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Artificial Intelligence in the Field of Scientific Research – Usage and Challenges –

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Abstract

Artificial intelligence represents a qualitative leap and a wealth that can be invested in all fields. Here, this intervention comes as an attempt to examine how to benefit from artificial intelligence in the field of scientific research by identifying its applications and tools that can be used in the field of scientific research, revealing its importance and role in the aforementioned field, and identifying the most important challenges that hinder the optimal use of this wealth, leading to a set of guidelines and recommendations that make artificial intelligence a mechanism to support and enhance scientific research.

Keywords: Scientific Research; Artificial Intelligence; Use; Challenges

Introduction

Artificial intelligence is considered a advanced field that focuses on th development of systems, devices, an technologies capable of simulating the huma mind. These technologies have prove effective in various domains, and with futur expectations of further advancements i artificial intelligence, it has become necessar to benefit from it in all fields—especially i scientific research. Indeed, any developmen in material or social life can only be achieve through scientific research, which is now i dire need of employing artificial intelligenc with its various tools and applications in orde to achieve greater efficiency in studying its phenomena.

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In light of this, the purpose of this research paper is to investigate how artificial intelligence can advance scientific research by posing the following queries:

- What are the applications and tools of artificial intelligence used in scientific research?
- What is the importance of artificial intelligence in scientific research?
- What are the main challenges facing the use of artificial intelligence in scientific research?
- What are the guidelines that enable us to make optimal use of artificial intelligence in scientific research?

These are the questions we tried to answer through a structure based on three main parts:

- The first part is dedicated to the concept of scientific research in terms of its definition, characteristics, objectives, and importance.

- The concept of artificial intelligence, including its definition, history, goals, significance, and types, is covered in the second section.
- An overview of artificial intelligence's application in scientific research is provided in the third section, which covers:
    - Its function and significance in scientific research.
    - Its applications and tools in scientific research.
    - The challenges of benefiting from it in scientific research.
    - Guidelines for its optimal use in scientific research.

II– Scientific Research:

1. Definition of Scientific Research

Several definitions have been given for scientific research, among them:

"An organized procedure designed to use particular scientific methods to find answers to particular problems or questions that may result in new scientific knowledge. (Malham, 2006, p. 47)".

"Inquiry characterized by precise organization in an attempt to reach new information, knowledge, or relationships, and to verify and develop existing information and knowledge using methods or approaches trusted for their reliability (Fahmi, 2023)."

In general, scientific research revolves around:

- A problem that requires a solution or a phenomenon that calls for being addressed through study .
- The research study of the problem must involve critical, organized, and precise investigation and inquiry, through which information and data are gathered .
- There are methods and procedures commonly agreed upon by researchers who use them and are assisted by them in solving problems .
- Scientific research generates new knowledge and expands the circle of human understanding.

2. Characteristics of Scientific Research:

Scientific research is characterized by a set of interrelated structural features that must be present in order to achieve the desired goals. These characteristics are summarized by (Hamed, 2003, p. 27) as follows:

- Objectivity and neutrality (The Objectivity)
- Accuracy and testability (The testability Accuracy)
- Possibility of repeating the results (Replicability)
- Simplicity and conciseness (Parsimony)
- Scientific research must have a purpose and a goal
- Using scientific knowledge to explain phenomena through the data collected about the subject of the study by means of research and relying on related theories
- Generalization of the study's results for practical benefit
- Reliance on methodological procedures to enrich and cover some of the gaps and shortcomings in the theoretical framework of the research and to modify them
- Dynamic and innovative, as it constantly seeks to renew knowledge through addition and modification.

3. Objectives of Scientific Research:

Scientific research seeks to achieve the following objectives (Saleh, 1993, p. 47):

- Understanding or interpretation: meaning the uncovering of relationships that exist between different phenomena and the relationship of phenomena with their outcomes.
- Description: which aims at providing a detailed and accurate representation of a subject or phenomenon, or in other words, producing a more truthful inventory of the characteristics of the phenomenon under study.
- Prediction: scientific research does not stop at interpreting and describing phenomena; one of its objectives is also to reach what could happen if these instructions were applied in other new situations.
- Control and regulation of the conditions that determine the occurrence of the phenomenon.
- Finding solutions to various problems by harnessing the entire universe to serve humans and achieve their happiness.
- Development of branches of knowledge in all fields.

4. The Importance of Scientific Research:

- The importance of scientific research is evident in the following aspects: (Ibrahim, 2001, p. 21)
- It is considered an organized scientific method for confronting our daily and general problems, as it contributes to establishing the principle of relying on research as a means of problem-solving.
- It provides us with the necessary scientific tools to improve our lifestyles, enhance our work methods, and develop ourselves in various fields.
- It opens wide horizons for researchers to discover different phenomena in the field of natural, social, and human sciences, and for that purpose, specialized research centers have been established.
- It is the means by which societies can overcome obstacles, plan for the future, avoid mistakes, and achieve material, educational, and cultural aspirations.

III- Artificial Intelligence:

1. The History of Artificial Intelligence

The phrase "artificial intelligence" first appeared in the 1950s, more precisely in 1950, when Alan Turing, a scientist, presented the Turing Test, which assesses a computer's intelligence and declares it intelligent if it can replicate the human mind. Christopher Strachey, head of programming research at the University of Oxford, wrote the first artificial intelligence program a year after the Turing Test was first published. He developed the game Checkers by running it on a computer. The University of Cambridge's Anthony Oettinger then created a computer simulation experiment that mimics the human shopping experience in multiple stores. The goal of this simulation was to gauge the computer's capacity for learning, and it was the first successful application of machine learning. (Fahmi, 2023, p. 294)

John McCarthy, who is credited with coining the term, was at the forefront of the first AI conference held by computer scientists in America at Dartmouth in 1956, where the term was formally introduced for the first time. McCarthy created an artificial programming language in 1958, and it subsequently became the common language used in all real-world artificial intelligence applications (Yasmin, 2022, pp. 26-27).

Research in artificial intelligence developed further in the 1960s, during which many programs were created to solve various problems such as (Yasmin, 2022, p. 27):

- Proving and testing mathematical theories.
- Solving puzzles.

- Early attempts at machine translation.

The first time a computer beat a human opponent at chess was in 1997. In the early years of the twenty-first century, the development of artificial intelligence accelerated to the point where interactive robots were sold in retail establishments. Furthermore, it went beyond that to the creation of robots that interact with various emotions via facial expressions, among other robots that started to carry out challenging tasks like the one that searches in remote areas of the South Pole and meteorite sites in the vicinity. (Fahmi, 2023, p. 294).

2. Definition of Artificial Intelligence

One of the areas of computer science and one of the main tenets upon which the modern technology sector is built is artificial intelligence (AI). It is described as:

"The ability of machines and computers to perform specific tasks that simulate and resemble those carried out by intelligent beings, such as the ability to think or learn from past experiences or other processes that require mental operations. Artificial intelligence also aims to develop systems that possess intelligence and behave in a way similar to humans in terms of learning and understanding, so that these systems provide users with various services such as education, guidance, interaction, and so on. (Zoubi, 2022, pp. 41-42)"

It is also defined as:

"The intelligence acquired by machines and programs through self-learning, which qualifies them to simulate some human mental abilities, allowing them to perform certain tasks that humans do without any programming intervention. It is a name given to any computer system trained to simulate intelligent human behavior and refers to systems and devices that mimic human intelligence to perform tasks and can improve themselves based on the information we collect. (Kabeer, 2023, p. 182)"

From the above definitions, we notice that artificial intelligence is sometimes used synonymously with machine learning and deep learning. However, they are not the same thing. This is confirmed by Yasmin Ahmed Amer Hassan, who sees that each has its own domain (Abdelkafi, 2022, pp. 22-23):

One area of artificial intelligence called machine learning is concerned with creating methods and algorithms that give computers the ability to learn and make software programs more accurate at forecasting results without explicit programming. Consequently, it is possible to argue that all machine learning methods are artificial intelligence, but not all AI methods are machine learning.

Deep Learning is a subfield of machine learning that allows machines to train themselves to perform specific tasks such as image and speech recognition by using neural networks. These are relatively complex mathematical algorithms that are suitable for solving problems that do not follow fixed mathematical rules and simulate the human mind in recognizing sounds, speech, and images.

To put it simply, machine learning is a subfield of artificial intelligence, deep learning is a subset of machine learning, and artificial intelligence itself is the larger and more comprehensive field.

According to every prior definition, artificial intelligence is:

- One area of computer science.
- Concerned with designing devices, systems, and applications capable of performing intelligent tasks.
- Involves machines possessing the ability to self-learn.

3. Characteristics of Artificial Intelligence

Artificial intelligence possesses numerous characteristics that have made it an effective investment across many fields (Fahmi, 2023, p. 299):

- When AI is applied to machines and devices, it allows them to use logic to plan and analyze issues.
- It has the ability to move objects and recognize speech and voices.
- AI-enabled gadgets are able to comprehend and carefully evaluate inputs to produce outputs that effectively satisfy user needs.
- Because the learning process is automatic and self-directed and doesn't require oversight or monitoring, it allows for continuous learning.
- It is capable of processing large volumes of information it encounters.
- It is more adept than the human brain at identifying and analyzing similar patterns in data.
- It can use its cognitive abilities to solve problems that are unfamiliar to it.

Additionally, AI is characterized by other features, including (Mokhledy, 2025, p. 90):

- Learning and understanding from past experiences.
- Applying previous experiences in new situations.
- Responding quickly to new circumstances and conditions.
- Handling difficult and complex cases and finding appropriate solutions for them.
- Providing the necessary information to make the right decisions at the right time and place
- The ability to think, reason, and express itself using natural language.
- The ability to interact and deal with the surrounding environment and its specific characteristics.
- The capacity to swiftly and effectively process data and carry out computations.

4. Objectives of Artificial Intelligence

Two key points can be used to summarize artificial intelligence's objectives (Yasmin, 2022, pp. 33-35):

- Making it possible for machines to process data similarly to how people solve problems.
- Achieving a better understanding of the nature of human intelligence by unlocking the mysteries of the brain, in order to simulate it more easily.

These two goals aim to produce intelligent systems and software that imitate human behavior in the following traits:

- **Thinking Ability:** Computational Thinking (CT) – a problem-solving approach that relies on computer science techniques and can be used to find algorithmic solutions to complex problems.
- **Visual Perception (Seeing Ability):** Computer Vision – enabling computers to "see" and recognize surrounding objects. Applications of this include robots that can identify and move items from one place to another. Today, it's possible to equip software and devices with very precise information that humans might not notice. An example is the Eliza system for psychotherapy, which can recognize patients' facial expressions to detect emotions such as sadness or happiness. Another example is modern software like Seeing AI, used by visually impaired individuals to identify and describe objects around them.
- **Hearing Ability:** Aims to make computers more interactive with humans by understanding and communicating in human language. Examples include Siri and Cortana – AI-based personal assistant programs where users ask questions in natural language. The program recognizes the user's voice, processes the request, and replies in natural language.
- **Speaking Ability:** The goal here is to equip computers with the ability to understand human speech from external audio inputs, reconstruct it, and respond appropriately – essentially understanding human language naturally.

- **Mobility and Movement:** Researchers aim to design robots with movement capabilities as a core function, integrating other AI techniques to enhance their ability to walk and interact physically with their environment.

5. The Importance of Artificial Intelligence

Artificial intelligence technologies can undoubtedly have a positive impact on our lives through a range of benefits, including the following:

- Transferring human expertise to smart machines for storage and preservation.
- Reducing risks and psychological stress for humans, as smart machines can perform arduous tasks that are difficult for humans to accomplish, in addition to tasks that are complex and require high concentration and strong mental effort.
- Facilitating communication between humans and machines. Instead of using complex programming languages, humans can use natural language to communicate with smart devices, making them accessible to all segments of society, including individuals with special needs, whereas dealing with devices was previously limited to programmers and specialists.
- Assisting in diagnosing diseases and prescribing medications, interactive education, professional and legal consultations, etc (Yasmin, 2022, p. 32).
- Predicting weather conditions intelligently and accurately and monitoring changes in it.
- Assisting in warning against natural disasters and creating disaster simulations to better understand and work more effectively to protect people from them.
- It is possible to eliminate human casualties in wars, as there are predictions that machines and robots will replace human armies in military defense and attack.
- These AI technologies are a fascinating blend of creativity and technology, and they will undoubtedly open wider doors for innovation for humans.
- Completely eliminating any mathematical or technical errors that could cost millions or sometimes human lives, as simply not involving humans and fully relying on a smart machine will undoubtedly mean eliminating mistakes (Fahmi, 2023, p. 302).

6. Types of Artificial Intelligence

Based on its capabilities and functions, artificial intelligence can be categorized.

In terms of ability: Artificial intelligence is classified according to the abilities it possesses into three types (Fahmi, 2023, p. 300):

Artificial intelligence that can accomplish specific and well-defined tasks, like self-driving cars, speech or image recognition software, or even the chess game on smart devices, is known as limited or narrow artificial intelligence. Nowadays, this kind of artificial intelligence is the most prevalent and accessible.

General Artificial Intelligence: This type focuses on giving the machine the ability to think and plan independently, much like a human, and can operate with capabilities similar to human thinking. There aren't any real-world examples of this kind, though, as all that has been done thus far is research that will take a lot of work to develop and make a reality. One approach to studying general artificial intelligence is the artificial neural network method, which entails building artificial neural systems for machines that resemble the human body.

Superintelligent Artificial Intelligence: This type of AI may be more intelligent than humans and is able to outperform specialized and knowledgeable humans in certain tasks. This type must have a number of qualities, including the capacity for learning, planning, automatic communication, and judgment. Nevertheless, the idea of superintelligent artificial intelligence is speculative and nonexistent in the modern world.

Regarding its functions, artificial intelligence can be divided into four categories, which are as follows (Fahmi, 2023, p. 301):

Interactive Machines: The simplest kind of artificial intelligence is that of interactive machines, which are incapable of learning from past trials or experiences to enhance subsequent tasks. To get the best result, it combines with existing experiences. Google's Alpha Go system and IBM's Deep Blue devices are two examples of this kind of intelligence.

Limited Memory: Artificial intelligence with limited memory has a finite amount of time to retain information from prior experiences. One of the best examples of this kind is the self-driving system, which stores the vehicle's last speed, its distance from other vehicles, its top speed, and other information required for road driving.

Theory of Mind: The focus of this kind of AI is on how well the machine interacts and communicates with humans, as well as how it comprehends human emotions. It is important to note that this kind of artificial intelligence does not yet have any real-world uses.

Self-Awareness: This type of artificial intelligence is a prediction for the future, where machines will become more intelligent than humans by developing self-awareness and particular emotions. This idea is not yet a reality.

IV- Use of Artificial Intelligence in Scientific Research:

1. Applications of Artificial Intelligence and its Tools in Scientific Research:

Artificial intelligence has a wide range of exciting uses in scientific research, including (Mokhledy, 2025, p. 95):

- **Data analysis and knowledge extraction applications:** Machine learning tools and data mining allow for extracting useful patterns and relationships from large datasets, which contributes to discovering new knowledge and research hypotheses.
- **Applications for simulating complex phenomena:** Such as using neural networks to simulate the behavior of living cells or processing complex climatic and environmental phenomena to understand them and predict their behavior.
- **Natural language processing applications:** Such as summarizing scientific research content, classifying it, and indexing it automatically using deep learning algorithms.
- **Decision support applications:** Such as using predictive models to recommend the best research applications or to prioritize spending on scientific research.
- **Applications for accelerating scientific discoveries:** Through the rapid simulation of laboratory experiments or self-learning mechanisms capable of independently formulating and testing research hypotheses.

Researchers and academic institutions can benefit from artificial intelligence applications in scientific research by:

- Accelerating the pace of discoveries and research results thanks to the ability of AI technologies to process vast amounts of data and find patterns and relationships between variables in record time.
- Increasing the accuracy of predictions and models, as big data allows for building more accurate AI models and algorithms through training on larger and more comprehensive datasets.
- Reducing research costs by replacing many laboratory experiments with computer simulations at a lower cost.
- Supporting collaborative research between different disciplines and institutions, thanks to the ease of sharing large amounts of data.

- The emergence of new research fields as a result of the intersection of computer science, statistics, and other fields.
- Broader dissemination and distribution of research results through the provision of open access data platforms.

Recently, several AI tools have appeared that researchers rely on in their scientific research, including:

- Academic writing and paraphrasing tools.
- Proofreading and spelling tools.
- Machine translation tools for texts.
- PDF merging and formatting tools.
- File and text searching tools.
- Mind mapping, graphics, presentations, and indicators tools.

2. The Importance of Artificial Intelligence in Scientific Research :

Artificial intelligence's significance becomes apparent in a number of ways through the tools and applications it has and can use in scientific research, including (Brima, 2024, p. 248):

- Artificial intelligence can comprehend researchers' questions more quickly and provide more precise and effective responses thanks to natural language processing techniques.
- AI tools enable researchers to analyze massive amounts of data faster and more accurately than traditional methods .
- IT teams can rely on artificial intelligence to collect information derived from various sources, saving researchers time and effort in preliminary research .
- Artificial intelligence helps reduce human errors and improve scientific research .
- Artificial intelligence focuses on providing techniques that allow machines to perform tasks that were previously assigned to researchers .
- Artificial intelligence can be used to improve the user experience through digital assistants and chatbots that respond to questions easily and efficiently .
- Artificial intelligence can contribute to accelerating the pace of scientific discoveries by designing experiments and generating new hypotheses, while also enhancing scientific collaboration among researchers.

Additionally, the importance of artificial intelligence in scientific research is highlighted through the role it plays in providing numerous possibilities for scientific research, which can be summarized as follows (Al-Kabir, 2023, p. 60):

- Artificial intelligence allows for the analysis of vast amounts of data with precision and efficiency, helping to extract new information and discover patterns and relationships that were not previously apparent.
- Artificial intelligence helps researchers design more accurate scientific models and conduct virtual simulations that reduce the need for actual experiments .
- Artificial intelligence can improve the performance of scientific devices and data analysis more efficiently .
- Artificial intelligence enables the prediction of results and forecasting future trends in various scientific fields, helping to make informed decisions .
- Artificial intelligence can also improve the academic writing process through language correction, grammar checking, formatting, organizing, reviewing, and editing.

3. Challenges of Benefiting from Artificial Intelligence in Scientific Research:

Even though artificial intelligence has a lot to offer scientific research, there are certain issues that need to be taken into account to guarantee its responsible and efficient application. The primary difficulties consist of (El-Mahdy, 2021, pp. 139-140):

- The high expense of maintaining, upgrading, and utilizing artificial intelligence tools.
- Concerns about the behaviors and practices related to ethics and human values that may arise from reliance on artificial intelligence tools.
- The inability of AI systems and their applications to change or develop their work systems when receiving the same data repeatedly, which could make them ineffective at certain stages.
- The replacement of many human workers due to reliance on artificial intelligence applications instead of humans, leading to an increase in unemployment as job opportunities are reduced.
- The need for a digital infrastructure for artificial intelligence applications in scientific research, which is not available in most research institutions, especially in cities and rural areas.
- The scarcity of specialists in developing artificial intelligence programs for scientific research.

4. Guidelines for Using Artificial Intelligence in Scientific Research:

There is no doubt that artificial intelligence, with its applications and tools, plays a vital role in scientific research. However, this role depends on how we use and benefit from this resource. It should not be used randomly; a set of guidelines must be followed to achieve the desired benefit from its use, including the following (Lotfi, 2023, pp. 47-52):

4.1 In terms of reliability and data protection used by artificial intelligence:

To ensure the reliability of data, we must:

- Verify the source of the data: The data's source must be verified for accuracy and authenticity, ensuring that it comes from trusted scientific references. The accuracy of the data must be checked to ensure it matches the adopted reference standards.
- Correct data transfer: Researchers must ensure the accuracy of the information they rephrase or transfer using artificial intelligence techniques. The researcher must also demonstrate their character and precision in conveying information accurately and without distortion.
- Specify the formats used: Researchers should choose formats that preserve texts and prevent theft or modification, such as protected PDF formats or using smart reader applications that prevent copying data.
- Data protection: Data must be protected from theft or manipulation, and it must be used in accordance with the applicable laws and regulations, while ensuring it benefits scientific research according to research ethics standards.
- Authorized use: Researchers must ensure that the use of data is with the consent of its owners when quoting or citing it in scientific research, adhering to relevant local and international regulations.

By following these guidelines, researchers can benefit from artificial intelligence technologies in a reliable and secure manner, while maintaining the confidentiality and integrity of the data used.

4.2 In terms of protecting individuals from artificial intelligence violations:

Protecting individuals from violations of artificial intelligence requires taking necessary measures to ensure their safety and privacy, including:

- Ensuring no harm comes to individuals, whether they are researchers or participants in a research study, and ensuring their physical and psychological well-being.
- Protecting individuals' data and privacy from violations by following appropriate security measures, encryption, and applying privacy policies.
- Complying with local and international laws and regulations related to data protection and individual rights, and ensuring alignment with these laws when using smart technology.
- Ensuring that smart technologies are not misused or individuals' rights are violated, and that they are not exploited for research purposes without their consent.

4.3 In terms Justice within the Ethics of Artificial Intelligence:

The following are key aspects of justice in the ethics of artificial intelligence:

- Justice in demographic coverage when selecting study samples.
- Justice in dealing with the sample regardless of gender, color, or race.
- Justice in the design of research, data collection, understanding, and analysis.
- The necessity of human involvement in interpreting results.
- Accountability when using artificial intelligence.

4.4 In terms of Transparency:

When artificial intelligence is used in scientific research, transparency guarantees that users are aware of how the technology functions and how findings are produced. It assists in averting possible harm and permits human intervention when required. To attain transparency and interpretability, this involves examining and validating data and training systems.

4.5 In terms of Integrity:

When using artificial intelligence applications in scientific research, integrity is essential, particularly in the following situations:

- Intellectual property rights and plagiarism issues.
- Determining the responsibility for scientific works produced by artificial intelligence software, such as writing books, scientific theses, and confidential articles.

4.6 In terms of Confidentiality:

Researchers using artificial intelligence applications must ensure the following:

- Algorithms do not violate privacy and data confidentiality.
- There are systems in place to interpret the data needed for AI to perform its tasks.
- Do not copy or obtain encryption systems from the service provider.
- Verify the identity or data of the AI system before using it.

Based on these guidelines, we can say that we are now living in a new technological era the era of artificial intelligence. It is important for research institutions to be prepared to benefit from AI applications across various fields of research. Here are some recommendations for research institutions in this regard (Lotfi, 2023, pp. 69-70):

- We recommend that universities and research centers recognize artificial intelligence applications as a legitimate partner for those working in the field of scientific research.
- We recommend that research institutions introduce researchers to smart search engines and guide them in using AI applications for summarizing scientific articles and books, generating academic content, analyzing data, and other beneficial research uses.
- We advise universities and research centers to organize comprehensive workshops and courses to train all their members on using AI applications. These courses should include content related to the legal and ethical frameworks recognized within the institution and should be part of the criteria for faculty promotion.

- We recommend organizing awareness campaigns, training courses, and programs to raise awareness of research ethics and how to responsibly handle AI applications. These campaigns should focus on the ethical issues and challenges that may arise from relying entirely on these applications in conducting research and writing scientific papers.
- A university course on artificial intelligence and its ethics should be a mandatory requirement for students, contributing to raising awareness and deepening students' understanding of this evolving field.
- We suggest placing increasing attention on the software and applications of AI in universities to ensure that students are trained to develop these applications and their associated software.

V- Conclusion:

There are many promising applications and tools for artificial intelligence that can be relied upon in scientific research. These tools and techniques have demonstrated the growing importance of AI and the significant services it can provide to enhance the efficiency of academic research, both in terms of quality and quantity.

Even though AI has many advantages for scientific research, there are a number of issues that must be resolved to guarantee its efficient and responsible application. Stated differently, the use of AI tools and applications in scientific research should not be haphazard; rather, it must adhere to a set of rules in order to yield the intended results.

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