

ORIGINAL ARTICLE

ARTIFICIAL INTELLIGENCE IN PEDIATRIC DENTISTRY

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ABSTRACT

Introduction: Artificial intelligence (AI) is defined as ‘a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior. The field of artificial intelligence has grown tremendously in the last decade. In the near future what this intelligence holds in pediatric dentistry is still an issue of discussion. **Aim:** The aim is to throw light on the use of AI to overcome various obstacles faced in day to day practice by a pediatric dentist. **Method:** A literature review was performed, using the search terms “Artificial Intelligence”, “Neural Networks”, “Clinical Decision Supporting System”, “Virtual Reality”, “Augmented reality”, “Machine learning”. Secondary literature searching was then performed. **Results:** The review suggested that the use of AI can transform the field of Pediatric and preventive dentistry in many ways, but they have a number of drawbacks and challenges that are yet to be overcome. **Conclusions:** AI is a tool. The choice about how it gets developed is ours. Although AI is a great aid to field of dentistry and dental education, biological systems are much more complex and AI systems can in no way replace human knowledge, skill and decision-making ability.

INTRODUCTION

The human brain is an inimitable structure composed of networks of interlinked neurons which transmit signals throughout the body. This unexampled nature of human brain has always made researchers and scientists inquisitive from time immemorial. History dates back to as early as 400 BC when Plato envisaged a basic model of brain function.¹ And over centuries newer technologies have developed based on principles that try to mimic the functioning of the human brain, however even today the machine that can think like a human is still a dream. An enormous amount of modern computer and technologies were inspired by Aristotle’s early attempts to formulate the logic and thinking

through his syllogisms (a three-part deductive reasoning)² In 1950, a British mathematician, Alan Turing devised a machine that could decode encrypted messages; this could be called the 1st breakthrough in the history of super computers. He devised the “Turing Test” which is designed to determine whether a computer exhibits intelligence.³ Today, we know a similar function as “artificial intelligence” (AI). Artificial intelligence (AI) is defined as ‘a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior.⁴

Today’s AI is invading our everyday lives, albeit in more subtle ways, such as digital assistants like Alexa and Siri. Now, Artificial intelligence in dentistry has arrived.⁵

WHAT IS ARTIFICIAL INTELLIGENCE?

Artificial Intelligence (A.I.) in its most generic form can be defined as the quality of intelligence being introduced in machines. Machines are usually dumb, so to make them smarter we induce some sort of intelligence so they can plan independently. Say, a washing machine, that can decide to ingest the right amount of water, decide on the required time for soaking, washing and spinning i.e. taking a decision when specific inputs are provided and therefore working in a smarter way. This intelligence is technically induced into the machine in an artificial way and that’s why the name Artificial Intelligence.

Artificial intelligence has two major subsets Machine learning and Deep learning. Deep Learning is a sub-field of machine learning in Artificial intelligence (A.I.) that deals with algorithms inspired from the biological structure and functioning of a brain to aid machines with in It happens that machine learning though works very well for a variety of problems, fails to excel in some specific cases which were very easy for humans. Say, classifying an image as a cat or dog or distinguishing audio clips as a male or female voice, etc. Machine learning mostly performs poorly with image, audio, and other unstructured data types. On researching the reasons for this poor performance, a thought of inspiration led to the idea to mimic the human brain’s biological process which is composed of billions of neurons connected and orchestrated to adapt learning new things.

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VARIOUS SYSTEMS COMPRISING ARTIFICIAL INTELLIGENCE

Modern medicine is faced with the challenge of acquiring, analysing and applying the large amount of knowledge necessary to solve complex clinical problems. The development of medical artificial intelligence has been related to the development of AI programs intended to help the clinician in the formulation of a diagnosis, the making of therapeutic decisions and the prediction of outcome. They are designed to support healthcare workers in their everyday duties, assisting with tasks that rely on the manipulation of data and knowledge. Such systems include Artificial neural networks (ANNs), fuzzy expert systems, evolutionary computation and hybrid intelligent systems.² Computer-based diagnosis is gaining momentum due to its ability to detect and diagnose lesions which may go unnoticed to the human eye, thereby paving way for a holistic practice. The various techniques of AI which are being applied in dentistry include artificial neural networks (ANN), Clinical decision support systems (CDSS), genetic algorithms (GA), and fuzzy logic.⁷

Augmented reality and Virtual reality is another field of AI which has variety of application in dentistry making it easy to understand for patients as well as dental students. Augmented reality is defined as “a technology that superimposes a computer-generated image on a user’s view of the real world, thus providing a composite view.” The invention of augmented reality has simplified the process of delivering aesthetic prosthesis and meeting the patient’s expectations. With the help of AI systems and augmented reality, the patient can try on a virtual prosthesis, that can be altered till the patient is satisfied and, the final prosthesis is made exactly according to these specifications.⁸ Virtual reality on the other hand is a computer-generated simulation of a three-dimensional image or environment that can be interacted with, in a seemingly real or physical way by a person using special electronic equipment. The AI systems along with virtual reality has been used not only to reduce dental anxiety but is also regarded as a powerful tool for non-pharmacological pain control.⁹

ARTIFICIAL NEURAL NETWORKS (ANN)

ANNs are computational analytical tools which are inspired by the biological nervous system.

They consist of networks of highly interconnected computer processors called ‘neurons’ that are capable of performing parallel computations for data processing and knowledge representation. Their ability to learn from historical examples, analyse non-linear data, handle imprecise information and generalise enabling application

of the model to independent data has made them a very attractive analytical tool in the field of medicine.²

CLINICAL DECISION SUPPORT SYSTEMS (CDSS)

CDSS are interactive computer programs, which are designed to assist physicians and other health professionals with decision making tasks. A working definition has been proposed by Dr. Robert Hayward of the Centre for Health Evidence: “Clinical Decision Support systems health observations with health knowledge to influence health choices by clinicians for improved health care”. CDSS are computer programs that are designed to provide expert support for health professionals making clinical decisions. These systems use embedded clinical knowledge to help health professionals analyze patient data and make decisions regarding diagnosis, prevention and treatment of health problems. Examples of such systems can be found in several disciplines in health care: dentistry, medicine and pharmacy, among others.¹⁰

More than 85% of dentists use computers in their offices. Although most of this growth is due to the use of patient accounting, billing and scheduling systems, the clinical use of information technology in the dental profession has increased substantially in the past 10 to 20 years. Despite the recognized need for CDSS, the implementation of these systems has been limited, for which there are several reasons. Lack of formal evaluation of these systems, challenges in developing standard representations, lack of studies about the decision-making process, the cost and difficulties involving the generation of knowledge base, and practitioner skepticism about the value and feasibility of decision support systems are among others.¹¹

GENETIC ALGORITHM

Evolutionary computation is the general term for several computational techniques based on natural evolution process that imitates the mechanism of natural selection and survival of the fittest in solving real-world problems. The most widely used form of evolutionary computation for medical applications are ‘Genetic Algorithms’. Proposed by John Holland (1975).¹² Genetic algorithms exploit the mechanism of natural evolution to search efficiently in a given space. They are applied to perform several types of tasks like diagnosis and prognosis, medical imaging and signal processing, and planning and scheduling.²

FUZZY LOGIC

Fuzzy logic is the science of reasoning, thinking and

inference that recognises and uses the real- world phenomenon – that everything is a matter of degree. Instead of assuming everything is black and white (conventional logic), fuzzy logic recognises that in reality most things would fall somewhere in between, that is varying shades of grey. It was popularised by Lofti Zadeh (1965) an engineer from the University of California.¹³ Fuzzy System uses Fuzzy logic which is a sort of computer logic. Ex- values are usually false (0) or true (1) but with fuzzy logic, a value of 0.8 or 0.971 is possible Fuzzy expert systems have the structure of a series of ‘if – then’ rules for modeling.

BASIC APPLICATION OF AI IN DAY TO DAY DENTISTRY

Correct diagnosis is the key to a successful clinical practice. In this regard, adequately trained neural networks can be a boon to diagnosticians, especially in conditions having multifactorial etiology. Today artificial intelligence based virtual dental assistants are available in the market. Booking and co-ordinating regular appointments, Managing of the paperwork and insurance according the convenience of the patients and dentists is one the the oldest use of AI since the introduction of computers. Voice recognition and interactive interphases enable the software to help the dentist perform different tasks effortlessly. The AI software can document all necessary data and present it to the dentist much faster and more efficiently than a human counter-part. (eg: collecting all necessary dental records, extra oral photographs and radiographs necessary for diagnosing any dental condition)¹⁴

PEDIATRIC DENTISTRY AND ARTIFICIAL INTELLIGENCE

AI application technology in pediatric dentistry is advancing remarkably. AI involves the clinical decision system, which provide professional guide with computer programs. Pediatric dentists with the help of AI can help to diagnose specific oral and dental problems, which helps in affordable, efficient treatment for the patient. AI will guide the dentists to perform the treatment more effectively than human assistants and could avoid the communication gap.¹⁵

BEHAVIOUR MANAGEMENT

Dental fear and dental behavior management problems (BMP) are common occurrences in child dental care. Virtual reality is branch of AI which we are all well aware of to reduce fear and anxiety in children (i.e use of VR Boxes). Vabitha Shetty et al (2019) conducted a study on 120, 5 to 8 yr old children to check the effect of Virtual Reality Distraction on Pain and Anxiety During

their Dental Treatment. And observed a significant reduction in pain perception and state anxiety in children, using VR distraction. The decrease in salivary cortisol levels was significantly greater in children using VR distraction.¹⁶ Klingsberg G et al (2014) applied machine learning on dental fear and behaviour management problems in children. The etiologies of dental fear and dental behaviour management problem in 2,257 swedish children were analysed using computerized inductive techniques within the field of AI.¹⁷ One can feed the data about the behaviour of the children in dental office, and a computerized system will assist us to correct behaviour management technique to be used.

CARIES DETECTION AND RADIOLOGY

Once a database in established using conventional radiographs (containing dental decay) with the help of skilled professional, a automatic caries detection tool can be established using AI. Saurabh Jha et al (2016) in his review commented that Deep Learning- like an outstanding radiology resident, the more image it analyses, the better it gets.¹⁸

Shashikant Patil (2019) conducted a the study to evaluate accurate detection of caries using dental images along with amalgamation Adaptive Dragonfly algorithm (DA) and Neural Network (NN) classifier and concluded that this novel and improved method shows substantially worthy performance in distinguishing dental caries using image processing techniques.¹⁹

Cheng Wang (2019) A Chinese dentist came up with “Smart dental detector” which uses UV LED light source to stimulate auto-fluorescence of teeth and an advanced camera where the images obtained can be transferred to mobile phone and doctors can diagnose caries easily at the early stage of tooth demineralization. This smart potable dental detector can futher more auto-classify dental caries.²⁰

MIXED DENTITION ORTHODONTICS

Developing Malocclusion prediction is now an easy task which can be performed by AI. A novel hybrid genetic algorithm and artiũcial neural network (GA – ANN) system can be used for predicting the sizes of unerupted canines and premolars during the mixed dentition period. The hybrid GA–ANN algorithm selected the mandibular ũrst molars and incisors and the maxillary central incisors as the reference teeth for predicting the sum of the mesio-distal widths of the canines and premolars. The prediction error rates and maximum rates of over/ underestimation using the hybrid GA–ANN algorithm were smaller than those using linear regression analyses.²¹

Automatic Cephalometric Analysis is now available reducing human errors. Felix Kunz et al (2019) created an AI algorithm able to analyze unknown cephalometric X-rays at almost the same quality level as experienced human examiners (current gold standard). This study is one of the first to successfully enable implementation of AI into dentistry, in particular orthodontics, satisfying **medical requirements**.²² One can narrow down the reasons of extraction of primary/ permanent teeth to correct developing/developed malocclusion within the fields of AI.²³

Post Ortho result prediction, Growth pattern analysis is now a matter of seconds taking Orthodontics to next level.²⁴

Masao Ozaki and Wataru Motokawa (2000) proposed computer based model(s) that are powerful tools that should enable anyone evaluate dental age with the accuracy of an expert pediatric dentist. Even simple microprocessors could provide that accuracy if fuzzy logic and neural network principles are incorporated which should allow wide application to medical and dental expert systems particularly in the field of pediatric dentistry.²⁵

PHARMACOLOGY

Pharmabot: A Pediatric Generic Medicine Consultant Chatbot. It is a conversational chatbot that is designed to prescribe, suggest and give information on generic medicines for children. It introduces a computer application that act as a medicine consultant for the patients or parents who are confused with the generic medicines.²⁶

CONCLUSION

The field of artificial intelligence has grown tremendously in the last decade. There is no doubt in the supremacy of AI, including advances in neural networking, natural language processing, image recognition, and speech recognition which has taken dentistry to the next level, despite some hitch like high initial capital equipment costs. The question then arises whether it can replace the role of a dentist. A dental robot has been created that can perform dental procedures, announced researchers at the 79th IADR where the dentists used joysticks and virtual reality glasses to operate handpieces and materials syringes to prepare caries for restoration, perform endodontic therapy and prepare tooth surfaces for bridges. Since clinical practice is not only about diagnosing but also correlating with clinical findings and providing personalized patient care it can never replace the role of a dentist. Although AI can assist in numerous ways, final call has to be made by the operator. However,

this is certain that they'll soon make us better Pedodontists by providing more data points for our clinical decision making.

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