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Short Communication

Biotechnology Section

Past, Present and Future Perspective of Artificial Intelligence in Healthcare and Nanotechnology: A Communication

MANSI JAIN[1], SAKSHI VATS[2], CHHAVI PAHWA[3], AKSH CHAHAL[4], KAMRAN ALI[5]

ABSTRACT

Artificial Intelligence (AI) is an emerging technology that has the potential to impact all professions, including medicine and medical education. Over the last decade, there has been a multiple-fold increase in the use of AI tools in medical allied sciences and rehabilitation, as well as in nanotechnology research. This paper highlighted some of the AI-based outcomes in bioengineering, neuroscience, and related disciplines. In addition, current trends and future perspectives of AI-based applications will also be discussed. Consequently, fundamental concepts in AI, its contributions, and the promise of nanotechnology coupled with AI will be summarised.

Keywords: Bioengineering, Education, Neuroscience

INTRODUCTION

The AI is a term used to describe the use of computers and technology to stimulate intelligent behaviour and critical thinking similar to that of human beings [1]. It refers to a machine's or software's ability to mimic intelligent human behaviour, perform calculations instantly, solve problems, and evaluate new data based on previously evaluated data [2]. Alan Turing is one of the founders of modern computers and AI, while John McCarthy is credited with coining the term in 1956 to describe the science and engineering of creating intelligent machines. The "Turing test" was created on the premise that intelligent computer behaviour involves the ability to perform cognitively demanding activities at a level equivalent to that of a human. Since then, AI has been emerging, particularly in the 1980s and 1990s [1].

With roots in logic, statistics, cognitive psychology, decision theory, neurology, linguistics, cybernetics, and computer engineering, AI is a vast interdisciplinary field. In 1956, a modest summer workshop at Dartmouth College marked the beginning of the contemporary discipline of AI. Since then, Machine Learning (ML), a subdiscipline of AI, has enabled advancements in Internet searches, e-commerce websites, recommender systems for goods and services, image and speech recognition, sensor technologies, robotic devices, and cognitive Decision Support Systems (DSSs) [3].

Most people agree that AI began with the development of robots. In 1921, author Karel Čapek coined the word "robot", pronounced "robota" in Czech, which represented a factory where forced labour was provided by biosynthetic machines. The term "robot" was popularised by Isaac Asimov in the mid-20th century while compiling a collection of contemporary science fiction short stories. Surprisingly, the first record of a humanoid automaton dates back to the third century in China, when Yan Shi, a mechanical engineer, presented a human-shaped mechanical figure made of wood, leather, and artificial organs to Emperor Mu of Zhou [4].

In the field of medicine, AI can be categorised into two groups: virtual and physical. Applications like electronic health record systems and neural network-based treatment decision guidance are examples of the virtual aspect, whereas the physical aspect includes aged care, intelligent prosthetics for the disabled, and robots assisting in surgery [1]. With the passage of time, nanoscience, biology, and information sciences are becoming increasingly important for modern scientific and technological growth [5]. The idea that biology, AI, and nanotechnology will combine to create a new technical and scientific revolution has been around for more than a decade. However, this anticipated integration of interdisciplinary research is still a work in progress.

While AI has significantly relied on biological inspiration to construct some of its most effective paradigms, such as neural networks and evolutionary algorithms, nanotechnology integrates understanding from physics, chemistry, and engineering. Establishing a connection between AI and existing nanosciences can advance research in both fields, potentially producing a new wave of information and communication technologies that will significantly impact our society. This integration may also pave the way for the eventual fusion of technology and biology [6].

AI paradigms are being applied to nanotechnology research for several reasons. The physical constraints of working at a scale where physics operates differently from the macroscopic world present challenges in nanotechnology. One such challenge is the accurate interpretation of the data produced by any system or device at this scale [6].

Ethics of Artificial Intelligence (AI)

The AI applications in healthcare, such as imaging, Electronic Medical Records (EMR), laboratory diagnosis and treatment, physician intelligence augmentation, new drug discovery, preventive and precision medicine, extensive biological data analysis, process acceleration, and data storage and access for health organisations, have radically transformed the medical field. Along with the benefits, certain challenges arise, including moral and legal issues that the scientific sector must address. Even though AI has advanced tremendously within communities and has the potential to improve treatment outcomes, not all cultures can afford it. Additionally, it is important to highlight the stigmas that arise while utilising AI, including moral dilemmas, privacy and data protection, informed consent, social disparities, medical consultation, empathy, and sympathy. Thus, practitioners and experts should consider the four medical ethical principles-autonomy, beneficence, non maleficence, and justice-in all aspects of healthcare before incorporating AI into the healthcare system [7].

Privacy and data protection: The European Union (EU) was the first to establish the General Data Protection Regulation (GDPR), which modified privacy laws in various nations, including the US and Canada. In accordance with these regulations, union-based data

processors or controllers handle all personal data as well as the operations of foreign communities and businesses to adequately secure the information of natural persons.

In practice, AI plays a crucial role in expediting health research efforts, improving diagnosis and outcomes, and analysing consumer health data and medical device images [7]. The appropriate use of AI-driven data security measures can also help to prevent phishing and malware attacks. AI tools can quickly identify suspicious links in phishing emails by thoroughly scanning the messages. This includes analysing the message content, attachments, links, metadata, and the sender of the email.

The ML and AI are also capable of identifying malware, ransomware, and advanced persistent threats. They can easily analyse large amounts of historical data to generate predictive patterns of cyberattacks. Moreover, AI can help develop countermeasures for threats as soon as it detects an abnormal pattern. For this reason, many enterprises use AI and ML for real-time analysis and monitoring of user data workflows. This approach helps to create more robust intrusion-detection systems, enabling network administrators to identify attacks and respond to them immediately [8,9].

Informed consent and autonomy: When a patient and healthcare professional engage in a communication process, informed consent should mandate the documentation of consent, the discussion of ethical issues, and the demonstration of decision-making ability and competency [10]. United States (U.S) informed consent law provides guidance on what information patients should receive before consenting to medical procedures or treatments. According to this law, the involvement of AI in a patient's health should be disclosed, but the extent of disclosure depends on the specific case. AI systems can be opaque, making it challenging for patients to understand their inner workings. To enhance patient autonomy, it is essential to provide understandable explanations centered on the patient's informational needs. Patients should have sufficient information to make informed decisions and consent to treatment [11].

As per the definition of ethical responsibility, patients are entitled to receive information about their diagnoses, health status, treatment plans, therapeutic outcomes, test results, expenses, health insurance coverage, and other medical details. Any consent provided by the patient should be clear, unambiguous, and specific regarding the intended use. Based on the principle of autonomy:

- Every individual has the right to know about all available and applicable treatment procedures.
- Patients should be aware of the course of the treatment procedure, any possible or potential risks associated with imaging and screening, programming errors, errors in data acquisition, data privacy, and access control, particularly regarding the protection of significant portions of genetic information obtained through genetic testing.
- Patients have the right to refuse treatment at any moment of time.
- Patients also have the right to know who bears the responsibility for malfunctions or errors in robotic medical devices. This response is critical to patient rights and the healthcare industry's workforce [12].

Medical consultation, empathy, and sympathy: The integration of AI in healthcare appears to be challenging and unachievable across the board [13]. It is not feasible for doctors and other healthcare professionals to consult with one another via autonomous (robotic) systems. Furthermore, it seems unrealistic that patients would choose "machine-human" interactions over "human-human" medical relationships. The compassionate and empathetic treatment that physicians and nurses are required to deliver significantly impacts patients' ability to recuperate. This level of care cannot be achieved with robotic doctors and nurses. When interacting with robotic healthcare providers, patients may not exhibit empathy, politeness, or appropriate behaviour, as these machines lack essential human qualities like compassion. This represents one of the biggest drawbacks of AI in the field of medicine [13].

Social gaps and justice: The issue of social gaps is another challenge that society faces as AI continues to develop. Every advancement, innovation, and discovery makes individuals in every nation more vulnerable to social injustice and inequality. While AI increases access to information on science, technology, global politics, events, and climate change, it also exacerbates social inequality [2,6].

Artificial Intelligence (AI) in Nanotechnology

The AI is significantly dependent on biological inspiration to construct effective paradigms, such as neural networks and evolutionary algorithms, as well as on nanotechnology, which combines an understanding of physics, chemistry, and engineering. Building a bridge between AI and existing nanosciences can advance research in both fields and generate a new wave of information and communication technologies, significantly influencing society and potentially paving the way for the fusion of technology and biology [6].

Robotic

When assessing how human performance has changed in circumstances such as rehabilitation, robots have been shown to be helpful. AI can also be utilised to monitor the targeted distribution of medications to specific organs, tissues, or tumours. The recent development of nanorobots designed to address delivery issues related to therapeutic agents targeting particular regions is a promising advancement. This issue often arises when a therapist attempts to treat the core of a tumour, which is typically the most proliferatively active yet least vascularised and anoxic area. Therapeutic nanoliposomes can be covalently attached to these nanorobots. According to initial data, the gradient of the required medication into the hypoxic zones has significantly increased [4].

Artificial Technology Nano Computing

When AI is combined with current and future nanocomputing-meaning computation using nanodevices-it results in a wide range of potential applications. AI paradigms have been applied to various stages of modeling, designing, and constructing nanocomputing device prototypes since the first attempts to create nanocomputers [14]. Machine learning techniques applied to nanotechnology, rather than semiconductor-based hardware, may also serve as the foundation for a new wave of more affordable and compact technology capable of performing high-performance computing tasks, including control and sensory data processing.

At least three distinct techniques are typically included in the notion of natural computing. These are:

- Approaches that draw inspiration from nature to create innovative methods of problem-solving;
- Approaches that rely on computer simulations of natural events;
- Approaches that use nanoscale natural materials for computation.

The last idea encompasses methods that are currently being thoroughly researched, such as quantum computing and Deoxyribonucleic Acid (DNA) computing [6].

Artificial Intelligence (AI) in Healthcare

There are two primary areas of AI application in medicine: virtual and physical. ML, also known as deep learning, is a virtual component represented by mathematical algorithms that enhance learning through experience. There are three categories of ML algorithms:

(1) unsupervised learning, which involves identifying patterns; (2) supervised learning, which uses prior examples to classify and predict; and (3) reinforcement learning, which involves using a series of rewards and punishments to create a strategy for operating within a particular problem space. By offering ML algorithms and knowledge management, AI has aided and continues to aid in genetics and molecular medicine discoveries [4].

The second way that AI is being used in medicine involves physical medical equipment and increasingly advanced robots that assist in providing care (carebots). The use of robots as assistants—such as a robot companion for the elderly population experiencing cognitive decline or limited mobility—may be the most promising strategy. The most advanced models of this technology are carebots developed in Japan. Robots can operate independently or as assistants to surgeons during surgery. A remarkable illustration of the usefulness of robots is their capacity to converse with and instruct children with autism. Before AI robots can be used regularly in this case or in many others where robotic assistance could be beneficial, significant ethical issues must be addressed [4].

While the exact definition of AI is unknown, AI is generally understood to be a machine's ability to mimic intelligent human behaviour. Although many other types of computer science fall under this broad term, in medicine, one can primarily focus on the following terms:

- Imager processing;
- Computer vision;
- Artificial neural networks;
- Convolutional neural networks;
- Machine Learning (ML);
- AI in radiology;
- Targeted drug delivery [15];
- Cancer treatment [16].

The future of Artificial Intelligence (AI) in science: AI, coupled with nanotechnology, could be used in:

- Bioengineering;
- Information science;
- Hybrid technology;
- Neurosciences and cognitive studies;
- Sustainable and precision agriculture [17];
- Precision cancer medicine [18].

CONCLUSION(S)

In present article, the pros and cons of AI coupled with nanotechnology are consolidated, and the important work carried out in the last decade is summarised. In particular, a detailed discussion of the different challenges we face in teaching, research, and medical sciences, and how AI plays a vital role in solving them, has been conducted.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Physiotherapy, Starex University, Gurugram, Haryana, India.
2. Assistant Professor, Department of Allied Healthcare Sciences (Physiotherapy and Occupational Therapy), Vivekananda Global University, Jaipur, Rajasthan, India.
3. Assistant Professor, Department of Physics, School of Basic and Applied Sciences, IILM University, Greater Noida, Uttar Pradesh, India.
4. Professor, Department of Physiotherapy, School of Medical and Allied Health Sciences, Galgotias University, Greater Noida, Uttar Pradesh, India.
5. Associate Professor, Department of Physiotherapy, School of Medical and Allied Sciences, GD Goenka University, Gurgaon, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Mansi Jain,
Assistant Professor, Department of Physiotherapy, Starex University,
Gurugram-122413, Haryana, India.
E-mail: 12345jainmansi@gmail.com

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