Short Communication

Artificial intelligence in dentistry

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Received Date: February 02, 2021

Publication Date: February 09, 2021

Technology continues to evolve every day in different ways and continues to influence our lives. In the last decade, the field of artificial intelligence (AI) in dentistry has evolved tremendously. The world of medicine and dentistry has been enormously influenced by developments in AI, such as neural networks, natural language processing, image recognition, and speech recognition.

Figure 1

What is Artificial Intelligence (AI)?

Founded in the 1950s, Artificial Intelligence or AI was described as any task performed by a machine or program that would have otherwise required a human thought process is carried out by one of us. Such a definition, though broad, is essentially the basis for this technology.

Artificial intelligence is typically the ability of a computer program to learn specific patterns by teaching the program to take actions that mimic human learning and problem-solving capabilities and with at least some of the following behaviors associated with human intelligence: reasoning, planning, learning, problem-solving, perception, and even creativity and social intelligence.

Machine Learning (ML) is a type of AI, where computer algorithms are written by humans through the

experience gained from inspecting large amounts of training data. The purpose of machine learning is to facilitate machines to learn from data so they can resolve issues without human input, the machine improves the algorithm or 'learns', thereby increasing its ability to produce the desired objective.

A specific type of ML model is artificial neural networks (ANN), which attempts to mimic the neural network of the human brain by being comprised of a mathematical model system of artificial neurons. By assembling artificial neurons in layers, and connecting these neurons and layers by mathematical operations, a neural network is engineered to solve specific tasks such as image classification to detect tooth decay easily missed by the human eye, or the specific location of canals for root canal treatment. In this way, AI is playing a valuable support role to dental professionals in practice.

A type of machine learning called deep learning or convolutional neural network which is an artificial neural network that takes the form of a complex multilayer system. Deep learning algorithms are capable of much more precise decision-making than conventional computational methods, such as being able to detect small details in an oral cavity image or to identify complex patterns of behavior or inferences in the provided data. One example is

the design of an artificial neural network that has been proven to accurately predict toothache, based on the link between toothache and a range of factors including toothbrushing frequency, duration, eating habits, and stress.

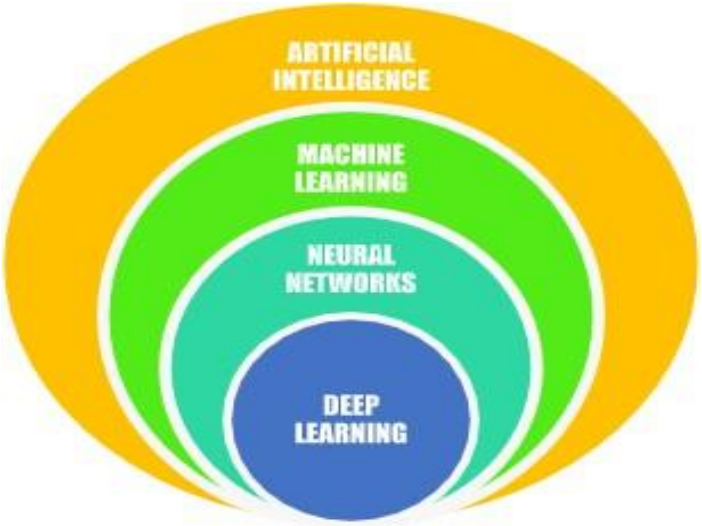

Figure 2

Artificial intelligence vs Automation…. Artificial intelligence is different than automation because AI software can learn and adapt to new situations as they receive more data, for example, they can process thousands of radiographs and X rays and apply what they learned to new data sets at higher rates of accurate diagnosis.

How is AI applied in dentistry?

The beauty of AI is that machines come from analyzing large data sets and "learn" from them to render optimal diagnoses. An example of such is reading radiographs to search for caries—a process during which even the most experienced and skilled clinician can make mistakes from time to time. It is estimated that the human misdiagnosis rate of caries from X-rays may be higher than 20 percent. this is not the case with AI, machines are not hindered by the inherent human bias and error, nor do they suffer from fatigue. As long as they are provided with the proper data set, and trained on how to recognize patterns, machines can facilitate faster, more efficient outcomes, another advantage is that machines don't get bored. The tasks that we gladly offload are monotonous and repetitive.

How can AI improve communication with our patients?

Natural language processing (NLP) is the ability of a computer program to recognize and analyze the human language and process that information to perform tasks. Voice-activated systems are being deployed as add-ons to dental imaging software that can be used for taking digital dental radiographs. As the Amazon Alexa platform, this system uses NLP prompts. The clinician tells the system what he or she wants, and the system recognizes the language and carries out the task. The use of NLP to expose digital radiographs allows the clinician to capture the image, as well as view and compare images hands-free. As a result, voice-activated systems can ultimately improve the dental workflow by optimizing infection control protocols, as well as saving clinicians time and decreasing the patient's time in the chair.

AI is also being used for communicating with patients and marketing, from scheduling appointments and analyzing data from patient records, to marketing agendas. Machine- learning programs can interface with dental practice software to track and optimize patient appointments, "to proactively schedule unfinished treatment and launch new-patient marketing campaigns based on profit maximization algorithms." For scheduling, it contacts the patient based on the person's appointment preference and matches the patient with an available appointment. "Once the ideal patients are

identified by proprietary algorithms, the program automates the process of scheduling existing patients with voice, text, or even video and will also initiate the ideal marketing campaign to convert new patients."

It can also mine data and find periods of decreased productivity and determine the most effective marketing campaign. This algorithm can monitor available appointments, detect cancellations, track marketing, and use deep learning techniques to search patient records for the most profitable patient treatment.

Applications of AI in dentistry

X-ray interpretation

Detection of dental caries, detection of vertical root fractures, detection of apical lesions, locating minor apical foramen, assessment of root morphology, diagnosis of salivary gland diseases, diagnosis of maxillary sinusitis, maxillofacial cysts, cervical lymph nodes metastasis, detection of osteoporosis, detection of periodontal bone loss, detecting the degree of alveolar bone loss.

And with the continued adoption of CBCT, interpreting cone beam images is another area in which AI can boost productivity. At this point, analyzing cone-beam data requires a specific level of training and expertise. This analysis can be time-consuming, involving sifting through hundreds of image slices. With AI, the entire process of interpretation can be automated to assess the image to detect dental pathologies more quickly and accurately.

Applications in orthodontics

Accurate diagnosis, treatment planning and prediction of prognosis are the key factors for successful orthodontic treatment. AI technology has been applied for deciding if extractions are necessary before the orthodontic treatment. Some studies used the artificial neural network (ANN) model was applied for deciding if extractions are necessary using lateral cephalometric radiographs, results were 92%accuracy using AI expert system for deciding on permanent tooth extraction, other studies were made using panoramic x rays were done, both are suggestive that the AI modes were effective and accurate in predicting the need for extraction.

Application of AI technologies in the specialty of endodontics

The stage is set for the rapid proliferation of truly impactful applications of AI in dentistry over the next year or two. In 10 to 15 years, the use of AI-based technologies in the practice will be as commonplace

and pervasive as practice management and imaging systems are today.

The success of root canal treatment mainly depends on the accuracy of working length determination. The prognosis of the treatment can only be ensured when instrumentation terminates at the apical constriction. A Study using an Artificial neural network (ANN) system was conducted in determining the working length and showed exceptional accuracy of 96% which is comparable to professional endodontists.

Application of AI technologies in the specialty of periodontics

Periodontal diseases are one of the most common oral diseases affecting mankind. Various studies have been done to ascertain AI technology application to diagnose and predict periodontal diseases. A study reported the use of a CAD system, based on a deep convolutional neural network (CNN) algorithm for diagnosing and predicting the teeth that are compromised with periodontal health. The outcome was quite acceptable with a mean predictive accuracy of 78.9 % on panoramic dental radiographs. The results of this study were like that of the expert opinions.

Application of AI technologies in the oral and maxillofacial surgery

Oral cancer survival rates depend on early diagnosis!

It is estimated that every year there are around 657,000new cases detected of cancers of the oral cavity and pharynx and is also a reason for 330,000 deaths as noted in an article on oral cancer by WHO. AI technology has been used for detecting cancers. positive and promising results when employed CNNs for an automatic approach for diagnosing Oral Squamous Cell Carcinoma when used with confocal laser endomicroscopy images. The study indicated that the AI model will be helpful for early diagnosis.

One of the greatest uses of Artificial Intelligence in Dentistry is in the area of oral and maxillofacial surgery, with the introduction of robotic surgery. Simulating human body motion and human intellect is a key task in the area of robotics. AI has, however, revolutionized the field of surgery, and today, under the supervision of an expert surgeon, many robot surgeons conduct semi-automated surgical procedures such as dental implants with increasing performance. In the area of bioprinting, one of the most ground-breaking implementations of artificial intelligence in dentistry is used, where living tissues and even organs can be built in subsequent thin layers of cells that may be used in the future for the regeneration of hard and soft oral tissues lost due to pathological or natural causes.

Application of AI technologies in the forensic odontology

Forensic odontology is relatively new, but it has made a stellar contribution to the field of dentistry. A dentist plays an important role when they must identify child abuse, crime, sexual assault, mass calamities, and other legal issues. Their moral duty compels them to pro-vide justice to the victims and their families, especially when there is no other evidence other than the dental remains. AI technology has been applied in this field and has shown excellent results. A study used an automated technique based on CNN's for staging lower third molar development for estimating the age of a person after applying on panoramic radiographs.

Also, for determining the gender using panoramic radiographs, the results were quite promising. This system is extremely useful as it automates and eases the method of identifying un-known gender or age with minimal errors.

Smart toothbrush

By evaluating your brushing pattern, these toothbrushes take the guesswork out of brushing. If the toothbrush decides that you need to shift the brushing angle or spend more time focused on those teeth, it will provide you with suggestions on how to make certain adjustments. To gain more processing resources that will make your brushing system perfect, several of the toothbrushes are connected to your smartphone or tablet.

Although AI is widely used in various fields of dentistry, some specialties such as pedodontics and oral pathology still lack the development and application of AI technology.

Retrieving and reviewing medical files

The artificial intelligence aspect of machine learning will provide dentists with improved and detailed processes in their operations. Without the need for human participation, they will interact with patients individually, give notes, and book their appointments. As a result, more efficient and valuable activities can be taken care of by your dental employees, which can further improve the effectiveness of your dental practice.

Dentists can forecast future lesions and diseases by machine learning by analyzing vast volumes of data and detecting trends. An algorithm is used that browses through a collection of radiographs and identifies patterns that a person is otherwise unaware of. This procedure is a better way for dentists to detect lesions or pathogens.

Analytics in dentistry

A good dental practice depends heavily on how you can operate your office efficiently. It will be harder for you to get an understanding of how you are doing without data-driven dental practice analytics. Most dentists are not business-minded, and because of the numerous unexpected problems that afflict their practices, they frequently struggle to keep their practice afloat. As such, through apps, the use of dental analytics will help them handle their services. This technology helps dental practitioners to concentrate on supplying their patients with the finest oral treatment while also maintaining their business activities. This way, there is a guarantee that the safety of the patient is prioritized, which will potentially raise the bottom line.

Limitations of AI in dentistry

AI can revolutionize dental practice. Whilst the applications of AI in medical- aided diagnosis, treatment, and disease prediction is exciting, the issues are data limitations, interpretability, computing power and ethical considerations.

Even though the application of AI in dentistry holds great promise, significant challenges both in technical and ethical aspects currently exist:

- The lack of data curation, sharing, and readability.
- The inability to illustrate the inner decision-making process of dental professionals.
- The neglect of ethical principles in the design of AI frameworks.
- AI-based systems are machine-based and controlled and conducted by computer scientists without any medical training which has led to a problem-oriented approach of many AI applications in dental delivery.
- AI cannot replace the contemporary healthcare delivery model who's working completely depends on clinician skills and patient-clinician communication.
- The use of robotic assistants creates a whole additional set of safety, privacy and issues social issues in healthcare.
- Dental professionals are reluctant in accepting AI-based technologies.

Conclusion

AI will never fully replace the human dentist by making you obsolete. On the contrary, this rise of machines will enable you to perform at a higher level in every aspect of your profession while essentially making your job much easier. The future of dentistry is very bright with artificial intelligence, and in the next 10-15 years, you can expect these tools to become commonplace in taking our field to the next level, however, certain that they'll soon make us better dentists by providing more data points for our clinical decision making.

And that is why Augmented intelligence[iv] is being proposed as a cognitive extension of AI in health care, emphasizing its role in assisting and supplementing the work of medical professionals. While fully autonomous medical robotic systems are not yet a reality, the virtual component of AI, usually software-type algorithms, is the main component used in dentistry.

For technology enthusiasts, our advice is to strap yourself in — there is an incredible voyage just ahead!

Volume 2 Issue 3 February 2021