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Adapting Artificial Intelligence Concepts to Enhance Clinical Decision-Making: A Hybrid Intelligence Framework

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Purpose: Artificial intelligence (AI) holds great potential for revolutionizing health care by providing clinicians with data-driven insights that support more accurate and efficient clinical decisions. However, applying AI in clinical settings is often challenging due to the complexity and vastness of medical information. This perspective article explores how AI development methodologies can be adapted to support clinicians in their decision-making processes, emphasizing the importance of a hybrid approach that combines AI capabilities with clinicians' expertise.

Patients and Methods: We developed a conceptual framework designed to integrate AI-driven hybrid intelligence into clinical practice to enhance decision-making. This framework focuses on adapting key AI concepts, such as backpropagation, quantization, and avoiding overfitting, to help clinicians better interpret complex medical data and improve diagnosis and treatment planning.

Results: Several AI methodologies were adapted to enhance clinical decision-making. First, backpropagation allows clinicians to refine initial assessments by revisiting them as new data emerges, improving diagnostic accuracy over time. Second, quantization helps break down complex medical problems into manageable components, enabling clinicians to prioritize critical elements of care. Finally, avoiding overfitting encourages clinicians to balance rare diagnoses with more common explanations, reducing the risk of diagnostic errors and unnecessary complexity.

Conclusion: The integration of AI-driven hybrid intelligence has the potential to enhance clinical decision-making. By adapting AI methodologies, clinicians can enhance their ability to analyze data, prioritize treatments, and make more accurate diagnoses while preserving the essential human aspect of health care. This framework highlights the importance of combining AI's strengths with clinicians' expertise for more effective and balanced decision-making in clinical practice. This perspective highlights the value of hybrid intelligence in achieving more balanced, effective, and patient-centered decision-making in health care.

Keywords: artificial intelligence, clinical reasoning, diagnostic accuracy, digital health, internal medicine, natural language processing

Introduction

The Role of AI in Medicine

Artificial intelligence (AI) has become a transformative technology in various fields, and its potential in medicine is increasingly recognized.[1,2] In health care, AI technologies have been developed to assist health care professionals by analyzing vast amounts of data, thus aiding in diagnosing diseases, predicting patient outcomes, and personalizing treatment plans.[3] Unlike traditional diagnostic tools, AI systems, such as machine learning and deep learning models, are designed to process large datasets and generate insights that would be difficult or time-consuming for humans to obtain.[4]

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AI's ability to quickly analyze complex data has opened new avenues for enhancing clinician decision-making, especially in fields like radiology, pathology, and precision medicine.[5–8]

The Need for Evidence-Based AI in Clinical Practice

While AI is proving to be a valuable tool in health care, understanding the efficacy, effectiveness, and safety of these tools remains a critical issue. Recent studies highlight the need for robust reporting guidelines for AI in medicine to prevent publication bias and ensure clarity in reporting outcomes.[9] Additionally, systematic reviews have highlighted potential discrepancies between AI and clinician performance, emphasizing the necessity of transparent and reliable AI reporting standards.[10,11] These findings suggest that the implementation of AI in clinical practice must be evidence-based and standardized to provide consistent, safe, and effective care.

Why are Generative AIs Revelational?

Generative AI represents a significant leap forward in the evolution of AI technology. Unlike traditional AI models that primarily focus on classification, prediction, or pattern recognition, generative AI systems, such as those powered by large language models, have the ability to create new content, including text, images, or even medical hypotheses, based on learned patterns from existing data.[1] In medicine, generative AI has the potential to assist in tasks ranging from generating clinical notes to suggesting potential diagnoses. Its ability to model language and generate content autonomously offers clinicians new tools for handling complex patient information, improving efficiency, and even reducing errors. However, despite its revolutionary capabilities, generative AI alone cannot replace the nuanced decision-making and ethical considerations required in clinical practice.[12,13]

The Concept of Hybrid Intelligence in Health Care

Despite the advancements of AI and generative models, the complexity and unpredictability of medical scenarios often require more than machine-driven insights. This is where the concept of hybrid intelligence comes into play—a system that combines the strengths of AI with human expertise.[14,15] Hybrid intelligence leverages AI's data-processing capabilities while allowing clinicians to apply their critical thinking, intuition, and ethical reasoning to decision-making. By balancing AI's efficiency with the human touch that is essential in health care, hybrid intelligence promises to not only enhance clinician performance but also safeguard against the limitations of AI, such as overfitting, bias, and misinterpretation of data.[13,16] Cognitive models, such as the predictive brain theory, which emphasize iterative learning through predictive error management, offer a valuable framework for integrating AI and human expertise in clinical decision-making.[17] Moreover, recent studies on foundational models for medical AI underscore the importance of hybrid approaches, where AI augments clinician capabilities without supplanting their role.[18]

Scope and Aims of This Perspective

In this perspective, we explore how generative AI can be integrated into the workflow of general internal medicine physicians to improve key aspects of their clinical practice. This perspective presents a conceptual framework that blends AI with human intelligence, offering clinicians practical strategies for navigating the evolving AI landscape in medicine. Through this exploration, we seek to provide a structured approach that equips health care professionals with the knowledge to make clinical decisions with AI technologies.

Materials and Methods

Study Design

This perspective focuses on how AI concepts, including backpropagation, quantization, and avoiding overfitting, can be applied in clinical contexts to improve diagnostic accuracy and treatment planning. The key AI methodologies were selected based on their potential to assist clinicians in handling complex data and making more accurate diagnoses.

Backpropagation in Clinical Decision-Making

Backpropagation, a foundational AI technique, involves refining models through continuous feedback based on errors in their predictions.[19] In clinical settings, we propose using this concept to allow clinicians to reassess and refine their initial diagnoses as new data become available. This iterative process mirrors backpropagation's role in improving AI models by integrating new information to reduce errors and enhance predictions over time.

Quantization for Simplified Decision-Making

Quantization in AI reduces complex data into manageable, simplified forms, making computations more efficient without sacrificing critical information.[20] Clinicians can apply this concept to streamline complex patient cases by breaking down intricate medical issues into smaller, prioritized components. This approach ensures that clinicians focus on the most urgent diagnostic and treatment priorities, much like AI models manage vast datasets through quantization.

Avoiding Overfitting in Clinical Judgments

Overfitting in AI occurs when a model is too narrowly trained on specific or rare data, resulting in reduced generalization capabilities.[21] In clinical practice, clinicians may overfit by focusing too heavily on rare or complicated diagnoses, neglecting more common and probable explanations. This issue can be addressed by applying principles from Bayes' Rule, which emphasizes the importance of considering prior probabilities (base rates) when making diagnostic decisions. Bayes' Rule encourages clinicians to weigh more common diagnoses over rare ones, especially in ambiguous clinical situations.[22]

Results

Backpropagation in Clinical Context

In one clinical scenario, a patient presented with fever, fatigue, and general malaise. Initially, the clinician considered a broad range of possible infections. A blood culture was ordered, and while awaiting results, the clinician made an initial diagnosis of a viral infection. However, once the blood culture revealed a bacterial infection, the clinician revisited the initial assessment. Using the backpropagation approach, the clinician asked the patient further detailed questions about potential entry sites. This iterative process—revisiting the initial diagnosis and refining it based on new information—helped the clinician identify the most likely source of infection, leading to a more targeted treatment plan with antibiotics. This process mirrors the backpropagation technique in AI, where models are refined based on new data, continuously improving their accuracy.

Quantization for Simplified Decision-Making

A second example involved a patient with multiple chronic conditions, including hypertension, diabetes, and chronic kidney disease, who presented with shortness of breath and swelling. The complexity of the case was initially overwhelming, with several possible causes for the symptoms, including cardiac failure, fluid overload, or pulmonary embolism. The quantization approach was applied by simplifying the problem into smaller, manageable parts. The clinician first focused on the most critical issue—evaluating the patient's fluid status—and ordered tests to assess kidney function and heart failure markers. By breaking down the complex list of problems into prioritized, manageable chunks, the clinician was able to rule out less likely causes and focus on the most urgent treatment priorities. This approach mirrors how AI models quantize data to manage and process it more efficiently, allowing clinicians to navigate complex cases with greater clarity.

Avoiding Overfitting in Clinical Judgments

In another case, a patient presented with abdominal pain, nausea, and a history of travel to a region known for rare tropical infections. The differential diagnosis initially included a rare parasitic infection based on the travel history, but the clinician, applying the principle of avoiding overfitting, decided to take a more balanced approach. While the rare parasitic infection was considered, the clinician also evaluated more common diagnoses like gastroenteritis or food poisoning. By avoiding an over-reliance on the rare diagnosis, the clinician ensured that simpler, more common causes were not overlooked. This approach helped prevent diagnostic errors and led to more efficient use of resources, paralleling the AI technique of avoiding overfitting, where models are trained not to focus too narrowly on outliers or rare data points.

Key Outcomes

The integration of these AI-driven concepts into clinical practice resulted in several key outcomes:

- Improved Diagnostic Accuracy: The iterative assessment process inspired by backpropagation allowed clinicians to correct initial errors and refine their diagnoses with the integration of new data, leading to better outcomes.
- Enhanced Decision-Making Efficiency: The application of quantization helped clinicians navigate complex cases more efficiently by breaking down the information into manageable parts and prioritizing critical factors.
- Reduced Cognitive Bias: Avoiding overfitting led to more balanced clinical judgments, helping clinicians avoid rare, complex diagnoses unless strongly supported by the clinical data, thus reducing unnecessary tests and treatments. The framework as a whole demonstrated the potential to enhance clinician decision-making by combining the strengths of AI with human expertise, supporting more accurate, efficient, and confident clinical decisions.[23]

Evidence from systematic reviews highlights the potential discrepancies in AI performance across different clinical contexts, underscoring the importance of ensuring that AI models are generalizable and relevant to diverse patient populations.[10,11] In line with these findings, the limited randomized controlled trials have demonstrated that AI models can improve the clinical outcomes.[24,25] By balancing the consideration of rare conditions with more likely diagnoses, clinicians reduce cognitive bias and unnecessary testing. This approach mirrors how AI models are trained to avoid overfitting, ensuring that decisions are more generalizable and applicable across a wider range of clinical scenarios.

Research has shown that clinicians often fail to appropriately use base-rate information in decision-making, which can lead to cognitive bias. For instance, in simulated medical decision-making tasks, clinicians sometimes incorrectly prioritize rare diseases despite symptom ambiguity favoring more common diagnoses. By balancing the consideration of rare conditions with more likely diagnoses, clinicians reduce cognitive bias and unnecessary testing.[26] This approach mirrors how AI models are trained to avoid overfitting, ensuring that decisions are more generalizable and applicable across a wider range of clinical scenarios.

Discussion

The Potential of AI-Driven Hybrid Intelligence in Medicine

Our perspective highlights the potential of AI-driven hybrid intelligence in clinical decision-making by adapting key AI methodologies such as backpropagation, quantization, and avoiding overfitting to medical practice. The results suggest that these AI concepts, when integrated into clinicians' workflows, can significantly enhance their ability to handle complex patient data and make more accurate, efficient, and balanced decisions.

The application of backpropagation in clinical settings introduces a new dimension to decision-making, where clinicians actively reassess and refine their diagnoses based on new information. This iterative process mirrors AI's capacity for learning and adjusting, ensuring that clinicians can continuously improve the accuracy of their assessments. In practice, this method has the potential to mitigate diagnostic errors and promote a more flexible, adaptive approach to patient care.

Similarly, quantization provided a structured way for clinicians to manage overwhelming amounts of medical data. In health care, particularly in complex cases, clinicians often face vast and intricate datasets. By focusing on the most critical components of the data, clinicians can better prioritize diagnostic and treatment decisions, making their processes more efficient without losing sight of the essential information.

Finally, the concept of avoiding overfitting addresses the cognitive biases clinicians may face when over-relying on rare or complex diagnoses. This AI-driven approach encourages a more balanced perspective by reminding clinicians to focus on common conditions and simpler explanations when appropriate. By applying this strategy, clinicians can reduce unnecessary diagnostic testing, streamline their decision-making processes, and avoid complications in patient management.

Limitations and Future Directions

Although our framework shows promise, it remains conceptual and will require empirical validation in clinical practice. Future research should focus on pilot studies where these AI-adapted concepts are tested in real-world clinical environments. This will help determine the practical challenges and the extent of improvements that can be achieved by integrating AI-driven hybrid intelligence into everyday health care settings.

Moreover, while our perspective addresses the adaptation of AI methods, there remains a need for continued training and education of clinicians in understanding and utilizing these AI frameworks effectively.[27] The collaboration between AI developers and health care professionals is crucial to ensure that the tools designed truly meet the needs of clinical practice.

The Role of Human Judgment in Hybrid Intelligence

One of the key strengths of hybrid intelligence is that it maintains the essential role of human judgment while leveraging AI's computational power. AI can provide data-driven insights, but it is the clinician's expertise, empathy, and ethical considerations that ultimately shape patient care. Hybrid intelligence frameworks like the one proposed in this study allow clinicians to use AI as a tool, not a replacement, ensuring that AI enhances rather than diminishes the human touch in health care.

Conclusion

This study presents a conceptual framework for integrating AI-driven hybrid intelligence into clinical practice, showing how AI methodologies such as backpropagation, quantization, and avoiding overfitting can be adapted to improve clinical decision-making. By combining AI's strengths with human expertise, hybrid intelligence can enhance the accuracy, efficiency, and quality of clinical judgments.

Our findings highlight the transformative role of AI as a collaborative tool for clinicians, allowing for more informed and adaptive decisions in complex medical environments. As health care continues to evolve with technological advancements, the integration of hybrid intelligence frameworks will be key to supporting clinicians in navigating the challenges of modern medicine while maintaining the human touch that remains essential in patient care.

To realize the full potential of this approach, further research and validation are needed to fully understand the real-world implications and to refine the framework for broader clinical application. However, the potential benefits highlighted in this study demonstrate that AI-driven hybrid intelligence can serve as a valuable asset to the future of health care decision-making.

Abbreviations

AI, artificial intelligence.

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Disclosure

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