

Artificial Intelligence in Pharma Industry- A Rising Concept

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ABSTRACT

Artificial intelligence and machine learning have been playing a significant role in the pharmaceutical industry and consumer healthcare business. Artificial intelligence is branch of computer science capable of analyzing complex medical data. Their potential to exploit meaningful relationship with in a data set can be used in the disease identification and diagnosis, treatment, helping identify patient for clinical trials, drug manufacturing and predictive forecasting. The most important advantage of artificial intelligence is that it reduces the costs that are related with drug developments and in turn, it reduces the costs that are related with drug development, enhances the returns on investment and may even cause a decrease in cost for the end user. The present review article describes the drug discovery, diagnosis, prediction of new treatment, development of novel peptides from natural foods, treatment and management of rare diseases, drug adherence and dosage challenges to adoption of artificial intelligence in pharmaceutical industry.

Keywords: Artificial intelligence, machine learning, pharmaceutical industry, drug discovery, drug manufacturing, clinical trials.

INTRODUCTION

Artificial Intelligence (AI) is the branch of engineering science which deals with creation of intelligent machines, particularly intelligent computer programs. It is the ability of computer or a robotic computer enabled system to process the given information and produce outcomes in a manner similar to the attention process of human in learning, decision making and solving problems. AI is a branch of computer science that aims to create intelligent machines, which becomes an essential part of the technology industry. AI has brought a prominent revolution in pharmaceutical industries. It is being majorly exploited in each and every field

of healthcare industry. This technology is a culmination of human intelligence and computer processing. It is an advanced version of computer aided technique that consists of collecting the information from various sources, then preparing rules accordingly to be followed for handling the required information, and drawing possible outcomes to determine appropriate results and processes can resemble the human behavior. It consists of subunits such as machine learning and deep learning which provide ease in working with neural works [1-3].

The sequence of the events in the research of AI was shown in figure 1.

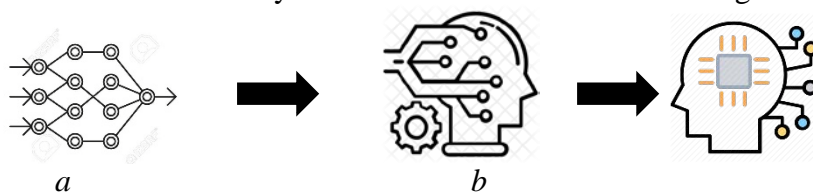


Fig. 1: Computer Programming Stages a. Neural networks b. Machine learning c.

Deep Learning

AI is a flourishing technology which finds application in multiple aspects of life and industry. In recent times the pharmaceutical industry discovers novel and innovative ways to use this powerful technology to help solve some of the biggest problems facing pharma today. Artificial Intelligence in pharma refers to use of automated algorithms to perform tasks which traditionally rely on human intelligence. Over the last five years, the use of artificial intelligence in the pharma and biotech industry has redefined how scientists develop new drugs, tackle disease, and more [1]. The year 1956 is usually considered to be the year when AI was born, as it was in 1956 that Dartmouth College had organized the famous conference. However, the preceding year, that is, 1955, saw its first AI system that was called Logic Theorist and the people

who developed it was Allen Newell, Herbert A. Simon. Nearly, 40 theorems of Principia Mathematica by Alfred N. Whitehead and Bertrand Russell were proved using this system. However, the designers of the system could not get it published^[4]. The scientists and engineers who are producing intelligent machines have made enormous progress in the speed and memory capabilities of their devices, to the point where they vastly exceed those of humans in many respects. However, the intellectual mechanism of even the most modern robots are still limited to what a designer can program into them in the first place. Now, with the advent of big data, companies are harnessing the power of AI to deliver more focused solutions in a variety of areas; AI helps them understand data in real time. The land marks were given in table 1 [5].

Table 1: Milestones in the Artificial Intelligence Process

Year	Milestone
1943	Neurons can do logical operations like “and”, “or” or “not”, when they are connected as network. This process was proved by Walter Pitts and Warren McCulloch.
1951	First neural network, which solved a problem from the real world i.e. SNARC (Stochastic Neural Analog Reinforcement Computer) was by Marvin Minsky
1956	At Dartmouth college conference the term “Artificial Intelligence” was coined.
1958	Perceptron (neural networks that transmit information in one direction) was created by Frank Rosenblatt which is the origin for today's AI progress.
1969	Minsky supported the symbolic representation of problems in his book-“Perceptron’s”.
1974-1980	During this period interest on AI was dropped, which is called as “First AI Winter”.
1986	Back propagation algorithm design was developed by Georey Hinton which is widely using in deep learning nowadays.
1987-1993	This phase is called as “AI Winter”
1997	This year IBM Deep blue defeated the Garry Kasparov (Russian grandmaster).
2013	Google used British Technology to perform efficient research on photos.
2016	Google DeepMind, software AlphaGo defeated the Go Champion lee Sedol.

AI, Machine Learning (ML) and Deep Learning (DL) [6]

AI is described as the use of techniques that enable computers to mimic human

behavior. AI also contains a subfield called machine learning (ML), which uses statistical methods with the ability to learn

with or without being explicitly programmed.

ML is categorized into supervised, unsupervised and reinforcement learning.

- 1) **Supervised Learning** comprises classification and regression methods where the predictive model is developed based upon the data from input and output sources. Output from supervised ML entails disease diagnosis under the subgroup classification; and drug efficacy and ADMET predication under the subgroup regression.
- 2) **Unsupervised Learning** comprises clustering and feature-finding methods by grouping and interpreting data based solely on input data. Through unsupervised ML, outputs such as disease subtype discovery from clustering and disease target discovery from feature finding methods can be attained.
- 3) **Reinforcement Learning** is largely driven by decision making in a given environment and its execution to maximize its performance. The outputs from this type of ML include *de novo* drug designs under execution – where both can be achieved via modelling and quantum chemistry.

A further subfield of ML called deep learning (DL) uses artificial neural networks that adapt and learn from the vast amount of experimental data. The big data and associated data mining and algorithm methods could provide us with the capacity to discover new compounds that could potentially be new drugs, uncover or repurpose drugs that could be more potent when used individually or in combination and improve the area of personalized medicine based on genetic markers. The emergence of DL was observed with the increasing amount of data and the continuous growth of computer power. The striking difference that makes DL a

subfield of AI is the flexibility in the architecture of neural networks such as convolutional neural network (CNNs), recurrent neural networks (RNNs) and fully connected feed forward networks. It is believed, with proper establishment of methods in AI, we will witness the transition into an era of minimized failures in clinical trials and a faster, cheaper and effective drug development processes.

Advantages of AI Technology [7-9]

AI is complex in nature and use. It is a combination of intense mixture of mathematics, computer science and other sciences. The complexity of programming helps the machines to reproduce the cognitive abilities of human beings. The major advantages are:

1) Error Reduction

- AI helps human beings to reduce the error and increases the chance of reaching accuracy with more precision.
- Intelligent robots are suitable to send to explore space, because they have metal bodies, resistant and have greater ability to tolerate the aggressive atmospheric conditions of space.

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 beings.
- By programming the robots, they can perform more hard work and laborious work easily without exhaust.

3) Daily application

- AI is useful for the daily application purpose.
- Everyone widely uses the GPS system, which is helpful in long 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.
- The AI system is widely used in financial and banking institutions to manage and organize the data to detect the swindles.

4) Digital Assistants

- AI systems 'avatar' which is models of digital 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 can perform multi-tasking and can think faster than human beings.
- Machines can perform dangerous tasks and their parameters can be adjusted i.e. speed and time.

6) Medical application

- Nowadays, the physicians are assessing the patients and analyzing 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 rate

- AI technology helps to enter into the world of more advanced technological innovations.
- The AI system has the potential to produce millions of computer

modelling programs, which are helpful to find new chemical compounds and entities. For example- QSAR, QSPR.

Disadvantages of AI Technology [7-9]

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 it leads to big problems.
- If the problems are unfamiliar to robots, they are unable to take the decision.
- At that time, they give false report or they undergo breakdown.

3) No improvement with experience

- Machines working with AI technology cannot be improved like human beings with experience.
- Machines lack care, concern, belonging or togetherness.
- 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.

- It will lead to large scale unemployment.
- Generally, human beings have high dependency nature. Due to this, they lose their creativity power and become lazy.

Types of Artificial Intelligence [2]

AI is wide ranging concept and can be classified into a number of ways. Based upon their caliber, AI system is classified as follows:

- 1) **Weak intelligence or Artificial narrow intelligence (ANI):** This system is designed and trained to perform a narrow task, such as facial recognition, driving a car, playing chess, traffic signaling. E.g. Apple SIRI virtual personal assistance, tagging in social media.
- 2) **Artificial General Intelligence (AGI) or Strong AI:** It is also called as Human Level AI. It has the ability to simplify human intellectual abilities. Due to this, when it exposed to an unfamiliar task, it has the ability to find the solution. AGI can perform all the things as humans.

- 3) **Artificial Super intelligence (ASI):** It is a brain power, which is more active than smart humans drawing, mathematics, space, etc. In each and every field from science to art, it ranges from the computer just little than the human to trillion times smarter than humans.

Tools of AI [10-12]

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 patient care and working with the physicians.

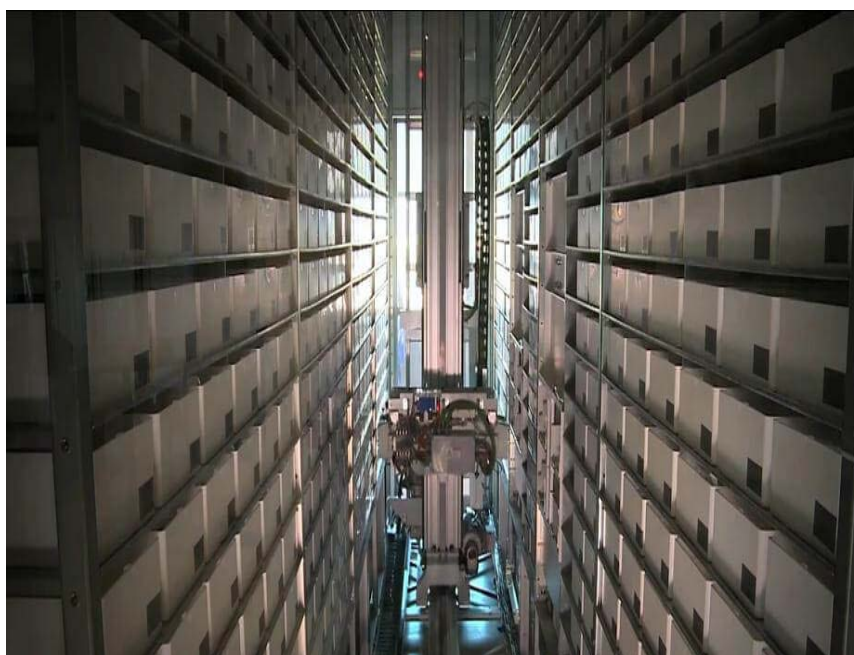


Fig. 2: ROBOT Pharmacy

MEDi Robot

MEDi is a short form for Medicine and Engineering Designing Intelligence. The pain management robot was developed as part of a project led by Tanya Beran, professor of Community Health Sciences at University of Calgary in Alberta. She got idea after working in hospitals where children scream during medical procedures. (10) The robot first builds a rapport with children scream during medical procedure. During the medical procedure, it guides them on what should be done, how to breathe during the procedure, and how to cope. Although the robot cannot think, plan, or reason, it can be programmed such that it shows to have AI.

MEDi, manufactured by Aldebaran Robotics, having inbuilt facial recognition technology, can speak 20 different situations. The retail price of the robot is \$9000; however, the cost rises to \$15000-\$30000 when the applications needed for the robot to help in medical procedures are installed. The robot was initially developed for pain management, but with time its use has expanded to comfort between procedures, physical rehabilitation, and fundraising.



Fig. 3: MEDi ROBOT



Fig. 4: MEDi Interacting with Child

Erica Robot

Erica is a new care robot that has been developed in Japan by Hiroshi Ishiguro, a professor at Osaka University. It was developed in collaboration with Japan Science and technology Agency, Kyoto University, and the Advanced Telecommunications Research Institute International (ATR). It can speak Japanese and has a blend of European and Asian facial feature. The robot cannot walk independently, however, it has been developed with the ability to understand and answer questions with human-like facial expressions. Erica is the “most beautiful and intelligent” android as Ishiguro fixed up the feature of 30 beautiful women and used the average for designing the robot’s nose, eye and so on.



Fig. 5: Erica – The Humanoid Robot

Tug Robot

Aethon TUG robots are designed to autonomously travel through the hospital and deliver medications, meals, specimens, materials, and haul carry heavy loads such as linen and trash. It has two configurations, i.e., fixed and secured carts as well as exchange base platform that can be used to carry racks, bins, and carts. The fixed carts are used for delivering medications, sensitive materials, and laboratory specimens, whereas, the exchange platform is employed to transport materials that can be loaded on different racks. The TUG can deliver several types of carts or racks thus making it a very flexible and utilizable resource.



Fig. 6: TUG Robot



Fig. 7 TUG Robot Handling Pills

Berg

Berg is Boston-based biotech and is one of the key players employing AI in its various processes. It has an AI based platform for drug discovery, which has a huge database of patients and this is used to find as well

as validate the various biomarkers responsible for causing diseases and then decides therapies according to obtained data.

The motto of the company is speed up the process of drug discovery and to bring about a reduction in the cost with the aid of AI as it obliterates guesswork that is involved in the process of drug development. The steps that are followed by Berg include procurement of sequencing data from samples of human tissue, finding information regarding metabolites, and protein formation, and testing of data using algorithms of AI to correctly determine the actual cause of disease.

Applications for AI in Pharmaceutical Industry [13-17]

1) Manufacturing Process Improvement

- In development and production, AI provides numerous opportunities to improve processes.
- AI can perform quality control, shorten design time, reduce materials waste, improve production reuse, perform maintenance and more.
- AI can be used in many ways to make production more efficient with faster output and less waste.
- For example, a process that typically relies on human intervention to input or manage process data can be done using CNC (computer numerical control).
- The AI machine learning algorithms not only ensure tasks are performed very precisely, but also analyze the process to find areas where it can be streamlined.
- This results in less material waste, faster production and more meeting

the product's Critical Quality Attributes.

2) Drug Discovery and Design

- From designing new molecules to identifying novel biological targets, AI is playing a role in drug target identification and validation; target-based, phenotypic, as well as multi target drug discoveries; drug repurposing; and biomarker identification.
- The key benefit for pharma companies is the potential for AI, especially when implemented during drug trials, to reduce the time it takes a drug to get approval and reach the market.
- This can result in great cost savings, which could mean lower cost drugs for the patients, as well as more treatment choices.

3) Rare Diseases and Personalized Medicine

- Combining information from body scans, patient biology and analytics, AI is being used in various ways to detect diseases such as cancer, and even predict health issues people might face based on their genetics.
- One example is the IBM Watson for Oncology, which uses each patient's medical information and history to recommend a personalized treatment plan.
- AI is also being used to develop personalized drug treatments based on an individual's test results, reactions to past drugs and historical patient for drug reactions.

4) Identifying Clinical Trial Candidates

- Besides helping to make sense of clinical trial data, another use of artificial intelligence in the pharmaceutical industry is finding patients to participate in the trials.
- Using advanced predictive analytics, AI can analyze genetic

information to identify the appropriate patient population for a trial, and determine the optimal sample size.

- Some AI technology can read free-from text that patients enter into clinical trial applications, as well as unstructured data such as doctor's notes and intake documents.

5) Drug Repurposing

- For budget-pressed pharma companies, repurposing drugs promises to be one of the most immediate areas that AI-based technologies can deliver great value.
- Repurposing previously known drugs or late-stage drug candidates towards new therapeutic areas is desired strategy for many biopharmaceutical companies as it presents less risk of unexpected toxicity or side effects in human trials and likely less R&D spend.

6) Drug Adherence and Dosage

- Ensuring compliance to a drug study protocol by voluntary participants in clinical studies is a huge problem for pharma companies.
- If patients in a drug study don't follow the trial rules, they must either be removed from the study or risk corrupting the drug study results.
- One of the important factors of a successful drug trial is ensuring that participants take the required dosage of the studied drug at the prescribed times.
- That's why having a way to ensure drug adherence is so important. Both through remote monitoring and algorithms test results, AI can sort the good apples from the bad.

7) Moving Toward AI in Pharma Development

- While the possibilities for using AI in pharma and biotech development are obvious, the actual move toward adopting such technologies can be slow going.
- Not only do traditional drug development and discovery processes require a more gradual adaption, the process for “training” AI in what works for drug discovery can take longer than in other applications.
- For example, when social media tags your photo using AI, it’s get immediate feedback from you about whether the results is correct or not, which allows the AI to learn quickly.
- With drug discovery, the feedback on a new molecule as drug candidate can take months or years to prove.
- Yet, it’s undeniable that AI will be the next big thing in the pharma industry, and those companies that adapt and adapt new processes will have a strategic advantage.

- A good place to starts is by using technologies that exist today for data analytics based on multivariate and predictive analytics.

8) Research and Development

- Pharma companies across the globe are developing advanced AI powered tools and ML algorithms to smoothen drug innovation process.
- These technology tools are designed to detect complex patterns in large datasets and therefore can be used to resolve problems associated with complex biological networks.
- The ability to study patterns of various diseases and to determine which composite formulations are best suited for the treatment of specific symptoms of a particular disease is excellent pharma industries can invest in the R&D of such drugs that are more likely to treat a disease or medical condition successfully.

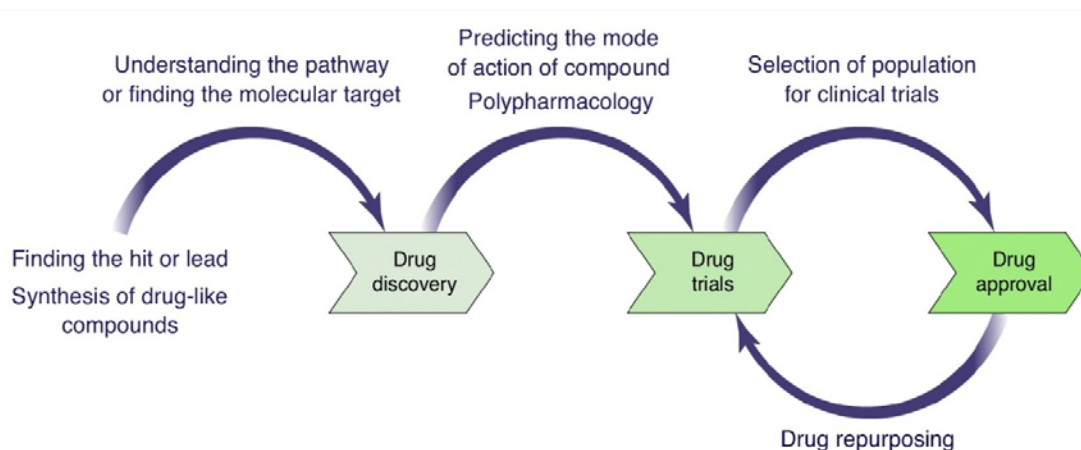


Fig. 8 AI in Drug Development

9) Marketing

- The pharmaceutical industry is sales driven sector; AI can be a handy tool in pharma marketing. With AI, pharma companies can explore and develop unique

marketing strategies that promise high revenues and brand awareness.

- AI can help to map the customer journey, thereby allowing companies to see which marketing

technique led visitors to purchase from them. In this way, pharma companies can focus more on those marketing strategies that lead to most conversions and increase revenues.

- AI tools can analyze past marketing campaigns and compare the results to identify which campaigns remained the most profitable. This allows companies to design the present marketing campaigns accordingly, while also reducing time and saving money.

The process of AI adoption in the pharma sector can be made easy by taking these steps:

- Partnering and collaborating with academic institutions that specialize in AI R&D to guide pharma companies with AI adoption.
- Collaborate with companies that specialize in AI-driven medicine discovery to reap the benefits of expert assistance, advanced tools, and industry experience.
- Train R&D and manufacturing teams to use and implement AI tools and techniques in the proper way for optimal productivity.

Challenges That Pharma Companies Face While Trying to ADOPT AI [1]

- 1) The unfamiliarity of the technology – for many pharma companies, AI still seems like a “black box” owing to its newness and esoteric nature.
- 2) Lack of proper IT infrastructure – that’s because most IT applications and infrastructure currently in use weren’t developed or designed with artificial intelligence in mind. Even worse, pharma firms have to spend lots of money to upgrade their IT system.
- 3) Much of the data is in a free text format – that means pharma companies

have to go above and beyond to collate and put this data into a form that’s able to be analyzed. Despite all these limitations, one thing is for certain. AI is already redefining biotech and pharma.

Artificial Intelligence and the Future of Pharma Industry [17]

- 1) Computers with learning capabilities, such as IBM Watson, are capable of interpreting millions of pages of scientific literature and data of clinical trials, discovering previously unknown connections between diseases and make an assessment within few minutes to assist pharma companies in development of new drugs.
- 2) IBM Watson Health and Pfizer Inc. announced a collaboration that will utilize IBM Watson for Drug Discovery to help accelerate Pfizer’s research in immune-oncology. Berg, a fast growing Botson biotech, uses artificial intelligence to find and validate disease-causing biomarkers and efficiently craft therapies based on the newly found data [17].

CONCLUSION

Artificial Intelligence serves as marked platform in the advancement of pharmaceutical sector. AI saves time as well as provides the required set of data analysis and quality control. The various components of AI such as ANN, deep learning, genetic programming etc. are being used for rationale design of drug molecules. The AI has also influenced the area of healthcare by playing a major role in clinical research by conclude the adverse effects. Artificial intelligence can lead to the development of various technologies and software that would help improve the pharmaceutical product development and health management strategies. Artificial intelligence is the design and application for analysis of learning and interpretation of data.

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