Review article:

Artificial Intelligence: Transforming Dentistry Today

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Abstract

With the enormous increase in the documented information and patient data, intelligent software for computation of this data has become a necessity. From data processing and finding relevant information to using neural networks for diagnosis and to the introduction of augmented reality and virtual reality in dental education, Artificial intelligence has found a number of applications in the field of medicine and dentistry. The introduction of robotics to the field of surgery has increased the precision and made surgical procedure more predictable. Virtual assistants that apply Artificial Intelligence software are helping dentists to diagnose cases accurately and treat patients efficiently without missing any relevant genetic information. Even with these amazing advances artificial intelligence may still be in its infancy and in no way can replace human intelligence and skill. Nevertheless, this technology is helping create more awareness regarding oral and maxillofacial diseases and risk factors while also encouraging patients to seek early treatment. The culmination of artificial intelligence along with digitization has seen a new era in the field of dentistry and its future aspects appear extremely promising.

Keywords: Artificial Intelligence, Neural Networks, Clinical Decision Supporting System, Virtual Reality.

INTRODUCTION

The human brain has been one of the most intriguing structures to researches and technologists for as long as the history dates back. 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).[1] In1950, 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.[2] 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 behaviour'[3] The applications of these Artificial Intelligence technologies like Expert systems, Game-playing, and Theorem-proving, Natural language processing, Image recognition and Robotics in various fields like telecommunication and aerospace have grown manifold. Technology has also revolutionized the field of medicine and dentistry in the last decade.[4]

CLINICAL DECISION SUPPORT SYSTEM CDSS

Almost everyone born in this century has tons of medical and genetic information documented in some way or the other. A lot of this information may not be relevant but now as more and more links are being identified between genes and susceptibility to dental diseases, the process of finding any relevant genetic information, although tedious may prove to be an irreplaceable insight into the accurate diagnosis and treatment of dental diseases. For this reason the involvement of computers and software in medicine and dentistry has become a necessity. A Clinical decision support system (CDSS), can perform this function quiet efficiently .The CDSS consist of a network between a dynamic (medical) knowledge base and an inferencing mechanism that are usually a set of rules derived from evidence-based medicine by experts and they are implemented through medical logic modules based on a language such as Arden syntax. [5] Another system that is used to predict genetic disorders and susceptibility to the same is a genetic algorithm (GA),which is a search heuristic that mimics the process of natural evolution.[6] Up until the last decade the most tedious part of this process was to enter structured information into the system but with the advent of voice recognition and the ability of artificial intelligence programs to identify and extract information from scanned paperwork, this process has been simplified.[7]Added to this is the interactive interphase that is designed to assist the health care professional to comprehend vast amounts of information more efficiently than human assistants and simultaneously bridge the gap between the doctor and the patient.

ARTIFICIAL NEURAL NETWORKS

Artificial neural networks are highly interconnected network of computer processors that are inspired by the biological nervous systems.[8] These systems help connect dental health care professionals all over the world.[1] With their personal smart devices, the patients can enter the symptoms that they are experiencing and can be made conscious of the most probable diagnosis of the illness. Today there are mobile applications available which help the patients to identify malignant melanomas by comparing the pictures from the patient with a vast interphase of pictures of lesions from around the world. (eg. Mole Check App, OnlineDerm Clinic, SkinXM).[9] A similar system can be applied and implemented for self-examination of suspected oral cancerous lesions. This technology helps patients to get an expert opinion at the earliest while also helping the dental health care professionals to prioritize the appointments when necessary.

One of the most important breakthrough in this technology was brought about when in 1958, a psychologist, named Dr Frank Rosenblatt developed Perceptron which worked on a multilayer feed forward mechanism.[10] Multiple layers of computer processors capable of performing parallel computations for data processing make up these networks. Each of these units is known as "neurons" and they are interconnected by links, each of which has a numerical weight associated with it. The network has the ability to "learn" though repeated adjustments of these weights. Another breakthrough in this technology came when Paul Werbos in 1974 introduced "backpropagation" learning.[11] Today we use this ability of the computers programs to "learn" from newer information to aid health care

162

professionals all over the world to better understand diseases , to diagnose them early, and to treat them effectively while also sharing this vital information with other health care professionals worldwide.

AUGMENTED REALITY AND VIRTUAL REALITY

Dentistry is an unique profession in the scope of medicine and is extremely demanding as requires assimilation of large amounts of knowledge combined with the acquisition of clinical skill.[12] 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.[13] 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.[14]

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 control of pain.[15]

ARTIFICIAL INTELLIGENCE SYSTEMS IN DENTAL EDUCATION

Since its inception in the 1980s, the field of intelligent tutoring systems has come a long way. Both these systems, augmented reality and virtual reality are being used widely in the field of dental

education to create situations that simulate clinical work on patients and eliminate all the risks associated while training on a live patient.[16] With the recent incorporation of artificial intelligence in intelligent tutoring systems like in the Unified Medical Language System (UMLS); there is a huge improvement in the quality of feedback that the pre-clinical virtual patient provides the students.[17,18] The interactive interphase allows the students to evaluate their work and compare it to the ideal thus creating high-quality training environments. A number of studies carried out on the efficacy of these systems have indicated that students attain a competency-based skill level at a faster rate than with traditional simulator units.[19, 20, 21]

APPLICATIONS IN THE VARIOUS FIELDS OF DENTISTRY

Today artificial intelligence based virtual dental assistants are available in the market, [22] As virtual assistants these software can perform a number of simple tasks in the dental clinic with greater precision, less manpower and fewer errors than human counterparts. Some of these tasks include:

- Booking and coordinating regular appointments according the convenience of the patients and dentists.
- Alerting the patients and dentists about checkups whenever any genetic or lifestyle information indicates increased susceptibility to dental diseases. (eg: periodontal screening for patients with diabetes and oral cancer screening for those who habitually use smoked or smokeless tobacco)
- Managing the paperwork and insurance

- Assisting the clinical diagnosis and treatment planning
- Alerting the dentist before every appointment about any allergies that the patient may have
- Alerting the dental healthcare provider about any relevant medical history (eg: use of prophylactic antibiotics in those patients who have had cardiovascular surgeries)
- Setting up regular reminders for patients who are on tobacco or smoking cessation programs. etc.
- Providing emergency tele-assistance in cases of dental emergencies when the dental health care professional cannot be contacted.

Besides these, AI software enables us to create a complete virtual database for every patient, which can be extremely detailed and extremely accessible at the same time.[23, 24] 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 counterpart.(eg: collecting all necessary dental records, extra oral photographs and radiographs necessary for diagnosing any dental condition). Because of its unique ability to learn, it can be trained to perform many other functions. It can be integrated with imaging systems like MRI and CBCT to identify minute deviations from normalcy that could have gone unnoticed to the human eye.[25] This can also be used to accurately locate landmarks on radiographs, which can be used for cephalometric diagnosis.[26] This happens simply through its ability to effectively acquire information, and sync with established decision support databases.[27] In the field of pathology it can be used to scan large number of sections to locate minor details which aids in diagnosis and clinical decision making.

In the field of orthodontics the software can perform a number of analysis on radiographs and photographs that aid in diagnosis and treatment planning.[28, 29, 30] With the advent of intra-oral scanners and cameras the ordeal of making a dental impression is also disappearing soon. These digital impressions are not only quicker and more accurate but also eliminate all the laboratory steps thus drastically reducing the number of errors. With the help of Artificial Intelligence, the computer can actually guide the dentist during the entire procedure of making a digital impression and aid in making an ideal impression. [31] Based on the information that is fed into the system, the set algorithms and statistical analysis, the AI software helps to predict tooth movement and final outcome of treatment too.

AI along with some designing software also aid the dentist to design the best possible and aesthetic prosthesis for patients while considering a number of variables like anthropological calculations, facial measurements, ethnicity and even patient's desire. [32, 33] The fabrication of the prosthesis is currently carried out with CADCAM technologies like subtractive milling and additive manufacturing technologies like 3D printing. It has replaced the time consuming and laborious process of conventional casting and simultaneously drastically reduced the human errors in the final prosthesis. These technologies can also be used to fabricate accurate orthodontic plates and appliances too.[34]

In the field of implantology and surgery, AI software has helped plan surgeries to the smallest

164

detail prior to the actual surgery. One of the greatest applications of AI is in the field of oral and maxillofacial surgery with the advent of robotic surgery. A crucial challenge in the field of robotics is simulating human body motion and human intelligence.[35] However AI has revolutionized the field of surgery and today there are many robotic surgeons that perform semi-automated surgical tasks with increasing efficiency under the guidance of an expert surgeon. Finally one of the most innovative applications of AI is seen in the field of "bioprinting", where living tissue and even organs can be constructed in consecutive thin layers of cells which in the future may be used for reconstruction of oral hard and soft tissues lost due to pathological or accidental reasons.[36]

CONCLUSION

The field of artificial intelligence has grown tremendously in the last decade .While the advances in AI like neural networking, natural language processing, image recognition, and speech recognition have transformed the field of medicine and dentistry in many ways, they have a number of drawbacks and challenges that are yet to be overcome. One of which is the high initial capital equipment costs involved.

The systems that have sought acceptance in the medical industry have some serious drawbacks when applied to clinical medicine. Mere flowcharts, statistical pattern matching and become unmanageable at some point. The algorithms usually make some unwarranted assumptions that have led to the relative skepticism about their accountability in a clinical scenario. Although Artificial Intelligence systems are 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.

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