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Ethical Conundrum in Applications of Artificial intelligence in Dentistry

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Abstract

The objective of this review is to discuss role of Artificial Intelligence in dentistry – its spectacular development and growth. Applications of Artificial Intelligence has expanded the potentialities of dental healthcare system which at one time couldn't be imagined. But limitations of Artificial Intelligence lead to ethical issues which required ethical guidelines to improve the quality of dental healthcare. Hence, varied applications of AI needs to be recognized and addressed ethically so as to have fair and safe Artificial Intelligence projects in dentistry.

Keywords: Artificial Intelligence, Artifical neural networks, Augmented Reality, Convulational neural network.

Introduction

Human, a special creation of god, is always starving to make life more and more productive. One such great innovation is Artificial intelligence. Artificial intelligence is the capacity of machines to do certain tasks which uses the intelligence exhibited by humans and animals Marvin Minsky and John McCarthy in 1950 defined it. They were known as Father of Artificial Intelligence [1]. The term "artificial intelligence" (AI) was coined at Dartmouth College in the 1956.[2]

Artificial intelligence allows the machines to understand and achieve specific goals. AI includes machine learning via deep learning. The former refers to machines automatically learning from existing data without being assisted by human beings.[1] Machine learning (ML) is a subfield of AI, in which algorithms are applied to learn the intrinsic statistical patterns and structures in data, which allows for predictions of unseen data [3],[4]. Deep learning allows the machines to absorb huge amounts of unstructured data such as texts, images and audio. Any AI system must be able to have some of following

characteristics such as observation, analytical, ability, problem solving, learning etc. [1],[5]

Timeline of Artificial intelligence begun in 1637 when Rene Discarte spondered the possibility that machines would one day think and make decisions. In 1956 professor John McCarthy in Dartmouth college organised a conference effort was made to plan for a framework to allow academic exploration and thus developing the thinking machines. Agenda included many fields like AI, Natural language processing, computer vision and neural network in 1966 Joseph Weizenbasim in MIT developed ELIZA –world's first chatbot and ancestor of today's ALEXA and SIRI[6]. And then evolved the statistical approach – When in 1988 IBM researches published a statistical approach to language translation, introducing the probability into field of machine learning. In 1997 IBM'S Deep blue began the first computer to competes Russian grandmaster thus created epic in history of technology. In 2016 ALPHAGO created by deep mind Proved the capability of thinking machines. Recently in 2018 development of self-driven cars use todays VR positive application capturing the public imagination [7].

Classification of Artificial Intelligence

AI can be broadly classified into two categories – Narrow AI and General AI.

Narrow AI is AI used everywhere today example detecting faces in pictures, customer care inquiries and taking online contents whereas General AI is still a concept. Actually GI is used to make this adaptable and flexible as human intelligence[1].

In field of science computer aided engineering augumented by AI is making the manufacturers able to discover machine learning guided insight and find solutions to complex design problems [8]. In healthcare Altaire's data solutions with AI reduce IT problems in areas like claims, reimbursment processing, revenue cycle management, interoperability, patient adherence, satisfaction analysis and physician performance analysis [9].

A. Types of networks in Artificial Intelligence

Artifical Intelligence in dentistry has two networks named as Artifical Neural Networks (Ann) And Convulational Neural Networks (CNN)[10][11].

ANNs are used to find patterns with in data and then teach machines to recognize those patterns. CNNs are used to for analysing visual images and image diagnostics. These AI techniques can help in advancement in dental health care delivery system'

Applications of AI in dentistry are varied and saves a lot of time and efforts. It give more precision to dental work

Implementations of Artificial Intelligence in dentistry

AI helps in improving dental examination by using image detection and segmentation. E.g. CNN detects dental caries using the basis of location and morphology of caries on radiographs so, more efficient way of diagnosis of caries [12,13]. Dental software creates a set of nodes and connections that accumulate and apply learning by actual data., works by emulating the structure and learning process of a human brain. It automatically highlights areas of decay over digital radiographs-by CNN image detection [14]. As mentioned earlier this technique provides image classification and segmentation and similar can be used to capture patterns from periodontally involved teeth images and do edge detection. By deep CNN there is capturing of regional patterns from periodontally involved teeth images in multiple convolutional and hidden layers [13,15]. It has an accuracy of 75.5%-93.3% with a sensitivity of 74.5%-97.1% [16] Hence AI application in Diagnosis is with objective accuracy.

A recent study reported the genetic algorithm-based approach to observe dental caries in the early stages to avoid the decay [17,18].

There are two computer-aided technologies named Augmented Reality (AR) which leads to the superimposition of computer-generated virtual content over the real environment. This term was coined by Caudell and Mizell in 1990[19]. Its application in the oral and maxillofacial branch of dentistry in surgeries requires appropriate planning with precision. This helps in providing accurate graphical information of sites modified from a data source [20]. Dental implantology is made easy with graphical results of the positioning of implants [21].

Augmented Reality (AR) is also used in Dental education by the combination of a digital variable with a real learning domain. It also made learning live anatomy easy by visualizing the operator's own body by using augmented mirrored images [22].

AI in Endodontics using CNN determines extra or missing canals. Once the presence or absence of atypia was observed image patches of the roots obtained from panoramic radiographs were processed by a deep learning algorithm to classify morphology. It gives an accuracy of 86.9% [16,23]

Neural networks aids in the early detection and diagnosis of oral cancer by analysis of images of oral lesions. As indicated by Garg and Karjodkar If premalignant or possibly threatening injuries are recognized sufficiently early, dangerous changes might be forestalled through and through or if nothing else the odds of coming out on top of the treatment at a beginning phase is more" [24] For remote diagnosis mobile applications are developed used for image capturing of oral lesions. In all these techniques deep learning is used to differentiate images with or without oral cancer signs. Even these techniques can classify these lesions as benign, malignant, or potentially malignant. As mentioned earlier it aids in early diagnosis and early appropriate care [13].

Some researchers in a study used an artificial neural network to assess the need for extraction during orthodontic treatment [16]. Also, AI-driven customized orthodontic treatment used in various phases of orthodontics from diagnosis to treatment planning and follow-up monitoring e.g., 3D scans, virtual models help in the assessment of dental abnormalities. Especially using 3D scans aligners can be printed and treatment can be customized [19]. These AI conjugated aligners reduce chances of errors, saves time, and provide more precise treatment. AR used in Orthognathic surgeries but expansion in facial skeleton osteotomy via partial visual immersion [25].

Wang et al developed a Digital convolution neural network with 16 convolution layers and two fully connected layers for detecting periodontitis [26]. ANN can easily be used in classifying Peridontitis into aggressive and chronic periodontitis using the basis of immune response profile [27].

In the field of prosthetics, few consideration factors are anthropological calculations, facial measurements, esthetics, and patient preferences. AI in prosthetic dentistry through CAD/CAM helped to attain finished restoration with precision like the beginning of onlays, inlays, crowns, and bridges [28].

The use of Natural language processing in operatories is similar to the use of google assistant or Alexa which uses voice-activated systems. When added to digital imaging software clinicians instructs the system to carry out the task. It not only capture the image, view image and diagnose handsfree, thus voice control system allows better dental workflow by keeping a keen eye on infection control protocol, saves patients chair time [29].

AI also works outside operatory like scheduling the appointments, analyzing patient's records. This application uses machine learning that uses dental practice software for optimizing patients' appointments, making out unfinished treatment, and starting new marketing campaigns both for patients' awareness and the clinician's profit. While scheduling the appointments once they recognize the patient by proprietary algorithms, it automatically schedules the patient with voice, text, or video. It can cancel appointments and using deep learning techniques track patient's record find their necessity of treatment access the most profitable treatment [30].

Henceforth, treatment planning can be more precise, there can be an improvement in workflow, also optimizes better treatment plans with proper schedules. For a clinician, AI assists in providing valuable information which can be used in real-time and thus increase the dentist's ability for the effectiveness of different treatment modalities.

Limitations of Artificial Intelligence[31],[32]

Every pro has its cons and it brings unintended consequences. Major cons of AI are AI needs human surveillance, AI requires human input and review to be leveraged effectively. Security additionally turns into an issue while consolidating an AI framework. The regulatory and social restrictions may limit AI's ability to facilitate medical practices. study finds 75 million jobs will be study finds 75 million jobs will be displaced or destroyed by AI by the same year. The major reason for this elimination of job opportunities is, as AI is more integrated across different sectors, roles that entail repetitive tasks will be redundant. AI depends heavily on diagnosis data available from millions of classified cases. In cases where little data exists on particular illnesses, demographics, or environmental factors, a misdiagnosis is entirely possible. AI is by and large ward on information networks, AI frameworks are helpless to security hazards.

Ethical considerations in Artificial Intelligence

To combat these cons and challenges of AI, Ethical regulations are must to improve quality of work and treatment. Ethics is knowing the contrast between what you reserve the privilege to do and what is the best thing to do.

The Ethics of Artificial intelligence is the branch of the ethics of technology-specific to artificially intelligent systems[33]. Roboethics is a term meaning the morality of how humans design, construct, use and treat robots. It considers how machines might be utilized to damage or help people, their effect on individual independence, and their consequences for social equity [34].

Machine ethics is the field of research linked with designing Artificial Moral Agents (AMAs), robots, or artificially intelligent computers that behave morally. Ethical issues arising from AI are a questionnaire about the usage of AI [35].

Isaac Asimov considered this issue first time in the 1950s [36]. He proposed the Three Laws of Robotics to govern artificially intelligent systems [37]. A panel gathered by the United Kingdom in 2010 revised Asimov's laws to clarify that AI is responsibility of both of its makers or its proprietor/administrator [38]. In the review of 84 ethics guidelines for AI 11 clusters of principles were found: transparency, justice, and fairness, non-maleficence, responsibility, privacy, beneficence, freedom and autonomy, trust, sustainability, dignity, solidarity [39]. Luciano Floridi and Josh Cowls created an ethical structure of AI standards set by four standards of bioethics (beneficence, non-maleficence, autonomy, and

justice) and an additional AI enabling principle – explicability[40] .

In 2016 a series of articles were published on AI for The Australian, related with “Ethics must travel as AI’s associate” They were chiefly concerned about What happens when AI and algorithmic dynamic prompts somebody being distraught or oppressed?[42]

By 2020, a study by Fjeld et al [43] of 36 principles and guidelines, revealed an extended list around eight key themes:

(1) Privacy, (in 97% of documents), (2) Accountability (in 97% of documents), (3) Safety and Security (in 81% of documents), (4) Transparency and Explainability (in 94% of documents), (5) Fairness and Non-discrimination (in 100% of documents), (6) Human Control of Technology (in 69% of documents), (7) Professional Responsibility (in 78% of documents), (8) Promotion of Human Values (in 69% of documents).

AI faces many ethical challenges. The information used to prepare these AI frameworks itself can have bias. Bias can sneek into algorithms in numerous ways. For example, Friedman and Nissenbaum identify three categories of bias in computer systems: existing bias, technical bias, and emergent bias [43].

Its also posing a threat to human dignity as Joseph Weizenbaum argued in 1976 that AI technology should not be used to replace people in positions that require respect and care.

Artificial intelligence represents a threat to human poise, Weizenbaum contends and proposes that we have experienced an "atrophy of the human spirit that comes from thinking of ourselves as computers."Approaches like machine learning with neural networks can bring about computers making decisions that they and the people who programmed them cannot explain. It is hard for individuals to decide whether such decisions are fair and trustworthy, leading potentially to bias in AI systems going undetected, or people rejecting the use of such systems. This has prompted backing and in certain purviews legitimate prerequisites for logical man-made consciousness.

In 2020, the EU Commission presented its “White Paper on Artificial Intelligence— A European approach to excellence and trust for regulation of artificial intelligence (AI)” and several other documents including a "Report on the safety and liability implications of Artificial Intelligence, the Internet of Things and robotics” for comments [46].

When AI is widely used in the field of mobile health and digital medicine [47], It serves different purposes from disease risk assessment to research on treatment efficacy. It can take many forms such as robotic devices, machine learning, or other deep learning systems in medicine and dentistry like

1) Diagnostic imaging is focal in numerous medical services fields with AI. It beats the fluctuation in an emotional individual assessment and build the viability of care. It also brings down the cost by wiping out routine undertakings.

2) Digital wellbeing information is universally gathered, and with the AI it gives cleaned, curated, and organized information.

3) AI permits to coordinate unique information, for instance, clinical/dental history, sociodemographic and clinical information, symbolism information, biomolecular information, interpersonal organization information, and so forth, consequently utilizing this staggering information and permitting to get a handle on their collaboration.

4) AI might smooth out routine work and increment the face-to-face time specialists/dental specialists and their patients. This may come via diagnostic assistance

systems, yet voice, discourse, and text acknowledgment and interpretation empowering specialists/dental specialists to lessen the time for record-keeping (Israni and Varghese 2019).

5) Using these continuously collected data may also overcome the disadvantages of "on-off-medicine" (Topol 2019), where patients are seen only for a few minutes, while most medical issue are normally procured over years, and go back and forth (in many cases raising) spans (e.g., periodontal infection).). Continuous non-invasive monitoring of wellbeing and conduct will empower a lot further, individual comprehension of the drivers and cycles basic wellbeing and illness.

6) Diagnostic and treatment costs may be decreased, thereby relieving healthcare systems burdened by an aging society with an increasingly high number of complex, chronically ill cases. Artificial intelligence may likewise assist with tending to deficiencies in the labor force, as noticed and expected to proceed in many pieces of the globe, in this way supporting to arrive at the World Health Organization (WHO)'

All these hopes also raised numerous ethical questions as a recent mapping review on AI in health care by Morley et al. (2020) highlighted that there is a strong need for more ethical AI in health care; otherwise, it could ensure a loss of public trust and unwanted results. Dentistry is also affected by this risk:

AI studies in dentistry are often bearing important methodological and reporting limitations that directly affect their transparency and replicability[3] 5 core principles mentioned by Jobin et al[39].: transparency, justice and fairness, nonmaleficence, responsibility, and privacy The most fundamental ethical principles reported for AI in the medical field were non-maleficence, beneficence, respect for patient autonomy, and justice in dentistry[48], where ethical questions are occasionally raised on the development of big data and digital technologies This is potentially worrying given the potential impact of these technologies because each practitioner is supposed to inform their patients about issues and risks of a medical decision to allow an informed decision (Schiff and Borenstein). This absence in the scientific literature could potentially reinforce biases and inequalities, especially in terms of access to these technologies, and weaken the confidence of both patients and practitioners in the future applications of AI [39].

Ethical Issues Categorized Using the 10 Principles of the Montreal Declaration summarizing the above discussion [49]

A. Prudence Each individual associated with AI development must practice caution by anticipating, as much as possible, the unfavorable outcomes of AIS use and by taking the proper measures to keep away from them. Example - A profound learning model might come up with a shortage of specialists, subtle decision-making capability due to constraints in technology and training data quality, thereby making it less useful than human diagnosis. (Yu et al. 2020)

B. Equity The Recent developments of applications of AIS should add to the making of a fair and impartial society. Example - lacking part for systemic conditions as a major contributory risk factor, and the analysis was restricted to clinical data in blend with The justification behind this was the deficient existing patient to arrange a particularly input. (Ozden et al. 2015)

C. Privacy and intimacy privacy and intimacy must be secured from AIS intrusion and DAAS. Example - Meanwhile, the X-ray image is deficient because it is related to patients' privacy, and usually we cannot get as much X-ray image data as we want. (Zhang et al. 2018)

D. Responsibility The development and use of AIS should not be not contribute to diminish the responsibility of people when decisions must be made. Example -By imitating the decision-making of expertise people, the AI system could be a guideline for less-experienced practitioners. It is the choice of Clinicians to follow that decision or not. These AI systems can be made using various philosophies of diagnosis. (Jung et al. 2016)

E. Democratic participation AI should meet comprehensibility, reasonability, and availability rules and should be exposed to democratic scrutiny, discussion, and control. Example - Most of all, the biggest limitation is the lack of transparency and interpretability of the prediction model. (Yoon et al. 2018)

F. Solidarity The advancement of AI should be viable with keeping up with the obligations of fortitude among individuals and ages**.** For example – the biggest drawback of the advancement of artificial intelligence, it may affect or lessen the job demand and security of well-experienced maxillofacial surgeons. (Choi et al. 2019)

G. Diversity inclusion The applications of AI should maintain social and cultural diversity and should not restrict the scope of lifestyle or personal experiences. Example The findings derived from a large sample are meant to be more representative of and can be generalizable to the bigger population. However, individual dental clinics might have diverse patient demographics and different features. (Hung et al. 2019)

H. The well-being advancement of AI should permit the growth of the well-being of all sentient beings. Example - Traditional methods do not indicate whether orthodontic treatment can change the social perception of a patient or affect how laypersons view patients. A study showed that smiling in malocclusion patients attracts so much attention that the times allocated to the eyes and nose are severely decreased. (Wang et al. 2016)

I. Respect for autonomy AI must be used while respecting people's autonomy and increasing people's control over their lives and their surroundings. Example -Since treatment result is presently and essentially surveyed by orthodontists, it is sensible to include an outsider to assist with assessing treatment result when the orthodontist has an alternate assessment from that of the patient. (Wang et al. 2016)

J. Sustainable development The advancement and applications should be completed to guarantee solid natural manageability of the planet.

Out of these 10 principles, prudence, responsibility, and privacy were the most frequent challenges mentioned by the authors of the various studies [50].

Conclusion

The future timeline will demonstrate if this time the assumptions for substantial AI applications are met by genuine results or if once again an AI-winter buries hopes and excitement [3]. Specifically in medical and dental services, a lot is on the line. There is a sensible concern about information protection and data security and about handing over critical health decisions to computers. However, AI has the potential to revolutionize dentistry and healthcare but at the same time, AI raises a wide range of ethical and societal concerns. In dentistry, it is rarely acknowledged. Various studies showed that we could pave the way for a more validated and ethically minded use of AI in dentistry. Dentistry and, explicitly, dental research, play a part to guarantee that AI will improve dental consideration, at lower costs, to the advantage of patients, providers, and extensively society.

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