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In the future, will artificial intelligence be able to replace doctors? -narrative review

En el futuro ¿la inteligencia artificial será capaz de reemplazar a los médicos? -revisión narrativa

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Abstract:

The article provides a comprehensive narrative review of the role of artificial intelligence (AI) in the future of medicine, focusing on its potential to replace physicians in various clinical applications. It explores AI technologies such as machine and deep learning, particularly convolutional neural networks (CNNs), and discusses their applications in AI-assisted diagnosis in areas such as oncology, cardiology, and dentistry. The article highlights both advantages and disadvantages of AI in medicine, including its ability to analyze large volumes of medical data and improve diagnostic accuracy, as well as ethical and practical challenges related to patient data protection and transparency in decision-making. Although AI shows great potential to transform medical care, the article concludes that it currently remains a support tool for clinicians and cannot completely replace clinical decision-making. It emphasizes the importance of addressing the remaining challenges and continuing research to maximize the potential of AI in medicine.

Keywords:

Artificial Intelligence, Convolutional Neural Networks, Medicine

Resumen:

El artículo ofrece una revisión narrativa exhaustiva sobre el papel de la inteligencia artificial (IA) en el futuro de la medicina, centrándose en su potencial para reemplazar a los médicos en diversas aplicaciones clínicas. Se exploran en detalle las tecnologías de IA, como el aprendizaje automático y profundo, especialmente las redes neuronales convolucionales (CNN), y se analizan sus aplicaciones en el diagnóstico asistido por IA en áreas como la oncología, cardiología y odontología. Se destacan tanto las ventajas como las desventajas de la IA en medicina, incluyendo su capacidad para analizar grandes volúmenes de datos médicos y mejorar la precisión del diagnóstico, así como los desafíos éticos y prácticos relacionados con la protección de datos de pacientes y la transparencia en la toma de decisiones. Aunque la IA muestra un gran potencial para transformar la atención médica, se concluye que actualmente sigue siendo una herramienta de apoyo para los médicos y no puede reemplazar completamente la toma de decisiones clínicas. Se resalta la importancia de abordar los desafíos pendientes y continuar investigando y desarrollando nuevas tecnologías para aprovechar al máximo el potencial de la IA en la medicina.

Palabras Clave:

Inteligencia Artificial, Redes Neuronales Convolucionales, Medicina

INTRODUCTION

Artificial intelligence (AI) refers to the ability of machines or computer systems to perform tasks that normally require human intelligence, including skills such as learning, perception, reasoning, problem-solving and decision-making.[1] In general, in the medical field, AI applications have two main branches: virtual and physical. Machine Learning (ML) and Deep Learning (DL, a subset of ML) constitute the virtual component of AI.[2] ML algorithms are classified into supervised, unsupervised and reinforcement learning. Supervised methods are excellent for classification and regression. Recent examples in medicine include the detection of a pulmonary nodule on a chest X-ray, detection of a pulmonary nodule on a chest X-ray, and detection of a pulmonary nodule on a chest X-ray[3], use in stroke classification and stroke simulations[4], arrhythmia detection on electrocardiogram[5], among others. Unsupervised learning does not require labeled data. It aims to identify hidden patterns present in the data, which are often used for data exploration and generating novel hypothesis. [3] Meanwhile, the most important deep learning scheme, a convolutional neural network (CNN), represents a particular type of multilayer artificial neural network that is highly efficient for image classification.[6] In addition to the virtual part, the physical

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branch of AI includes medical devices and robots, such as the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) and nanorobots for targeted drug delivery.[2]

In Mexico, it is uncommon to implement Artificial Intelligence in Medicine compared to other countries, mainly due to the associated costs. However, during the COVID-19 season, some studies were conducted and used AI to diagnose CT scans and determine pulmonary conditions, demonstrating excellent accuracy in 1 to 3-minute period. [7] On the other hand, Telemedicine (or Remote Medicine) is an aspect implemented in the health system in Mexico. This modality allows physicians to remotely monitor patients through applications to effectively supervise the patients' condition. Likewise, the recently established nursing centers that automatically notify when a patient shows signs of instability represent some key implementations in this area.[8]

CONVOLUTIONAL NEURAL NETWORKS (CNN)

Inspired by the brain's neural architecture, DL uses deep neural networks (DNN) to develop complex models with multiple hidden layers to analyze various data types and generate predictive results.[9] Among DNN models, convolutional neural networks (CNN) are the most popular DL architectures. They have been used for detecting, recognizing, segmenting, and classifying medical images of cancerous lesions.[10,11]

The typical CNN architecture (Figure 1) is formed by stacking three main layers: convolutional layers, clustering layers and fully connected layers. To achieve it, CNNs convert the original images, layer by layer, from pixel values to final prediction scores. Convolutional layers combine input data (feature maps) with convolutional kernels (filters) to form a transformed feature map. The filters in the convolutional layers are automatically adjusted based on the learned parameters to extract the most useful features for a specific task.[12]Therefore, this architecture is utilized in imaging studies such as computed tomography and X-rays. This procedure is called computer-aided diagnosis (CAD) and encompasses three steps: target segmentation, feature calculation and disease classification.[13] Consequently, CNNs in medical imaging work by extracting relevant features from images through convolutions, learning patterns through multiple layers of processing and using this information to make accurate predictions about the presence or absence of certain medical conditions in the images.[14]

BACKGROUND OF THE ARTIFICIAL INTELLIGENCE

In 1950, Alan Turing proposed the famous "Turing Test," a criterion for determining whether a machine could exhibit intelligent behavior equivalent to that of a human.[15] In 1980, the most powerful computer was created. Large data sets fueled the growth of AI. In 1997, IBM's "Deep Blue" chess program defeated world champion Garry Kasparov.

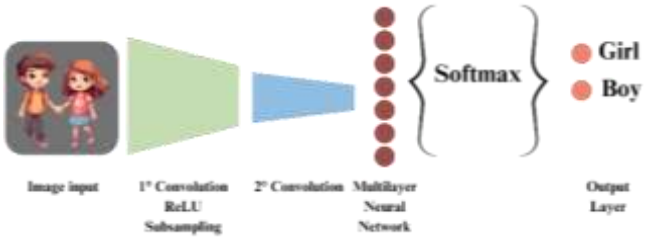

Figure 1. Example of the structure of a convolutional neural network[9,13]

Over the past two decades, deep learning has revolutionized AI, enabling machines to learn through layers of artificial neural processing, simulating the structure and function of the human brain, which has driven significant advances in areas such as speech recognition, computer vision, machine translation, and autonomous vehicles.[16]

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN CLINICAL PRACTICE

AI-assisted diagnosis

There are approximately 20 FDA (Food and Drug Administration)-approved AI applications that specifically address clinical oncology; each performs a specific task, primarily focusing on identifying lung nodules in conjunction with imaging.17 The existing advances in this field are predicting cancer through genomic data acquired from various studies.18 One of the most prominent efforts, IBM's Watson Oncology project, has attempted to develop a broad prediction machine to guide cancer care but has been limited by suboptimal agreement with the recommendations of human oncologists and subsequent mistrust.[19]

In cardiology, the AI application has increased exponentially annually, specifically in diagnosing coronary artery disease[20], implementing CNNs because most studies are implemented imaging and allow for better image processing, for example, eliminating noise from low-dose images of cardiac CT scans.[21]

Deep learning algorithms can analyze medical images, such as X-rays, MRI and CT scans, to detect abnormalities with accuracy comparable to that of radiologists. These systems can help streamline the diagnostic process, reduce errors, and improve clinical outcomes for a variety of diseases.[22]

In dental medicine, it can be used in various ways to improve dental care and dentistry, such as tooth segmentation and identification[23], dental implant treatment planning, identification and classification of dental implant systems, to diagnose maxillary sinusitis on panoramic radiography, detection of dental caries on periapical and bitewing X-ray images.[24,25] Most advances in this area are focused on image analysis through CNNs since they provide greater diagnostic precision.[26,27]

In plastic surgery, a model developed using data obtained from a portable reflective spectrophotometer to determine burn depth and healing time, with an average accuracy of 86%.[28] Similarly, applications have been developed to identify melanoma in images of biopsied lesions taken on smartphones with dermatoscopic lenses.[29] In rhinoplasty, the use of ChatGPT is being implemented as advice for specialists, showing excellent results.[30] In addition to equipment that can perform simulations for cosmetic surgeries.

In 2023, the FDA approved about 108 medical devices which stands out in the area of radiology having 79%[31] (figure 2), mainly the implementation of AI is for the diagnosis of images to define a treatment. The reliability of these softwares will depend on the amount of information provided for the training of neural networks because if it is little the margin of error will be greater, for this reason it is still considered as a support tool for the specialist.

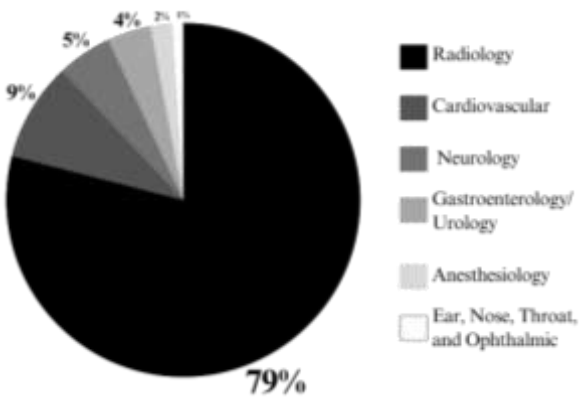

Figure 2. FDA-approved devices implementing AI.[31,32]

ETHICAL CHALLENGES AND CONSIDERATIONS

As the healthcare sector embraces the transformative power of AI, it must confront a complex web of ethical challenges that accompany these innovations. While AI offers enormous potential to improve patient care and streamline processes, it also introduces unique ethical considerations that require careful consideration and thoughtful resolution.

- Patient data protection: Artificial intelligence in healthcare generates large amounts of sensitive patient data. Ensuring the privacy and security of this data is paramount, as any breach could have severe consequences for patient trust and data integrity.[33]
- Data management: Healthcare institutions should adopt responsible practices for collecting, storing, and using patient data, which includes robust data anonymization techniques, encryption, and secure data exchange protocols to safeguard patient information.[34]
- Transparency and explain ability: transparent decision-making processes are vital in AI healthcare. Patients and healthcare providers must understand the rationale for AI-driven recommendations, fostering trust and accountability.[35]
- Clear accountability for the AI systems' actions: Establishing accountability in AI systems is a crucial challenge. Determining who is responsible for errors or adverse events is essential for ethical use.[36]
- Ethical guidelines and frameworks: Decision-making processes should be based on clear ethical guidelines and frameworks. These should be accessible to all stakeholders and regularly updated to address emerging ethical challenges.[37]

Addressing these challenges and ethical considerations is critical to promoting the responsible and beneficial use of artificial intelligence in the medical field, ensuring that this technology improves medical care without compromising patient privacy, equity, or safety.

ADVANTAGES AND DISADVANTAGES OF AI IN MEDICINE

AI can help doctors and other healthcare professionals analyze large amounts of medical data, such as images and patient records, to detect and diagnose diseases faster and more accurately.[38] It can be used to analyze genetics and patient data to create personalized medicine plans and treatments tailored to each patient's needs.

A further advantage is that AI can help physicians and other healthcare professionals to make decisions by providing real-time information and alerts based on patient data.[39] It can also help monitor vital signs, symptoms, and other data to detect potential health problems early, especially chronic diseases, to avoid complications.[40] In medical research, it is used to analyze large volumes of medical data, identify patterns, and make discoveries that can help understand disease pathology and ultimately develop new treatments.

Disadvantages, AI can perpetuate and even reinforce biases and discrimination due to the data uploaded., which can lead to incorrect diagnosis or treatment for certain groups of people.[41] Due to its advancement, physicians develop some dependence on AI, and some may no longer be able to perform tasks without its help.[42] It can also automate certain tasks, such as images and patient data analysis, that can lead to job displacement and unemployment.[43,44] Finally, AI systems lack human touch and emotions relevant to some healthcare tasks.[45]

DOCTORAL PERSPECTIVES ON ARTIFICIAL INTELLIGENCE

Most AI applications focus on image processing, suitable for automated analysis, such as radiology, pathology, and dermatology. However, there is little knowledge about

physicians' views on the ethical issues associated with AI implementation in healthcare. AA study that surveyed physicians in the Netherlands, Portugal, and the USA and showed that students and physicians are under-trained in these technologies.[46] Meanwhile, pathologists commented that concerning medico-legal medical-legal liability for diagnostic diagnosis errors made by a human/AI combination, opinions are divided between those who believe that the platform provider and the pathologist should be held equally responsible. Others believe that liability remains primarily a human liability.[47]

Some physicians' statements were as follows[46]: "We should be conservative in promoting AI in healthcare because of unresolved ethical issues", "AI medical tools should only be used if physicians understand how AI decisions are made", "The physician-patient relationship will dramatically change once AI is implemented completely in healthcare systems", and "AI will diminish the physician's autonomy and authority." In summary, there is an opinion divergence in the healthcare field. However, it is undeniable that AI implementation is inevitable due to its ability to optimize various tasks. Therefore, it is essential that healthcare educational healthcare programs incorporate subjects to get the students familiarized with these new technologies, thus ensuring their proper use.

CHALLENGES AND FUTURE DIRECTIONS

AI has been used in medicine to interpret plain radiographs, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and radioisotope scans.[48] It has also been implemented for primary disease diagnosis by creating classification algorithms that, based on the images, identify the difference between pathological and healthy.

Every modern proposed technology goes through a hype cycle known as the Gartner Cycle. The first phase is the launch phase, which consists of the creation of a potential technological breakthrough. The second phase is the expectation peak, where technology receives significant media and industry attention. The third phase is the is undermining disillusionment, where technology often faces challenges and obstacles not initially anticipated leading to a decline in public interest, and a generalized sense of disillusionment about the technology's actual capabilities. The fourth phase is the consolidation ramp, where a more realistic understanding of the technology's capabilities and limitations occurs. Finally, the productivity plateau phase, where the technology reaches a mature level where its benefits become widely understood and accepted, best practices, standards, and business models are established around the technology.[49] An impediment to the current realization of a technology's utility results from developing a technology through these stages. With greater engagement and collaboration of researchers, medical implementation, government, and community experts can overcome these obstacles.

In addition, these platforms can be used in conjunction with other digital technologies, such as telemedicine for virtual consultations and the Internet of Medical Things (IoMT), to improve referral practices. Emerging trends are explainable AI, and interpretable DL.[50] Explainable AI explains performance, strengths and weaknesses, likely behavior, and possible biases of a model to a specific audience while allowing for accuracy, fairness, accountability, stability, and transparency in decision-making. Interpretability is a concern for DL models, as these models achieve high accuracy at the expense of high abstraction.

In the future, the medical application of neural networks may advance in two directions: automated diagnosis and assistance to healthcare professionals. Currently, 45% of the countries that are part of the WHO have less than one doctor per 1,000 inhabitants. Automated diagnostic systems based on neural networks are in widespread demand to assess patients safely, relieving physicians from the workload and establishing a visit rhythm. There are several specialties where automatic diagnosis using imaging (such as X-rays, ultrasound, CT, and MRI scans) can address common and debilitating diseases that affect older adults in particular and pose significant public health challenges, such as cardiovascular, cerebrovascular, and oncological diseases. They will drive the development of minimally invasive methods such as interventional radiology, interventional cardiology, and interventional neuroimaging.[51]

To conclude, investing in healthcare AI development is a strategic decision with the potential to transform medical care radically. AI can process large amounts of clinical data quickly and accurately and can help in the early disease diagnosis, treatment personalization, and medical process optimization. For this reason, economic investment is relevant to continue studying and designing new devices and software; it is a bet on a healthier and more equitable future for humanity.

CONCLUSION

Technological advances and international cooperation can facilitate the global adoption of artificial intelligence (AI) in medicine, although some countries have advantages due to their resources. The maturity of AI has led to its use in diagnostics and patient management, but it cannot yet replace critical decisions by healthcare professionals. Neural networks, especially convolutional ones, offer promising prospects. However, challenges such as safety, accuracy, and ethics in data management remain. Collaboration between researchers, clinicians, and ethicists is key to maximizing the potential of AI in healthcare.

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