REVIEW ARTICLE

A Role of Artificial Intelligences in Drug Discovery and Drug Development – A Critical Review

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ABSTRACT

Artificial intelligence (AI) is lowering the period and cost of the medication research and discovery process Artificial Intelligence is a revolution of medical research in pharmaceutical companies. In a review article, we give a summary of the many artificial intelligence tools of machine learning (ML) and deep learning (DL) techniques that will be used in drug research and discovery in the future. AI techniques and tools are more specifically designed or better programmed to mimic the operations of the human brain. AI is frequently used in drug discovery for de novo drug creation, virtual screening, reaction prediction, and de novo protein design. In addition, the application of AI and techniques of AI. ML is a disease diagnosis, de novo drug design, drug prediction for diseases, and big data prediction using ANN, CNN, and SNN, as well as deep learning. Furthermore, the function, applications, and methods of AI. Technological hurdles also face the contemporary XAI, and "low level" molecular representations (such as SMILES strings) that are useful for machine learning and AI tools are 'deep chem' in drug development several cutting-edge methods referred to as Knowledge Base Systems (KBS). The AI-based nanorobots are drug discovery on creating implantable nanorobots for the targeted delivery of medications and genes, factors including sustained release, dose modification, and control release need to be taken into consideration. Finally recent development of ML and DL techniques and AI models are more useful in the drug development and drug discovery process.

Keywords: Artificial intelligences, Drug discovery, De-novo drug design, Nanorobots, Deep learning, Deep chem.

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INTRODUCTION

Artificial intelligence has several effective uses, ranging from language modeling to pharmaceutical industry enhancement, and it speeds up and lowers the cost of medication discovery and development. Developing a strategy that is both efficient and limits adverse effects while delivering medicinal substances to their intended target is a difficulty faced by professionals in drug development. Furthermore, the process of creating novel pharmaceutical compounds is costly and time-consuming. The process of finding novel drugs to treat ailments is known as "drug discovery." AI techniques are made possible by the advancement of high-performance computer technology and the accessibility of multi-data. The concept of artificial intelligence (AI), also known as machine intelligence, is the simulation in human intelligence, wherein a machine replicates the cognitive processes involved in learning and problem-solving in the human brain.[1] The AI, including its potential approaches, practical uses, and underlying difficulties. Firstly, a thorough overview of AI covering all of its subfields, including deep learning (DL), machine learning (ML), natural language processing etc.[2] In-depth research and development in several fields, including production technology, packaging concerns, and customer-focused marketing approaches, is typically the basis for innovation in the pharmaceutical industry. Small molecule drugs and biologics are examples of novel pharmaceutical developments. Better stability and high potency are preferred to address unmet needs in disease treatment. They examine prospective solutions, including data augmentation and explainable AI (XAI), as well as practical issues with AI use in drug discovery, including data availability, ethical problems, and integrating AI with conventional approaches.[2] The AI medicine takes only 12 months to go to trial, compared to five years for traditional drug development. The exponential rise in machine learning and life sciences has provided vast statistical insights into the rise in AI-driven drug innovation-focused firms in recent years[4] (Figure 1).

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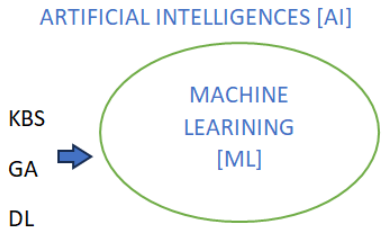

Figure 1: Artificial intelligence in drug discovery [AIDD][5]

AI in the Drug Screening

In the past, the main methods for discovering new drugs were the extraction of medicine from natural materials or machinery.[6] Phase II clinical studies and regulatory approval are unsuccessful for ten medicinal compounds. Based on synthesis feasibility, algorithms including RF, SVMs, DNNs, RF-Nearest- The classifiers, and extreme learning machines are utilized for VS. These algorithms can also assume toxicity and *in-vivo* activity. When developing new medication, physicochemical characteristics such as partition coefficient (log P), drug's solubility, and ionization degree, and since intrinsic permeability affects the drug's pharmacokinetics and target receptor family indirectly, it needs to be considered Among the first fields where the discovery paradigm developed were the synthesis of organic compounds and the use of identification techniques like mass spectrometry, gas chromatography-mass spectrometry (GC-MS), nuclear magnetic resonance (NMR), and high-performance liquid chromatography (HPLC). The area of drug design advanced in the early 1980s thanks to advancements in computers and crystallography, which led to the rise in popularity of rational drug design and structure-based drug discovery[7] techniques over 'random searches. Artificial intelligence (AI) can be used to test and refine compounds online, predict protein-drug interactions, and assess the bioactivities of molecules. Virtual screening can benefit from artificial intelligence by developing prediction models that select substances that have a high chance of attaching to a target protein.[8]

Basic Concept and the Role of AI

Because of their many benefits, small molecules are the subject of ongoing research in the pharmaceutical business to improve goods and consumer satisfaction.[9] The algorithm that endows computers with mental faculties and functional abilities.[10] The evolution of AI has had many ups and downs, ranging from artificial neural networks (ANNs) to support vector machines (SVMs) to perceptual machines, but it is now prospering because of the availability of hardware support. While DL can technically be classified as ML, both DL and ML fall under the AI umbrella. Nevertheless, the focus of our ML discussion in this paper is limited to conventional ML techniques like SVMs and random forests (RF)[11] **(**Table 1). The big data era is are current huge amounts of clinical and biological data collected in the present big data era that have set the stage for the application of AI to medical and pharmaceutical research.[12]

Table 1: Role of AI[1]

Approaches	*Evalution*
A I in drug design	Prediction of 3D structure of target protein. De novo drug design Evaluation of the drug's activity
AI in poly pharmacology	Bio-specific pharmaceutical compounds and multi-targeted design
AI in drug screening	Toxicity, bioactivity, physiochemical property prediction Target identification
AI in repurposing	Identify the therapeutic target and prediction
AI in chemical synthesis	Synthetic route are designing and prediction of retrosynthesis pathway

Prediction of Toxicity

To prevent harmful consequences, it is essential to forecast the toxicity of every therapeutic molecule. To determine a compound's toxicity, animal experiments are frequently conducted after exploratory research using cell-based *in-vitro* assays, which drives up the cost of drug discovery. There are numerous web-based programs available to assist with cost reduction. the Tox tree, pk CSM and Lim Tox. The Environmental Protection Agency **(**EPA**)** US Food and Drug Administration (FDA) and the National Institutes of Health collaborated to organize on Tox21 Data Challenge, an effort to assess several computer methods for predicting the toxicity of 12,707 pharmaceuticals and environmental chemicals.[1]

AI Goals

Expert system

Development is the process of building intelligent, automated machines that can advise humans on what to do.[13]

Developing computer intelligence closer to human intelligence

Artificial Intelligence (AI) seeks are mimic the mental processes of humans, enabling the machine to behave. People are liked and capable of making good choices, especially in complex, demanding environments. Machine learning plays are vital role in task automation and worker stress reduction.

Application in a variation of the domain

Logic, linguistics, statistics, space technology, computer science, cognitive science, medicine, psychology, engineering, ethics and natural sciences are just a few of the fields in which artificial intelligence finds application.

Application in computer sciences

Numerous techniques, including logic, control theory, search and optimisation, language analysis neural networks, statistical learning methods classifiers, and probabilistic methods for uncertain reasoning.[14]

AI Use in Drug Discovery

The are identification and growth of novel pharmacological compounds are being approached differently in research due to the impact of artificial intelligence.

Validation of Target Identification

Artificial intelligence algorithm scans vast biological database[8] and the target is carried out in quickly and accurately than other techniques.

Target validation using computational algorithms: The ML algorithms predict the efficacy and biological activity are select the target[15] and improve lead optimization and Hit identification computational models are research for lead compounds [16] high capacity screening identifies the potential compounds are more quickly.[17]

Deep Learning (Dl) and Machine Learning (Ml) Techniques

Machine learning [ML]

- *Machine learning*

Artificial intelligence (AI), often regarded as machine computer science intelligence, refers to the ability of machines that have been programmed or customized to mimic human brain functions.[18] This is where artificial intelligence (AI) fits in due to the discipline issues in a number of ways to use to organize various algorithms to analyze and extract knowledge from data. Additionally, closely connected to numerous fields, such as machine learning, probability theory, statistics, fuzzy models, and neural networks—collectively referred to as "Computational Intelligence."[19-23] With this data, machine-learning algorithms can identify genetic variations, biomarkers, and patient-specific traits that affect the toxicity and effectiveness of medications.[24] Any kind of information must first be used, and machine learning needs to be appropriately adjusted and the parameters of a particular model developed. Thus, machines can learn the model with available parameters by using trained data. Additionally, the model can forecast future data in order to extract information from data.[25]ML may be used to create prediction models from any type of data. The dataset needs to be cleaned, errors removed, and missing values imputed before a model can be created and the Important phases include choosing the right data, extracting features, choosing important attributes and algorithms, developing the model, and evaluating the model[26-27](Figure 2).The ML role on disease diagnosis, *De novo* drug design, and the disease prediction of drugs.Table 2. Modern ML data collection approaches have emerged in combination with the application of ML techniques that increase the possibility

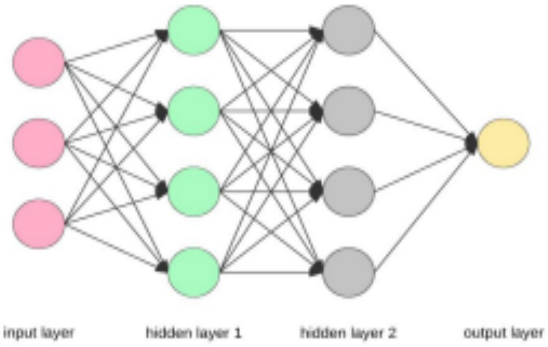

Figure 2: Model of deep learning[29]

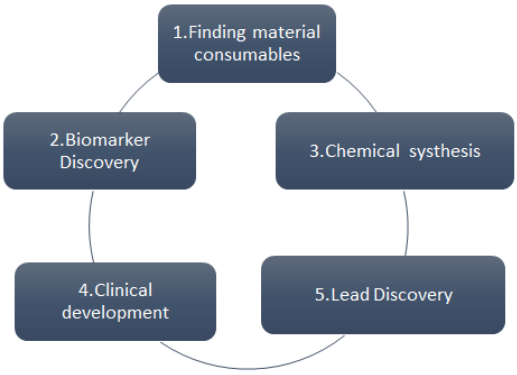

Figure 3: Several fields in drug discovery with machine learning[18]

of finding a treatment for conditions related to the central nervous system. The drug activation process, which includes both design and activity measurement, has benefited from the use of ML approaches[28] (Figure 3).

Deep Learning

Deep learning (DL), a subset of machine learning, is a process in which the system learns on its own from unlabeled and unstructured data. In the late 20th century, Igor Aizenberg *et al*. coined the term "deep learning" to refer to an artificial neural network (ANN).[31] The DL performs very effectively on challenging tasks involving massive volumes of high-dimensional data. However it requires more computations than traditional machine learning and is commonly referred to as an "AI black box" since the user is unable to observe many of the processing layers. Thus, there are more challenges and risks

Table 2: Subfield of machine learning in AI

Unsupervised machine learning	*Supervised machine learning*	*Reinforcement learning*
Unsupervised learning is used when there is an input variable but no output variable. Its main goal is to gain a better understanding by comprehending the data distribution. It is further separated into clustering and association.[29]	Supervised machine learning (ML) is the process by using labelled datasets to trained algorithms for data categorization or precise result predicting. The model updates the weights using reinforcement learning (RL) after input is received to make sure the model fits correctly. Many organisations and areas use supervised learning to address a variety of issues in the real world. They are two categories of learning under supervision are regression and classification. [29]	Real-time learning is an intriguing area of machine learning are garnered significant attention in both the academic and business domains. RL is an autonomous continuous learning strategy as opposed to supervised and unsupervised learning. Because RL responds quickly to changing conditions, it is used in robotics, gaming, and trading.[30]

involved in understanding the concept. Big Language Models (LLMs): DL models trained on large datasets to generate language similar to that of humans.[32]

Deep learning has the capacity to use many layers to extract a higher level of features from input data.[33] DL models in the creation of novel medications, drug-target interaction (DTI) and prediction. They begin by giving a comprehensive overview of numerous drug representations, protein, deep learning applications, are often used examples for data sets model testing and training. This study's identification of a few roadblocks of bright future of de novo drug development and DL-based DTI prediction is one of its strong points.[34]The most modern virtual screening (VS) machine learning (ML) applications, together with the instruments, resources, and databases, methods used to build their model.[35]Deep learning major role on Big data prediction, ANN, CNN, and SNN.

Available Tools

A number of software instruments have been created to make the interpretation of the model easier in light. The focus is now being placed on deep learning applications one well-known instance is Captum, an addition to PyTorch.[36] Another popular package is Alibi.[37]It offers explanations unique to each instance for specific models learned using the sci-kit-learn[38], Anchors, contrastive explanations, and counterfactual examples are a few of the techniques for explanation that are used and the variety of explanations, approaches that might be used for a particular assignment. The current XAI also confronts technical challenges[36], and its XAI-generated explanations must be sufficiently informative for the relevant scientific community, non-trivial, and non-artificial for human decision-making (Figure 4). To make sure that XAI approaches fulfill their intended purpose and produce trustworthy results, discovering such solutions will, at least for the time being, require the cooperative effort of expertise in deep learning, data scientists, chemo informaticists, biologists, and other domain specialists. Exploring the potential and constraints and current chemical language describing these models' decision space will be especially crucial. Building upon interpretable "low level" molecular representations such as SMILES strings that are suitable for machine learning and have immediate relevance for chemists is one step in the right direction.[39-40]

AI-Based Advanced Application

AI-based nanorobots for drug delivery

The main parts of nanorobots are integrated circuits, sensors, a power supply, and a safe data backup., and computational technologies like AI manage these components.[42-43]The Considerations are creating implanted nanorobots for the controlled delivery of medications and genes, considerations such as dose modification, sustained release, and control release must be made. Furthermore, the medication release needs to be automated using AI tools like NNs, fuzzy logic, and integrators (Table 3)[44]and programmed to avoid target identification, detection and final excretion from the body. The development of nano/microrobots has made it possible for them

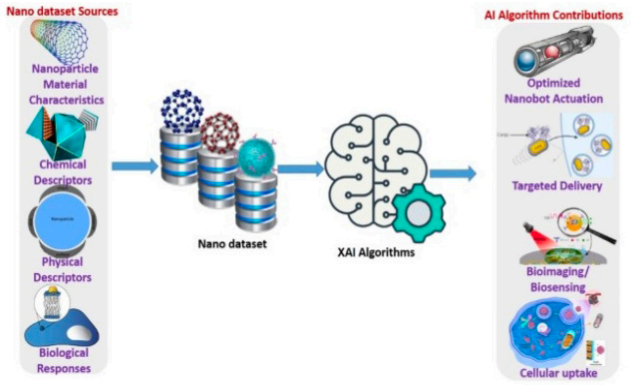

Figure 4: The XAI's part in drug discovery and other drug delivery-related developments.[41]

to navigate to the intended location depending on physiological factors, such as pH, increasing their effectiveness and reducing systemic negative effects.[45]

Future Scope

Increasing efficiency and lowering costs are AI's primary benefits for the pharmaceutical sector.[52] It Compared to standard AI and information subsampling techniques, AI models need half or less information. The important elements of this better execution include reducing bias and repetition, as well as gathering more important data to manage decision-making limits. Therefore, screening costs look to be lowered by up to 90 percent without accounting for the projected mechanical overhead involved in executing dynamic learning tasks.[53] Complex analyses involving large and high-dimensional data sets can be handled via machine learning approaches. Specifically, deep learning, human knowledge and skills may be the most effective means of coordinating multiple massive data sources. AI innovation is expected to revolutionize computer-supported medication plans and streamline many aspects of drug discovery and development. as clinical data continues to be collected and AI computations improve.[54]The use of AI in its many forms across a wide range of areas, including robotics, voice translation, picture analysis, etc., has made AI techniques quite popular these days.[55]By using AI, logical programming platforms (Prologue,[56,57] that were comparable to conventional programming languages were created. Later, a number of innovative techniques known as Knowledge base systems (KBS) for machine learning (ML)[58] were introduced. These included ANN, DL, genetic algorithms (GA), fuzzy systems (FS), SVM, pattern recognition tools, classifiers, etc. All of these techniques found applications in AIDD.[59]

Many tools have been developed that are based on the fundamental design networks of AI systems. One device that was developed using AI technology is the IBM Watson supercomputer, located in New York, USA. It was developed to help in the examination of a patient's medical records and their relationship to a huge database, resulting in suggestions for cancer treatment regimens. Detecting illnesses quickly is another use for this method. The fact that it could detect breast

Table 3: Examples of AI Tools used in drug discovery

Tools	*Details*	*Websites*
Deep Chem	MLP system are finds a good candidate for drug discovery using an AI system built on Python	https://github.com/deepchem/deepchem [46]
Deep Tox	Programming that forecasts the toxicity of twelve thousand medications	www.bioinf.jku.at/research/DeepTox. [47]
ChemDB	A chemical database that includes the expected or experimentally determined physicochemical properties of around 5 million small molecules that are commercially available.	http://cdb.ics.uci.edu.48
Drug Bank	A database containing useful information about pharmaceuticals, their targets, and 3D structures.	http://www.drugbank.ca.49
SIDER	A registry offering details on pharmaceuticals that are sold and the side effects that have been documented for them.	http://sideeffects.embl.d.50
Chemputer	It is helps to provide standardised reporting for chemical synthesis techniques	https://zenodo.org/record/14817 31 cited on 23/07/23.51
Deep Neural Net QSAR	A Python system that detects the chemical activity of substances through computational tools	https://github.com/Merck/Deep Neural Net-QSAR cited on 23/07/23-51

Table 4: AI tools and engaged in drug discovery and development in machine learning.[60]

Artificial neural network	*Decision tree[non-parametric supervised algorithm*	*Instance-based [memory-based algorithm*
• Perceptron • Recurrent neural network • Boltzmann network • Feed/Forward network	• Random Forest • Classification and regression tree	• Support vector machine • Self-organizing map

cancer in less than 60 seconds demonstrated accuracy[61-62] (Table 4).

Application and Techiques in AI

The process are finding innovative drugs is generally highly time-consuming and unsuccessful.[63] AI tools like machine learning and deep learning may analyze diverse datasets that include patient information, pharmaceutical features, molecular descriptors, and clinical outcomes.[64] Popular AI uses in drug discovery include de novo protein design [65]retrosynthesis and reaction prediction [66], de novo drug design [67], and virtual screening.[68] Present were the AI-based models for drug-target interaction, binding affinity prediction, drug-target structure prediction, and de novo drug creation.[69] The general elements of medication development[67,70] and associated ideas, including chemical space[71] and Target prediction[72] QSAR[73-74] ideal qualities for drug candidates[75] VS [visual screening] [76-77]and computer-aided drug design[78] marked the beginning of the era of deep learning.[79] Furthermore well-known obstacle to the process of developing drugs is the great sensitivity of molecular characteristics to small structural alterations. When two structurally similar molecules show noticeably differing activities, it is referred to as the "activity cliffs"[80-82]. Artificial intelligence (AI) is being used in small-molecule drug discovery for a variety of purposes, such as virtual screening, quantitative structure-activity relationships, and drug design, which is primarily divided into two tasks: molecule production and molecular property prediction.

Drug Discovery in the Era

The application of AI in drug discovery is widespread. Machine learning methods, such as random forest (RF), have been used for VS and QSAR [3d structure used]. Since the early 2000s.[83-84] The advancement of artificial intelligence (AI) methods in vision on computers and natural language processing has recently provided more insight into drug development [85-88]and researchers from MIT discovered halicin in 2020, a potential antibiotic contender against bacteria resistant to antibiotics.[89] Be aware that AI can be used at several phases of the drug development process, from determining the drug's response to validating targets[86,90] lead optimization. In this setting, ML and DL are primary AI methodologies. Target validation and

Table 5: Application of AI [93,1]

Drug discovery	*Application*
Product development	Nanomedicine Controlled release delivery and nanorobots Monitoring and modifying the process development.
Manufacturing	Continuous manufacturing Personalized manufacturing.
Quality control & Quality assurances	Medicine-aided SOP's, Guide future production cycle, and understand the process of parameters
Precisions medicine & prescription	Telemedicine Digital prescription
Clinical trails	Clinical trails design Patient monitoring
Drug discovery of Drug design	Evaluation of the target protein's structure
Drug screening	Prediction of bio activity and toxicity

discovery use both ML and DL techniques.[91] DL contributes to the clinical research's design, monitoring, and data analysis during the clinical phase IV trial[92] **(**Table 5).

CONCLUSION AND FUTURE PROSPECTS

Innovative medication at the beginning of the identification of new drug molecules to the release of the medicine into the market, discovery is a labor-intensive, expensive, and time-consuming process that involves challenges. The advanced software and models are used in AI it can predict new lead molecules by pharmacokinetics and pharmacodynamic parameters and save time, economical to reduce the adverse effects, finally increasing the therapeutic efficacy of drug compounds. The main issue around the integration of modern technology is the possible loss of employment as well as the strict regulations needed to integrate artificial intelligence. But these tools aren't meant to fully replace people; rather, they're just meant to make tasks easier. The AI technology on 'Black box 'models and other AI models are utilized in drug discovery, and ML algorithms and deep learning approaches are integrated into pharmaceutical firms' AI technology. The review includes AI technology used for ML and DL approaches employed in the pharmaceutical industry, and specific applications are used to successfully complete clinical trials as well as drug repurposing. AI drug discovery is are attractive, promising field of research that has the potential to modify the approach of medication development given by increasing interest and attention from researchers, pharmaceutical firms, and regulatory authorities, as well as the potential benefits of artificial intelligence. Finally, recent development of ML and DL techniques and AI models are more useful in the drug development and drug discovery process.

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