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REVIEW ON PHARMACEUTICAL APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

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ABSTRACT

To increase productivity and expedite the process of discovering novel medications, artificial intelligence (AI) is applied in drug research. Drug design, virtual screening, and target selection can all benefit from AI. Machine learning is a branch of artificial intelligence (AI) that enables machines to learn from their experiences and get better over time. It analyses data, finds trends, and makes judgements using algorithms. To evaluate data, forecast characteristics, and find possible drug candidates, artificial intelligence (AI) is utilised in the drug discovery process. Artificial Intelligence (AI) can assist increase the success rate of new pharmaceuticals, lower costs, and speed up the drug discovery. The present review discusses about the advancement of AI in pharmaceutics, development and optimization of drug design. Drug discovery is greatly aided by machine learning (ML), which analyses large datasets to predict drug properties, identify potential targets, virtually screen chemical libraries, optimise drug design, and identify potential side effects. In other words, ML improves the efficiency of drug development at all stages, from target identification to clinical trials, and essentially speeds up the process.

KEYWORDS: Artificial intelligence, machine learning, drug discovery, ligands, lead optimization.

INTRODUCTION

Artificial intelligence can be defined as a discipline of computer science that assists in problem-solving using symbolic programming. Regardless of your familiarity, throughout the

20th century, we all became reliant on AI. We currently use real-world instances of artificial intelligence in our daily lives. Development of expert system is a main application of A.I. (Artificial intelligence). A.I was came into existence in year 1956. People who developed A.I are Allen Newell, Herbert A. Simon. Logic Theorist was first Artificial Intelligence system seen in 1956.[1] The terms automation and robotics are frequently used interchangeably with artificial intelligence. AI is the display of human-like behavior's or intelligence by any computer or machine, whereas robotics is just the construction of machines capable of doing complex repetitive tasks.[2] The scientific field of artificial intelligence (AI) combines machine learning and intelligent computer programs to provide better results in a range of academic and scientific fields. Correct analysis, system creation, and data analysis are among its objectives. It is feasible to achieve objectives more rapidly and lessen the workload of human resources by utilising AI in a number of pharmaceutical sector domains, such as drug research and development, drug repurposing, boosting pharmaceutical production, clinical trials, etc., to name a few workers.[3] Significant progress has been made in the pharmaceutical industry's use of digitalisation. However, one of the challenges that change constantly brings may be the need for analysis and reliable information to solve problems associated with its acquisition and use in the field.[4] While ML is a subset of AI that accesses data, analyses trends, and produces intelligent, actionable insights, AI is the superset of tasks that exhibit traits of human intelligence.[5] Machine learning provides an answer. Machine learning has been increasingly versatile and potent in recent years. For example, it can learn from the data to identify complex patterns and inferences without explicit guidance, it can teach and enhance the models on its own, and it can make incident predictions.[6] Given the rapid expansion of biological sequences discovered in the postgenomic age, artificial intelligence approaches in proteomic-based prediction analysis for physicochemical, therapeutical, and toxicological characterisation of proteins and peptides are tangible.[7] Supervised learning, a popular method for artificial intelligence, involves labelling training data (i.e., occurrences with and without disease) before feeding it into an algorithm for pattern recognition, validation, and performance evaluation.[8] Precision medicine has entered a new era of efficiency and creativity as a result of the use of Artificial Intelligence (AI) into drug discovery procedures. With its ability to enhance treatment results and minimize side effects, precision medicine which is defined as individualised healthcare based on individual characteristics has become increasingly popular.[9]

Type of Artificial Intelligence[10]

A. Based on the calibre and their presence

A 1. Artificial Narrow Intelligence (ANI), also known as Weak AI: This type of AI is focused on particular activities, such regulating traffic lights, driving a car, practicing chess, and facial recognition, among others.

A 2. Artificial General Intelligence (AGI) or Strong AI: Also known as human-level AI, it has the ability to replicate human abilities. This kind of AI can manage new activities and optimise human cognitive processes.

A 3. Superintelligent artificial intelligence (ASI): According to what is already accessible and what is still being developed, it outperforms human intellect and has noticeably higher activity in domains like drawing, mathematics, and space-related activities.

B. Based on presence

B1. Reactive Machine: Because it lacks a memory system, it can only be used for specialised, one-time tasks and is unable to learn from the past. Reactive machines are the name given to this category. IBM's chess program, which can recognise chessboard pieces and make predictions, is a notable example of such a system.

B2. Limited memory system: It has a limited memory system that uses prior knowledge to solve a number of problems. When it comes to autonomous cars, this system is skilled at generating choices based on observations that are captured and used for later actions, but these recordings are not kept forever.

B3. Theory of mind: It is predicated on the idea of "Theory of Mind," which holds that each person's distinct ideas, intentions, and wants impact their decision-making. There aren't any AI systems like this one yet.

B4. Self-consciousness: It has self-awareness, which includes self-consciousness.There isn't currently an AI system of this kind, though.

Machine learning has grown more versatile and potent in recent years. For example, it can learn from data to identify complex patterns and conclusions without direct guidance, it can teach and refine models on its own, and it can forecast future occurrences.[6] ML is an application of AI that combines knowledge and makes it possible for algorithms to be improved on their own using data. In general, estimating a function that characterises the

connection between inputs and outputs is a component of statistical learning.[11] Drug discovery makes extensive use of Bayes' theorem, which has been widely applied in the field of machine learning.[12] The first mechanical calculator and the present binary system were developed in the 1600s, which is when machine learning first emerged. By the middle of the 1950s, these innovations—which are still essential to modern machine learning—had been incorporated into modern ML. Arthur Samuel of IBM first used the term "machine learning" in 1952 when he developed a computer program that could get better at checkers the more it played.

ML can be split into two parts

- Learning that is both supervised and unsupervised. 18 In supervised learning, an algorithm is guided to resolve a predetermined issue.
- No predetermined questions are addressed by unsupervised learning. Bias should be minimised at every stage of data mining and machine learning.[13]

By cherry-picking compounds and doing low to medium-throughput screening, machine learning techniques are most frequently employed in the pharmaceutical sector for virtual screening of compounds, which eliminates the need to provide more high-throughput screening data.[14]

AI use in Drug Discovery

Target identification, lead generation and optimisation, and preclinical development are the three phases of the early drug discovery process where artificial intelligence has been applied. AI-based techniques have been applied in target discovery to combine diverse data sets and find trends in order to comprehend the molecular underpinnings behind illnesses and medication actions. Artificial intelligence (AI) techniques help the automation and optimisation of the de novo drug design processes and enhance the scoring functions and quantitative structure–activity relationship (QSAR) models in virtual screening pipelines for lead generation and optimization.[15] Creating medications (small molecules, peptides, antibodies, or more recent modalities like short RNAs or cell treatments) that will change the illness state by modifying the activity of a molecular target is the most effective method in drug development.[16]

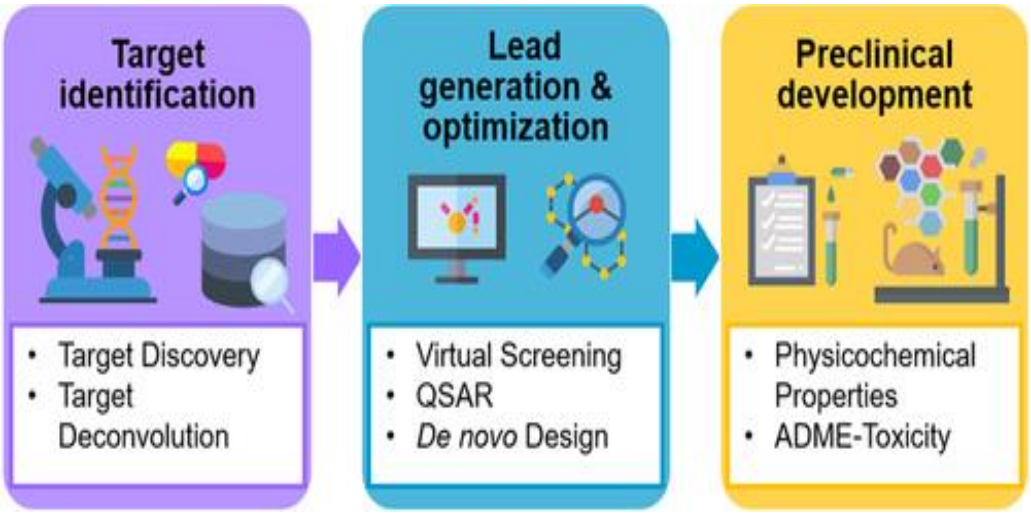

Fig 1 AI applications in the drug discovery pipeline. AI/ML approaches provide a range of tools that can be applied in all the three stages of early drug discovery to improve decision making and speed up the process. ADME, absorption, distribution, metabolism, and excretion; AI, artificial intelligence; machine learning; QSAR, quantitative structure–activity relationship.[15]

Artificial intellect (AI) is a catch-all phrase for human intellect exhibited by a machine, such as learning and problem solving.[17] Deep learning interest in drug development has only recently resurfaced, yet it has already resulted in an unparalleled surge of innovative modelling techniques and applications. As deep learning continues to advance, several branches of the chemical sciences have already benefited.[18] Preclinical candidate identification, preclinical study, clinical study, hit to lead generation, lead optimisation, and drug target identification and validation are all steps in the drug research and development process. The average pretax cost to produce a new prescription medication is around 2.558 billion USD, and it takes ten to fifteen years. Nevertheless, the anticipated clinical approval success rate of novel small molecules during the medication discovery and development process is still just 13%, with a comparatively high probability of failure in the long run, despite the significant expenditure. Based on logical direction to the process, one of the most ambitious attempts to change this difficult scenario is the creation of computer-assisted drug design techniques. The book Computer-Assisted Drug Design contains information on the related computer-assisted drug design techniques and the drug discovery process. Along with producing lead molecules with advantageous properties in silico, computational methods also ensure a systematic evaluation of the molecular characteristics (e.g., bioactivity, selectivity, side effects, physicochemical properties, absorption, distribution, metabolism, and excretion)

at the theoretical level.[19] For the quantitative and categorical characterisation of pharmacological compounds, thousands of molecular fingerprints and quantitative structure–activity relationship (QSAR) descriptors have been created.[20]

The entire drug discovery process will be sped up by using various drug design techniques and virtual screening to create and identify logical drug molecules based on the target macromolecule that interacts with the drug. Here, we'll talk about virtual screening, ligand-based drug design, and structure-based drug design.

Drug Design Based on Structure

The structural models of the target proteins that are available through molecular modelling, nuclear magnetic resonance (NMR), or X-ray diffraction must be used for structure-based drug design. When it comes to medication design, structure-based design is crucial.

Designing Drugs Using Ligands

Ligand-based drug design does not search small molecule libraries, in contrast to structure-based drug design. Rather, it depends on the understanding of known molecules attaching to the desired target macromolecule. These well-known chemicals can be used to create a pharmacophore model, which outlines the minimal structural properties a molecule has to have in order to bind to the target.

Screening Virtually Significant advancements in the creation of lead compounds have resulted from the quick growth of small molecule databases and computational resources. Computational techniques are being employed more and more to speed up the drug development process as the number of new pharmacological targets grows dramatically.[21]

Predicting pharmacokinetic characteristics is the primary obstacle in drug discovery. There are numerous instances of developing medications that are unusable due to their formulation, pharmacokinetics, toxicity, and adverse effects. The four phases of pharmacokinetics are referred to as ADME (absorption, distribution, metabolism, and excretion). The stages of absorption, distribution, and excretion are contingent upon the drug's formulation and delivery, the location of the target, and the drug molecule's solubility.[22]

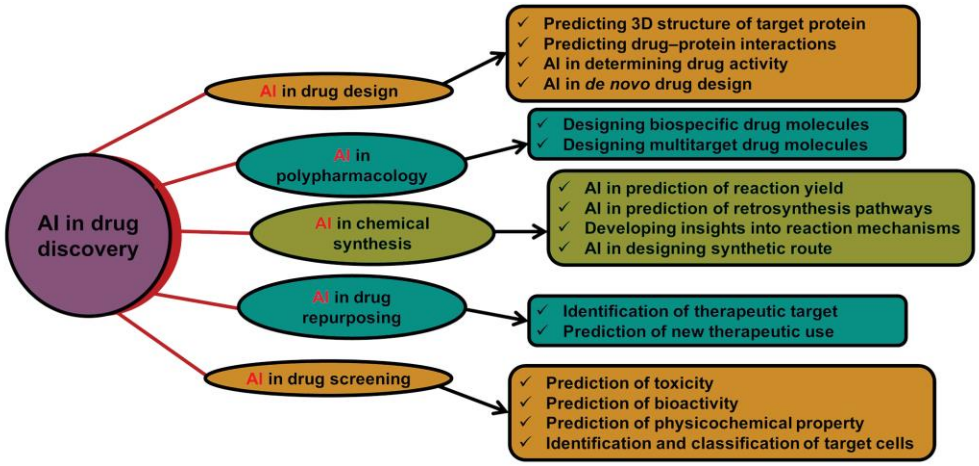

Fig 2 Role of artificial intelligence (AI) in drug discovery. AI can be used effectively in different parts of drug discovery, including drug design, chemical synthesis, drug screening, polypharmacology, and drug repurposing.[23]

Applications of artifcial intelligence in drug development process

Finding appropriate and bioactive therapeutic molecules among the enormous amount of chemical space roughly 1060 molecules is the most difficult and discouraging stage in the drug discovery and development process. Additionally, the process of finding and developing new drugs is thought to be time-consuming and expensive. The fact that nine out of ten therapeutic compounds typically fail phase II clinical trials and other regulatory approvals is the most frustrating aspect. Every phase of the drug development process involves AI, including the design of small compounds, the determination of therapeutic dose and related effectiveness, the prediction of bioactive agents, protein-protein interactions, protein folding and misfolding detection, structure and ligand-based VS, QSAR modelling, drug repurposing, toxicity and bioactive property prediction, and drug compound mode of action.[24]

The application of machine learning to drug discovery

Drug discovery is one of the many areas of the pharmaceutical industry where machine learning is being used more and more, which is helping the sector as a whole. The growing number of businesses where machine learning is essential to their organisational structure is evidence of machine learning's accomplishments. They claimed that big pharmaceutical corporations have also looked into using machine learning techniques for drug research and development.[25]

Advanced machine-learning techniques.[26]

Reinforcement learning

Both academia and industry are showing interest in RL, an exciting subfield of machine learning. Established in the 1950s, its recent surge in popularity was spurred by RL models defeating expert human opponents in a game of Go, a feat no computer had previously been able to do. One of the oldest games still played today is Go, which serves as a standard for artificial intelligence. This is significantly more than the amount of protons in the universe and the number of proteins in the human body.

Learning transfer

There are methods to get around this issue if there is a lack of data. Transfer learning, which is the process of applying knowledge gained from completing one task to another related one, is one such method.

Multitask learning

Multitask learning is the simultaneous learning of multiple tasks inside a single model, whereas transfer learning is the sequential learning and subsequent transfer of knowledge to another task. When noise is substantial and data sets are small, multitask learning is very beneficial.[26]

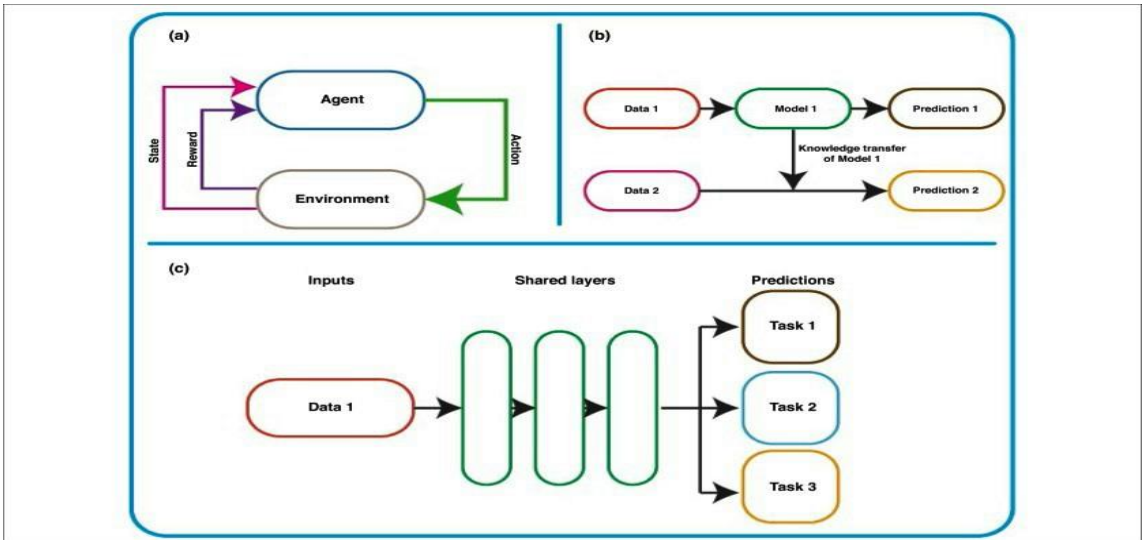

Fig 3 Schematic representations of (a) reinforcement learning (RL), (b) transfer learning and (c) multitask learning.[26]

Regression and classification are two common uses of machine learning. By mapping input variables to a continuous function, regression analysis forecasts outcomes with a continuous output. A continuous response variable or result and predictor or explanatory variables are related numerically using regression models.[27]

Drug discovery applications of Machine Learning

1) The intricacy of the systems involved presents a significant calculation difficulty for these features. Proteins interacting with tiny ligands in a solvent, massive molecular crystals, and small molecules must all be adequately described by the models used. A wide range of interactions between numerous distinct chemical elements, including various bonding types and (perhaps) chemical reactivity, regulate these systems.[28]

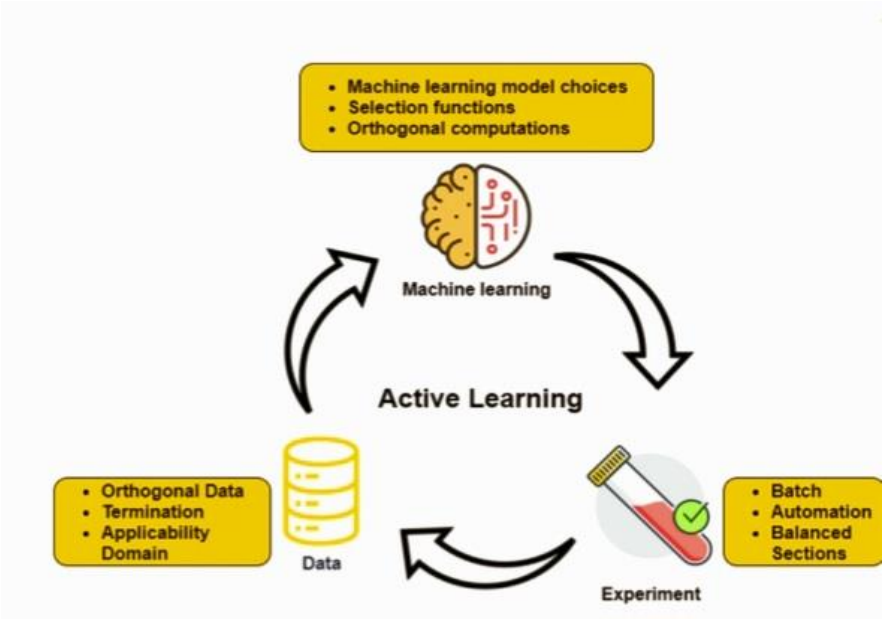

Fig 4 Machine learning in drug discovery.[25]

2) A wide range of domains, including computational chemistry, bioinformatics, speech recognition, picture recognition, natural language processing, and big data, have effectively employed machine learning. Machine learning can assist in predicting toxicity in the era of big data and artificial intelligence.[29]

3) Concerns about bias, transparency, and data privacy have also been brought up by machine learning and deep learning. Creating ethical frameworks and rules is essential to ensuring the proper use of these technologies, which are being used more and more in a variety of businesses.[30]

CONCLUSION

To fully realise its potential, careful consideration of data quality, model interpretability, ethical implications, and robust validation practices are essential to ensure the safe and effective implementation of AI-driven drug discovery strategies. The use of machine learning

and artificial intelligence in drug discovery represents a significant shift towards a more efficient, data-driven approach, enabling faster identification of potential drug candidates, optimisation of lead compounds, and prediction of crucial properties like toxicity and efficacy. This could ultimately reduce costs and increase the likelihood of successful drug approvals.

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