

Peer Review File

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Reviewer A

Comment: Very nicely written article regarding AI technology, in particular the emerging applications in the field of musculoskeletal radiology.

Reply: The authors thank Reviewer A of their assessment. It accurately reflects the aim of the manuscript.

Changes in the text: Not applicable

Reviewer B

Comment: The review “Interpretative Applications of Artificial Intelligence in Musculoskeletal Imaging: Concepts, Current Practice, and Future Directions surveys key concepts in AI/ML/DL and surveys some applications of ML/DL in MSK radiology.

This is a very comprehensive review with 19 written pages. Most of the review addresses all sorts of topics in AI, some are presented at the beginning and some at the end. Various examples of MSK papers are provided in the middle section of the review.

Reply: The authors thank Reviewer B for their assessment. It accurately reflects the topics covered in the manuscript.

Changes in the text: Not applicable

Specific comments:

Comment #1: What is “Algorithm democratization”? Only 80 hits on this term in google search, and most of them are unrelated.

Reply: Algorithm democratization in the context of artificial intelligence is a concept which refers to making AI accessible for a wider range of uses and users. This can be accomplished in several ways, such as by making large data sets and algorithms publicly available, and also by making use of federated and transfer learning applications. The authors believe detailed explanations of federated and transfer learning techniques are beyond the scope of this manuscript.

Changes in the text:

Introduction section (see pages 2-3, lines 45-50): “Advancements in computing power coupled with the increased availability of large data stores or “Big Data” have also revolutionized AI and machine learning (ML) applications in medical imaging. Similarly, AI democratization, the idea

that AI processes such as data and algorithms should be made available for a wider range of uses and users has garnered increased attention, with many institutions following suit by making large datasets publicly available for algorithm development. (1,2).

Comment #2: In the abstract, the authors state that “ML adaptation... expected to rise at a rapid pace”. In the conclusion the authors state that “many of these applications remain in their early stages, and there exist more questions and uncertainty than answers... It will require many more years before these...”.

Reply: We thank Reviewer B for this comment. The authors believe that for the foreseeable future, there will be a rapid increase in ML applications which will take the form of “narrow AI” focusing on narrow and explicit tasks. Accordingly, many questions and uncertainty will remain regarding how these applications will fit into the clinical workflow which is not limited to narrow questions and pathologies. In other words, as noted in the conclusion, it will require many more years before these algorithms can answer a wider range of clinical questions, similar to subspecialized musculoskeletal radiologists. We have made changes to the conclusion section to clarify and reconcile these two statements.

Changes in the text:

Conclusion section (see pages 12-13, lines 285-294): “Improvements in computing power, increased access to large datasets, and algorithm democratization have revolutionized AI and ML. As such, research applications leveraging these technological advancements is predictably expanding, and their use is expected to continue to increase rapidly. However, many of the current applications remain in their early stages, and there exist more questions and uncertainty than answers. Today’s algorithms largely represent “narrow AI”, meaning that they only focus on narrow and explicit tasks. It will require many more years before these algorithms can attain a more generalized capacity to undertake a wide range of clinical questions, similar to medical subspecialists. As a result, for the foreseeable future, modern AI will not be capable of replacing all of a musculoskeletal radiologist’s work”

Comment #3: Can the authors provide an explanation of the term “imaging value chain “and why they chose to use it?

Reply: Through the American College of Radiology (ACR), Boland et al created a series of articles describing what the authors termed the “imaging value chain”. The chain refers to a series of discrete tasks performed in radiology which together serve to create value for the organization, the referrer and the patient. Examples include: Protocol design and optimization, optimization of modality operations, and actionable reporting among others. The authors used this term to emphasize the broad range of applications for AI in radiology (i.e. protocoling, image interpretation and reporting, operations), and to describe our focus on the image interpretation aspects of the chain, concentrating on the interpretative uses of AI applications in MSK radiology.

Changes in the text:

Introduction section (see page 3, lines 60-64): “In radiology, the imaging value chain refers to a series of discrete tasks which together serve to facilitate volume-to-value healthcare, and which aim to create value for the organization, the referring provider and the patient (6–12). While AI and ML have been leveraged to optimize many links in the imaging value chain, this article focuses on the image interpretation aspects of the chain, and discusses the interpretative uses of AI in MSK radiology.”

Comment #4: The abstract details only AI/ML. Although DL is a subset of both, most imaging algorithms are indeed DL.

Reply: The authors agree that DL is a subfield of AI/ML, and that many medical imaging algorithms to date have employed deep learning techniques. Figure 1 aims to provide the reader with an overview of the relationship between artificial intelligence (AI), types of machine learning (ML) tasks, and ML subcategories, including DL.

Changes in text: Not applicable

Comment #5: “MSK radiology is uniquely positioned to be a leading subspecialty in the application of these techniques...”. Why is that?

Reply: A recent paper by Pesapane et al., cited as reference #3 in the manuscript evaluated the number of AI-related articles indexed on EMBASE stratified by radiological subspecialty/body part. While neuroradiology outpaced all other subspecialties in radiology at 34%, the bone, spine and joints category had the second greatest number of AI-related articles at 9%. Similarly, the breadth of applications discussed in this article also emphasize the opportunity for MSK radiology to be a leading subspecialty in leveraging AI-related applications.

Changes in the text:

Introduction section (see page 3, lines 51-58): “Over the last decade, research publications on the use of AI in radiology have more than doubled demonstrating a rapidly growing trend. Pesapane et al., recently evaluated the number of AI-related articles indexed on EMBASE stratified by radiological subspecialty/body part. As of 2017, neuroradiology outperformed all other radiological subspecialties at 34% of AI-related radiology publications, however, the bone, spine and joints category had the second greatest number of AI-related articles at 9% of publications (3). This promising data, coupled with breadth of applications discussed in this article, showcase how MSK radiology is uniquely positioned to be a leading subspecialty in the application of these techniques (3–5).”

Comment #6: The search methodology in PubMed is disorganized. For instance, how did the authors pick up on “ACL”?

Reply: The authors used general search terms applicable to the current work, such as “deep learning”, “bone”, “muscle”, “radiology” among others listed. The authors also searched for

more specific terms such as “sarcoma”, “radiomics”, based on author expertise of prior work in this field, and relatable content to both musculoskeletal imaging and artificial intelligence. For reference # 30 which refers to a study by Bien et al., which addresses using a deep learning model to evaluate knee pathology, including ACL tears, a combination of the search terms “deep learning” and “musculoskeletal” was used. These search terms are listed in the paragraph detailing the PubMed reference search criteria.

Changes in the text: None

Comment # 7: A small typo: “The ultimate goal is for these algorithms is to”.

Reply: The typo has been corrected.

Changes in the text:

Overview section (see page 4, lines 90-91): “The ultimate goal for these algorithms is to achieve accurate outputs when provided with previously unseen testing data.”

Comment #8: Redundancy: “reliance on ground truth, which the algorithm assumes to be true”

Reply: We have edited this sentence, and also added additional context to clarify the concept of ground truth.

Changes in the text:

Supervised learning section (see page 5, lines 98-100): “The hallmark of supervised learning is the reliance on “ground truth,” or data which the algorithm believes to be accurate. In radiology, “ground truth” typically refers to radiologists’ image annotations, results of radiology reports, or histopathological diagnoses.”

Comment #9: My suggestion is to cut the paper by half or two thirds. Focus on either MSK or AI.

Reply: The authors thank Reviewer B for this comment. We have made a significant reduction to the content of the manuscript, reducing the content by approximately 40%. A few additions were made to address reviewer B comments #1-8. The authors also removed several sections describing AI concepts to increase the focus on MSK content. The sections remaining which describe AI concepts are basic in nature, and the authors feel they serve to provide context to the reader, and to facilitate understanding of the MSK research cited within the manuscript.

Changes in the text:

The section entitled “Artificial Neural Networks and Deep Learning” was shortened for improved clarity and understanding (see pages 6-7, lines 137-150). The sections entitled “Transfer Learning”, “Bayesian Inference” “The Surge of AI in Imaging: Why Now?”, “Training The Model”, “Hardware Innovation”, “Black Box”, “Overfitting”, “Brittleness & Narrowness”, and “Big Data” were removed to increase the focus of the manuscript on MSK content.