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Review Article

The Impact Of Artificial Intelligence *(AI)*On Pharmaceutical Practices: A Comprehensive Review

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ABSTRACT

Artificial Intelligence (AI) is rapidly transforming various sectors, including healthcare and pharmacy, by enhancing efficiency, precision, and personalized care. This review article explores the integration of AI in pharmacy, highlighting its potential to revolutionize drug discovery, development, and delivery. Artificial Intelligence has emerged as a powerful tool for addressing data and number-related challenges, leading to numerous technological advancements across various fields, including engineering, architecture, education, accounting, business, and healthcare. In healthcare, AI has significantly advanced the management and storage of data and information, such as patient medical histories, medication inventories, and sales records. Additionally, AI has played a crucial role in the development of automated machines, software, and computer applications, including diagnostic tools like MRI and CT scanning technologies, which have streamlined healthcare processes. AI has undeniably transformed healthcare, making it more effective and efficient, with the pharmacy sector benefiting as well. In recent years, there has been a growing Interest in the application of AI technology in key areas of pharmacy, such as drug discovery, dosage form design, polypharmacology, and hospital pharmacy. Recognizing the increasing significance of AI, we aim to create a comprehensive report that will help practicing pharmacists understand the most significant breakthroughs made possible through the use of AI in their field.

INTRODUCTION

Background

A crucial aspect of intelligence is the ability to reason logically, which has been a central focus of AI research for a long time. A major breakthrough in this area was a theorem-proving program developed in 1955–1956 by Allen Newell, J. Clifford Shaw, and Herbert Simon at the RAND Corporation and Carnegie Mellon University. AI

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refers to the capability of a computer or computer-controlled robot to perform tasks that are typically associated with intelligent beings.[1] This term is often used in the context of developing systems with human-like cognitive abilities, such as reasoning, understanding, generalizing, and learning from experience. Since the 1940s, when the first digital computers were invented, it has been shown that computers can be programmed to perform highly complex tasks.[2] In today's pharmaceutical industry, drug development is a lengthy and expensive process, with most drugs costing billions of dollars and taking over a decade to reach the market. This makes drug development both time-consuming and costly. AI is seen as a promising solution to these challenges, potentially enabling more efficient drug development.[3] AI is being applied in innovative areas such as pharmaceuticals, prosthetics, and advanced robotics. In drug development, AI offers additional advantages, such as identifying drug targets, proposing molecules from data libraries with chemical modifications, and even repurposing existing drugs.[4]

Introduction

AI is a branch of science focused on intelligent machine learning, particularly intelligent computer programs, which produce results in a manner similar to human cognitive processes.[5] This typically involves gathering data, developing systems to effectively utilize that data, drawing precise or approximate conclusions, and making self-corrections and adjustments.[6] Generally, AI is applied to analyze machine learning in order to mimic human cognitive tasks. AI technology is used to perform more precise analyses and derive meaningful interpretations.[7] In this context, various statistical models and computational intelligence methods are integrated into AI technology. In recent years, AI technology has become a crucial element across various industries, playing a key role in many technical and research applications. Looking back over the past 25 years, the pharmacy sector has effectively met the rising demand for prescriptions despite challenges such as pharmacist shortages, increasing operational costs, and reduced reimbursements. The industry has successfully utilized automation technology to streamline workflows, reduce operating costs, and ensure safety, accuracy, and efficiency in all pharmacy environments. Automated dispensing systems have allowed pharmacists to spend more time engaging with a larger number of patients, improving their health outcomes.[8] The use of computers in pharmacy likely began in the 1980s, and since then, they have played a key role in various areas, including data collection, retail pharmacy management, clinical research, drug storage, pharmacy education, and clinical pharmacy. With the rise of artificial intelligence, the potential for further advancements in the pharmacy field is vast.[9] Numerous expert systems have been developed to assist doctors with medical diagnoses, and recently, several programs have been introduced to focus on drug therapy.[10] This article aims to review various topics related to artificial intelligence (AI), including a general overview and classification of AI, its applications in hospitals, the pharmaceutical industry, and retail pharmacies. Additionally, it seeks to raise awareness of AI as an integral part of future pharmacy practice, encouraging pharmacists to embrace this technology and actively work to develop the necessary skills that will enable them to contribute to the anticipated advancements in the field.

AI Goals:

- **Expert system development:**

It involves building automated systems that function intelligently and provide guidance to individuals on the best course of action.

- **Human intelligence in computers:**

It will help develop similar cognitive patterns, allowing them to act like humans and take appropriate actions to solve complex problems.

- **Multi domain application:**

AI will assist in the application of various fields, including psychology, medicine, ethics, natural sciences, healthcare, and others.[11]

The basic concept of AI in pharmaceutics:

AI developments can be divided into two main categories. The first involves technological approaches and software, like expert systems, which simulate human experience and make decisions based on predefined rules. The second category includes devices like artificial neural networks (ANNs) that replicate brain functions. A key benefit of ANNs is their ability to generalize.These characteristics make them excellent for dealing with issues relating to formulation optimization in the development of pharmaceutical products.

How does AI works:

Developing an AI system entails mimicking human traits and abilities in a machine, then leveraging its computational strength to exceed human performance. Gaining insight into the various AI subfields and their potential applications across different industries requires an in-depth exploration of the topic.

- **Machine learning (ML):**

ML trains a computer to make decisions and draw conclusions by using previous knowledge. It identifies patterns and analyzes past data to understand the relevance of these data points and reach a possible conclusion, without depending on human experience.[12]

- **Deep learning (DL):**

DL is a machine learning technique that gained renewed interest in the 2000s with the development of deeper neural networks. It trains machines to process inputs through multiple layers to classify, infer, and predict outcomes. DL enables understanding complex internal representations, which are essential for tasks like comprehending difficult language or analyzing objects. This is achieved by progressing through deep layers of activity vectors and identifying the connection strengths that drive these vectors, using methods such as stochastic gradient descent.[13]

- **Neural networks (NN):**

This systems that function similarly to human neurons. They consist of algorithms designed to imitate the workings of the human brain by understanding the connections between various underlying factors.[14]

- **Computer vision:**

By dissecting an image and examining various aspects of the item, computer vision algorithms attempt to comprehend an image. This aids the machine in classifying and learning from a collection of photos, enabling it to produce superior results based on prior observations.[15]

- **Cognitive computing:**

Aims to mimic human brain functions by analyzing text, audio, images, and other types of input. By doing so, these algorithms attempt to replicate human-like processing and deliver the intended outcomes. Additionally, consider enrolling in free courses on AI applications.[16]

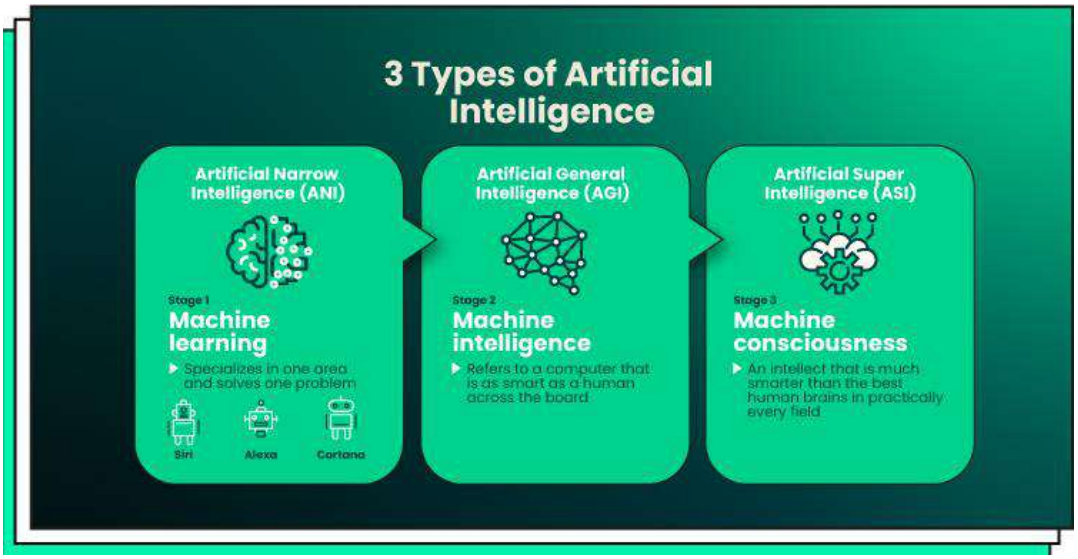

Fig no 1 3 types of AI

1. Weak Intelligence, or Artificial Narrow Intelligence (ANI), refers to systems designed and trained to perform specific tasks, such as facial recognition, driving, playing chess, or managing traffic signals. Examples include virtual assistants like Apple's Siri and social media tagging systems.
2. Artificial General Intelligence (AGI), also known as Strong AI or Human-Level AI, mimics human cognitive abilities and can solve unfamiliar problems when encountered, much like humans. AGI is capable of performing a wide range of tasks, just as people do.
3. Artificial Super Intelligence (ASI) surpasses human intellect, excelling in every field from mathematics to art. It could range from being slightly smarter than humans to being trillions of times more intelligent.

Applications of AI

AI in diagnosis and targeted genomic treatments

- **Maintaining of medical records:**

Maintaining patient medical records is a complex task that can be streamlined through the use of AI systems. AI helps simplify the processes of collecting, storing, organizing, and retrieving data. Google's DeepMind Health project, for instance, enables quick access to medical records, facilitating more efficient healthcare. This project has supported Moorfields Eye Hospital NHS in enhancing eye treatment.[17]

- **Treatment plan designing:**

In designing treatment plans, AI plays a crucial role, especially in critical patient cases where choosing an appropriate treatment can be challenging. AI systems analyze past data, reports, and clinical expertise to assist in creating effective plans.IBM Watson for Oncology, a cognitive computing decision support system, evaluates patient data based on thousands of historical cases and insights developed through collaboration with physicians at Memorial Sloan Kettering Cancer Center. It provides oncology clinicians with treatment options backed by literature curated from over 300 medical journals, 200 textbooks, and nearly 15 million pages of text.[18]

- **Health support and medication assistance:**

Health support services and medication assistance have increasingly benefited from AI technology in recent years. Molly, a virtual nurse developed by a start-up, features a friendly voice and warm demeanor, designed to assist patients in managing their treatment and provide support for chronic conditions during doctor visits. Ai Cure, a smartphone app using the device's webcam,

monitors patients and helps them manage their conditions. This app is especially useful for patients with complex medication regimens and those participating in clinical trials.[19]

- **Accuracy in medicine:**

AI has made significant advancements in the field of genomics and genetic research. Deep Genomics, an AI system, helps identify patterns in genetic information and medical records, allowing it to detect mutations and their links to diseases[20]. This system provides doctors with insights into cellular changes caused by genetic variations. Craig Venter, known for his role in the Human Genome Project, developed an algorithm that predicts a patient's physical traits based on their DNA. Additionally, AI technology from Human Longevity aids in the early detection of cancer and vascular diseases by pinpointing their exact locations.[21]

- **Healthcare system analysis:**

In the healthcare system, having all data digitized allows for easy retrieval. In the Netherlands, 97% of invoices, which include treatment details, physician names, and hospital information, are stored digitally. As a result, accessing this data is simple. Zorgprisma Publiek, a local company, uses IBM Watson cloud technology to analyze these invoices. If any issue arises, the system quickly identifies it and takes the appropriate action, helping to prevent patient hospitalization and improve care outcomes.[22]

AI and development of pharmaceuticals:

Leading pharmaceutical companies are increasingly collaborating with AI vendors to integrate AI technology into their manufacturing processes, research, and drug discovery efforts. According to reports, about 62% of healthcare organizations are planning to invest in AI soon, and 72% believe it will be vital for future business operations. Pharma News Intelligence explores current AI applications, optimal uses of the technology, and its future in the sector. The McKinsey Global Institute estimates that AI and machine learning could add nearly $100 billion annually to the U.S. healthcare system. Experts suggest that these technologies enhance decision-making, boost innovation, improve the efficiency of research and clinical trials, and provide valuable tools for physicians, patients, insurers, and regulators. Major pharmaceutical companies like Roche, Pfizer, Merck, AstraZeneca, GSK, Sanofi, AbbVie, Bristol-Myers Squibb, and Johnson & Johnson have already partnered with or acquired AI technologies. In 2018, MIT teamed up with Novartis and Pfizer to revolutionize drug design and manufacturing through its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium.[23] Research is continuously conducted to discover new active compounds for diseases and conditions that currently have no cure, enhance the safety of existing medications, address drug resistance, and reduce treatment failures. As a result, the size and diversity of biomedical datasets used in drug development have grown. These factors, among others, have driven the progress of AI in the pharmaceutical industry. Today, several companies provide software that plays a crucial role in drug development, data analysis, and predicting treatment outcomes.[24] GNS Healthcare utilizes an AI software called Reverse Engineering and Forward Simulation (REFS) to identify cause-and-relationships within various types of data that are not easily detected through direct analysis. REFS processes vast amounts of data, including clinical, genetic, lab, imaging, drug, consumer, geographic, pharmacy, mobile, and proteomic information.Meanwhile, Atomwise, another company, developed AtomNet, the first deep learning neural network for structure-based drug design and discovery. AtomNet analyzes millions of experimental affinity measurements and protein structures to predict how small molecules will bind with proteins. By providing 3D representations of

protein-ligand pairs, AtomNet aids pharmaceutical chemists in key drug discovery tasks such as hit discovery, lead optimization, and toxicity prediction, significantly speeding up the process from years to weeks.[25] Insilico Medicine launched an AI initiative called Pharm AI, employing Generative Adversarial Networks (GAN) and reinforcement learning algorithms. GANs consist of two neural networks: a generator that creates new samples and a discriminator that classifies them as real or fake. As the generator improves at producing realistic samples, the discriminator becomes more adept at distinguishing between real and generated data. Using this approach, Insilico Medicine claims Pharm AI can generate new molecular structures and explore the biological basis of diseases.[26,27]

AI in pharmacy practice in hospital and community pharmacies

Machine learning models enable email personalization at a speed and accuracy beyond human capability. Chatbots can be used to enhance service delivery efficiency by simulating interactions between customers and customer service or sales staff. These bots can autonomously resolve customer complaints and queries, escalating complex issues to human employees. In retail pharmacy, chatbots could be designed to simulate pharmacist-patient interactions.[28] Walgreens, for example, partnered with Medline, a telehealth company, to offer patients access to healthcare professionals through video chats. AI is also valuable for inventory management. Imagine, as a retail pharmacist, being able to predict your patients' future needs, stocking necessary medications, and using personalized software to send reminder emails to patients about their drug requirements. By leveraging AI-powered data analytics, pharmacists can predict future drug purchases, allowing them to make more informed stock decisions.[29] While some pharmacy inventory management systems, such as McKesson, Liberty, Winpharm, PrimeRx, and WinRx, are widely used, not all incorporate AI or machine learning. For example, Blue Yonder, an AI firm, created software for Otto Group, a German online and catalog retailer. This software predicts with 90% accuracy what products Otto will sell in 30 days, reducing delivery times from a week to as little as two days by shipping directly from the supplier to the customer, bypassing warehouses.[30] At the University of California, San Francisco (UCSF) Medical Center, robotic technology is used to improve patient safety in medication preparation and tracking. Their robots have prepared 350,000 doses without error, surpassing human performance in both accuracy and efficiency. The robots are capable of preparing oral and injectable medications, including hazardous chemotherapy drugs, allowing pharmacists and nurses to focus on direct patient care and collaboration with physicians. In UCSF's automated pharmacy system, computers receive medication orders electronically, and robots pick, package, and dispense individual doses. These doses are then organized on a bar-coded plastic ring, containing all the medications a patient needs over a 12-hour period. The system also prepares sterile chemotherapy drugs and fills intravenous syringes accurately.[31]

CONCLUSION

AI has proven its value across various areas of drug discovery, assisting scientists with the design, planning, quality management, maintenance, and control of pharmaceutical development and delivery. While it is not a cure-all or a solution that will cause immediate transformative change, AI has the potential to enhance efficiency, offer valuable insights, and introduce new perspectives to the drug discovery process. The pharmaceutical industry is currently experiencing a significant shift, with risks being carefully managed as new scientific approaches are developed. The success of AI in drug research and development will

depend on its ability to integrate diverse and unfamiliar areas. AI is also being applied in data management, drug discovery, diabetes treatment, and digital consultation. There is strong evidence that medical AI can significantly improve the delivery of healthcare for both doctors and patients in the 21st century.

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