INTERNATIONAL JOURNAL IN PHARMACEUTICAL SCIENCES

Journal Homepage: https://www.ijpsjournal.com

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Review Article

A Review - Artificial Intelligence In Pharma Industry

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ARTICLE INFO

Received: 04 Dec 2023
Accepted: 07 Dec 2023
Published: 16 Dec 2023

Keywords:
Application of AI, Tools of AI, MES, ACPS, Drug Discovery, Treatment and management of rare disease, Drug adherence and dosage, Challenges to adoption of ai in pharma industry.

DOI:
10.5281/zenodo.10373995

ABSTRACT

Artificial intelligence (AI) is a branch of computer science that deals with problem-solving through the aid of symbolic programming. It has greatly evolved into a science of problem- solving with the hug applications in business, health care, and engineering. The article describes the challenges to adopting Al in pharma as well as the use of Al tools, manufacturing execution systems, automated control processes systems, Al to predict new treatment, treatment and management of rare diseases, drug adherence and dosage, and challenges to use Al in pharmaceutical technology. The use of artificial intelligence in pharmaceutical technology has increased over time.

INTRODUCTION

Artificial intelligence (AI) is a subfield of computer science that focuses on using symbolically programming to solve problems. Over the past five years, Al has revolutionized the way scientists develop new drugs, treat diseases, and more in the pharmaceutical and biotech industries. It has greatly evolved into a science of problem- solving with enormous applications in business, health care, and engineering.[1] In the pharmaceutical sector, artificial intelligence (AI) pertains to the utilisation of automated algorithms for tasks that conventionally necessitate human intellectual abilities [2]. Recently AI plays an important role in various fields of pharmacy like drug discovery, drug delivery formulations development, polypharmacology, hospital pharmacy, etc. the main objective of this artificial intelligence is to identify useful information processing problems and give an abstract account of how to solve them. Such an account is called a method and it corresponds to A theorem in

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

mathematics. Recently, AI technology has become a very fundamental part of the industry for useful applications in many technical and research fields. Reflecting on the past 25 years, pharmacy has done a great job of addressing the growing demand for prescription, even when faced with pharmacist storages, growing operating costs, and lower reimbursements.[3] Artificial Intelligence (AI) is a scientific discipline concerned with the study of intelligent machine learning, particularly intelligent computer programs that yield outcomes akin to human cognitive processes In recent times, artificial intelligence (AI) technology has emerged as an integral component within various industries due to its valuable applications in numerous technical and research domains. The progressive acceptance of AI technology in the field of pharmacy, encompassing drug discovery, drug delivery formulation development, and other healthcare applications, has transitioned from being mere hype to a promising reality.[4] Change matters in every human being's life, like that change is important in various processes and various departments, so in the field of pharmaceutical sciences and medicine also change is much needed in drug discovery aspects, compounding of chemical products and also manufacturing process of new chemical entities. Artificial intelligence is the one of the innovative processes which may change the various aspects of pharmaceuticals for the beneficiary purpose of pharmaceutical Sciences. There is a requirement for the advancement of novel and innovative principles and interpretation techniques in the mechanical and chemical innovation of pharmaceuticals. [5] The utilisation of artificial intelligence (AI) in the realm of drug discovery and the pharmaceutical industry has experienced significant growth in recent years. AI algorithms possess the capability to scrutinise extensive volumes of data, detect patterns, and generate predictions, thereby expediting the process of drug discovery. And enhancing patient outcomes. [6] In accordance with a customary principle, artificial intelligence frameworks operate by dissecting substantial quantities of designated training data to identify correlations and patterns. Subsequently, these patterns are utilised to generate predictions regarding forthcoming conditions.AI programming focuses on the following cognitive skills: Learning, Reasoning, Selfi correction, Planning, Knowledge representation. Automated decision-making. Examples of artificial intelligence (AI) encompass various applications such a speech recognition, language processing, autonomous vehicles, tailored social media content, and customised web searches.[7]The pharmaceutical industry is utilising artificial intelligence to aid in the research and development of novel drugs for the treatment of diseases that pose significant challenges. This involves the employment of AI to analyze clinical data in a more efficient manner, facilitating a better understanding of it. Additionally, the use of AI expedites the selection of dependable trial participants. Furthermore, robotic automated pharmacies are being utilised to dispense medication, fill prescriptions, and oversee supply chains, logistics, and marketing.[8]

HISTORY

The artificial intelligence program was initially developed in 1995 by Simon and Newel, alongside John McCarthy, who is widely recognized as the father of artificial intelligence and introduced the term to the global community. Artificial intelligence can be categorised into four types: reactive machines, theory of minds, self-awareness, and limited memory.[5] The Logic Theorist was developed by Allen Newell and Herbert A Simon in 1956, coinciding with the renowned conference organised by Dartmouth college's It has been projected that the AI market will experience a ten-fold increase in revenue between 2017 and 2022. The natural language

processing market, which encompasses various applications such as text prediction, speech, and voice recognition, is expected to grow by 28.5% in 2017. In 2015, the global revenue from big data and business analytics amounted to US$ 122 billion, and it is anticipated that this figure will exceed US$ 200 billion by 2020 Artificial intelligence has a complex history dating back to the 1950s.[1]

Maturation of AI (1943-1952)

● **1943:** Warren McCulloch and Walter Pits created a model of artificial neurons in 1943, which is regarded as the first piece of work that is currently classified as artificial intelligence.

● **Year 1950:** English mathematician Alan Turing published "Computing machinery and intelligence," in which he proposed a test that can determine whether a machine is capable of exhibiting intelligent behavior comparable to that of a human. This test is calked as the Turing test. Year 1949: Donald O. Hebb demonstrated an updating rule for modifying the connection strength between neurons.

The birth of AI (1952-1956):

● 1955 saw the creation of the first artificial intelligence program, known as "Logic theorist,"by Allen Newell and Herbert A. Simon. This program proved 38 out of 52 mathematical theorems and discovered new, more elegant proofs for a few others.

● 1956 saw the adoption of the term "artificial intelligence" by American computer scientist John McCarthy at the Dartmouth conference, marking the first time Al was used as a recognised academic field.

The golden years-early enthusiasm (1956-1974):

● **Year 1966:** Researchers focused on creating algorithms that could solve mathematical puzzles. and complicated questions with lightning speed.Watson showed that it was capable of understanding spoken language. In 2012, Google Joseph Weizenbaum developed the first chatbot, called ELIZA, in 1966.

● **Year 1972:** Japan built WABOT-1, the first intelligent humanoid robot.

The first AI winter (1974-1980):

● The first Al winter, which ended in 1980, was a period of time when computer scientists struggled with a severe lack of government funding for Al research.

● During this time, there was a decrease in interest in Al-related publicity.

A boom of AI (1980-1987):

● **Year 1980**: Following a period of Al hibernation, Al reappeared with the development of the "Expert system," a computer program designed to mimic human experts' decision-making abilities. The inaugural national conference of the American Association of Al took place at Stanford University in 1980.

The second AI winter (1987-1993):

● The second Al winter occurred between 1987 and 1993. Once again, despite the extremely low cost of expert systems like XCON, the government and investors withdrew funding for Al research due to the technology's high cost and poor performance.

The emergence of intelligent agents (1993-2011):

● Year 1997: IBM Deep Blue defeats Gary Kasparov to become the first computer to win a World chess championship.

● Year 2002: Al made its home debut in the form of a Roomba vacuum cleaner.

● Year 2006: Al made its way into the business world and was used by companies like Facebook, Twitter, and Netflix.

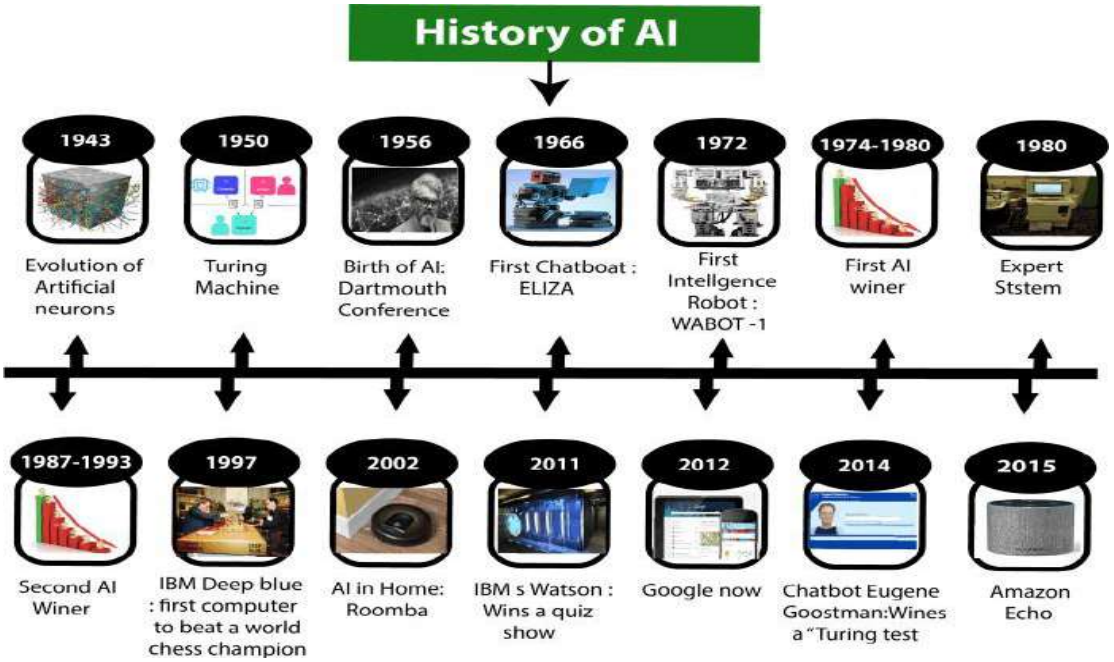
Deep learning, big data and artificial general intelligence (2011-present):

● 2011: IBM's Watson emerged victorious in the game show Jeopardy, where it had to solve riddles introduced the "Google Now" feature for Android apps, which allowed users to receive predictions along with information.

● Year 2014: In the infamous "Turing test," chatbot "Eugene Goostman" emerged victorious in a competition.

● 2018: The IBM "Project Debater" performed incredibly well when debating difficult subjects alongside two expert debaters.

● Google unveiled "Duplex," an Al program that functions as a virtual assistant and has a scheduled hair appointment. The woman speaking with the machine was unaware that she was speaking with a machine. [9]



APPLICATION OF ARTIFICIAL INTELLIGENCE IN PHARMA INDUSTRY:

Pharmaceutical companies can make all business operations more efficient, cost-effective and hassle- free by integrating and implementing Al systems in their core workflows. What's more, since Al systems are built to continuously learn from new data and experience, they can be an effective tool in the research and development division of the pharmaceutical industry. Artificial intelligence (AI) can be implemented in almost every aspect of the pharmaceutical industry, right from drug discovery and development to manufacturing and marketing.

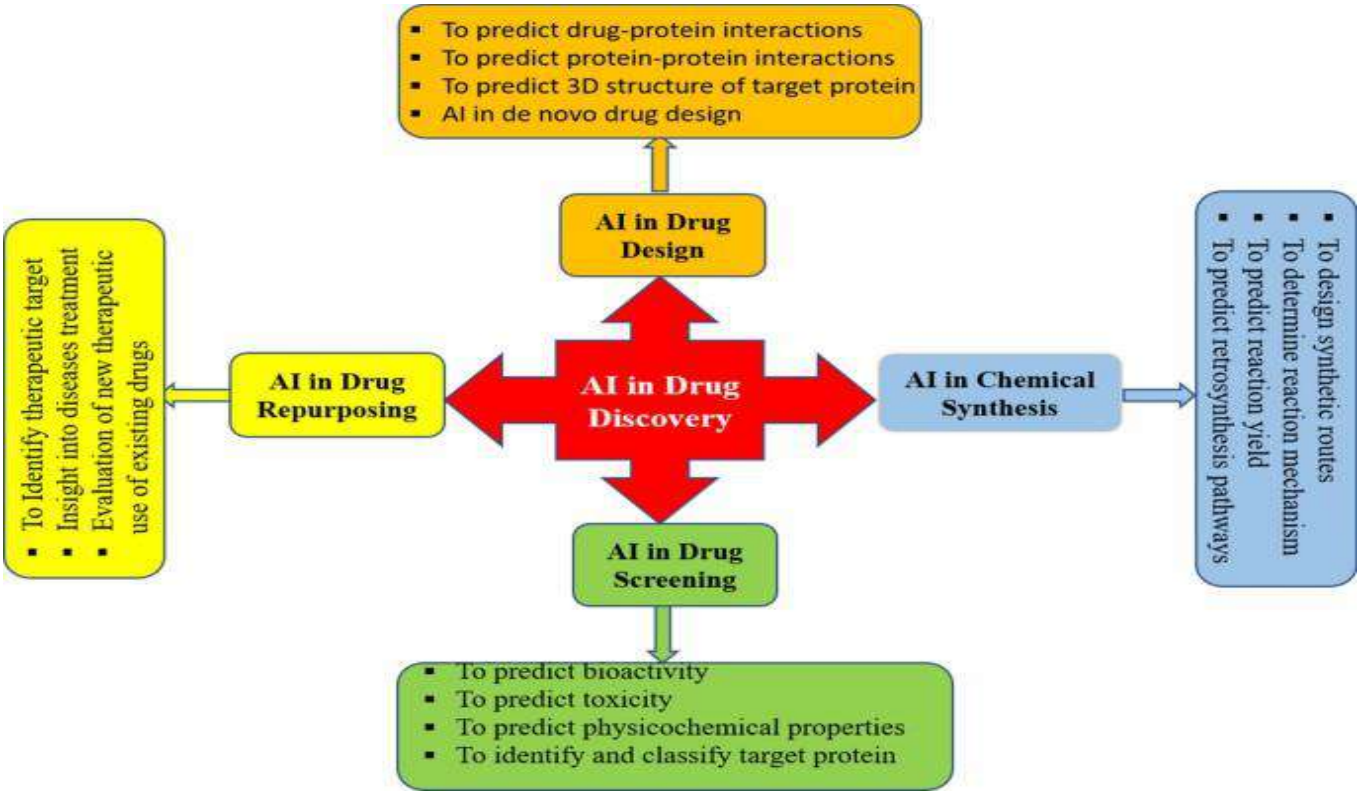
1. Research & Development :

Global pharmaceutical companies are using artificial intelligence (AI) and sophisticated useful in the identification and validation of drug targets, from the development of small molecules machine learning (ML) tools to accelerate the drug discovery process. These intelligent tools are made to recognize complex patterns in large datasets, which makes them useful for resolving problems related to complex biological networks. This capability is great for analysing the patterns of different diseases and figuring out which drug compositions would be most effective for treating particular traits of a given disease. Pharma companies can then allocate resources to the research and development of these drugs that have the best chance of effectively treating a disease or medical condition [10].

2. Drug Discovery Process and Design:

Artificial Intelligence (AI) is becoming more and more prevalent in the pharmaceutical industry for the purpose of drug design and development. Al is to the identification of novel biological targets. It is also used in the field of multi-target drug innovation and the identification of biomarkers,

providing an effective approach with a high degree of one of the main advantages of the pharma industry is that the use of Al in drug testing reduces the amount of time needed to complete clinical trials and launches products into the market. Pharmaceutical researchers, for instance, can use data from longitudinal EMR (Electronic Medical Records) records and other omic data to find and validate novel cancer drugs. Al systems that leverage machine learning (ML) and other data analytics algorithms can extract insights from EMR data to design and develop drugs that effectively cure tumours [11]



3. Drug Development:

Al has the potential to enhance research and development. From designing and identifying new molecules to target-based drug validation and discoveries AI can do it all [9]. Artificial intelligence (AI) has the potential to enhance the research and development (R&D) process in a number of ways, including target-based drug validation and discovery, molecule design and identification, and more. Only 13.8% of drugs make it through clinical trials, according to an MIT study. In addition, a pharmaceutical company must pay anywhere from US$ 161 million to US$ 2 billion for a drug to complete the clinical trial process and receive FDA approval. These are the primary causes of the growing adoption of Al by pharmaceutical companies, which aims to lower operating costs, develop more affordable drugs and therapies, and boost the success rates of new drugs [10].

4. Diagnosis:

The FDA recently approved the marketing of Gl Genius, a medical device that uses an Al algorithm and machine learning to detect signs of colon cancer. With the help of this device, clinicians can easily identify portions of the colon with potential lesions during a colonoscopy. ML systems can use the data stored in EMRS to make real-time predictions for diagnosis purposes and suggest treatments for medical conditions. Across the

globe, healthcare providers are using machine learning (ML) technology to securely store sensitive patient data in the cloud or a centralised storage system. These records are known as electronic medical records (EMRS), and doctors can consult them as and when they need To [10]. These days, deep learning, brain systems management, and computation-based innovation would be widely applied for the differentiation, extraction, and provisioning of theelatively. Large amount of gathered data. The two main diseases where artificial intelligence has gained importance are cancer and memory. [12]

5. Disease Prevention:

Pharmaceutical companies can use Al to find treatments for rare diseases as well as well-known illnesses like Parkinson's and Alzheimer's. Typically, these companies don't invest time and money in finding treatments for rare diseases because the return on investment (ROI) is very low when compared to the time and expense involved in developing drugs for treating rare diseases. Nearly 95% of rare diseases lack FDA- approved treatments or cures, according to Global Genes. However, things are quickly improving because of Al and ML' screative powers [10].

6. Epidemic Prediction:

Many pharmaceutical companies and healthcare providers already use artificial intelligence (AI) and machine learning (ML) to track and predict epidemic outbreaks worldwide. These technologies leverage data collected from various online sources, analyze the impact of different geological, environmental, and biological factors on population health in different regions, and attempt to establish links between these factors and past epidemic outbreaks. These models of AI/ML become particularly helpful in developing nations lacking the financial resources and medical infrastructure needed to contain an epidemic. The ML-based malaria outbreak prediction model, which acts as a warning system for malaria outbreaks and assists medical professionals in choosing the most effective course of action to combat it, is a good illustration of this [10].AI and ML are already used by many pharma companies and healthcare providers to monitor and forecast epidemic outbreaks across the globel. These technologies use data collected from various online sources to analyze the relationship between geological, environmental, and biological factors and population health in various geographic locations. They also attempt to establish a link between these factors and past outbreaks of epidemics. Such AI/ML models become especially useful for underdeveloped economies that lack the medical infrastructure and financial framework to deal with an epidemic outbreak. [9]

7. Remote Monitoring:

A significant advancement in the pharmaceutical and healthcare industries is remote monitoring. Numerous pharmaceutical companies have already created wearables with Al algorithms that enable them to remotely monitor patients with life-threatening illnesses. Tencent Holdings, for example, has partnered with Medopad to develop Al technology that can remotely monitor patients with Parkinson's disease and cut down on the time required to complete a motor function assessment from thirty minutes to three minutes. By combining this Al technology with smartphone apps, it is possible to monitor a patient's opening and closing motions from a distance.[10] The potential for Remote Patient Monitoring (RPM) devices to revolutionize at-home care was highlighted during the pandemic, which demonstrated the challenges of remote care and brought rapid growth to the sector. A recent report by global data found that the market for RPM devices is expected to reach $760 million by 2030. The Thematic Research - Virtual Care and Telemedicine - 2023 report explores how technology is enabling the healthcare industry to improve efficiency and overcome geographical

barriers through remote consultations, diagnosis, and treatment in non-emergency cases [13].

8. Manufacturing:

Pharma companies can use artificial intelligence (AI) to manage and enhance all aspects of the manufacturing process, including: Pharma companies can use Al to improve productivity, efficiency, and speed up the production of life-saving drugs. Process automation, waste reduction, quality control, predictive maintenance, and Designed optimization [10].

1. Quality control:

lowering the high attrition rate and failure rate, cutting paperwork, standardizing operating procedures with machine assistance, and raising quality standards with less experiment [14].

2. Predictive Maintenance
3. Waste reduction
4. Design Optimization
5. Process automation

9. Marketing:

Since the pharmaceutical industry is a sales-driven industry, artificial intelligence (AI) can be a useful tool in pharmaceutical marketing. With Al, pharmaceutical companies can research and create novel marketing strategies that promise high revenues and brand awareness. Al can assist in mapping the customer journey, which enables companies to see which marketing technique led visitors to their site (lead conversion) and ultimately persuaded the converted visitors to make a purchase from them. This allows pharmaceutical companies to concentrate more on those marketing strategies that lead to the greatest number of conversions and increase revenues. Al tools can also analyze historical marketing campaigns and compare the results to determine which campaigns remained the most profitable. The pharma industry still lacks the industry knowledge and skills necessary for the integration and adoption of Al, but these steps can facilitate the adoption of Al in the industry.

- collaborating and partnering with academic institutions those focus on Al research and development to assist pharmaceutical companies in adopting Al
- Partnering with Al-driven medicine discovery companies can help you take advantage of their advanced tools, industry experience, and expert assistance.
- to achieve maximum productivity, teach R&D and manufacturing teams how to properly use and apply Al tools and techniques. [10]

10. Drug Adherence and Design:

These are all important pharmaceutical use cases for embracing artificial intelligence (AI). Al in Pharmaceuticals and Healthcare will undoubtedly accelerate process automation and drive more accuracy than ever before. These Al trends & use cases in pharma will help drug development and healthcare companies in ensuring efficacy across end-to-end production lines and performing to the highest standard in front of the FDA.AI adoption in Pharmaceuticals and Healthcare is growing at a rapid pace for identifying the right amount of drug intake to ensure the safety of drug consumers [10].Artificial intelligence in pharmacy is expanding at an unprecedented rate. Al in pharma is now being used to identify the right amounts of drug intake to ensure the safety of drug consumers. It not only helps to monitor the patients during clinical trials but also suggests the right amount of dosage at regular intervals [11].

Type of Artificial Intelligence (AI):

Type 1 (Based on Ability):

a) Weak AI or Narrow AI:

This type of AI is limited to a single narrow task and refers to the phenomenon whereby Machine that lake the Intelligence to perform tasks on their own can be constructed to appear intelligent. For instant in a poker game where a machine defeats a human player, all rule S moves must be input into the system; therefore every scenario must be

mannualy entered beforehand. Every weak AI will contribute to the development of a strong AI.

b) Strong AI: The machines that can actually think and perform tasks on its own just like a human beings. There aren't any appropriate examples of this yet, but some prominent figures in the industry very keen on getting close to build a strong AI which has resulted in rapid progress [15].

Type 2 (Based on Functionality):

(a) Reactive Machine: which is one of the basic forms of AI which doesn't have past memory and cannot use past information for future actions. Eg: IBM chess program that beat Garry Kasparov in the 1990s.

(b) Limited Memory: Some of the decision-making functions in self-driving cars have been designed with limited memory Limited Memory: observations used to inform actions happening in the not too distant future, like a car that has changed lanes, are not stored permanently. This also applies to Apple's Chatbot Siri.

(c) Theory of Mind: This type of AI should be able to understand people's emotion, belief, thoughts, and expectations and be able to interact socially

(d) Self-awareness: An AI that has its own conscious, super intelligent, self-awareness and in simple words act as a complete human being [16].If the machine has self-awareness, it understands the condition and uses the ideas present in others' brains.This is a non-existing AI[17].

Advantages & Disadvantages of AI:

Advantages of AI technology:

1) Minimize the error:

By reducing the risk enhance the chance to reach the accuracy with more degree of precision [18].

2) Difficult Exploration:

It can be used in mining and fuel exploration sectors.

• AI system can be suitable to investigate the ocean to overcome the limitations of human The robots can carry out more demanding and tiresome tasks with ease and without becoming tired thanks to programming.

3) Daily application:

AI is useful for the daily application purpose.

• The GPS system is widely used by everyone and is useful for lengthy drives. In androids, due to the installation of AI, it predicts what the person is going to type and corrects the errors in spelling. For example, Lady SIRI and Cortana robots.

• When anyone is posting photographs on social media 'like twitter, facebook, the AI program identifies and tags the person's face.

4) Digital Assistants:

AI systems 'avatar' which is models of digitals assistants are used by organization to reduce the need for human resources.

• The avatars are free of emotional thinking, so they think logically and take right decisions. Human emotions are generally associated with moods that disturb the judgment and affect the human efficiency.

• This problem was not observed with machine intelligence.

5) Repetitive Jobs:

Humans can do only one task at a time. Machines are faster thinkers than humans and are capable of multitasking. Dangerous tasks can be carried out by machines, and their parameters- such as speed and time-can be changed.

6) Medical application:

Nowadays, the physicians are assessing the patients and analysing the health risks with the help of AI.

• AI program is educating the physicians about various medicines and their side effects.

7) Increase technological:

Growth rates AI technology helps to enter inti the world of more advanced technological innovations. Millions of computer modelling programs could be created by the Al system, which would be useful for discovering new chemical

compounds and entities. For example- QSAR, QSPR

Disadvantages Of AI technology:

1) High cost:

The launch of AI needs a huge amount due to their complex design of machinery, repair and their maintenance.

• There is need of updating software programmes in the machine frequently.

• The reinstalling and the recovery of the machine take huge amount time and money. The R & D division takes a long period to design one AI machine.

• Hence money consumption is more.

2) No Replicating Humans:

Robots which have the AI technology can think like human beings with the added advantage of not having any emotions and moral values.

•So they perform the given task as programmed and they are unable to make judgement. Sometimes its leads to big problems.

• If the problems are unfamiliar to robots, they are unable to take the decision.

•They either give a false report at that point or have a breakdown.

3) No improvement with experience:

Machines working with AI technology cannot be improved like human beings with experience.

•Machines are not concerned with belonging, caring, or unity.

• They fail to identify the hard working and nonworking individual.

4) Unemployment:

If the machines are used in all the sectors in place of human beings.

• There will be widespread unemployment as a result.

•Generally, human beings have high dependency nature. Due to this, they lose their creativity power and become lazy. [19]

Current Challenges / Future with AI:

a) Many big pharmaceutical companies are investing in AI in order to develop better diagnosis or biomarkers, to identify drug targets and to design new drugs and products.

b) In March 2012, Merk partnership with numerate, focusing on developing novel small molecule drugs which lead for CVS disease target.

c) Robotics plays an active role in developing medical devices. Robotics are used in manufacturing to reduce costs, and production is heavily regulated by the food and drug administration. d) In December, 2016 Pfizer and IBM announced partnership to accelerate drug discovery in immuno-oncology [18].

Top 10 Pharma Industries Using Artificial Intelligence (AI):

AstraZeneca

In order to discover new approaches to treat, prevent, or even cure diseases, AstraZeneca is utilizing data science and artificial intelligence (Al) to boost productivity in research and development. They are also utilizing Al to improve their research capabilities and optimize their operations.

Bayer

Bayer is using big data and advanced analytics, including Al, to improve their R&D efforts, Bayer is using Al to bring about a fundamental shift in the pharmaceutical industry's innovation paradigm.

Bristol Myers Squibb

Bristol Myers Squibb is a firm believer in the ability of science to tackle the most pressing issues in modern healthcare, and he sees computer science and digital capabilities such as artificial intelligence (AI) and machine learning as means of enabling and enhancing that power.

GlaxoSmithKline

In order to provide anatomical and functional data for the development and identification of novel biomarkers/phenotypes and imaging endpoints in

clinical trials, GlaxoSmithKline is utilizing Al and ML.

Johnson & Johnson

Johnson & Johnson is leveraging AI in various aspects of its operations. However, specific details about their AI initiatives are not readily available in recent news articles.

Novartis

Augmenting its Al capabilities from research to commercialization, Novartis and Microsoft have partnered to significantly accelerate the development of transformative medicines for patients globally.

Takeda Pharmaceutical

To speed up its digital transformation, which includes the application of Al, Takeda Pharmaceutical has partnered with Accenture and Amazon Web Services on a five-year strategic agreement. [20]

Pfizer

Pfizer announced a partnership with IBM Watson to accelerate drug discovery in immuno-oncology in December 2016. In May 2018, Pfizer announced a fast-tracked Al collaboration, and the Massachusetts Institute of Technology announced Pfizer as a member of its Machine Learning for Pharmaceutical Discovery and Synthesis Consortium. Pfizer also announced a partnership with Chinese tech startup XtalPi to advance their work in drug designing and to investigate the molecular stability of an organic compound. [21] In April 2019, Pfizer partnered with Concerto Health Al to leverage Al and real-world data in oncology. The partnership will conduct novel synthetic control arm and prospective Real World Data outcomes study designs for therapeutics that are both pre- and post-approval.

Roche

Al is being used by Roche to speed up the drug discovery process, increase the effectiveness of clinical trials, and find new potential targets for drugs by analyzing vast amounts of data.

Sanofi

Sanofi is utilizing artificial intelligence (Al) to augment its R&D endeavors. Specifically, Al is being employed to scrutinize copious amounts of data in order to pinpoint novel drug targets and optimize the effectiveness of clinical trials. [20]

What are top 3 use cases of AI used by pharma companies?

1. **Exscientia:**

In early 2020, Exscientia reported the first Al-designed drug candidate to enter clinical trials. The UK-based company, Exscientia, led the way in utilizing Al in small-molecule drug design and has since expanded its Al- based platform to develop novel therapeutic antibodies through generative Al design. Exscientia is working with Bristol-Myers Squibb on a few drug candidates that are headed to the clinic, and it has also partnered with Sanofi, GSK, and Path Al on drug discovery projects. Additionally, the company is collaborating with MD Anderson to develop novel small-molecule oncology therapies.

2. **Atomwise:**

A member of the Alliance for Artificial Intelligence in Healthcare (AAIH), which promotes Al research and implementation in the pharmaceutical industry, Atomwise specializes in using Al in small molecule drug discovery. The company has developed Atom Net, a deep learning-driven computational platform for structure-based drug design, and its library comprises over three trillion synthesizable compounds. Despite announcing a 30% headcount reduction in December 2022, Atomwise has raised more than $194 million from investors and partnerships to date.

3. **Recursion Pharmaceuticals:**

Recursion is a clinical-stage biotechnology company based in Salt Lake City that specializes in drug

discovery through machine learning using its proprietary Recursion Operating System. The company claims to have one of the most extensive biological and chemical datasets in the world, and it is focusing on gene mutation-related diseases. It currently has several compounds in phase 1 and 2 studies, including a small molecule therapeutic for neurofibromatosis type 2 and another for cavernous cerebral malformation. Recursion states that it uses robotic lab automation, machine learning, and supercomputers to perform millions of experiments every week. The company went public in 2021. These use cases highlight the potential of Al in accelerating drug discovery and development, enhancing the effectiveness of clinical trials, and enh[20]

Tools of Artificial Intelligence (AI):

Many tools have been developed to address the various issues facing the pharmaceutical business. The results of these instruments have shown promise. The following are a few well- known tools that have attained astounding popularity. [22]

1) Robot Pharmacy:

The objective of improving the safety of patients, UCSF Medical Center uses robotic technology for the preparation and tracking of medications. According to them, the technology has prepared 3,50,000 medication doses without any error. The robot has proved to be far better humans both in size as well as its ability to deliver accurate medications. The abilities of the robotic technology include preparations of oral as well as injectables medicines which include chemotherapy drugs that are toxic. This has given freedom to the pharmacists and nurses of UCSF so that they can utilize their expertise by focusing on direct with the physicians.[19]

Fig. 3: Robot Pharmacy

2) Erica Robots :

The new care robot Erica was created by Professor Hiroshi Ishiguro of Osaka University in collaboration with Kyoto University, the Advanced Telecommunications Research Institute International, and the Japan Science and Technology Agency (ATR). It speaks Japanese and has a combination of European and Asian facial traits. It is similar to any other typical human person in that it likes to watch animated movies, dreams of traveling to Southeast Asia, and is looking for a life partner with whom it can have conversations. Despite being unable to move on her own, Erica can understand questions and respond with human-like facial expressions. Ishiguro altered the traits of thirty attractive women and used the average to create Erica, making her the "most beautiful and intellectual" android. [22]

Fig. 4: Erica - The humanoid Robot

2) Medi Robot:

The term "MEDi" stands for "Medicine and Engineering Designing Intelligence." Tanya Beran, a professor of community health sciences at the University of Calgary in Alberta, oversaw the development of the pain management robot as part of a research project. The robot first establishes rapport with children who scream during medical procedures, guiding them on what to do, how to breathe, and how to cope. Despite its inability to think, plan, or reason, it can be programmed to appear to have artificial intelligence (AI)

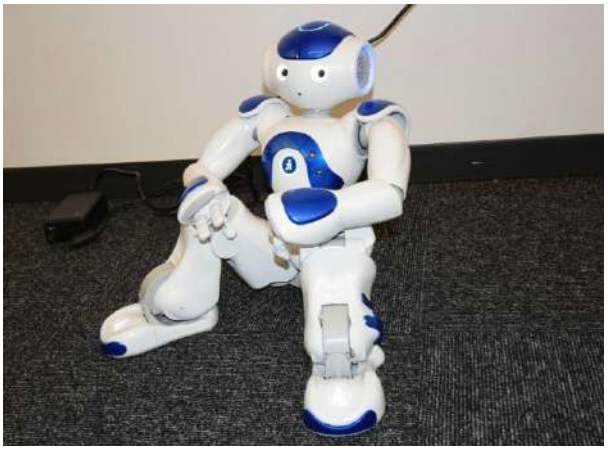


Fig. 5: Medi Robot

The robot retails for $9000, but when the applications are installed that the robot needs to assist with medical procedures, the cost increases to $15,000-30, 000,000.[19]

4) Tug Robot:

Aethon TUG robots are made to move around hospitals on their own, carrying heavy loads like trash and linen. They come in two configurations: fixed and secured carts and an exchange base platform that can be used to carry racks, bins, and carts. The fixed carts are used to carry medications, sensitive materials, and laboratory specimens, while the exchange platform is used to move materials that can be loaded on different racks. The TUG can deliver a variety of carts or racks, making it a highly flexible and useful resource.[19]

• Sensing process variable value
• Transmission of signal to measuring element
• Measure process variable
• Presenting the value of the measured variable
• Set the value of the desired variable
• Comparison of desired and measured values
• Control signal transmission to the final control element
• Control of manipulated value [2]

Fig. 6: Tug Robot

Automated control process system [ACPS]:

The elements of [ACPS] include:

● Sensing process variables‟ value.
● Transmission of signal to measuring element. Measure process variable.
● Presenting the value of the measured variable. Set the value of the desired variable.
● Comparison of desired and measured values.
● control signal transmission to final control element.
● Control of manipulated value.

MANUFACTURING EXECUTION SYSTEM [MES] :

The benefits of using MES include compliance with guaranteed legal regulations, minimized

risks, increased transparency, shortened production cycles, optimize resource utilization, controlled, and monitored production steps, and optimized up to batch release.[1]Verge is using automated information gathering, social media, and analysis to address fundamental problems with drug disclosure. In the end, they are using an algorithmic approach to identify numerous attributes that presume intricate roles in brain diseases such as Alzheimer's, Parkinson's, or ALS. Verge hypothesizes that social media and the analysis of high-quality information will significantly impact the medication disclosure stage starting with the preclinical preliminary stages. The idea is that Verge can use Al to screen the impact that specific medication medicines have on the human mind starting with the preclinical stage. As a result, drug manufacturers can almost instantly improve picture regarding the suitability of a medication on human cells. More specifically, Verge uses man-[26].

Role of Artificial Intelligence in Pharma Industry:

1. Disease diagnosis:

Disease analysis becomes pivotal in designing a considerate treatment and safeguarding the wellness of patients. The inaccuracy generated by humans creates a hindrance for accurate diagnosis, as well as the misinterpretation of the generated information creating a dense and demanding task. AI can have varied applications by bringing about proper assurance in accuracy and efficiency. After a vivid literature survey, the applications of various technologies and methodologies for the purpose of disease diagnosis have been reported. With the evolution of the human population, there is always an ever-increasing demand for the healthcare system, according to varied environmental manifestations.

2. Digital therapy/personalized Treatment :

Al in Radiotherapy:

A simple automated computer program with structures can implement the clinical guidelines. The treatment planning system can analyze the patient's anatomy and physiology and can also mimic the reasoning process, which is generally followed in manual treatment planning. Three-dimensional dose distribution and dose models for spatial dose have shown promising therapy. Radiomics can aid in the planning of radiotherapy treatments. Automated treatment planning is a relatively new technology that is highly beneficial to the field of radiotherapy treatment planning. Automated treatment planning is efficiently improving the plan quality, consistency, and error rate. The treatment workflow can be organized into three categories.

AI in Retina:

Testing compounds against samples of diseased cells is a time-consuming process in drug discovery; finding compounds that are biologically active and worth further investigation requires even more analysis. Novartis research teams use machine learning algorithm images to predict which untested compounds might be worth exploring in more detail. Computers are far faster than humans at finding new data sets, so new and effective drugs can be made available sooner. Additionally, the operational costs associated with the manual investigation of each compound are reduced.

AI in Cancer:

Al has become increasingly important in the fields of cancer diagnosis and treatment due to its wide range of applications. The non- Hodgkin lymphoma subtypes were predicted using gene expression data in a multilayer perceptron neural network; the neural network has 20,863 genes as the input layer and lymphoma subtypes as the output layer. The lymphoma subtypes that were predicted by the Al neural network included Burkitt, diffuse large B-cell lymphoma (DLBCL), mantle cell lymphoma (MCL), follicular

lymphoma, marginal zone lymphoma, and Burkitt. The Al neural network predicted the lymphoma subtypes with high accuracy.

1. Colorectal cancer (CRC) screening technology is used in gastrointestinal cancer to assess patient malignancy, and visual nocturnal prediction of Helicobacter pylori infection plays a critical role in predicting the progression of gastric cancer. Early diagnosis through appropriate blood tests, endoscopic imaging, and Al can influence the cancer's progression; however, Al lacks proper randomization and blindfolded controlled studies, so only retrospective data can be gathered. Additionally, there have been studies where the prognosis of cancers could not be justified by the prediction models; eventually, different models like Multi-task logistic regression algorithm, Cox survival regression algorithm, and random survival forest algorithm have gained multiple facets and are likely to predict.
2. Al is a versatile clinical aid for lung cancer detection in early stages and screening purposes. Deep learning and machine learning Al techniques give a supportive measure in lung cancer screening due to their ability to maintain a vast amount of data and characterize pulmonary nodules with precision. Currently, Al eases the tasks of pathologists and accommodates remote institutes suffering from a shortage of pathologists. Several Al applications are found to be helpful in the field of lung cancer such as the segmentation of carcinoma foci, detection of lymph node metastasis, counting of tumor cells, and prediction of gene mutations.
3. Al-assisted techniques, which combine quantitative and qualitative MRI features, have shown great promise in the last ten years in the diagnosis of breast cancer. They can be used to predict treatment response in breast cancer patients even before the start of neoadjuvant chemotherapy (NAC). Al has potential in lesion identification, segmentation and classification, breast density assessment, and breast cancer risk assessment. Al-based software can help radiologists distinguish between benign and malignant breast lesions and lower the likelihood of misinterpreting false-negative mammograms. However, these developments are still in their early stages and have a number of limitations, including the lack of large public datasets and the need for high quality images.

Al in Other Chronic Diseases:

Many computer programming techniques have led to the development of various computerized therapies, centered around the behavioral and cognitive approach and involving multiple- choice questions or joysticks. More recently, intelligent computer assisted instruction has been developed, which has the potential to use other Al technologies like natural language understanding and expert systems. With the use of Al, one can develop a combination therapy based upon the patient's own biopsy and can adopt n-of-1-medication recommendations. Chronic disease requires regular monitoring, and Al allows this monitoring to be carried out by virtual medical assistants, many of which have been installed. These assistants typically provide virtual [23].

3. Drug discovery

A. Prediction of bioactivity and toxicity

B. Clinical trials: Clinical trial design, patient identification, recruitment and enrolment, monitoring trial, patient adherence and endpoint detections.

4. Forecasting of an epidemic/pandemic: Pandemic is boundless and capable of causing morbidity and mortality. Globally, there have been several pandemic outbreaks, to name a few, Black Death, Spanish flu, Cholera, Influenzas, AIDS, COVID-19, and they are capable of causing social and economic interruption.[23] In the

pharmaceutical industry, artificial intelligence (AI) has become a crucial element that is transforming drug discovery, clinical trials, and supply chain management. It is impacting the way pharmaceutical companies function, from increasing manufacturing efficiency to improving patient quality of life. Pharmaceutical companies use Al in the drug discovery process by employing machine learning models to identify potential drug targets and predict the efficacy of drug candidates. This method greatly expedites the process of discovering effective drugs, saving billions of dollars and valuable time. In clinical trials, artificial intelligence (Al) plays a role in patient selection, study design optimization, and clinical study termination reduction. Al technologies can analyze medical records to identify eligible candidates based on criteria like current health status, medical history, and exclusions. This leads to a more efficient and successful drug trial process. Drug discovery, drug repurposing, and patient selection are three key areas in which artificial intelligence (AI) and predictive analytics are being used in the pharmaceutical industry. Al tools help pharmaceutical companies better understand disease mechanisms, identify patients who will respond favorably to a drug, and develop more effective products-all of which save time and money while also improving patient lives. Furthermore, Al and predictive analytics are being used more and more to help improve operations in commercial and sales teams. These technologies facilitate the integration of insights from large datasets, optimize workflows for sales call planning, forecast market trends, effectively segment customers, improve product launch strategies, and reduce inefficiencies associated with advertising spend. In supply chain management, Al helps with predictive maintenance and workflow optimization, which decreases downtime and boosts team productivity [24]. Al pharmaceutical is unquestionably a game-changer; its influence on the pharma market generated approximately $100 billion across the US healthcare system in 2021.AI algorithms and machine learning models have a significant impact on the biotech industry, ranging from life-saving drug discovery, development, and production to clinical trials, communication, and drug target identification.[25]

Artificial Intelligence in Drug Discovery:

Testing compounds against samples of diseased cells is a time-consuming process in drug discovery; finding compounds that are biologically active and worth further investigation requires even more analysis. Novartis research teams use machine learning algorithm images to predict which untested compounds might be worth exploring in more detail. Computers are far faster than humans at finding new data sets, so new and effective drugs can be made available sooner. Additionally, the operational costs associated with the manual investigation of each compound are reduced. The current AI initiative by the top biopharmaceutical companies include:

- Utilizing a mobile platform, health outcomes can be enhanced by making patient recommendations based on real-time data collection.
- drug discovery- pharma companies in conjunction with software companies are trying to implement the most cutting –edge technologies in the costly and extensive process of drug discovery [1]
- Portable stage to further develop prosperity results – the ability to recommend patients by strategies for consistent data combination and in like manner work on lenient outcomes.
- Drug disclosure Pharma associations identified with programming associations are endeavoring to realize the most cutting – edge headways in the costly and wide cooperation of medicine.

- The objective of working on the security of patients, UCSF Medical Center uses mechanical development for the availability and following of drugs. As shown by them, the development has organized 3, 50, 000 medication partitions with no error. The robot has wind up being far better than individuals both in size similarly as its ability to pass on careful remedies. The limits of the robotized development consolidate plan of oral similarly as faultless remedies which fuse chemotherapy sedates that are hurtful. This has offered freedom to the medication subject matter experts and disclosure.[26]

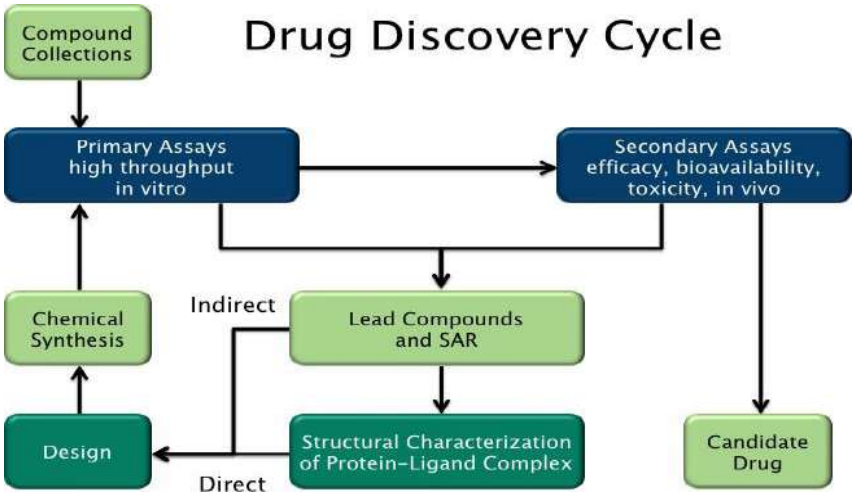


Fig. 8: Drug Discovery Cycle

Challenges to Adoption of Artificial Intelligence in Pharma:

Even while AI has a significant potential to help reshape the pharmaceutical sector, adoption is not without its challenges. Challenges that pharma companies face while trying to adopt AI: The lack of appropriate IT infrastructure stems from the fact that most current IT applications and infrastructure were not created or designed with artificial intelligence in mind. To make matters worse, pharmaceutical companies must invest a significant amount of money to improve their IT infrastructure. Given the esoteric and youthful nature of Al, many pharmaceutical businesses still view the technology as a "black box." Despite these limitations, one thing is certain: Al is already changing the biotech and pharmaceutical industries, and in ten years, the pharmaceutical industry will just become more sophisticated. [19]

AI for Pharmaceutical Market Analysis 2022 In-depth Research Studies on Products, Countries, Companies and Industry Segmentation by 2030:-

The global market for artificial intelligence in the pharmaceutical industry was valued at $XXXX billion in 2019 and is projected to reach $XXXX billion at a compound annual growth rate (CAGR) of 49.8% from 2020 to 2030. The market is expected to grow significantly in the future due to rising demand for the product, increased product awareness, and significant investments to improve product efficiency and close the gap between supply and demand. According to Fatpos Global, the major components are "Al for Pharmaceutical Market Insights, Size, Opportunities, Share, Growth, Emerging Trends, Forecast to 2031." The report includes a number of in- depth research studies on various aspects of the global Al for Pharmaceutical market. It's commendable effort to provide a true, transparent picture of the current state of the industry. [21]

AI TO PREDICT NEW TREATMENTS:

Verge's approach to drug discovery involves automating data collection and analysis in order to map out hundreds of genes that are involved in complex brain diseases such as Alzheimer's, Parkinson's, or ALS. Verge believes that collecting and analyzing gene data will have a positive effect on the drug discovery phase beginning with preclinical trials. The idea is that Verge can use artificial intelligence (AI) to monitor the effects that particular drug treatments have on the human brain beginning with preclinical phase. This will give drug manufacturers a better idea of how effective a drug is on human cells early on. Specifically, Verge uses artificial intelligence to monitor the effects that certain therapies have on the human brain with a particular.

Treatment and Management of Rare diseases:

Al advancements have sparked a renewed interest in treating rare diseases. Currently, over 350 millionpeople worldwide suffer from over 7,000 different rare diseases. Nevertheless, there is hope for patients with these illnesses as Heal, a UK-based biotech company, has secured $10 million in Series A funding to use Al to develop novel drugs for rare conditions, and Thera chon, a Swiss biotech company, has received $60 million in funding. [1]

COVID-19 Accelerates Use of Ai in the Pharmaceutical Industry:

A team from the Johns Hopkins School of Public Health used artificial intelligence to develop a COVID-19 mortality risk calculator, which could inform public health policies around preventive research. The COVID-19 pandemic has accelerated the adoption of artificial intelligence (AI) in the pharma market in domains such as healthcare. Artificial intelligence has demonstrated applications in enhancing multiple areas of care, from medical imaging and chronic disease management to population health and precision medicine. These algorithms could increase the efficiency of care delivery, reduce administrative burdens, and accelerate disease diagnosis.

AI in COVID-19 vaccine development:

Drug development benefits from artificial intelligence (AI) as it can find the best chemical compound for potential drugs, conduct simulation tests faster than humans can, and identify new targets for new medicines. For example, in January, Google Deep Mind unveiled Alpha Fold, a deep-learning system that predicts the structure of several understudied proteins, including those linked to COVID-19. While protein structure prediction is a time- consuming process, this technology helps scientists better analyze viruses and aids in the development of vaccines that can elicit an immune response. Alpha Fold has made these predictions available to the general research community.[27]

Drug adherence and Dosage form:

In order to improve drug adherence and enhance drug trial vigilance, Abbvie partnered with Acura of New York. Specifically, Abbvie used the facial and image recognition algorithm of the Ai Cure mobile SaaS platform to monitor adherence; in other words, patients used their smartphones to record themselves swallowing a pill, and the Al-powered platform verified that, in fact, the right person had swallowed the right pill. The results were astounding, with adherence increasing by up to 90%. Genpact's Al solution has been used several times in clinical trials to modify the dosage given to specific patients in order to optimize the results. In this partnership, Bayer utilizes Genpact's Pharmacovigilance Artificial Intelligence (PVAI) to not only monitor drug adherence but also detect potential side effects.[1]

Artificial Intelligence in Pharma is a good idea:

Artificial intelligence, or the development of computer systems capable of performing tasks normally requiring human intelligence, such as

speech recognition, visual perception, decision-making, and language translation, comes to mind as a recent technological advancement that can help the pharmaceutical industry accelerate innovation. According to an estimate by IBM, the Healthcare domain as a whole has approximately 161 billion GB of data as of 2011, which is a huge amount of data. Artificial intelligence can be of real help in analyzing the data and presenting results that would help in decision-making, saving Human effort, time, and money-and ultimately help save lives. Epidermic outbreak prediction; using machine learning and artificial intelligence one can study. [1] Pharmaceutical Industry can accelerate innovation by using technological advancements. The recent technological advancement that comes to mind would be artificial intelligence, development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. An estimate by IBM shows that entire Healthcare domain has approx. 161 billion GB of data as of 2011. With humongous data available in this domain, artificial intelligence can be of real help in analyzing the data and presenting results that would help out in decision making, saving Human effort, time, money and thus help save Lives. Epidermic outbreak prediction; using mechine learning /artificial intelligence one can study the history of epidermic outbreak, analyse the social media activity and predict where and when epidermic can effect with cocidarable accuracy. Apart from the a fore mentioned use-cases there are numerous others like: Personalizing the treatment Help build new tools for the patient, physicians etc. Clinical trials research: applying predictive analytics to identify candidates for the trial through social media and doctor vists.[1]

Limitations:

1. Electronic documents that need to be streamlined must first be cleaned up because they are disorganized and dispersed over several databases.
2. Transparency: Given the difficulty of AI-based processes, consumers require transparency in the health care they receive. Medical data are confidential and legally accessible, according to data governance. It is crucial to obtain public approval. Pharma businesses are renowned for being conservative and change resistant. To provide the greatest care possible, we must eliminate the stigma.[2]
3. Streamlining electronic records: They need to be cleaned up first since they are disorganised and untidy throughout the many databases.
4. Transparency: People require openness in the medical treatment they receive, which a difficult undertaking is given the intricacy of the artificial intelligence-based systems.
5. Data governance: Medical information is confidential and legally accessible. It's crucial to obtain public approval.
6. Hesitant to change: The pharmaceutical industry is notorious for being conservative and reluctant to change. To provide the greatest treatment possible, the stigma must be eliminated [22]

The Future of AI in the Pharmaceutical Industry:

Artificial Intelligence (AI) is a significant player in the pharmaceutical industry, and there's no indication that its use will slow down in the near future. Al with machine learning has the potential to revolutionize the field, from automating healthcare processes to assisting in drug discovery. More businesses should start utilizing Al to improve R&D methods and patient care. Al-capable computers, like IBM Watson, can interpret millions of pages of scientific literature and clinical trial data, uncovering previously unidentified connections between diseases and

providing an assessment in a matter of minutes, thereby helping pharmaceutical companies develop new drugs. IBM Watson Health and Pfizer Inc. recently announced their partnership.[21]

Benefits and Issues:

The pharmaceutical and life science industries are searching for more sophisticated and decision-making solutions as a result of the increasing amount of information about our daily lives and health. The potential of artificial intelligence (AI) technology leaves no choice but to join the digitalization and guarantee that pharma's most crucial processes are in their "hands." It will optimize your resource spending and make various aspects of your pharma business more creative and effective. The use of Al solution made a significant impact on decision- making. Creating innovative for patient health, remote patient monitoring, and conducting medical research. Additionally, artificial intelligence pharmaceutical automation allows you

- Efficient use of incomplete data sets. Quick data analysis
- Flexibility to account for preferences and limits
- Capacity to produce clear rules.
- improving product performance
- Quality at a cheap cost
- Shorter time to market
- Development of new products
- Improved customer response
- Improved confidence amongst patients
- Shortening the time to market
- Creating innovative products.
- Getting better client feedback
- Boosting confidence.

If Al is properly coded, it can perform tasks that humans would find difficult or dangerous, explore space, and endure problems that would harm or kill humans. It can even be used to mine and dig fuels in places where humans would not be allowed to work. Al can replace humans in repetitive, tedious tasks and in many laborious places of work. It can predict what a user will type, ask, search, and do. It can easily act as an assistant and can recommend or direct various actions.

CONCLUSION

The human brain, which is striving to create something far more efficient than a human being in performing any given task, is the most sophisticated machine that has ever been created, and it has been somewhat successful in this endeavour. The field has undergone a significant transformation thanks to AI tools such as the robotic pharmacy, pull robot, and Watson for cancer. The infrastructure required for the health-care industry will need to be more sophisticated and technologically advanced as it grows. The creation and use of algorithms for data analysis, learning, and interpretation constitute AI.

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HOW TO CITE: Pooja S. Devkate*, Vikas B. Wamane*, A Review - Artificial Intelligence In Pharma Industry, Int. J. in Pharm. Sci., 2023, Vol 1, Issue 12, 330-350. https://doi.org/10.5281/zenodo.10373995