16,17]

ANNs provide many of the advantages that have contributed to their being the dominant type of AI in radiology. ANNs may be ' used ' through supervised learning, which involves comparisons of the predicted outcomes. It can also learn through unsupervised learning, whereby the weighting of their interactions is modified through interpretations of and correlation with the input data.

AI gradually nudges its position in the area of dental radiology, concentrating on patient information of digital scans and radiographs. More knowledge can be obtained and processed to include AI for accelerated diagnosis and better healthcare management.[18] Effective evaluation is the secret to good clinical practice. In this regard, properly trained neural networks can be helpful

for diagnosis, particularly in conditions with multifactorial etiology.

The neural network, through radiological (X-rays, panoramic, lateral cephalograms) images, recognizes and separates the major anatomical regions (jaws, teeth, etc). Thus distinguishes different diseases and illnesses by determining (normal appearance, filling, crown, root canal, implant, periapical pathosis, etc.) and gives a probable range of diagnosis.

AI in automated analysis – For training set, the clinical expert analyze and prepare a certain dataset from vast amount of radiographs available. The annotation of the training data is done by a oral radiologist or a experienced clinician manually following which the AI software is trained, using those datasets to create a adapting dataset.

The accuracy of the adapting data set is evaluated in the testing dataset (a fresh set of radiographs not evaluated previously). Thus AI helps in automated analysis of the dental radiographs. Tuzoff et al (2019) found a sensitivity of 0.9941 and a precision of 0.9945 for automated teeth detection whereas for tooth numbering, the sensitivity and specificity was 0.9893 & 0.9994 respectively.[19]

It can help to locate landmarks which are of low contrast, overlapping or of bad quality thus making it difficult to detect for a naked human eye. CNN helps in detection of anatomical in more accurately using pixel by pixel elaboration and knowledge-based algorithms.[20] Thus automated analysis of dental radiographs enables the exact confinement of landmarks and can also be utilized with CT and MRI to recognize variations from the norm in pictures that may go unnoticed.[21]

Ai in dental caries detection

AI helps to identify interproximal caries using a series of bitewing radiographs. A pre-trained deep learning network can be used for diagnosis of dental caries in bitewing, periapical and as well as panoramic radiographs. Lee et al (2018) found that within 3000 dental radiographs, the accuracy of identifying dental caries in premolars, molars, and both premolars and molars are 89%, 88%, and 82%, respectively. [22,23]

Ai in periapical pathologies detection

AI can help in detection of periapical pathologies such as periapical cyst, granulomas and abscess which sometimes gets unnoticed by a clinician's eye. AI can accurately locate the exact boundaries of the lesions and enable proper detection. In the future, these systems will help in the early detection of peri-implantitis with appropriate interventions.[21]

Ai in detection of bone loss

ANN will help radiologists to reduce cognitive bias and diagnostic efforts and further increase the diagnostic accuracy of the periodontal pathology. Koris et al (2019) found that neural network showed higher diagnostic performance, with an accuracy of 81%, than individual clinicans, who showed an accuracy of 76%, in the radiographic detection of periodontal bone loss (P=0.067). [24]

Ai in detection of oral cancer

AI can also help in early diagnosis of oral carcinomas. ANN also been helpful in detection of cervical lymph node metastasis which may result in improving the prognosis of head and neck cancer. Kim et al (2019) found that deep learning improved prediction of cancer survival and helping experts in selecting better treatment options and reducing unnecessary treatment protocols. The accuracy they found of the training and testing sets, were 81% and 78.1% respectively.[25]

Ariji et al (2019) mentioned the use of CNN enhanced the diagnosis of cervical lymph node metastasis. The performance of a CNN image classification system

resulted in an accuracy of 78.2%, a sensitivity of 75.4%, and a specificity of 81.0%, comparable to that of experienced radiologists.[26]

Current Scenario and Future Prospects Without doubt, AI seems to have a promising future ahead of it as a potentially 'game changing' device in oral radiology. However, this unprecedented technical progress has not come without the emergence of an aspect of uncertainty in the field of radiological research, a concern that has generated insecurity among the radiological communities around the world, as certain radiological practitioners doubt whether AI can eliminate the need for qualified radiologists.[27]

With such data tools, future AI technologies might be able to rely on algorithms that are far more reliable and effective, resolve high false positives and recall problems and identify anomalies in any imaging modality, including the detection of unusual and challenging cases that would otherwise be overlooked.

Conclusion

AI, which is waiting to be accepted worldwide, seems to be a positive adjunctive resource for diagnosis and treatment planning lo oks like a trustworthy, hardworking partner rather than a foe to oral radiologists.

With an exponential rise in the volume of data and the prospect of utilizing AI to classify observations that are either detectable or not identified by the human eye, radiology is already shifting from a subjective observational capability to a more analytical method. Radiologists who have been at the forefront of the modern revolution will lead the application of AI to healthcare.

Radiologists will not be substituted as radiology requires predictive coordination, recognition of patient interests and needs, professional decision, quality control, research works.

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