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THE INTENSIFICATION OF ARTIFICIAL INTELLIGENCE IN PHARMACEUTICAL INDUSTRY

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ABSTRACT

Artificial Intelligence (AI) has become a popular remedy for issues involving numbers and data. Numerous technological advances have resulted from this discovery in almost every industry, including engineering, architecture, education, business, accounting, health, and so forth. AI has made significant contributions to the healthcare industry in a number of areas, including the management and storage of data and information about patient medical histories, medication stocks, sale records, and more; automated machinery; software and computer applications; and diagnostic tools like CT and MRI diagnostics. The goal of artificial intelligence (AI) is to create intelligent modeling, which facilitates knowledge imagination, problem solving, and decision making. These days, artificial intelligence (AI) is a major factor in many pharmacy domains, including polypharmacology, hospital pharmacy, drug discovery, and drug delivery formulation development. Different Artificial Neural Networks (ANNs), such as Deep Neural Networks (DNNs) or Recurrent Neural Networks (RNNs), are used in drug discovery and drug delivery formulation development. Currently, a number of drug discovery implementations have been examined, supporting the technology's potential in quantitative structure-property relationships (QSPR) and quantitative structure-activity relationships (QSAR).

Keywords: Hospital pharmacy, drug delivery research, drug development, artificial intelligence, and artificial neural networks

INTRODUCTION

Artificial Intelligence (AI) is a branch of research that deals with intelligent machine learning, mostly with intelligent computer systems that produce outcomes that resemble human attention **[1]**. In general, this process entails gathering information, creating effective methods for using that information, presenting precise or approximative conclusions, self-corrections, and changes **[2]**. AI technology is used to obtain meaningful interpretation and to conduct studies that are more accurate **[3]**.

AI technology has recently grown to be a vital component of the industry with practical applications in numerous technical and scientific domains. When looking back over the previous 25 years, pharmacies have done a fantastic job of meeting the rising demand for prescription drugs despite shortages of pharmacists, rising operating expenses, and declining reimbursements. Pharmacy has also done a fantastic job of utilizing technology automation to support safety, accuracy, and efficiency in every pharmacy setting, as well as to increase workflow efficiency and reduce operating costs. Pharmacists can interact with more patients and improve their health outcomes when automated dispensing saves them time **[4]**. It is likely that the first computer was used in a pharmacy in the 1980s. Since then, computers have been used in a variety of applications, including data collection, clinical research, retail pharmacy management, drug storage, pharmacy education, and much more. With the development of artificial intelligence, it is impossible to predict how much more the pharmacy industry will change over time. Several expert systems have been created in the medical field to help doctors diagnose patients **[5]**. A number of drug-focused programs have been reported recently **[6]**.

AI general overview

AI, or machine intelligence, is a word that is frequently used synonymously with automation and robots. Artificial intellect (AI) is the ability of any computer or machine to exhibit human-like behaviors or intellect, whereas robotics is just the construction of machines capable of performing complex repetitive tasks **[7]**. Artificial Intelligence is widely used in the creation of digital computers or computer-controlled robots that can do intellectual and cognitive tasks that humans can. These mental and cognitive functions include language, learning, reasoning, solving problems, and perception. Because it is solely intended to carry out specific activities, such as internet search,

voice and facial recognition, managing and operating cars, and so on, the type of artificial intelligence that is now in use is known as narrow AI or weak AI.

Knowledge engineering, which involves building robots with access to a wealth of data and information about the human environment so they may replicate human behavior, may be the foundation of artificial intelligence. Another kind of artificial intelligence is machine learning, which uses statistical models and algorithms to increase software programs' ability to predict outcomes accurately without requiring explicit programming. It was founded on the notion that computers are capable of learning from data, recognizing issues, and making judgments with little assistance or intervention from humans. Another branch of artificial intelligence is machine perception, which is the design and construction of machines that can infer knowledge about the various facets of the world from sensory inputs. Computer vision refers to a machine's capacity to interpret visual inputs, including motions, objects, and facial data **[8]**.

Pharmacy

Pharmacy science is one topic of study. Among the many customary responsibilities of pharmacists are preparing prescriptions and distributing them. It also covers more contemporary health care services like clinical services, prescription information, and safety and efficacy assessments of pharmaceuticals. Consequently, pharmacists are the primary healthcare providers that utilize medications for their patients in the most efficient manner and are experts in drug therapy. The goal of pharmacy is to ensure that medications are used in a safe, effective, and economical manner. It is the application and research of where to find, make, prepare, distribute, inspect, and track medications. Because it connects the natural sciences, pharmaceutical sciences, and health sciences, it is a miscellaneous science.

Combination of AI and Pharmacy

Pharmacists' attention can be significantly influenced by AI to move from distributing prescription drugs to offering a wider range of patient care services. Using AI, the pharmacist can assist patients in maintaining their health and getting the most out of their medications. Pharmacists can benefit from AI's ability to estimate prescription demand, manage their medication inventory, and spot possible drug interactions and side effects. This can assist pharmacists in managing medication regimens and prescribing drugs with more knowledge. The entire influence of artificial intelligence (AI) on the pharmaceutical industry may not yet be fully

felt by pharmacy frontline staff. Although speech pattern monitors and facial recognition software can be used to identify uncommon diseases, it's not like neighborhood pharmacies have these kinds of tools.

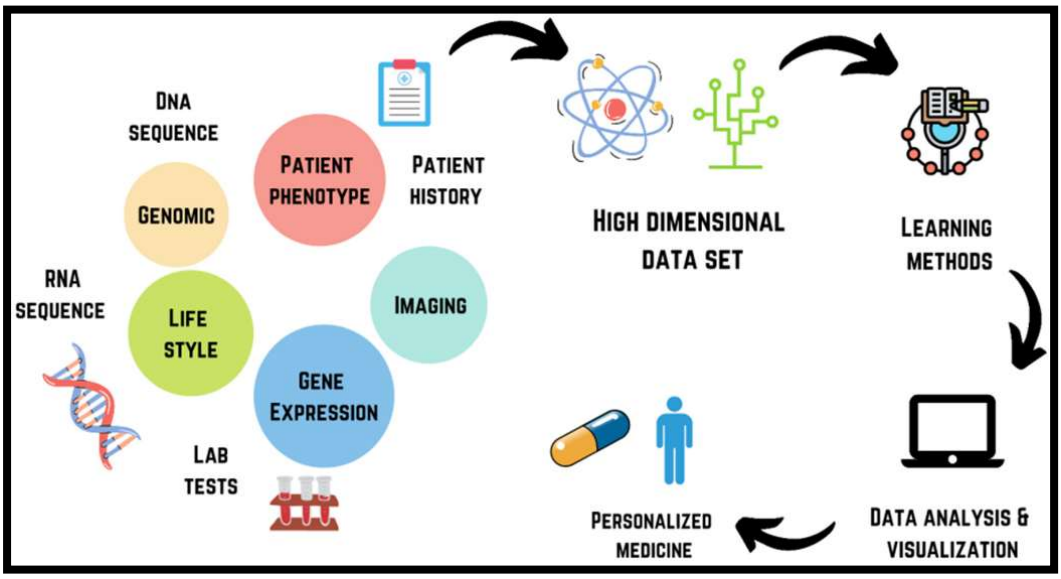

Figure 1: Combination of AI and Pharmacy

Existence of AI

AI has made significant contributions to the healthcare industry in a number of areas, including the management and storage of data and information about patient medical histories, medication stocks, sale records, and more; automated machinery; software and computer applications; and diagnostic tools like CT and MRI diagnostics. All of these have been developed to support and streamline healthcare procedures. Without a doubt, artificial intelligence (AI) has transformed healthcare to be more effective and efficient, and the pharmaceutical industry is not exempt. Over the past few years, there has been a noticeable increase in interest in the applications of AI technology for the analysis and interpretation of several significant pharmacy domains, including drug development, dosage form design, polypharmacology, and hospital pharmacy **[9]**.

AI in clinical trials

The recognized method for confirming the safety and effectiveness of novel medications is still through conventional "linear and sequential" clinical studies. The rigorous, time-tested method of discrete and set phases in randomized controlled trials (RCTs) was created primarily for the testing of mass-market medications, and it hasn't altered much in recent years.

Clinical trials can be shortened in duration by using AI and RWD to help with subgroup

discovery, trial eligibility criteria refinement, and the removal of patients who are very unlikely to benefit from the treatment. Clinical trials consume the final two years of a new drug's 1.5–2.0 billion USD development cycle, which spans ten to fifteen years. Because of this, the total loss resulting from a clinical trial that fails might be anywhere between 800 million and 1.4 billion USD, taking into account both the trial's original investment and preclinical development costs. Merely 10% of compounds that are enrolled in a clinical study ultimately make it to the market. This is mostly because of poor patient cohort selection and recruitment tactics, along with insufficient patient monitoring throughout the trial. We outline how the most recent advancements in artificial intelligence (AI) may be used to alter crucial clinical trial design phases in order to improve trial success rate **[10]**.

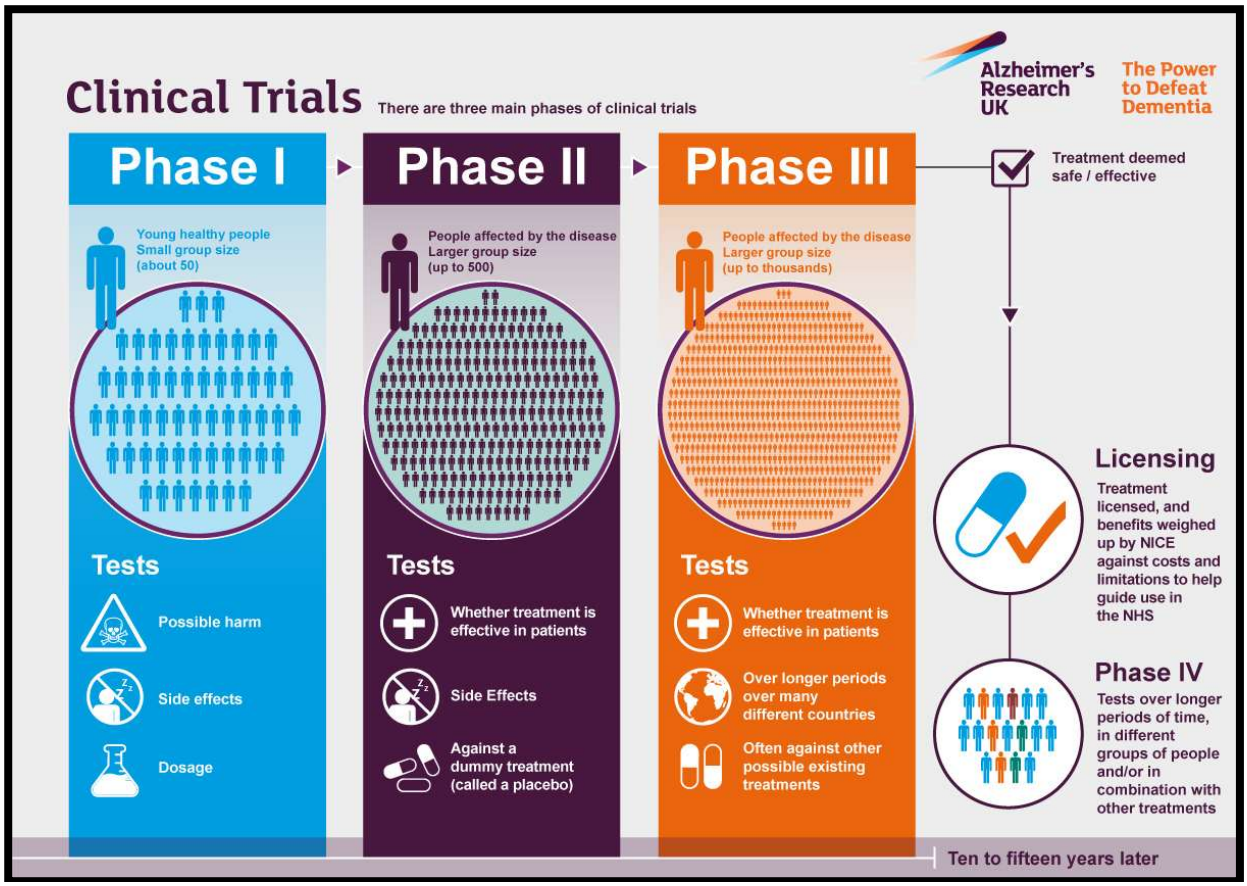

Figure 2: Clinical Trials Phases

History

The concept of "artificial intelligence" originated with ancient philosophers who debated issues related to life and death thousands of years ago. Inventors of antiquity created mechanical devices known as

"automatons" that moved without the need for human assistance. The ancient Greek word "automaton" meant "acting of one's own will." The first known mention of an automaton dates back to 400 BCE and describes a mechanical pigeon built by Plato's acquaintance. Many years later, in or around 1495, Leonardo da Vinci developed one of the most well-known automatons. Although the concept of a computer capable of independent thought is not new, for the sake of this article we will concentrate on the 20th century, as scientists and engineers started to make significant progress toward the development of modern artificial intelligence **[11]**.

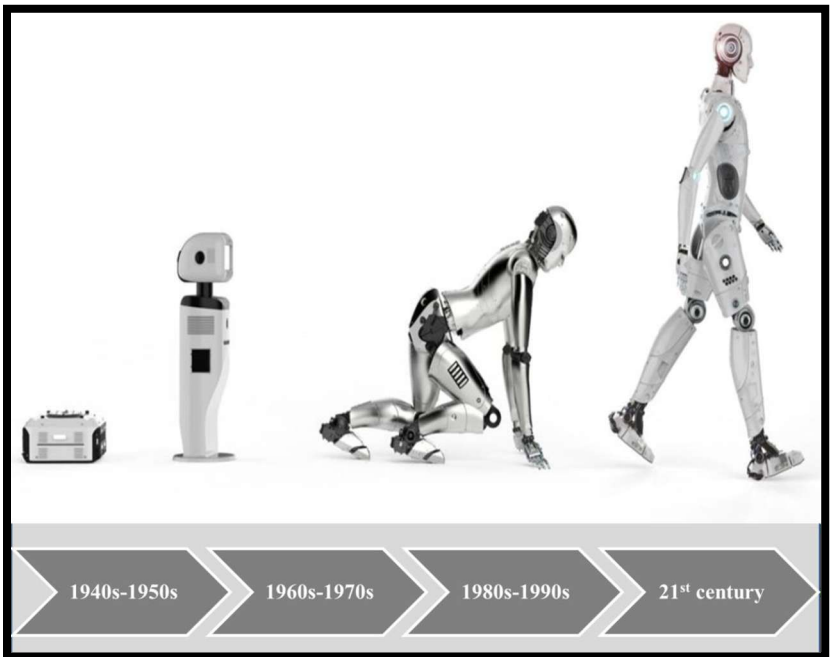

Figure 3: History of AI

- .**1940s and 1950s:** At the 1956 Dartmouth Conference, when scientists explored the prospect of building robots that could mimic human intelligence, the term "artificial intelligence" was first used. John McCarthy and Alan Turing, two early AI pioneers, set the foundation for the discipline **[12]**.
- **1960s and 1970s:** The 1960s and 1970s witnessed a great deal of advancement in AI research thanks to the creation of expert systems and the release of the LISP programming language, which was widely used in AI applications. However, as early computer hardware and software had limits, researchers' initial enthusiasm for AI diminished **[13]**.

- **1980s and 1990s:** The 1980s and 1990s saw a rebirth of artificial intelligence (AI) thanks to developments in natural language processing, machine learning, and neural networks. Expert systems spread throughout many industries, and AI applications started to have real-world effects **[14]**.
- **21st century:** Artificial Intelligence has advanced rapidly in the twenty-first century due to advances in big data, algorithmic developments, and processing capacity. AI technologies are already widely used in industries including healthcare, banking, transportation, and more because to advances in deep learning, reinforcement learning, and robotics.

AI is a quickly developing topic these days, with uses ranging from recommendation engines and virtual assistants to self-driving cars and medical diagnostics. The ethical and societal implications of AI use are becoming more and more relevant conversation points as the technology develops.

Types of AI

Artificial intelligence are mainly 2 types and then it further divided into other parts.

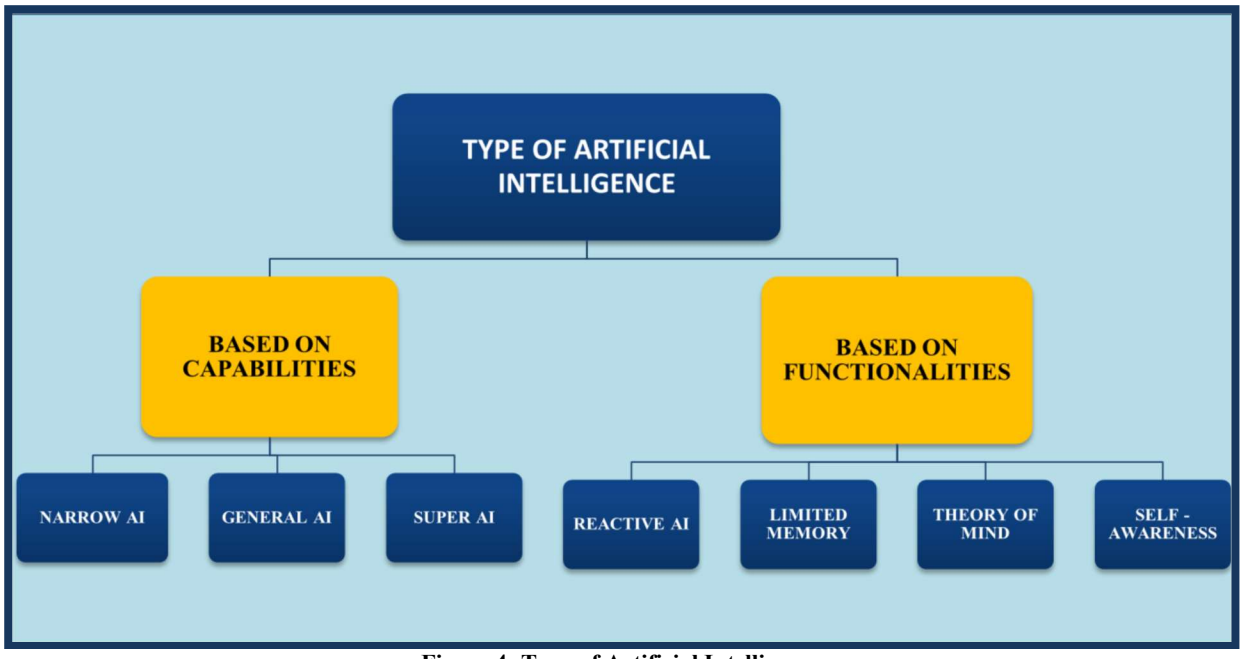

Figure 4: Type of Artificial Intelligence

(A) Types of AI Based on Capabilities

1. Artificial Narrow Intelligence

Artificial narrow intelligence (ANI), sometimes referred to as weak AI or narrow AI, is the term used to characterize AI systems that are created to execute very particular commands or behaviors. Artificial neural networks (ANI) are limited to a single cognitive function; they are not capable of learning new skills on their own. To finish these predetermined tasks, they frequently make use of neural network methods and machine learning.

Artificial intelligence (AI) that processes natural language, for example, is a form of restricted intelligence since it is limited to recognizing and responding to voice commands.

Self-driving cars, AI virtual assistants like Siri, and image recognition software are a few instances of artificial limited intelligence **[15, 16]**.

2. Artificial General Intelligence

Artificial general intelligence (AGI), sometimes referred to as strong AI or general AI, is the term used to characterize AI that has human-like abilities to learn, think, and carry out a wide range of tasks **[17]**. The aim of artificial general intelligence design is to be able to build computers that can carry out several jobs and function as intelligent, lifelike aides for humans in daily life. Although still in its early stages, technology like supercomputers, quantum hardware, and generative AI models like ChatGPT could lay the foundation for artificial general intelligence **[18]**.

3. Artificial Superintelligence

Science fiction is the domain of artificial super intelligence (ASI), sometimes known as super AI. It is predicted that once artificial intelligence (AI) reaches the level of general intelligence, it would learn so quickly that its knowledge and power will eventually surpass even that of people **[19]**.

The foundational technology for fully autonomous AI and other individualistic robots would be ASI. The widespread cultural cliche of "AI takeovers," which can be seen in movies like Ex Machina or I, Robot, is also fueled by its notion. But it's just conjecture at this moment.

According to David Rogenmoser, CEO of AI writing startup Jasper, artificial super intelligence "will become by far the most capable forms of intelligence on Earth **[20]**.

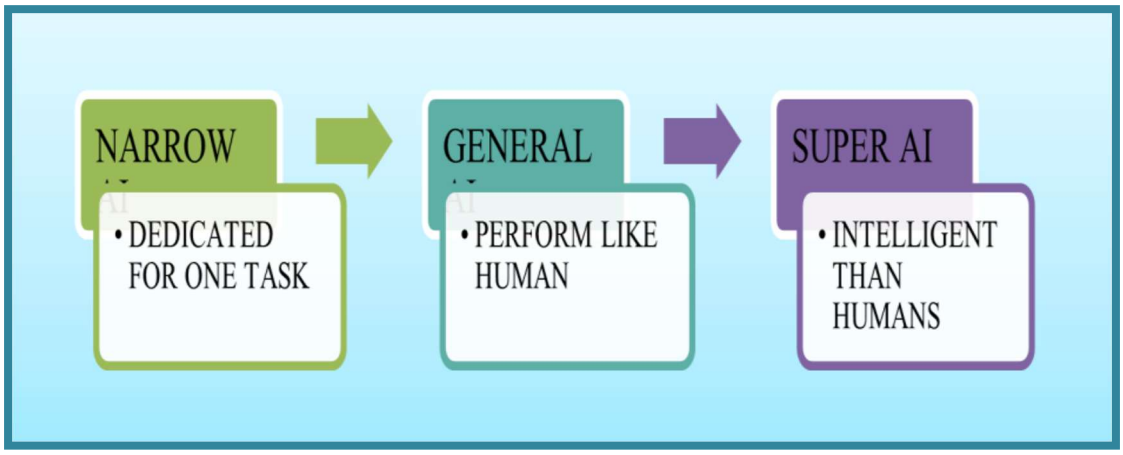

Figure 5: Type of AI Based on Capabilities

(B)Types of AI Based on Functionality

1. **Reactive Machines**

   Artificial intelligence starts with robots that are purely reactive.

   These AI systems don't keep track of memories or past encounters for use in the future.

   These devices simply consider the situations that exist right now and respond to them in the best way feasible. Reactive machines can be seen in IBM's Deep Blue system, for instance. Reactive machines also include Google's AlphaGo **[21]**.

2. **Limited Memory**

   Machines with limited memory can temporarily store certain data or memories. These devices have a certain amount of time to use stored data.

   One of the greatest applications of limited memory systems is in autonomous vehicles. In order to negotiate the road, these automobiles can store information such as the speed limit, distance between other cars, and the recent speed of adjacent cars.

   AI with little memory is also frequently utilized in natural language processing, chatbots, and virtual assistants **[22]**.

3. **Theory of Mind**

   THEORY OF MIND AI should be able to communicate socially with humans and comprehend human emotions, people, and beliefs. Although these kinds of AI devices have not yet been created, academics are working very hard to advance their development **[23]**.

The AI machine's capacity to ascribe mental states to other entities is known as theory of mind capability. The word, which comes from psychology, refers to the requirement that AI discern entities' intents and motives, such as their beliefs, feelings, and objectives. AI of this kind has not yet been created **[24]**.

4. Self-Awareness

Future artificial intelligence is known as self awareness. These robots will be extremely intelligent and possess sentience, emotions, and self-awareness. These devices will surpass human intelligence **[25]**.

Self-Recognition AI is still a theoretical idea and does not now exist in reality.

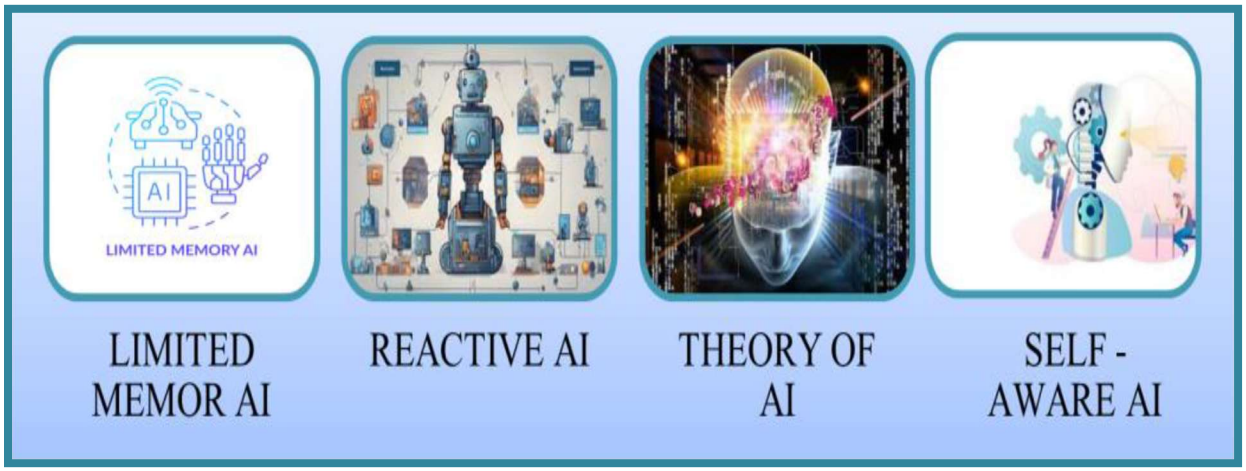

Figure 6: Type of AI Based on Functionalities

Role of AI (Artificial Intelligence)

AI play a special role in various field which are:

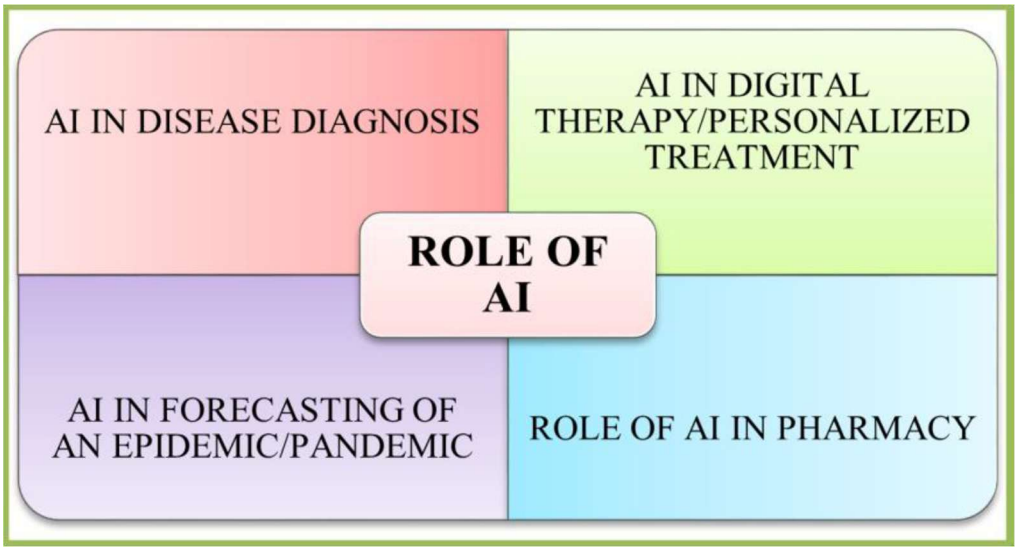

Figure 7: Role of AI

- **AI In Disease Diagnosis:** AI has demonstrated tremendous promise in the diagnosis of illnesses, and in 2023 and beyond, its potential in this field is expected to rise even more. Large amounts of medical data, including patient records, test results, x-rays, and genetic data, can be analyzed by AI-powered diagnostic systems to find trends and generate precise health predictions.

  AI algorithms can help radiologists diagnose patients more accurately by assisting in the interpretation of medical imaging scans, such as CT, MRI, and X-rays. These scans can be used to identify anomalies. AI can also be used in pathology to examine tissue samples and find anomalies or malignant cells.

  AI is also capable of analyzing genetic data to determine a person's genetic susceptibility to a particular disease or to tailor a treatment plan according to that person's genetic profile.

  AI-powered diagnostic tools can also assist medical professionals in enhancing the precision and speed of disease diagnosis, which may result in earlier disease detection and better patient outcomes.It's crucial to remember that even while AI offers a lot of promise for diagnosing diseases, medical experts will always be needed. Rather, artificial intelligence (AI) is a potent instrument that may supplement and enhance the abilities of healthcare professionals, ultimately resulting in more effective and efficient healthcare delivery **[26, 27]**.

- **AI In Digital Therapy/Personalized Treatment:** AI holds great promise for the fields of personalized medicine and digital therapy. AI-powered digital therapy platforms can offer individualized interventions and support to those dealing with mental health issues in the context of mental health. These platforms can customize therapeutic approaches to meet the unique needs of each user by using AI algorithms to assess user data, including self-reported symptoms, behavioral patterns, and treatment responses.AI can also be utilized to create chatbots or virtual mental health assistants that offer users real-time help and guidance. These tools can offer individualized mindfulness exercises, psychoeducation, and

coping strategies tailored to each user's requirements and preferences.

AI has the power to transform customized healthcare in a way that extends beyond mental health. Artificial intelligence (AI) can assist in determining the best course of action for each patient based on their specific traits and risk factors by evaluating enormous datasets of patient information, including genetic data, medical history, and treatment outcomes.AI can also help with precision medicine techniques, which are focused on delivering personalized treatments based on a patient's genetic composition and unique illness features. This may result in less harmful treatments that are also more effective, which would eventually benefit patients' results **[28]**.

- **AI In Forecasting of An Epidemic/Pandemic:** By evaluating vast amounts of data to find patterns and trends that might guide public health actions, artificial intelligence (AI) has the potential to greatly improve the forecasting and management of epidemics and pandemics. AI can be used in the following ways to forecast pandemics and epidemics **[29]**:

A. **Early detection:** In order to identify early indicators of possible outbreaks, AI systems can examine a variety of data sources, including social media posts, internet search trends, and medical records. Artificial intelligence (AI) can assist public health officials in taking preventive actions to stop the spread of infectious diseases by spotting odd patterns or clusters of symptoms.

B. **Predictive modeling:** With the aid of artificial intelligence (AI), predictive models that project the spread of infectious diseases based on variables like population density, travel habits, weather, and healthcare infrastructure can be created. Authorities can better plan resource allocation and predict the course of an epidemic or pandemic with the use of these models.

C. **Resource Allocation:** AI can analyze real-time data on hospital admissions, ICU capacity, and medical supply chains to optimize the allocation of healthcare resources. When allocating

resources to regions most impacted by an epidemic or pandemic, this can assist authorities in making well-informed decisions.

D. **Risk Assessment:** AI may evaluate risk factors for infectious diseases at the individual and population levels by examining environmental factors, health records, and demographic data. By using this data, public health programs may be customized, and vulnerable populations can be given priority when it comes to preventive care.

E. **Behavioral Analysis:** AI can examine human behavior patterns to comprehend how people react to social distancing programs or vaccination drives, for example, and how communities as a whole. This knowledge can help in the development of public health initiatives that are more successful.

- **Role of AI In Pharmacy-**

There are the some important role of artificial intelligence are :

A. **Drug discovery and development:** Artificial intelligence (AI) algorithms are used to evaluate vast amounts of data, such as chemical structures, genetic data, and clinical trial outcomes, in order to find possible drug candidates, forecast their efficacy, and accelerate the drug development process.

B. **Personalized medicine:** AI is used to evaluate patient data, including genetic profiles, health histories, and lifestyle variables, in order to create individualized treatment programs and forecast each patient's reaction to a given drug, resulting in more specialized and efficient therapy.

C. **Medication adherence and management:** In order to enhance compliance and treatment results, AI-powered systems can track patient adherence to medication schedules, send reminders, give tailored interventions, and optimize drug management.

D. **Drug interaction and adverse effect prediction:** Artificial intelligence systems are capable of analyzing drug interactions, forecasting possible adverse effects, and helping medical professionals prescribe medications with confidence.

E. **Pharmacovigilance:** To improve pharmacovigilance efforts and guarantee patient safety, artificial intelligence (AI) is used to evaluate adverse event reports, social media data, and other sources to discover potential safety risks associated to pharmaceuticals.

F. **Inventory management:** AI-driven technologies can increase operational efficiency in pharmacies and healthcare institutions by forecasting medicine demand, streamlining the supply chain, and optimizing inventory levels.

G. **Clinical decision support:** By helping pharmacists and medical professionals make evidence-based decisions on medicine selection, dosage, and monitoring, AI-based clinical decision support systems improve patient care.

H. **Patient counseling and help:** AI-driven chatbots and virtual assistants can improve patient education and engagement by answering queries, offering pharmaceutical information, and providing help for medication adherence and management.

Future Perspective of AI

The future of AI in the pharmacy field holds tremendous potential for further advancements and innovations. Some key future perspectives include:

1. Precision Medicine: AI will continue to play a crucial role in advancing the development of personalized medicine by leveraging complex datasets, including genomics, proteomics, and metabolomics, to tailor treatments to individual patients. This could lead to the identification of highly targeted therapies and the prediction of patient responses with unprecedented accuracy.

2. Drug Repurposing and Combination Therapies: AI algorithms will increasingly be used to identify new indications for existing drugs and to optimize the use of combination therapies. This could lead to the discovery of novel treatment options for complex diseases and the repurposing of drugs to address unmet medical needs **[30]**.

3. Predictive Analytics for Adverse Events: AI will be used to develop more sophisticated predictive models for adverse drug events, allowing pharmacists and healthcare providers to proactively identify patients at risk and intervene before serious complications arise.

4. Autonomous Pharmacy Operations: AI-driven automation and robotics will continue to transform pharmacy operations,

streamlining medication dispensing, inventory management, and prescription processing. This could lead to increased efficiency, reduced errors, and improved patient safety.

5. Drug Manufacturing and Formulation: AI will play a critical role in optimizing drug manufacturing processes, enabling the development of more efficient production methods and the design of novel drug formulations with enhanced therapeutic properties.

6. Telepharmacy and Remote Monitoring: AI-powered telepharmacy platforms will enable pharmacists to provide remote medication counseling, monitoring, and support to patients, particularly in underserved or remote areas. This could improve access to pharmacy services and enhance patient outcomes.

7. Ethical and Regulatory Considerations: As AI continues to advance in the pharmacy field, there will be a growing need to address ethical considerations related to patient privacy, data security, and the responsible use of AI technologies. Regulatory frameworks will need to adapt to ensure the safe and ethical implementation of AI in pharmacy practice.

Overall, the future of AI in the pharmacy field holds immense promise for transforming drug discovery, patient care, and pharmacy operations. However, it will be essential to address potential challenges such as data privacy, algorithm transparency, and healthcare disparities as AI technologies continue to evolve **[31]**.

Application of AI

There are numerous uses for AI in a variety of sectors and fields. Common uses for artificial intelligence include:

1. Healthcare: AI is utilized in predictive analytics for patient outcomes, disease diagnosis, medication discovery, and medical imaging analysis.

2. Finance: AI is used in chatbots for customer support, algorithmic trading, fraud detection, risk assessment, and customized financial advise.

3. Retail: AI is applied in supply chain optimization, inventory control, recommendation systems, and demand forecasting.

4. Manufacturing: AI is used in robotic automation, supply chain management, process optimization, quality control, and predictive maintenance.

5. Transportation: AI is utilized in intelligent transportation infrastructure, driverless vehicles, traffic control systems, and route optimization.

6. Customer Service: Natural language processing, sentiment analysis, chatbots, and virtual assistants driven by AI are utilized for customer service, support, and tailored customer engagements.

7. Education: AI is used in intelligent tutoring systems, tailored learning pathways, adaptive learning platforms, and recommended educational content.

8. Agriculture: AI is utilized in pest identification, yield prediction, crop monitoring, autonomous farming equipment, and precision agriculture.

9. Cybersecurity: AI is used in behavior analysis, threat detection, anomaly detection, and automated security incident response.

10. Entertainment: AI is utilized in virtual reality experiences, music production, video game development, content suggestion, and personalized streaming services.

These are only a few instances of the various fields and industries that AI is being used in. The potential uses of AI technology are growing as it develops, spurring innovation and change in a variety of industries.

CONCLUSION

To sum up, AI is helpful for new medicine R&D in every way. In addition to significantly lowering the cycle time and cost of medication R&D, it can be utilized in preclinical research, clinical trial design, post-market surveillance, drug target discovery, and the design and development of new pharmaceuticals. The AI-based drug research and development method still has several shortcomings. However, we think that AI is becoming an essential tool in the pharmacological R&D process and that it is increasingly helping us to solve the puzzle of huge and complex biological systems. Additionally, AI technology will transform the pharmaceutical sciences' paradigm for research and development in the future, enabling us to more effectively treat complicated disorders.

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