Review Article

The Era of Artificial Intelligence in Pharmaceutical Industries - A review

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ABSTRACT

As a growing sector, the Era of Artificial Intelligence, Machine Learning and Data Science in the Pharmaceutical Industry contributes in the drug discovery process, giving emphasis on how new technologies have improved effectiveness. As in the current scenario artificial intelligence including machine learning may be considered the future for a wide range of disciplines and industries specially the pharmaceutical industry. As we know today pharmaceutical industries producing a single approved drug cost the company millions with many years of rigorous testing prior to its approval, reducing costs and time is of high interest. The involvement of Artificial Intelligence will be useful to the pharmaceutical industry and also be of interest to anyone doing research in chemical biology, computational chemistry, medicinal chemistry and bioinformatics.

Key words: Artificial Intelligence, Pharmaceutical, Machine Learning, Research, Chemistry

Artificial intelligence (AI) is a branch of study that combines intelligent machine learning, particularly intelligent computer programmes that produce outcomes like human attention processes [1]. This procedure typically entails gathering data, creating effective mechanisms for using that data, illuminating precise or approximative conclusions, and making oneself modifications or adjustments [2]. AI is typically used to analyse machine learning to mimic human cognitive functions [2, 3].

AI is used to conduct analyses that are more accurate and to get helpful interpretation [3]. According to this the development and invention of AI applications are frequently linked to the concern about the threat of unemployment. However, practically all developments in the use of AI technology are being applauded because of the industry's massive reliance on its effectiveness. The practical uses of AI technology in numerous technological and scientific disciplines have recently made it a highly vital component of industry [3, 4].

The emerging movement to accept AI applications in pharmacy, including drug discovery, formulation creation for drug administration, and other healthcare applications, has already moved from hype to hope [5, 6]. Predicting in vivo reactions, therapeutic drug pharmacokinetic characteristics, appropriate dose, etc. is also made possible by the use of AI models [2, 7]. According to the importance of pharmacokinetic prediction of drugs, the uses of in silico models facilitate their effectiveness and inexpensiveness in the drug research [8].

Artificial intelligence (AI) has become more prevalent in a number of societal fields, most notably the pharmaceutical industry. In this review, we focus on how AI is being used in a variety of pharmaceutical industry fields, such as discovery and development, drug repurposing, increasing pharmaceutical productivity, and clinical trials, among others. This use of AI lessens workload of human workers while also achieving goals quickly. We also talk about how various AI tools and methodologies interact, current problems and solutions, and the potential applications of AI in the pharmaceutical sector. The pharmaceutical industry has dramatically increased its data digitization during the last few years. The difficulty of gathering, examining, and applying that knowledge to address challenging healthcare situations is a challenge that comes along with digitalization [9].

Because AI can handle massive amounts of data with improved automation, this encourages its usage [10]. Technology-based artificial intelligence (AI) systems can replicate human intelligence by using a variety of cutting-edge tools and networks. However, it does not pose a danger to totally replace human physical presence [11, 12]. AI makes use of hardware and software that can analyse and learn from input data to make independent judgements for achieving predetermined goals. As this review describes, its uses in the pharmaceutical industry are constantly expanding. According to the McKinsey Global Institute, the rapid advances in AIguided automation will be likely to completely change the work culture of society [13, 14].

AI: Networks and Tools: AI encompasses a number of approach fields, including machine learning as its core paradigm as well as reasoning, knowledge representation, and solution search (ML). In machine learning (ML), algorithms are used to find patterns in a set of data that has been further categorised. Deep learning (DL), a branch of machine learning that uses artificial neural networks (ANNs). These are a collection of intricately connected computing components that simulate the electrical impulse transmission in the human brain by using "perceptons" that are similar to biological human neurons [15]. Every node in an ANN receives a different input, and they all work together or alone to solve issues by converting inputs to outputs using algorithms [16]. ANNs involve various types, including multilayer perceptron (MLP) networks, recurrent neural networks (RNNs), and convolutional neural networks (CNNs), which utilize either supervised or unsupervised training procedures [17, 18].

Classification of AI

According to their ability, AI can be categorized as

i) Artificial Narrow Intelligence (ANI) or Weak AI: It performs a narrow range task, i.e., facial identification, steering a car, practicing chess, traffic signalling, etc.
ii) Artificial General Intelligence (AGI) or Strong AI: It performs all the things as humans and also known as human level AI. It can simplify human intellectual abilities and able to do unfamiliar task.
iii) Artificial Super Intelligence (ASI): It is smarter than humans and has much more activity than humans drawing, mathematics, space, etc.

According to their presence and not yet present, AI can be classified as follows

i) Type 1: It is used for narrow purpose applications, which cannot use past experiences as it has no memory system. It is known as reactive machine. There are some examples of this memory, such as a IBM chess program, which can recognize the checkers on the chess playing board and capable of making predictions.
ii) Type 2: It has limited memory system, which can apply the previous experiences for solving different problems. In automatic vehicles, this system is capable of making decisions there are some recorded observations, which are used to record further actions, but these records are not stored permanently.
iii) Type 3: It is based upon "Theory of Mind". It means that the decisions that human beings make are impinged by their individual thinking, intentions and desires. This system is non-existing AI.
iv) Type 4: It has self-awareness, i.e., the sense of self and consciousness. This system is also non-existing AI.

Artificial Intelligence and Robotics: Robotics and artificial intelligence share a shared origin and a long history of interaction and scholarly debate. It might be argued that not all machines are robots, and that artificial intelligence likewise has concerns for virtual agents. Robots are produced as hardware and artificial intelligence is a hypothesis. The two are related because a software agent that controls the robot examines data from these sensors, decides what to do next, and then directs the actions to be taken in the real environment. It has numerous robotics applications [20]. Patients will also look into potential drug options as they become more involved in their healthcare decision. Through target audience marketing, pharmaceutical companies can further assure the right information is presented at the right time to facilitate informed patent and provider discussions [19].

"It is time for Connected Pharma": However, progress is far from uniform and progress is likely to be "lumpy" at best. AI technology is well on its way to becoming ubiquitous and has huge scope, enhancing technology at many levels, leading to much better, faster patient outcomes.

Pharmaceutical Automation: Assisted by artificial intelligence Industrialization produced automation because it was necessary to boost output, produce items of consistently high quality, and free people from dangerous and taxing tasks. Technology advancements today provide the fundamental foundation of automation. The majority of Pharma players are aware of the advantages of implementing new technology, but there is still a persistent and alarming gap between strategy and an organization's capacity to implement a workable data analytics solution [21].

The adoption of AI allows for learning from real - time data.

- Identifying the right candidates for clinical trials.
- Processing real time patient feedback.
- Integrating data exchanges with partners.
- Distributors and caregivers.

There are just few examples on how to improve drug discovery outcomes, while aligning operational efficiencies to deliver better care to the patients, often getting the right medication to the right patient at right time is really about getting right information in front of healthcare provider. Armed with complete real-time drug insights, doctors are able to choose right prescription for the best possible outcome. Automation applications continue to grow with enabling technologies such as [22]:

1. Wireless
2. Nanotechnology

3. Advance storage and memory
4. Sensors and analyzers
5. Advance software algorithms
6. Artificial intelligence.

AI in Advancing Pharmaceutical Drug Devlopment: The subsequent inclusion of a novel therapeutic molecule into an appropriate dosage form with the requisite delivery properties is necessary. The traditional method of trial and error can be replaced in this area by AI [23]. With the use of QSPR, a variety of computational methods can be used to overcome challenges with stability, dissolution, porosity, and other aspects of formulation design [24]. Decision-support tools operate through a feedback mechanism to monitor the entire process and sporadically adjust it [25]. They employ rule-based systems to choose the type, nature, and quantity of the excipients based on the physicochemical properties of the medicine. Based on the input parameters, the Model Expert System (MES) decides and gives suggestions for formulation development. ANN, in contrast, ensures hassle-free formulation development by using backpropagation learning to link formulation parameters to the intended response, which is jointly regulated by the control module [26]. The influence of the powder's flow behaviour on the die-filling and tablet compression process has been studied using a variety of mathematical tools, including computational fluid dynamics (CFD), discrete element modelling (DEM), and the Finite Element Method [27, 28]. The effect of tablet geometry on its disintegration profile can also be studied using CFD [29]. The quick manufacture of pharmaceutical items may benefit greatly from the integration of these mathematical models with AI.

AI in Pharmaceutical Marketing: Modern manufacturing systems are attempting to impart human knowledge to robots as a result of the growing complexity of production processes, as well as the growing desire for efficiency and greater product quality [30]. The pharmaceutical business may benefit from the application of AI in manufacturing. Utilizing the automation of many pharmaceutical activities, tools like CFD use Reynolds-Averaged Navier-Stokes solvers technology to examine the effects of agitation and stress levels in various pieces of equipment (such stirred tanks). Similar methods, including big eddy simulations and direct numerical simulations, use sophisticated techniques to address challenging flow problems in manufacturing [31]. The innovative Chapter platform, which uses a scripting language called Chemical Assembly and several chemical codes, aids digital automation for the synthesis and manufacture of molecules [32]. Sildenafil, diphenhydramine hydrochloride, and rufinamide have all been successfully manufactured using this method, and the yield and purity are noticeably similar to those obtained through manual synthesis [33]. AI technology can effectively complete granulation in granulators with capacities ranging from 25 to 600 l [34]. Neuro-fuzzy logic and technology were used to correlate key factors with their answers. In order to anticipate the proportion of granulation fluid to be supplied, the necessary speed, and the diameter of the impeller in both geometrically identical and dissimilar granulators, they developed a polynomial equation [35].

AI in Quality Control and Quality Assurance: A balance of different factors must be achieved throughout the production of the desired product from raw materials [36]. It takes human intervention to maintain batch-to-batch consistency and conduct quality control testing on the products. This illustrates the need for AI deployment at this time and may not be the optimal strategy in every situation [37]. By implementing a "Quality by Design" approach, the FDA modified Current Good Manufacturing Practices (cGMP) in order to better understand the crucial process and precise standards that determine the ultimate quality of the pharmaceutical product [38].

AI in Clinical Filed: Clinical trials take about 6-7 years to complete and include a substantial financial outlay in order to determine the safety and effectiveness of a medicinal product in people for a specific illness condition. Only one out of every ten compounds that undergo these trials, however, receive successful clearance, which represents a significant loss for the industry [39]. These failures may be the result of bad infrastructure, poor technical requirements, and poor patient selection. With the use of AI, these problems can be minimised thanks to the abundance of digital medical data that is currently available [40].

CONCLUSION

As a result of the AI technological approaches' belief that humans can imagine knowledge, solve problems, and make decisions, there has been an increase in interest in using AI technology for analysing and interpreting some critical areas of pharmacy, such as drug discovery, dosage form design, poly pharmacology, hospital pharmacy, etc. It has been found to be beneficial to use automated workflows and databases for efficient studies that apply AI techniques. The construction of novel hypotheses, strategies, predictions, and assessments of many connected elements can be done with the ease of less time consumption and affordability thanks to the usage of AI technologies.

REFERENCES

1. Mak KK, Pichika MR. Artificial intelligence in drug development: Present status and future prospects. Drug Discov Today. 2019; 24(3):773-80.
2. Hassanzadeh P, Atyabi F, Dinarvand R. The significance of artificial intelligence in drug delivery system design. Adv Drug Deliv Rev. 2019; 151:169-90.
3. Russel S, Dewey D, Tegmark M. Research priorities for robust and beneficial artificial intelligence. AI Mag. 2015;36(4):105-14.

4. Duch W, Setiono R, Zurada JM. Computational intelligence methods for rulebased data understanding. Proc IEEE. 2004; 92(5):771-805.
5. Dasta JF. Application of artificial intelligence to pharmacy and medicine. Hosp Pharm. 1992; 27(4):319-22.
6. Jiang F, Jiang Y, Zhi H. Artificial intelligence in healthcare: Past, present and future. Stroke Vasc Neurol. 2017; 2(4):230-43.
7. Gobburu JV, Chen EP. Artificial neural networks as a novel approach to integrated pharmacokinetic-pharmacodynamic analysis. J Pharm Sci. 1996; 85(5):505-10.
8. Sakiyama Y. The use of machine learning and nonlinear statistical tools for ADME prediction. Expert Opin Drug Metab Toxicol. 2009; 5(2):149-69.
9. Ramesh A. Artificial intelligence in medicine. Ann. R. Coll. Surg. Engl. 2004; 86:334–338.
10. Miles J., Walker A. The potential application of artificial intelligence in transport. IEE Proc.-Intell. Transport Syst. 2006;153:183–198
11. Yang Y., Siau K. A Qualitative Research on Marketing and Sales in the Artificial Intelligence Age. MWAIS; 2018.
12. Wirtz B.W. Artificial intelligence and the public sector—applications and challenges. Int. J. Public Adm. 2019; 42:596–615.
13. Smith R.G., Farquhar A. The road ahead for knowledge management: an AI perspective. AI Mag. 2000; 21 171–178.
14. Lamberti M.J. A study on the application and use of artificial intelligence to support drug development. Clin. Ther. 2019; 41:1414–1426.
15. Beneke F., Mackenrodt M.-O. Artificial intelligence and collusion. IIC Int. Rev. Intellectual Property Competition Law. 2019; 50:109–134.
16. Steels L., Brooks R. Routledge; 2018. The Artificial Life Route to Artificial Intelligence: Building Embodied, Situated Agents.
17. Bielecki A., Bielecki A. Foundations of artificial neural networks. In: Kacprzyk Janusz., editor. Models of Neurons and Perceptrons: Selected Problems and Challenges. Springer International Publishing; Polish academy of sciences, Warsaw, Poland. 2019. pp. 15–28.
18. Kalyane D. Artificial intelligence in the pharmaceutical sector: current scene and future prospect. In: Tekade Rakesh K., editor. The Future of Pharmaceutical Product Development and Research. Elsevier; 2020. pp. 73–107.
19. Russell S, Dewey D, Tegmark M. Research priorities for robust and beneficial artificial intelligence. Ai Magazine. 2015 Dec 31; 36(4):105-14.
20. Lakshmi Teja T, Keerthi P, Debarshi Datta NB. Recent trends in the usage of robotics in pharmacy, Indian Journal of Research in Pharmacy and Biotechnology, 2(1), 1038-1043.
21. Yussupova N, Kovács G, Boyko M, Bogdanova D. Models and methods for quality management based on artificial intelligence applications. Acta Polytechnica Hungarica. 2016; 13(3):45-60
22. Brady M. Artificial intelligence and robotics. Springer, Berlin, Heidelberg. In Robotics and Artificial Intelligence 1984, 47-63.
23. Guo M. A prototype intelligent hybrid system for hard gelatin capsule formulation development. Pharm Technol 2002;6:44–52.
24. Mehta C.H. Computational modeling for formulation design. Drug Discovery Today. 2019; 24:781–788.
25. Zhao C. Toward intelligent decision support for pharmaceutical product development. J. Pharm. Innovation. 2006; 1:23–35.
26. Rantanen J., Khinast J. The future of pharmaceutical manufacturing sciences. J. Pharm. Sci. 2015; 104:3612–3638.
27. Ketterhagen W.R. Process modeling in the pharmaceutical industry using the discrete element method. J. Pharm. Sci. 2009; 98:442–470.
28. Chen W. Mathematical model-based accelerated development of extended-release metformin hydrochloride tablet formulation. AAPS PharmSciTech. 2016; 17:1007–1013.
29. Meziane F. Intelligent systems in manufacturing: current developments and future prospects. Integr. Manuf. Syst. 2000; 11:218–238.
30. Steiner S. Organic synthesis in a modular robotic system driven by a chemical programming language. Science. 2019; 363:eaav2211.
31. Faure A. Process control and scale-up of pharmaceutical wet granulation processes: a review. Eur. J. Pharm. Biopharm. 2001; 52:269–277.
32. Landin M. Artificial intelligence tools for scaling up of high shear wet granulation process. J. Pharm. Sci. 2017; 106:273–277.
33. Das M.K., Chakraborty T. ANN in pharmaceutical product and process development. In: Puri Munish, editor. Artificial Neural Network for Drug Design, Delivery and Disposition. Elsevier; 2016, 277–293.
34. Gams M. Integrating artificial and human intelligence into tablet production process. AAPS PharmSciTech. 2014; 15:1447–1453.
35. Aksu B. A quality by design approach using artificial intelligence techniques to control the critical quality attributes of ramipril tablets manufactured by wet granulation. Pharm. Dev. Technol. 2013; 18:236–245.
36. Goh W.Y. Application of a recurrent neural network to prediction of drug dissolution profiles. Neural Comput. Appl. 2002; 10:311–317.
37. Drăgoi E.N. On the use of artificial neural networks to monitor a pharmaceutical freeze-drying process. Drying Technol. 2013; 31:72–81.
38. Reklaitis R. PharmaHub; 2008. Towards Intelligent Decision Support for Pharmaceutical Product Development.
39. Wang X. 2009 International Conference on Computational Intelligence and Software Engineering. Intelligent quality management using knowledge discovery in databases; IEEE; 2009. 1–4.
40. Hay M. Clinical development success rates for investigational drugs. Nat. Biotechnol. 2014; 32:40–51.

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