REVIEW

Revolutionizing healthcare: the role of artificial intelligence in clinical practice

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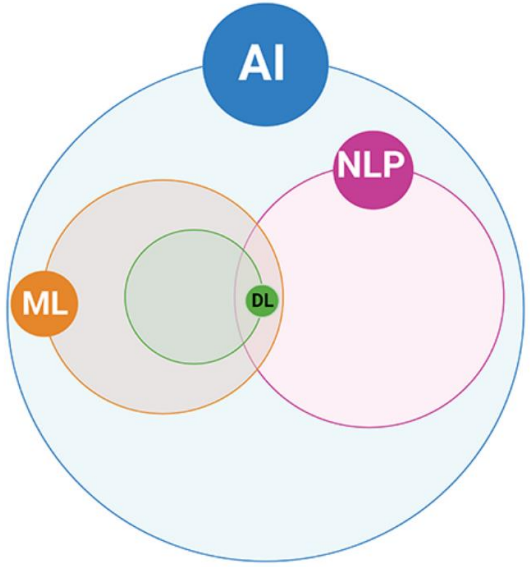
Introduction

- Artificial Intelligence (AI) is a rapidly evolving field of computer science that aims to create machines that can perform tasks that typically require human intelligence. AI includes various techniques such as machine learning (ML), deep learning (DL), and natural language processing (NLP). Large Language Models (LLMs) are a type of AI algorithm that uses deep learning techniques and massively large data sets to understand, summarize, generate, and predict new text-based content.

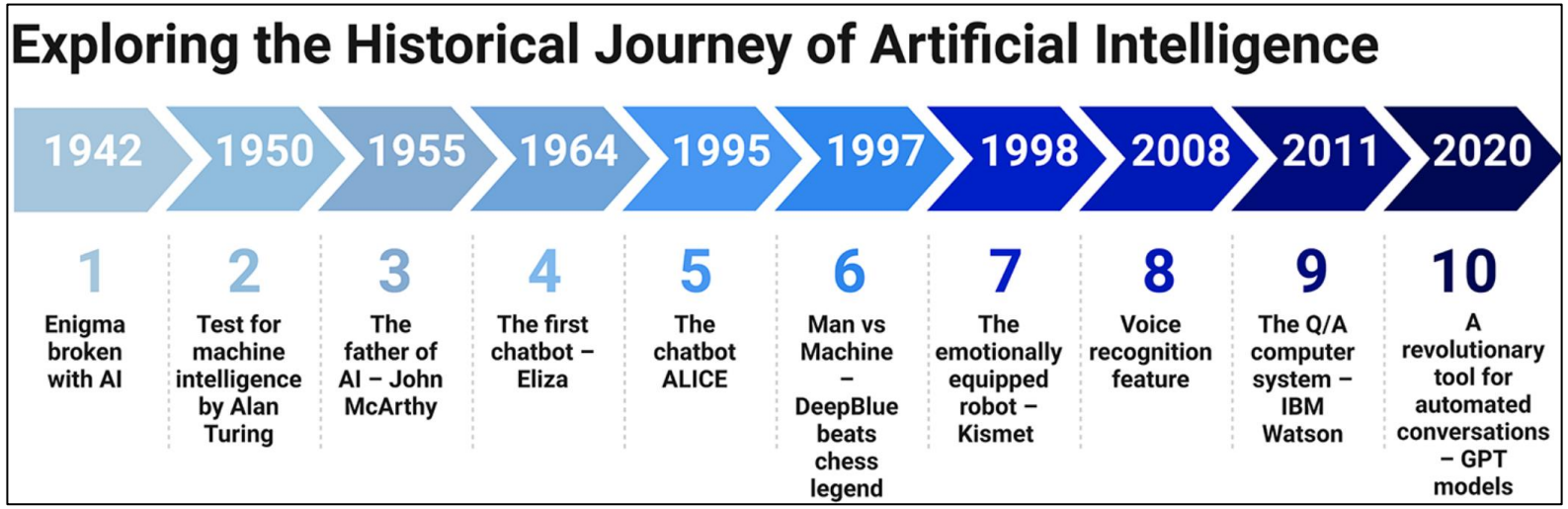
Understanding the Relationship Between AI, ML, DL, and NLP



- AI is a broad field that includes anything related to making machines smart.
- NLP is the branch of AI focused on teaching machines to understand, interpret, and generate human language.
- ML is a subset of AI that involves systems that can learn by themselves.
- DL is a subset of ML that uses models built on deep neural networks to detect patterns with minimal human involvement.

Introduction

- Over the years, AI has undergone significant transformations, from the early days of rule-based systems to the current era of ML and deep learning algorithms.
- Today, AI is transforming healthcare, finance, and transportation, among other fields, and its impact is only set to grow. AI has been used to analyze large datasets and identify patterns that would be difficult for humans to detect; this has led to breakthroughs in fields such as genomics and drug discovery. AI has been used in healthcare settings to develop diagnostic tools and personalized treatment plans.
- The rapid progression of AI technology presents an opportunity for its application in clinical practice, potentially revolutionizing healthcare services. It is imperative to document and disseminate information regarding AI's role in clinical practice, to equip healthcare providers with the knowledge and tools necessary for effective implementation in patient care. This review article aims to explore the current state of AI in healthcare, its potential benefits, limitations, and challenges, and to provide insights into its future development.



Materials and methods

- **Search strategy and inclusion:** Indexed databases, including PubMed, Scopus, and EMBASE, were independently searched with no time restrictions, but the searches were limited to the English language.
- **Databases search protocol and keywords:** In the review article, the authors extensively examined the use of AI in healthcare settings. The authors analyzed various combinations of keywords such as NLP in healthcare, ML in healthcare, DL in healthcare, LLM in healthcare, AI in personalized medicine, AI in patient monitoring, AI ethics in healthcare, predictive analytics in healthcare, AI in medical diagnosis, and AI applications in healthcare.
- **Data extraction:** Publications were screened through a meticulous review of titles and abstracts. Only those that met the specific criteria were included. Any disagreements or concerns about the literature or methodology were discussed in detail among the authors.

Results: AI assistance in diagnostics

- **Diagnosis accuracy and speed:** With all the advances in medicine, effective disease diagnosis is still considered a challenge on a global scale. The development of early diagnostic tools is an ongoing challenge due to the complexity of the various disease mechanisms and the underlying symptoms. AI can revolutionize different aspects of health care, including diagnosis. ML is an area of AI that uses data as an input resource in which the accuracy is highly dependent on the quantity as well as the quality of the input data that can combat some of the challenges and complexity of diagnosis.
- A study was published in the UK where authors input a large dataset of mammograms into an AI system for breast cancer diagnosis. This study showed that utilizing an AI system to interpret mammograms had an absolute reduction in false positives and false negatives by 5.7% and 9.4%, respectively.
- Another study was conducted in South Korea, where authors compared AI diagnoses of breast cancer versus radiologists. The AIutilized diagnosis was more sensitive to diagnose breast cancer with mass compared to radiologists, 90% vs. 78%, respectively. Also, AI was better at detecting early breast cancer (91%) than radiologists 74%.
- Furthermore, a study utilized deep learning to detect skin cancer which showed that an AI using CNN accurately diagnosed melanoma cases compared to dermatologists and recommended treatment options.

Results: AI assistance in diagnostics

- Researchers utilized AI technology in many other disease states, such as detecting diabetic retinopathy and EKG abnormality and predicting risk factors for cardiovascular diseases.
- Furthermore, deep learning algorithms are used to detect pneumonia from chest radiography with sensitivity and specificity of 96% and 64% compared to radiologists 50% and 73%, respectively.
- Also, a study was done on a dataset of 625 cases to diagnose acute appendicitis early to predict the need for appendix surgery using various ML techniques; the results showed that the random forest algorithm achieved the highest performance, accurately predicting appendicitis in 83.75% of cases, with a precision of 84.11%, sensitivity of 81.08%, and specificity of 81.01%.
- AI tools can improve accuracy, reduce costs, and save time compared to traditional diagnostic methods. Additionally, AI can reduce the risk of human errors and provide more accurate results in less time.

Results: AI assistance in diagnostics

- **AI in lab:** Clinical laboratory testing provides critical information for diagnosing, treating, and monitoring diseases. It is an essential part of modern healthcare which continuously incorporates new technology to support clinical decision-making and patient safety.
- A published systematic review showed that numerous MLs were evaluated for microorganism identification and antibiotic susceptibility testing with high sensitivity and specificity. This allows for a solid result within the first 24 to 48 h, facilitating the selection of suitable antibiotic treatment for patients with positive blood cultures. Consequently, incorporating AI in clinical microbiology laboratories can assist in choosing appropriate antibiotic treatment regimens, a critical factor in achieving high cure rates for various infectious diseases.
- For malaria, Taesik et al. found that using ML algorithms combined with digital in-line holographic microscopy (DIHM) effectively detected malaria-infected red blood cells without staining. This AI technology is rapid, sensitive, and cost-effective in diagnosing malaria.

Results: AI assistance in diagnostics

- **Decision making:** ML research in medicine has rapidly expanded, which could greatly help the healthcare providers in the emergency department (ED) as they face challenging difficulties from the rising burden of diseases, greater demand for time and health services, higher societal expectations, and increasing health expenditures.
- Emergency department providers understand that integrating AI into their work processes is necessary for solving these problems by enhancing efficiency, and accuracy, and improving patient outcomes.
- AI algorithms can analyze patient data to assist with triaging patients based on urgency; this helps prioritize high-risk cases, reducing waiting times and improving patient flow.
- Fortunately, AI can assist in the early detection of patients with life-threatening diseases and promptly alert clinicians so the patients can receive immediate attention. Lastly, AI can help optimize health care sources in the ED by predicting patient demand, optimizing therapy selection (medication, dose, route of administration, and urgency of intervention), and suggesting emergency department length of stay.

Results: AI assistance in diagnostics

- **genomic medicine:** The advent of high-throughput genomic sequencing technologies, combined with advancements in AI and ML, has laid a strong foundation for accelerating personalized medicine and drug discovery. Despite being a treasure trove of valuable insights, the complex nature of extensive genomic data presents substantial obstacles to its interpretation. The field of drug discovery has dramatically benefited from the application of AI and ML. The simultaneous analysis of extensive genomic data and other clinical parameters, such as drug efficacy or adverse effects, facilitates the identification of novel therapeutic targets or the repurposing of existing drugs for new applications.
- A specific area where AI and ML have demonstrated significant efficacy is the identification of genetic variants associated with distinctive traits or pathologies. Examining extensive genomic datasets allows these techniques to detect intricate patterns often elusive to manual analysis. For instance, a groundbreaking study employed a deep neural network to identify genetic variants associated with autism spectrum disorder (ASD), successfully predicting ASD status by relying solely on genomic data.
- In the field of oncology, categorizing cancers into clinically relevant molecular subtypes can be accomplished using transcriptomic profiling. Such molecular classifications, hold substantial implications for diagnosis, prognosis, and treatment selection.

Results: AI assistance in treatment

- **Precision in the choice of treatment:** The potential applications of AI in assisting clinicians with treatment decisions, particularly in predicting therapy response, have gained recognition. A study conducted by Huang et al. where authors utilized patients' gene expression data for training a support ML, successfully predicted the response to chemotherapy. In this study, the authors included 175 cancer patients incorporating their gene-expression profiles to predict the patients' responses to various standard-of-care chemotherapies. Notably, the research showed encouraging outcomes, achieving a prediction accuracy of over 80% across multiple drugs. These findings demonstrate the promising role of AI in treatment response prediction.
- In another study performed by Sheu et al., the authors aimed to predict the response to different classes of antidepressants using electronic health records (EHR) of 17,556 patients and AI. The AI models considered features predictive of treatment selection to minimize confounding factors and showed good prediction performance. The study demonstrated that antidepressant response could be accurately predicted using real-world EHR data with AI modeling, suggesting the potential for developing clinical decision support systems for more effective treatment selection.

Results: AI assistance in treatment

- **Dose optimization:** AI plays a crucial role in dose optimization and adverse drug event prediction, offering significant benefits in enhancing patient safety and improving treatment outcomes.
- In a study that aimed to develop an AI-based prediction model for prothrombin time international normalized ratio (PT/INR) and a decision support system for warfarin maintenance dose optimization The authors analyzed data from 19,719 inpatients across three institutions, and the algorithm outperformed expert physicians with significant differences in predicting future PT/INRs and the generated individualized warfarin dose was reliable.
- a novel dose optimization system “CURATE.AI” is an AI-derived platform for dynamically optimizing chemotherapy doses based on individual patient data. A study was conducted to validate this system as an open-label, prospective trial in patients with advanced solid tumors treated with three different chemotherapy regimens. CURATE.AI generated personalized doses for subsequent cycles based on the correlation between chemotherapy dose variation and tumor marker readouts. The integration of CURATE.AI into the clinical workflow showed successful incorporation and potential benefits in terms of reducing chemotherapy dose and improving patient response rates and durations compared to the standard of care.

Results: AI assistance in population health management

- **Predictive analytics and risk assessment:** AI can be used to optimize healthcare by improving the accuracy and efficiency of predictive models. AI algorithms can analyze large amounts of data and identify patterns and relationships that may not be obvious to human analysts.
- ML algorithms and other technologies are used to analyze data and develop predictive models to improve patient outcomes and reduce costs. One area where predictive analytics can be instrumental is in identifying patients at risk of developing chronic diseases such as endocrine or cardiac diseases. By analyzing data such as medical history, demographics, and lifestyle factors, predictive models can identify patients at higher risk of developing these conditions and target interventions to prevent or treat them.
- Predicting hospital re-admissions is another area where predictive analytics can be applied. By analyzing patient demographics, medical history, and social health factors, predictive models can identify patients at higher risk of hospital re-admissions and target interventions to prevent readmissions.

Results: AI assistance in population health management

- **Establishment of guidelines:** AI is transforming how guidelines are established in various fields. In healthcare, guidelines usually take much time, from establishing the knowledge gap that needs to be fulfilled to publishing and disseminating these guidelines.
- AI can help identify newly published data based on data from clinical trials and real-world patient outcomes within the same area of interest which can then facilitate the first stage of mining information. Then, under the supervision of scientists and experts in the field, AI algorithms can analyze vast amounts of data to identify patterns and trends that can inform the development of evidence-based guidelines in real-time, which allows for a fast exchange of information with essential supervision clinicians for its clinical and ethical implications.

Results: individuals choice between AI and human

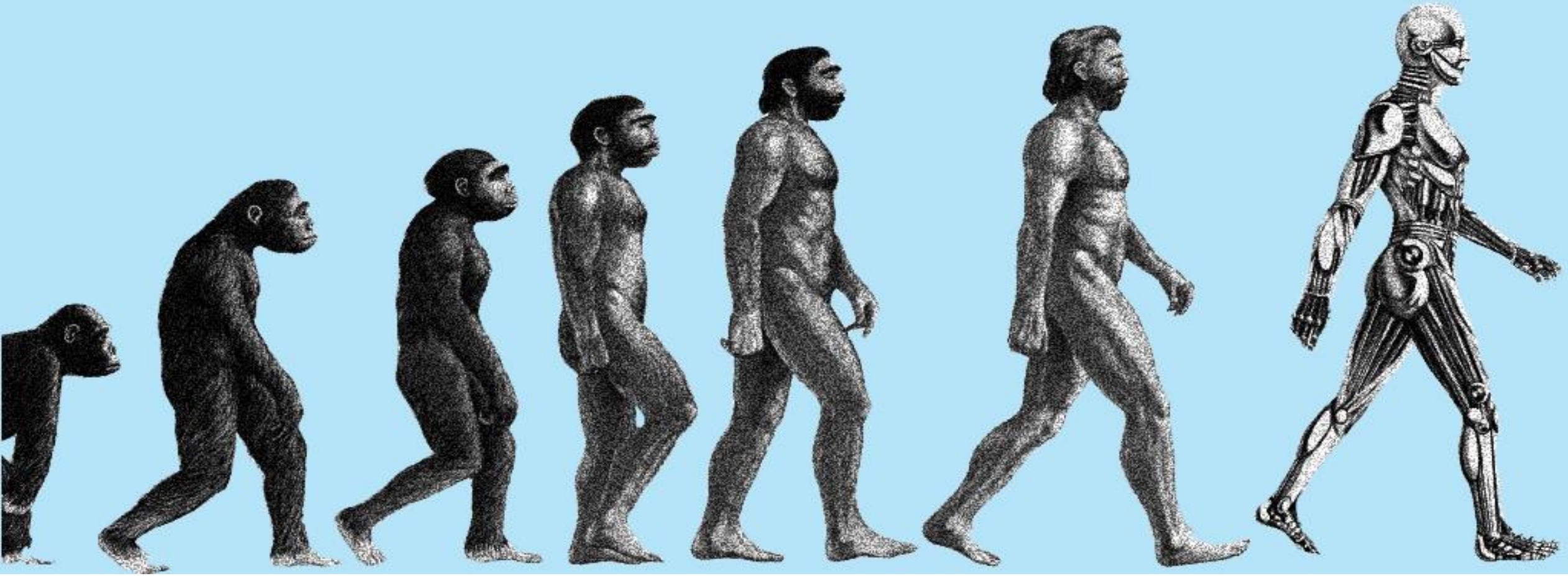
- Public perception of the benefits and risks of AI in healthcare systems is a crucial factor in determining its adoption and integration. People's feelings about AI replacing or augmenting human healthcare practitioners, its role in educating and empowering patients, and its impact on the quality and efficiency of care, as well as on the well-being of healthcare workers, are all important considerations. patient-physician trust is vital in improving patient care and the effectiveness of their treatment. For the relationship between patients and an AI-based healthcare delivery system to succeed, building a relationship based on trust is imperative.
- search on whether people prefer AI over healthcare practitioners has shown mixed results depending on the context, type of AI system, and participants' characteristics. Some surveys have indicated that people are generally willing to use or interact with AI for health related purposes such as diagnosis, treatment, monitoring, or decision support. However, other studies have suggested that people still prefer human healthcare practitioners over AI, especially for complex or sensitive issues such as mental health, chronic diseases, or end-of-life care.
- In a US-based study, 60% of participants expressed discomfort with providers relying on AI for their medical care. However, the same study found that 80% of Americans would be willing to use AI-powered tools to help manage their health. people's trust and acceptance of AI may vary depending on their age, gender, education level, cultural background, and previous experience with technology.

Results: Future obstacles and solutions for AI

- AI has the potential to revolutionize clinical practice, but several challenges must be addressed to realize its full potential. Among these challenges is the lack of quality medical data, which can lead to inaccurate outcomes. Data privacy, availability, and security are also potential limitations to applying AI in clinical practice.
- Additionally, determining relevant clinical metrics and selecting an appropriate methodology is crucial to achieving the desired outcomes. Human contribution to the design and application of AI tools is subject to bias and could be amplified by AI if not closely monitored.
- The AI-generated data and/or analysis could be realistic and convincing; however, hallucination could also be a major issue which is the tendency to fabricate and create false information that cannot be supported by existing evidence. This can be particularly problematic regarding sensitive areas such as patient care.

Conclusion

- The integration of AI in healthcare has immense potential to revolutionize patient care and outcomes.
- AI-driven predictive analytics can enhance the accuracy, efficiency, and cost-effectiveness of disease diagnosis and clinical laboratory testing.
- Additionally, AI can aid in population health management and guideline establishment, providing real-time, accurate information and optimizing medication choices.
- Integrating AI in virtual health and mental health support has shown promise in improving patient care.
- However, it is important to address limitations such as bias and hallucination to ensure equitable and effective use of AI.



Thanks for your attention!