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EDITORIAL

Importance of the algorithm as a tool for expert decision making: artificial intelligence in ophthalmology

Importância do algoritmo como ferramenta para tomada de decisão do especialista: inteligência artificial na oftalmologia

Ricardo Noguera Louzada[1,2,3], Ivar Vargas Belizario[2], Agma Juci Machado Traina[2], Milton Ruiz Alves[3]

1. Programa de Pós-Graduação em Ciências Cirúrgicas, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.
2. Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos, SP, Brazil.
3. Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

"All effective innovations are breathtakingly simple.
Indeed, the greatest praise an innovation can receive is for people to say:
This is obvious! Why didn't I think of it?"
Peter Drucker

Artificial intelligence (AI), machine learning (ML), and deep learning (DL) are frequently used terms in medical practice for referring to computer algorithms that respond dynamically as they are exposed to more data[1]. **ML** emerged in the 1980s, and it is a subset of AI in which computers are programmed with algorithms to learn from past experiences through an induction process that involves making general inferences using a series of examples to automatically recognize patterns in the data and integrate this information to predict future data under uncertain conditions[2,3]. Traditionally, in ML algorithms, it is essential to first extract or preprocess-structured data (features) and then recognize patterns of these data in the process of learning induction. In contrast, **DL** algorithms are a subtype of ML algorithms and work similar to the human brain as they include artificial neural networks (ANN)[4]. In DL, algorithms directly learn from complex unstructured data, such as images, text documents, and audio. Feature extraction is an essential part of these types of algorithms, making them less dependent on human intervention. Recently, the combination of ML and DL algorithms has also been studied to improve the accuracy of the results. The relationship between ML and DL is notable; although all DL algorithms are ML algorithms, not all ML algorithms are DL algorithms as the associated technologies involve training on test data to determine which model best fits the data. However, traditional ML methods required a certain level of human interaction to preprocess the data before the algorithms were used. ML is a subset of AI that gives computers the ability to learn without being specifically program-

Corresponding author: Ricardo Noguera Louzada. E-mail: louzadaricardo@ufrj.br
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med to produce a specific result. The algorithms used by ML help the computer learn to recognize things[5]. Unless this training involves automated techniques, it can be tedious and requires significant amounts of human effort and specialist time.

The **algorithm** is a sequence of reasonings, instructions, or operations created to achieve a goal, and it requires steps that are finite and systematically operated. AI algorithms are a series of precise steps that do not require much mental effort, but if followed precisely and mechanically, they provide the desired results without error margins. AI, ML, DL, conventional ML, natural language processing, computer vision, robotics, reasoning, general intelligence, expert systems, automated learning, and scheduling are all AI technologies that systematically implement algorithms to understand the underlying interrelationship between data and information. Algorithms are often surprisingly able to recognize objects in images. AI is a multidimensional technology with multiple components, such as advanced algorithms, ML, and DL. Notably, it is hoped that these algorithms will provide ophthalmologists with automated tools for early diagnosis, biomarker identification, and timely treatment of eye diseases. Large amounts of machine-consumable combined digital data with increasingly sophisticated statistical models are combined to enable machines to find potentially useful data patterns beyond human capabilities with instant results, thereby replacing the reliance on manual assessment[6].

Building AI algorithms is becoming more common for interpreting data structures and statistics in medical practice. Demonstrating how these AI products reduce costs and improve outcomes requires clinical implementation and industry-wide integration in routine procedures. The various tests and aggregated technologies involved in ophthalmology for patient assessment generate a large database of information, demonstrating great potential of using AI for creating a data interpretation center that can facilitate diagnosis using quantitative and aggregated information in an intelligent manner[7,8].

Several studies have reported that multimodal imaging for diagnosis in ophthalmic practice, such as retinography and optical coherence tomography, among other ophthalmic examinations applied in AI, ML, and DL techniques, is a powerful diagnostic tool for the identification of different stages of different diseases. The accuracy of the algorithms demonstrates incredible promise, and AI, ML, and DL applications can support patients in remote areas via sharing expertise and limited resources. To create more reliable AI, ML, and DL systems, multimodal imagery must be integrated[9,10].

Studies on the applications of algorithms in ophthalmology have reported high accuracy, sensitivity, and specificity in detecting age-related macular degeneration (AMD), glaucoma, diabetic retinopathy, etc[1,9,11]. Collectively, these resources will soon make use of these procedures in routine practice for the diagnosis and treatment of AMD and other pathologies that require regular monitoring. AI, ML, and DL have great potential to revolutionize early detection screening, diagnosis, and classification when used for eye diseases[1]. They also have the potential in recognizing the development, progression, and treatment as well as in identifying and evaluating new risk factors[9]. However, there is no well-defined gold standard for these algorithms to determine the presence and severity of pathology. Therefore, more robust disease definitions should be used in future studies to develop and optimize current methods and data for AI, ML, and DL analysis and to improve methods of information extraction from learned outcomes.

In ophthalmology, the accurate and rapid evaluation of clinical images helps both in diagnosis and in the indication for treatment. However, repeatability, validity, precision, reliability, sensitivity, specificity, and correct disease staging in the implementation of AI-, ML- and DL-based algorithms in clinical practice are crucial. Therefore, the development of algorithms to support image analysis is essential. As AI becomes more sophisticated, many ethical challenges may arise, including transparency, bias, human values, data and intellectual property protection, social displacement, cyber security, decision making, accountability, and legal and regulatory issues.

Further studies are needed to elucidate the applicability and validity of algorithms in the clinical setting of ophthalmology and to determine whether the use of algorithms can lead to better care and comparable outcomes to those of current ophthalmic assessment. Specialist interpretation of images in many ophthalmic settings can be time-consuming, with variable interpretation, repeatability, and variable agreement between different observers. Notably, computer algorithms can assess eye diseases more objectively. The DL algorithm is expected to become a routine application to aid in the interpretation and practice of care in ophthalmology. The implementation of AI, ML, and DL will revolutionize the diagnosis and treatment of diseases and will have a significant clinical impact on the healthcare system. The intelligent systems used in some specific ophthalmic clinical trials and the associated ethical, regulatory, and legal issues are addressed with the aim of implementing the algorithm as an assisting tool in patient assessment.

Automated imaging technologies can potentially enhance access to healthcare and screening and reduce diagnosis and management time, leading to better overall eye health. Appropriately implemented technologies with assistance from specialists exhibit a hugely favorable impact on ophthalmology in terms of decision-making processes.

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AUTHOR'S INFORMATION

» **Ricardo Noguera Louzada**
https://orcid.org/0000-0002-9610-5768
http://lattes.cnpq.br/5978866539118374

» **Agma Juci Machado Traina**
https://orcid.org/0000-0003-4929-7258
http://lattes.cnpq.br/5136155977351408

» **Ivar Vargas Belizario**
https://orcid.org/0000-0001-5970-2283
http://lattes.cnpq.br/7221568202094697

» **Milton Ruiz Alves**
https://orcid.org/0000-0001-6759-5259
http://lattes.cnpq.br/6210321951145266