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The Role of Artificial Intelligence in Scientific Research

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Abstract

In the rapidly developing area of artificial intelligence (AI), intelligence that can comprehend natural language, identify patterns, and make data-driven decisions—tasks that normally require human intellect—is developed. The many studies on artificial intelligence in scientific inquiry are reviewed in this article. It concluded that artificial Intelligence is reshaping scientific research by enhancing data analysis, accelerating results, and enabling the handling of large, complex datasets. Tools like Chat GPT streamline qualitative research by reducing manual effort and uncovering hidden patterns, making analysis more efficient and scalable. However, ethical, privacy, and governance concerns must be addressed, and AI should be viewed as a complement—not a replacement—for human cognitive input, particularly in theory development. With proper guidance, transparency, and understanding of AI capabilities, researchers can effectively integrate AI tools to advance scientific inquiry while maintaining the integrity and depth of traditional research methodologies.

Keywords: Artificial intelligence (AI), Quantitative Research, Research methodologies, Human intelligence, Scientific research, Qualitative Research, etc.

1 Introduction

While incorporating AI into research procedures must carefully address ethical, privacy, and governance concerns, it also presents previously unheard-of potential to improve data processing, boost productivity, and promote creative discoveries. With the use of artificial intelligence (AI) technology, especially generative models, researchers may test hypotheses and comprehend system dynamics without doing

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physical experiments by simulating complicated study contexts and situations [1]. AI's ability to process and analyse large datasets allows researchers to find patterns and insights at a scale that was previously impossible, which leads to more accurate scientific enquiries and better informed decision-making. It also facilitates cross-disciplinary research by allowing the integration and analysis of data from various fields, which leads to holistic approaches to solving complex global challenges [2]. Finally, it speeds up the research lifecycle by rapidly prototyping experiments and analysing their results, which significantly accelerates the pace of innovation. Regardless of whether the tested hypothesis was validated or not by the quantitative analysis in the basic research, this work introduces innovative methodologies that will ultimately result in the creation of working models. These models will be created by starting with research hypotheses and using AI tools specific to each research hypothesis to achieve the specific objective [3].

A. Artificial Intelligence

A variety of sophisticated functions, such as the capacity to see, comprehend, and translate spoken and written language, analyse data, and provide recommendations, are made possible by artificial intelligence (AI) technologies [4]. Artificial intelligence is a scientific discipline that focusses on the development of computers and machines that are capable of reasoning, learning, and acting in a manner that would typically necessitate human intelligence or which entails data that is too large for humans to analyse [5], [6]. Artificial intelligence is a multifaceted field that includes a variety of disciplines, such as computer science, data analytics and statistics, hardware and software engineering, linguistics, neurobiology, and even philosophy and psychology [7]. A set of technologies that are predominantly based on machine learning and deep learning, AI is a set of technologies that are used for data analytics, predictions and forecasting, object categorisation, natural language processing, recommendations, intelligent data retrieval, and more on an operational level for business use [8].

B. Scientific Research

Many methods exist for defining research. In essence, research is the process of collecting, organising, and utilising information to elucidate, substantiate, or prove a theory or area of study. Research is essential in both scientific and non-scientific fields; however, scientific research is one of the most comprehensive and pertinent categories of research [9]. In the past few centuries, the field of scientific research has made remarkable progress and achieved remarkable feats. This trend is expected to persist in the near future. In order to elucidate the reasons behind specific phenomena that manifest in the real world, scientific research employs a diverse array of scientific models, theories, and data collections [10]. A variety of methods can be employed to conduct scientific research, including experiments, case studies, and focus groups. Enlarging human knowledge is the ultimate objective of scientific research. Our comprehension of the workings of the world is significantly enhanced by scientific research [11], [12]. It also contributes to the advancement of a variety of disciplines, including biology, chemistry, psychology, medicine, and other disciplines. Furthermore, scientific research addresses both existing issues and potential future ones [13].

C. Types of Scientific Research

Scientific study comes in a wide variety of forms, ranging from mixed to quantitative and qualitative. Since there are many different classifications for it, the categorisation mostly relies on the study topic, data gathering methods, and research methodology. Some of the most fundamental forms of scientific investigation are as follows:

Quantitative Research: As the name suggests, investigations based on numbers are included in quantitative research. In quantitative approaches, some kind of data is either measured or counted. The goal of this kind of scientific study is to assess the what, when, and where of the research subject or query since it is numerical in nature. Graphs, statistics, and numbers are the primary ways it is represented. Methods for gathering quantitative data include experiments, surveys, and observations. To find patterns, it essentially measures numerical data.

Qualitative Research: The quality of the data is the primary focus of qualitative research, rather than its quantity. This is a form of descriptive and exploratory research, which is why qualitative methods such as literature reviews, interviews, focus groups, and case studies are employed. Qualitative research, in contrast to quantitative research, is designed to enquire about the rationale and methodology behind the decision-making process. Through the organisation, interpretation, and summarisation of data, this is accomplished. To put it differently, qualitative research is employed when the objective is to comprehend textual data, as opposed to quantitative research, which attempts to verify a hypothesis through numerical data. This type of investigation is designed to enhance comprehension of the subject matter or the prospective issues it may raise. In the end, this results in a solution that may or may not be grounded in empirical data.

Mixed Research: Combining quantitative and qualitative methodologies is known as mixed research. The combined approach is beneficial because it balances the shortcomings of both qualitative and quantitative research while enhancing their strengths.

D. Example of AI in Scientific Research

AI-Driven Robotic Scientists: AI algorithms are currently being implemented in robotic systems, which are frequently referred to as "robot scientists." These algorithms enable them to independently analyse data, refine hypotheses, and conduct experiments. Additionally, these robotic scientists are capable of conducting genetic screenings and synthesising compounds.

Drug Discovery and Development: Advanced By utilising AI in scientific research, scientists can expedite the discovery of new medications by generating novel drug molecules with distinctive structures and characteristics. AI is capable of predicting the potential interactions between various medications. Making pharmaceuticals safer for patients can be achieved through the analysis of extensive data.

Bioinformatics: Since AI-based protein structure predictions can forecast the behaviour of specific components, they are a key tool for comprehending protein function and medication development. On

the basis of genomic data analysis, machine learning can identify genetic variations among species and, as a result, enable the development of personalised therapies. Various biological functions, such as protein-protein interactions, are employed in scientific research by AI to investigate potential drug targets.

Real-World Example: Material Science Research: Another area that benefits from AI-driven automation is material science, which develops novel chemicals and materials for uses such electronics or renewable energy. The discovery of materials with desired qualities like "strength, conductivity, or heat resistance" may be accelerated by AI-powered robotic systems, which can investigate and test material combinations significantly more quickly than human researchers.

Reducing Human Risk in Hazardous Research: AI-driven robotic systems may do investigations in areas involving radioactive materials, toxic chemicals, or other risky substances without endangering human researchers. In chemistry, where studies sometimes call for poisonous or reactive compounds, this skill is very helpful.

E. Sector-Specific Applications- specially focus on social science research

Political Science: Because AI provides new methods for data analysis, predictive modelling, and public opinion comprehension, it is being employed more and more in "political science for social science research". AI can improve research and decision-making by analysing massive databases, finding trends, and simulating the possible outcomes of political actions.

Education: AI is being used more and more in education social science research for tasks including data analysis, individualised instruction, and improved administrative effectiveness. AI can automate instructor duties, personalise learning experiences, and analyse massive datasets to determine student learning patterns.

Public Policy: AI has a number of uses in public policy, particularly for social science research. These include better policy decision-making, predictive modelling, and increased data analysis. Additionally, it may be used to improve public involvement, track social trends, and model social interactions.

Economics: AI provides strong tools for economics social science research, allowing for the study of big datasets, pattern recognition, and trend forecasting. These applications have the potential to promote multidisciplinary cooperation, improve policymaking, and deepen our knowledge of human behaviour.

2 Literature Review

(Zhang et al., 2025) [14] To create a framework for creating prompts especially made to assist younger researchers and stakeholders interested in using AI for qualitative research, a co-design session with 13 qualitative researchers and semi-structured interviews with 17 participants were undertaken. This study provides insights for qualitative researchers into how AI is perceived in LLM applications, in addition to emphasising the value of well-crafted prompts. Lastly, we highlight the possible ethical hazards and

the influence that researchers—especially novices—have on future advancements in AI research and ethical standards.

(Hitch, 2024) [15] NLP-based AI will be defined and explained in this paper, along with its advantages and disadvantages for reflective theme analysis in health research. ChatGPT is the most popular and most accessible of the several platforms. To demonstrate possible use in reality, a working example that augments reflective thematic analysis with ChatGPT is shown. The purpose of this paper is to stimulate further discussion on the use of AI in qualitative research and to provide useful advice for investigators who want to use this technology.

(Mădălina, 2024) [3] Examines the ways in which incorporating Artificial Intelligence (AI) into research methods is altering the paradigm of research by enhancing data analysis, productivity, and creativity across industries. In addition, this proposed study will take into account the ELM framework and expand its dimension, offering a more modern viewpoint on persuasion and cognitive engagement by incorporating AI and big data into the ELM methodologies dimension. This will demonstrate a paradigm shift in research and serve as an example of how to transition from methodologies based on conventional qualitative and quantitative methods to emerging ones based on AI and BIG DATA.

(Waly, 2024) [16] This article investigates the correlation between artificial intelligence (AI) and scientific inquiry. Researchers can uncover patterns, correlations, and trends that may otherwise remain obscured by utilising AI to facilitate the extraction of meaningful insights from large datasets. Additionally, artificial intelligence facilitates predictive analytics, enabling scientists to anticipate outcomes and pinpoint potential areas for additional research. In addition, the utilisation of AI systems in experimental design and optimisation is on the rise, which has the effect of expediting processes and improving efficiency in laboratory environments. Although AI offers numerous advantages, the integration of AI into scientific research poses obstacles regarding ethical considerations, interpretability, and data quality.

(Christou, 2023) [17] Motivated by conceptualisation and critical methodological dynamics, the goal of this work is to explore the function of artificial intelligence in the process of developing theories. As such, it offers a conceptual map of the relationship between AI and theory formation, critically assesses the potential and constraints of AI in theory construction, and outlines important factors to take into account when using AI to establish new theories or advance current ones. It is debatable if AI tools are necessary for developing theories since researchers' cognitive and evaluative abilities are seen to be crucial in this process, however the importance of AI in developing theory should not be understated.

(Hamilton et al., 2023) [18] Investigates how the artificial intelligence chatbot ChatGPT may support human-centered activities like qualitative study analysis. In this research, the themes that emerged from qualitative analyses of interviews with guaranteed income pilot participants conducted by humans and AI are compared. The findings show that human and AI-generated analyses vary and are comparable in that human coders identified some motifs that Chat GPT did not, and vice versa. According to the study's findings, artificial intelligence (AI) technologies like Chat GPT provide a potent way to support intricate

human-centered work. It also forecasts that these tools won't be the only ones used to make research jobs easier. To find mistakes, different perspectives, and biases, future studies should investigate feeding Chat GPT raw interview transcripts and adding AI-generated topics to triangulation conversations.

(Morgan, 2023) [19] Particularly, it investigates the degree to which the themes that were initially selected to summarise the two previous analyses can be replicated in the responses from Chat GPT. The findings indicate that Chat GPT performed satisfactorily; however, it was less effective in identifying nuanced, interpretive themes and more successful in reproducing concrete, descriptive themes in both instances. This resulted in a program that was relatively straightforward to operate and necessitated minimal effort in comparison to methods that required manual coding. It is crucial to acknowledge, however, that both artificial intelligence-based processes and coding are merely instruments that must be implemented as part of a more comprehensive analytical process. The results of this investigation indicate that artificial intelligence may have the potential to challenge the dominant paradigm of qualitative data analysis, which is the categorisation of data segments.

(Mungara, 2022) [20] Examine the studies conducted on artificial intelligence methods in big data analytics. The Systematic Literature Review (SLR) approach is used by the writers to choose relevant research articles. Four groups—machine learning, knowledge-based and reasoning techniques, decision-making algorithms, search methods, and optimisation theory—are taken into consideration to study these processes. Within each category, many articles are examined. Additionally, this assessment compares the scalability, efficiency, accuracy, and privacy of the chosen AI-driven big data analytics methodologies, highlighting their advantages and disadvantages. Additionally, some key topics are offered to improve big data analytics methods in the future.

3 Conclusion

The integration of Artificial Intelligence (AI) and Big Data tools into scientific research is revolutionizing research paradigms by accelerating data analysis, enhancing accuracy, and enabling the processing of large and complex datasets. AI tools like ChatGPT offer promising advantages in qualitative research by reducing labor-intensive tasks and uncovering hidden patterns through advanced modeling techniques. However, their use also raises ethical, privacy, and governance concerns that necessitate careful adaptation of research methodologies. While AI significantly improves efficiency and scalability in qualitative analysis, the cognitive and evaluative roles of researchers remain vital, especially in tasks such as theory development. Our findings suggest that improved transparency, guidance on AI prompts, and a deeper understanding of AI capabilities can enhance user interaction and foster positive attitudes toward AI use in research. AI should be seen as a complementary tool that supports, rather than replaces, human insight. Despite the challenges in implementation, the potential of AI to transform qualitative and quantitative research is substantial. For meaningful results, researchers must use these tools judiciously, ensuring responsible and ethical integration. As scientific inquiry evolves, AI will continue to shape the future of research by expanding the boundaries of knowledge generation and analysis.

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