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How Artificial Intelligence Improves Orthopaedic Practice

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Abstract

The use of Artificial intelligence (AI) has received much attention in different fields of medical sciences, particularly in medicine. Different AI techniques have been used to improve the performance of clinicians, clinical devices, diagnostic techniques, and treatment methods. Moreover, AI was shown to be useful in predicting clinical outcomes and preventing morbidities and mortalities. Different subsets of AI including image processing, machine learning, natural language processing, and deep learning have been used to assess, analyze, and interpret clinical data. These clinical data comprise narrative and imaging data. Narrative data comprise but are not limited to examination notes, operative notes, radiology reports, and laboratory values. Imaging data can include X-rays, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. AI models, just as a human brain, can be trained by these data, learn the patterns between the input data, and create neural networks. Using these neural networks, an AI-based system can process and interpret the received data and generate the preplanned outcome. Herein, we aimed to share our opinions based on our recent experience on the use of AI methods in different aspects of orthopaedic practice in order to shed light on the potentials of this novel technology to improve the performance of healthcare providers in this field.

Keywords: *Artificial Intelligence; Machine Learning; Deep Learning; Convolutional Neural Network; Orthopaedic Surgery; Natural Language Processing*

Abbreviations

AI: Artificial Intelligence; CNN: Convolutional Neural Network; CT: Computed Tomography; MRI: Magnetic Resonance Imaging; NLP: Natural Language Processing; RNN: Recurrent Neural Network

Introduction

In the era of data science and rapid technological advances in data analysis, artificial intelligence (AI) has become substantially ingrained within many facets of medicine and often times functions invisibly in the background of many medical applications, softwares, and devices that are being used routinely in the clinical settings. Machine learning algorithms as a subset of AI, are able to receive different datasets, find correlations among different features of these datasets, and create networks that are known as convolutional neural networks (CNN). The learning process, similar to the human brain, will take place through iterations and frequent exposure to the data. This process is called training. A trained CNN will be able to analyze and find the correlations of the data with the predesigned outcome. The outcome can be the diagnosis of a disease, prediction of comorbidity, suggesting a treatment, providers' performance, healthcare quality, etc. The process of decision-making by the algorithm is not apparent most of the time and that is why CNNs are also known as

"black box" [1]. Based on the input data, different types of algorithms are designed. Natural language processing (NLP) algorithms are mostly designed to analyze narrative data such as examination notes, laboratory data, radiology, and pathology reports. Deep learning techniques, as another subset of machine learning, can be used for image processing and image analysis through deep CNNs. Deep CNNs are more complex versions of CNNs that use hierarchical tiers to segregate and manage the final result. The network layers begin with an initial layer that then progresses to a number of hidden layers comprised of extracted features from the images. These hidden layers allow for a deeper understanding of the input data leading to the development of deep CNN without being explicitly programmed to do so. These deep CNNs are able to successively refine and edit themselves by receiving new datasets [1,2]. Particularly in orthopaedic settings, faster and more precise care delivery to the patients who have mostly suffered a trauma in the musculoskeletal (MSK) system is of great importance in order to reduce morbidities and mortalities, and future disabilities. Having AI techniques applied on relevant orthopaedic datasets can automatize and hasten the analytical process and outcome reports while maintains a high accuracy, validity, and reliability [2-4]. In this report, we briefed the potentials of different AI techniques to improve the performance and the quality of can in orthopaedic settings.

Improving clinical image interpretation

Our recent experience as well as previously published reports on using different CNN and deep CNN algorithms as well as a novel recurrent neural network (RNN) algorithm on different imaging modalities including X-rays, CT scans, and MRIs have shown promising results in terms of increasing the accuracy and hastening the interpretation process [5,6]. AI can detect even subtle injuries that can be obscured in an image or missed by the clinician. Occult fractures or subtle joint instabilities are among the injuries that can be easily missed while can be detected by machine learning algorithms. CNNs, Deep CNNs, and RNNs, particularly in multisequence imaging such as CT or MRI, can analyze and extract features from the images, compare with healthy images, and appreciate the abnormality. Moreover, using the saliency map (heat map) algorithm they are able to locate the site of injury or abnormality within the image [7]. However, based on our experience, having the training dataset sorted and annotated by human experts plays an undeniable role in developing a valid and reliable algorithm. Using these capabilities, machine learning algorithms can act as an assistant to the care providers to reduce costs and the need for ordering further imaging, save time, increase accuracy, double-check, and highlight the sites of injuries. This can also be helpful for settings with limited resources, inexperienced staff, and less advanced imaging devices.

Analysis of narrative data

One of the pain points in the assessment of a patient is having to overview the whole dataset, past medical history, and reports of any abnormalities in the notes provided by different providers. Having all that in mind and trying to come up with the best decision have always been a concern for the clinicians. Machine learning methods, particularly NLP algorithms, provide the ability to receive all notes and narrative data, extract features and values, and analyze them. After being trained, these algorithms can be used in creating big databases that normally need a great amount of effort and funds to screen, classify, and sort the data. In many healthcare registry systems currently, NLP algorithms are used, more or less, to automatize the process of data monitoring [8].

Prediction models

Machine learning algorithms have been widely used for predicting the outcomes of different treatment methods as well as the future morbidities and mortalities of orthopaedic diseases [2,5]. These algorithms can receive the narrative and imaging data, find correlations of these data with the predesigned outcome. These predesigned outcomes can be hip fractures in osteoporotic patients, non-unions in bone fractures, prediction of medical costs of a specific disease, prediction of infections in joint replacements, prediction of hardware loosening, prediction of post-traumatic osteoarthritis, etc [2,5,9,10]. These prediction models not only can be used by the providers to come up with better treatments with fewer complications or better preventive solutions, but also patients can learn more about the possible clinical conditions they might face and plan for reducing or managing them by affecting the modifiable data [10].

Educational potentials

If AI models are trained well and able to provide high accuracy in the detection of various orthopaedic conditions as well as appreciating MSK abnormalities on the images, medical trainees can use these capabilities to train and test themselves [6]. In our recent experience, we have developed several educational videos for orthopaedic trainees on ankle fractures, how to diagnose and how to manage them. Through AI-based platforms, we can test their knowledge and teach them about the frank and occult fractures as well as subtle instabilities, i.e. subtle syndesmotic instability in the ankle. Another aspect of AI methods is their use in virtual reality and augmented reality techniques. Through these techniques, the trainees are able to feel themselves in the simulated real environment, practice, and gain the necessary skill sets before starting hands-on procedures [6]. We aimed to develop a comprehensive educational platform comprised of two-dimensional (2D) and 3D videos, virtual reality, and augmented reality features to facilitate the education of medical trainees and providers, even for those in austere and limited-resource settings; this leads to democratizing knowledge and expertise throughout the world.

Limitations of the Study

Among the biggest limitations of developing AI models, the size of the dataset and the diversity among the data components can be mentioned. Small and homogenous datasets will lead to outlier bias. Another limitation is the need for experts to screen and annotating the data. If the narrative data are not screened by experts or the images are not interpreted by experts, the validity and reliability of the outcomes cannot be guaranteed. Lastly, financial supports must come through independent sources, grants, or the healthcare setting itself. Receiving funds from private companies might lead to conflicts of interest for the developers and data providers.

Conclusion and Future Perspective

It is critical that we as MSK specialists realize, embrace, and apply AI models to maximize the quality and cost-effectiveness of healthcare. AI is not a rival for human clinicians, it can be used as an augmentation method. It is necessary to exercise caution when incorporating new technologies into our healthcare system. We must understand the concerns, flaws, and limitations of incorporating AI into the decision-making process. The more the outcome of AI algorithms can be visualized, and one can see the process of decision making rather than receiving the outcomes from a black box, will help to build more trust and reliability in these methods. By harnessing the power of robust datasets screened and annotated by experts, AI models are poised to transform orthopedics in particular and medicine in general by automation of redundant tasks and save time, assist providers for making decisions, identifying the risk factors for complications, and predicting outcomes based on patient-specific values [6]. AI will lead us to a new era that can be called "AI-aided healthcare services".

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Conflict of Interest

None declared.

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