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Artificial Intelligence and Machine Learning in the Pharmaceutical Industry

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ABSTRACT

The incorporation of Artificial Intelligence (AI) in the pharmaceutical industry has transformed many elements of drug discovery, development, manufacturing, clinical trials, and marketing. AI's capabilities range from enhancing accuracy and minimizing errors to enabling previously impossible new ideas. AI is being used in drug development by the pharmaceutical sector, with applications like as predicting molecule structures and optimizing drug designs. Furthermore, AI aids drug repurposing by quickly finding current pharmaceuticals for new medicinal applications, saving time and money. AI-powered automation in manufacturing simplifies operations, improves quality control, and optimizes production parameters. Advanced process control and fault detection enable efficient manufacturing, while AI-powered trend analysis aids in the identification and resolution of future problems. Clinical trials, a vital stage of drug research, benefit from AI's role in patient recruiting, data processing, and monitoring. The application of AI algorithms for identifying medical diseases and forecasting trial outcomes offers significant promise for improving patient care and trial success rates. Despite its various benefits, AI adoption in the pharmaceutical industry is hampered by factors like high initial costs, concerns about job displacement, and limits in data collection. Looking ahead, the pharmaceutical industry for AI is likely to grow significantly, owing to its potential to change drug development processes and enhance patient outcomes. The integration of AI in the pharmaceutical industry marks a significant advancement, offering a multitude of benefits while addressing the complexities and challenges of modern healthcare and drug research.

INTRODUCTION:

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and perform tasks like humans. AI is sometimes described as a technology that enables machines to mimic a variety of intricate human talents. The idea of AI was first put up in 1956 during a meeting organized by Marvin Minsky and John McCarthy. [1][2]

Classification of AI:

1. Artificial Narrow Intelligence (ANI): This AI can perform specific tasks well, like facial recognition, driving cars, or playing chess, but it's limited to those tasks and lacks general human-like intelligence.

2. Artificial General Intelligence (AGI): AGI is as smart as a human and can handle a wide range of tasks, learn from experience, and solve different problems, just like humans do.

3. Artificial Super Intelligence (ASI): ASI is even smarter than humans and can excel in areas like advanced mathematics, painting, and scientific research, going beyond human abilities.[3]

Goals of AI:

1. Developing Expert Systems:

The primary goal is the development of automated systems with intelligent behavior, to guide and advise individuals to help them make the best judgments possible.

2. Developing Human-like Intelligence in Computers:

AI aims to replicate human cognitive patterns, allowing computers to act like people and make wise judgments, particularly in challenging and complicated settings. Algorithms are crucial for automating tasks and reducing the stress on workers.

3. Applications in a Variety of Domains:

AI has uses in a variety of disciplines, including computer science, cognitive science, statistics, psychology, engineering, ethics, the natural sciences, medicine, space technology, logic, and linguistics, among others.

4. Applications in Computer Science: Several mechanisms, such as Search and

Optimization, Logic, Control Theory, Language Analysis, Neural Networks, Classifiers, Statistical Learning Methods, and Probabilistic Methods for Uncertain Reasoning, are developed with the help of AI to address a wide range of difficult problems in the field of computer science.

A branch of artificial intelligence and computer science called machine learning (ML) enables systems to automatically learn from experience and interpret it better.ML is incredibly helpful for managing suppliers and paperwork, organizing the transfer of commodities, and predicting likely supplier demand.[4]

Due to a growing reliance on digital technologies for patient data collecting, the COVID-19 pandemic may further expedite the use of AI/ML in clinical trials. [5]

With the advent of contemporary AI techniques, pharmaceutics, and biomedical science now have access to extremely trustworthy computational approaches. Artificial intelligence (AI) simulates human intelligence in computer models to improve or mimic human performance.

Drug development is a procedure that is exceedingly expensive, time-consuming, and subject to several formalities in the pharmaceutical industry. An important change in the success rate of drug development has been the introduction of artificial intelligence (AI), deep learning (DL), machine learning (ML), and computational chemistry. [6]

In the recent decade, there has been a tremendous increase in the number of pharmaceutical companies and startups employing AI in drug research and development. Several pharmaceutical companies, like Novartis and Pfizer with IBM Watson, have either partnered with or bought AI technologies. [7]

Machine Learning:

Computer algorithms that provide computers the ability to automatically learn and improve from experience are the subject of the study known as machine learning. The majority of people consider it to be a branch of artificial intelligence. The systems' ability to learn from experience and improve through the use of machine learning algorithms. Making decisions is made possible by machine learning algorithms. [8]

Machine learning description:

It is built on an AI application that teaches fundamentally algorithms or computer programs the capacity to familiarize automatically with a task and also build expertise without programming. The ability of computer programs to approach data and use it for learning is improved by it. To redact advancements, a system needs programmers to write and review appropriately. [9]

Types of machine learning:

There are basically three distinct categories of machine learning. These are they

1. Supervised learning

When the data consists of input variables and output target values, supervised learning is used. The algorithm learns how to translate the input function to the output function. The goal is to establish the risk generator and to seek trials in clinic optimization.

2. Unsupervised learning

This is the inverse of supervised learning. This means unsupervised learning is used when the data is only accessible as an input and there is no corresponding output variable. Clustering is one of the most common types of unsupervised algorithms. This technique discovers intrinsic groups in data and then uses them to predict output for unknown inputs. Predicting customer purchase behavior is an example of this strategy.

3. Reinforcement learning

It is similar to the unsupervised learning method. It is the Machine Learning instruction to build a decision order. A game-like situation is presented to an artificial intelligence. Examples: 1. Teaching agents to play computer games.

2. Doing robotics tasks with a specific objective in mind. [8] [9]

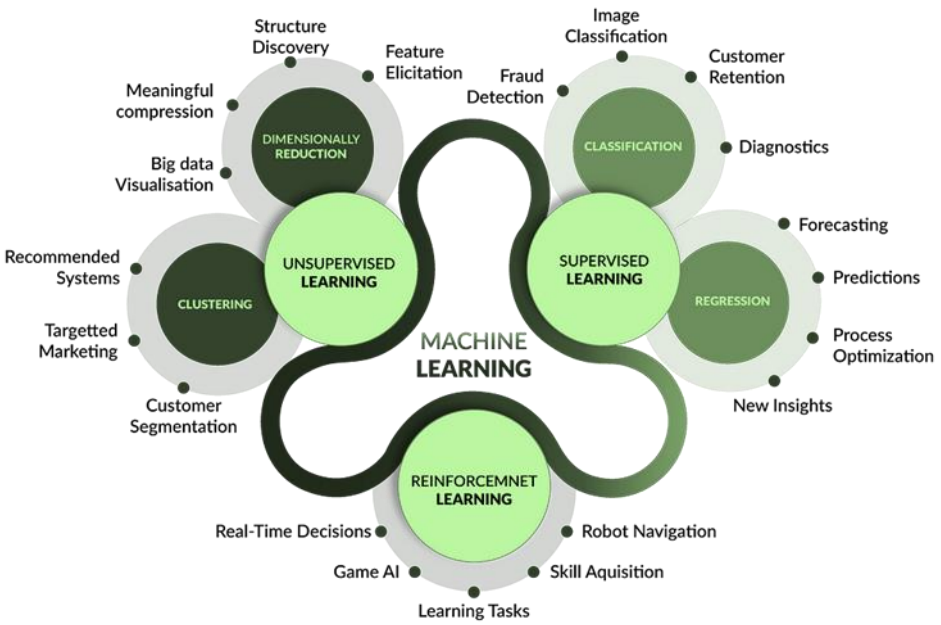

Fig. 1: Types of Machine Learning

Applications of Machine Learning in the Pharmaceutical Sector:

1. **Disease identification**:

Detection and diagnosis of diseases are fundamental aspects of machine learning research in the medical field. Among various medical conditions, cancer remains a significant area of focus. It has been observed through extensive research that cancer treatment relies on a vast array of medicines and drugs.

2. **Improved Medical Outcomes** :

Machine learning can enhance medical treatment but not replace doctors. Physicians have vast knowledge and data, while machine learning may struggle to interpret and apply information effectively.

3. **Personalized care**:

Personalized treatment using health data is highly effective. Micro-devices and biosensors will likely expand, enabling better health measurements and remote monitoring for improved fluency in treatment.

4. Evaluation of drug effectiveness:

Determining expert bio-diagnostics is challenging due to vast genomics, proteomics, and metabolomics data. Machine learning uses biological factors, but accessing specific information from patient data remains limited. Merging machine learning with data mining unlocks unique insights.

5. Improved patient care:

Handling vast patient data is challenging for physicians, but machine learning can manage it effectively. Various machine learning programs exist to reduce physicians' workload and efforts. [9]

Pharma Companies Collaboration with AI Technology:

AI and pharmaceutical companies have created partnerships to develop therapeutic products. Many of the industry's collaborations with AI are related to drug discovery and clinical studies.

AI plays a crucial role in tackling many of the industry's most pressing issues.

We will look at the top ten highest-grossing pharmaceutical businesses that use AI or machine learning for drug discovery, clinical research, disease diagnostics, innovative treatment, predictions, data analysis, and so on.

Table 1: **Pharma company collaboration with AI** [10][11]

Sr. No.	Pharmaceutical company	AI Company/technology provider	Collaboration Scope
1	Pfizer[12]	IBM Watson XtalPi Concerto Health AI Catalia Health	Using AI to analyze vast datasets and used in drug discovery To apply AI & quantum physics to improve the accuracy and efficiency of drug solid-state research to employ artificial intelligence and real-world data in oncology The major goal of this collaboration is to use artificial intelligence to better comprehend patients' clinical journeys.
2	Novartis	Google Deepmind	Clinical trials: Applying AI algorithms to optimize patient selection, treatment protocols, and data analysis during clinical trials.
3	Johnson & Johnson	Exscientia	High-throughput screening: Using AI to accelerate the screening of compounds and identify potential drug leads.
4	Merk	Berg Health	Biomarker research: Using AI to identify and validate biomarkers that can aid in disease
5	Roche	BenevolentAI	Drug development: Leveraging AI to uncover new drug targets and validate potential drug compounds.
6	GSK (GlaxoSmithKline)	Insilico Medicine	AI-driven drug design: Utilizing AI to design and optimize drug molecules for enhanced potency and safety.
7	Bayer	Atomwise	Developing the best AI platform & using it to transform small-molecule drug discovery
8	Sanofi	ORKIN	AI is being used to stratify patient groups to provide more targeted and effective therapies.
9	AstraZeneca	BenevolentAI	Use machine learning and artificial intelligence to find potential novel medications for chronic renal disease and idiopathic pulmonary fibrosis.
10	Abbvie	Aicure	Using an AI-based patient monitoring technology enhanced adherence in an AbbVie phase 2 schizophrenia trial.

Difficulties in adopting AI in pharma:

1. Unfamiliarity with the technology: Due to its youth and complexity, AI is viewed as a "black box" by many pharmaceutical companies, who are hesitant to adopt and deploy it.

2. Inadequate IT infrastructure: It is difficult for pharma companies to easily integrate AI because current IT systems and infrastructure were not initially created with AI in mind. As a result, upgrading the IT infrastructure will demand significant financial investments.

3. Unstructured data: A sizable percentage of the pharmaceutical industry's data is available in free text format, necessitating additional work to organize and convert the data into a format appropriate for AI analysis.[13]

Examples of AI Tools:

Numerous AI tools have been developed to address the present requirements of the pharmaceutical industry, yielding promising results. Among the AI tools that have gained significant popularity in the pharmaceutical sector are the following:

Table 2: **AI tools and their characteristics**

Sr No.	AI Tool	Characterization	Reference
1	DeepChem	A Python AI system with an MLP model that helps discover potential drug candidates.	https://github.com/deepchem/deepchem cited on 23/07/23
2	ORGANIC	A tool that generates molecules with specific properties.	https://github.com/aspuru-guzik-group/ORGANIC cited on 23/07/23
3	Hit Dexter	An ML technique to forecast molecules that could show positive responses in biochemical tests.	http://hitdexter2.zbh.uni-hamburg.de cited on 23/07/23
4	PotentialNet	Utilizes neural networks to forecast the binding strength of ligands.	https://pubs.acs.org/doi/full/10.1021/acscentsci.8b00507 cited on 23/07/23
5	Alphafold	Predict a protein's 3D structure based on its amino acid sequence.	https://deepmind.com cited on 23/07/23
6	Chemputer	Assists in the reporting of chemical synthesis procedures in a standardized way.	https://zenodo.org/record/1481731 cited on 23/07/23
7	DeltaVina	A function that assigns scores to evaluate the strength of drug-ligand interactions.	https://github.com/chengwang88/deltavina cited on 23/07/23
8	Deep Tox	Chemical compound toxicity can be predicted.	https://www.frontiersin.org/articles/10.3389/fenvs.2015.00080/full cited on 23/07/23
9	DeepNeural NetQSAR	A Python system that uses computational tools to detect the molecular activity of compounds.	https://github.com/Merck/DeepNeuralNet-QSAR cited on 23/07/23
10	Neural graph fingerprint	Aids in the prediction of the properties of new compounds	https://github.com/HIPS/neural-fingerprint cited on 23/07/23

Application of AI:

AI In Drug Discovery:

Drug discovery is a complex and time-consuming process that often takes 10 to 15 years. Only a small fraction of potential drug candidates makes it through clinical trials and regulatory approval, leading to declining productivity in the pharmaceutical industry. To address this, the industry is increasingly embracing Artificial Intelligence (AI) due to its ability to speed up drug discovery and reduce costs.

AI applications in drug discovery include quickly identifying promising compounds, validating drug targets, and optimizing drug designs. In silico methods and machine learning help predict chemical structures that have desired effects, assess compound properties, and plan synthesis efficiently. Deep learning, a type of AI, is especially useful in handling the massive amount of data generated during drug discovery. [14]

AI has transformed drug research and development in a variety of ways. The following are some of the most important contributions of AI in this domain:

1. **Target Identification:**

AI systems can analyze different kinds of data, such as genetic information, protein data, and clinical records. This helps them find possible targets for treatments. By discovering these targets and understanding how molecules work in diseases, AI helps in creating medications that can influence biological processes.

2. **Virtual Screening**

AI speeds up drug discovery by efficiently screening vast chemical libraries. It identifies potential drug candidates that can bind to specific targets, helping researchers prioritize compounds for experimental testing and saving valuable time and resources.

3. **Structure-Activity Relationship (SAR) Modeling:**

The chemical structure of substances and their biological function can be connected using AI models. This enables scientists to create compounds with desirable properties, such as high potency, selectivity, and advantageous pharmacokinetic profiles, to optimize therapeutic prospects.

4. De Novo Drug Design:

AI algorithms can suggest brand-new chemical structures that resemble medicinal molecules using reinforcement learning and generative models. Artificial intelligence (AI) broadens the chemical domain and supports the creation of novel therapeutic candidates by learning from chemical libraries and experimental data.

5. Drug Repurposing

To find existing medications with potential as therapeutics for various ailments, AI algorithms can examine large-scale biomedical data. AI speeds up the drug discovery process and lowers costs by repurposing current medications for new applications.

6. Toxicity Prediction

By examining a compound's chemical structure and properties, AI systems can forecast drug toxicity. Machine learning algorithms can predict negative effects or recognize dangerous structural characteristics after being trained on toxicological databases. This assists researchers in identifying safer compounds and minimizing any negative effects during clinical trials. [15]

Application Of AI In Manufacturing:

AI has revolutionized the conventional trial-and-error approach to formulation development, replacing it with a more systematic and rationalized process through Quality by Design (QBD) principles. [16]

Artificial Intelligence presents a wide range of opportunities for the pharmaceutical sector, including but not limited to process design and control optimization, smart monitoring and maintenance, and trend tracking to promote continuous development. To accomplish desired results, modern manufacturing technologies can be used in conjunction with the application of AI to support pharmaceutical manufacturing. The following examples show how artificial intelligence could be used in pharmaceutical manufacturing:

1. Process Design and Scale-up:

By utilizing AI models like machine learning that are developed from process development data, it is possible to rapidly discover the best processing parameters or scale-up processes. This results in reduced development time and waste.

2. Advanced Process Control:

This technology enables dynamic control of the production process to provide the required results. AI techniques can also be utilized to create process controls that can foresee how the manufacturing process will progress by using real-time sensor data combined with AI techniques. Several pharmaceutical manufacturers have previously reported using APC methods, which integrate an understanding of the underlying chemical, physical, and biological transformations occurring in the manufacturing process with AI techniques.

3. Process Observation and Fault Finding: To minimize process downtime, maintenance actions might be triggered when equipment performance deviates from typical. AI techniques can also be used to track product quality, such as the quality of packaging.

Example - vision-based quality control involves using AI-based software to analyze images of packaging, labels, or glass vials. The software detects any deviations from the required quality attributes of a product.

4. Trend detection: AI can play a vital role in analyzing consumer complaints and deviation reports, even when they contain substantial amounts of text. By using AI, it becomes possible to identify clusters of problem areas and prioritize them for continuous improvement. The key advantage is the ability to detect trends related to manufacturing deviations, which helps in thoroughly understanding the root causes.[17]

To create the best formulation or process, AI tools, NNS, and expert systems anticipate the optimal values for complex variables under investigation. [16]

To address the issue of tablet capping on the manufacturing line, researchers employed Artificial Neural Networks (ANNs) and fuzzy models. These advanced computational techniques were utilized to explore and analyze the correlation between machine settings and the occurrence of tablet capping.

Meta-classifiers and tablet-classifiers represent cutting-edge AI tools utilized to ensure the highest quality standards of the end product. These advanced technologies play a crucial role in identifying potential errors or deviations during the tablet manufacturing process. [18]

Application Of AI in Drug Design:

The three-dimensional (3D) conformation of a target protein plays a pivotal role in structure-based drug discovery. This is crucial because the design of novel drug molecules often

revolves around understanding the 3D chemical landscape of the ligand-binding site within the target protein. To achieve this goal, researchers have traditionally employed methods such as homology modeling and de novo protein design. These techniques have been widely utilized in the field to gain insights into the target protein's structure and guide the rational development of potential therapeutic agents. [19]

In recent advancements within the field of structure-based drug discovery, a remarkable AI tool known as Alpha Fold has demonstrated exceptional capabilities in accurately predicting the 3D structure of drug target proteins. The performance of this tool has been nothing short of impressive, showcasing its potential to revolutionize the way we approach protein structure prediction and its implications for drug design. [20]

Application Of AI in Drug Repurposing:

Drug repurposing involves utilizing already known drugs or drug combinations in unanticipated medical situations. The process of communicating new effects of medications or drug combinations based on current drugs is known as drug repurposing. This approach is crucial in expediting the pre-clinical phase of developing new drugs, as it saves time and costs compared to the traditional process of starting from scratch in drug discovery. Drug repurposing has gained favor as a speedier alternative to de novo drug synthesis for identifying therapeutic medications or drug combinations since the COVID-19 outbreak.

The de novo drug discovery method is effective, but it is costly and time demanding. Repurposing existing medications with well-established mechanisms and pharmacokinetics provides a speedier and less expensive option. This technique saves time and money, drawing the attention of governments and pharmaceutical corporations. AI technology aids in drug repurposing, cutting time and costs even further. [21]

The discovery of drug repurposing has often been the result of accidental findings during random testing and explorations.

For example: sildenafil citrate was initially developed as a hypertensive drug, but Pfizer repurposed it, leading to the creation of a new drug called Viagra for treating erectile dysfunction. [22]

Traditional drug development typically consists of five stages:

i. Pre-clinical research,

ii. Clinical research

iii. FDA review

iv. FDA post-market safety monitoring and development

v. Discovery and development,

However, the process of repurposing drugs involves just four steps:

i. Clinical research,

ii. compound acquisition,

iii. compound identification,

iv. clinical research, and FDA post-market safety monitoring and development. [23]

Through the use of DL applications, in silico techniques for drug repurposing and drug prediction using transcriptome data encompassing multiple biological systems and situations have been reported.

Researchers are developing new applications for current medications by employing computer-based approaches to forecast how pharmaceuticals will act. They accomplish this by employing sophisticated computer systems known as deep neural networks (DNNs) to analyze genetic data from various biological systems and circumstances. These networks, which are made up of interconnected artificial neurons, are capable of tremendous data transformation.

In one study, researchers demonstrated that DNNs can understand the intricate workings of medications, including the routes they affect in the body. They can then classify medications based on their purposes, efficacy, therapeutic applications, and probable negative effects.

The goal of precision medicine is to provide patients with individualized care. Generative adversarial networks (GANs), a method of next-generation artificial intelligence, enable researchers to create novel medicinal compounds. [24]

AI & Synthesis of Drug:

After identifying molecules, one of the most crucial and challenging tasks is to synthesize the selected compounds. Traditionally, this is accomplished through the process of retrosynthesis. A software program called Synthia (formerly known as Chematica) has been

developed to aid in this process by suggesting potential synthesis pathways for eight essential medicinal targets. This is achieved by encoding a set of rules into the computer, resulting in increased efficiency, higher yield, and cost reduction. Moreover, Synthia has proven to be valuable in synthesizing previously unproduced substances and offering alternative synthetic methods for patented items. [25]

Automation of experimental operations using AI-based automated chemical synthesis technologies is transforming research by eliminating the need for manual labor. The synthesis of peptides, oligonucleotides, natural products, and medicinal compounds are just a few of the numerous reactions that these systems are capable of performing.

The effectiveness of automatic synthesis is likewise being improved. A growing number of people are using high-throughput experiments (HTEs), which allow dozens or even hundreds of reactions to be carried out concurrently. These HTEs can conduct low-volatile solvent reactions at room temperature and utilize 24- or 96-well reactors. Metal-catalyzed cross-coupling reactions, which involve numerous reaction variables, are one area of significant investigation in HTEs. Ahneman and colleagues' RF approach, which outperforms conventional linear regression analysis and sheds light on the catalyst inhibition process, can forecast the tolerance of palladium catalysts in specific reactions. [26]

In the pursuit of de novo drug synthesis, researchers have explored an innovative approach called Reinforcement Learning for Structural Evolution. This method employs generative and predictive Deep Neural Networks (DNNs) to create novel molecules. [25]

As scientists create better algorithms for predicting reactions, they can quickly and accurately figure out the best conditions for reactions and find the most efficient ways to make chemicals. By using these clever algorithms together, researchers can build automated systems that do the work for them, saving time and effort. This helps scientists focus on more important aspects of their research and makes chemistry experiments easier and faster. [26]

AI in a clinical trial:

Ineffective methods for patient recruitment and selection, as well as difficulties in successfully monitoring participants throughout the research, are frequently to blame for clinical trial failures. The main cause of clinical trial delays is the challenge of enrolling a enough number of qualified patients within the allotted timeframe. Up to 86% of trials, according to studies, miss their enrollment targets.

The use of artificial intelligence (AI) techniques to improve patient recruiting and selection processes offers considerable potential for resolving these problems. These AI-powered systems can also gather and analyze data simultaneously from several clinical trial facilities, enabling a more thorough patient characterization. [27]

Only approximately a third of Phase II trial chemicals currently make it through Phase III. These studies take 10 to 15 years to complete and cost billions of dollars. Preclinical development costs are also lost due to unsuccessful studies.

For diagnosing medical disorders like diabetic retinopathy, stroke, and more, the US FDA has authorized more than 30 AI algorithms. AI's potential to improve healthcare by providing early diagnoses and other benefits is demonstrated by the more than 300 clinical trials filed under the "Artificial Intelligence," "Machine Learning," or "Deep Learning" titles.

Researchers may be able to predict trial outcomes earlier with AI, which would lessen the risk of injury to participants, and they may be able to implement AI-assisted randomization schemes with a wide range of variables. In short, AI has the potential to speed up medical progress and enhance patient care. [14]

AI in marketing:

In 2023, successful pharmaceutical brands are expected to fully integrate AI into all aspects of their marketing strategies. The vast amount of data generated by people, machines, sensors, and devices, coupled with the prevalence of cloud computing, smartphones, and social media platforms, presents a significant opportunity for AI to make a substantial financial impact in various industries, including healthcare. [28]

Pharma businesses can employ artificial intelligence to design marketing efforts that are more targeted and focused because the pharmaceutical sector is primarily sales-driven.

AI tools can be applied in marketing to:

1. Gather data from customers in real-time, chart their journey, and better comprehend their wants, preferences, behavior, etc.

2. Create distinctive marketing plans that are in line with the specific requirements of the consumer and the corporate objectives.

3. Evaluate important performance measures, such as conversion rates and retention rates, to assess the effectiveness of marketing efforts.

4. To identify any inefficiencies in current strategies, analyze and compare previous marketing initiatives. Additionally, it can be used to forecast the performance of marketing initiatives.[3]

AI is already being utilized in customer service requests in pharma marketing through the use of chatbots. These hyper-smart marketing technologies are leading to higher return on investment (ROI) and predictive models help in understanding compliance and drop-off consequences.

Pharmaceutical sales are also expected to be influenced by AI, with machine learning enabling highly specific customer segmentation and personalized sales activities. AI could increase labor productivity by up to 40%, providing a boost to sales representatives. [28]

Advantages of AI:

1. Error Reduction:

AI, or Artificial Intelligence, plays a vital role in improving the efficiency of various processes by minimizing errors and increasing accuracy. Intelligent robots are designed with strong metal bodies, making them capable of enduring harsh conditions in space. As a result, they are chosen for space exploration missions. [29]

2. Difficult Exploration:

AI demonstrates its valuable applications in the mining industry and proves equally beneficial in fuel exploration. Additionally, AI systems play a crucial role in oceanic exploration by effectively mitigating errors caused by human intervention.

3. Daily Application:

AI is quite useful in our daily actions and activities. GPS, for example, is widely utilized in long-distance driving. AI installation on Androids aids in predicting what a person would type. It also aids in the repair of spelling errors. For Ex- Lady SIRI.

AI systems find extensive applications in financial and banking institutions, where they efficiently handle and organize data to detect fraudulent activities.

4. Digital Assistant:

Modern organizations employ AI systems, like digital assistant 'avatars,' to minimize human dependency. These avatars make logical decisions without being influenced by emotions. Unlike humans, emotions don't impact their judgment, resulting in more efficient decision-making and problem-solving. Machine intelligence helps overcome the limitations of human emotions and enhances overall effectiveness.

5. No Breaks:

In contrast to human beings, who typically work for eight hours a day with breaks, machines are programmed to work continuously for extended hours without becoming confused or bored.

6. Increased Technological Growth Rate:

AI technology is widely used in the most advanced technical advances across the world. It is capable of developing various computational modeling programs and tries to invent newer compounds. AI is also being employed in the creation of medicine delivery formulations.

7. Medical Application:

Physicians are now using artificial intelligence to screen patients and analyze health concerns. The AI program educates physicians on numerous medications and their side effects.

Disadvantages of AI:

1. High Cost:

Introducing AI requires significant investment due to the intricate machinery design, repair, and maintenance involved. Frequent software program updates are necessary for the machine. The process of reinstalling and recovering the system demands considerable effort and financial investment. Additionally, the R&D department invests a significant amount of time in designing a single AI machine, leading to increased expenses.

2. Unemployment:

The widespread adoption of machines replacing humans in various fields may lead to a significant increase in unemployment. Human beings, often highly dependent on technology, might become complacent and lose their creative abilities.

3. No Replicating Humans:

AI-powered robots can simulate human thinking, but they lack moral principles and emotions. As a result, they carry out their assigned duties precisely as planned, without using judgment. It can sometimes lead to major problems. If the circumstance is unfamiliar to them, robots are unable to make a decision. At that time, they either produce a false report or collapse.

4. No Improvement with Experience:

AI-powered machines lack the ability to improve through experience, unlike human beings. They do not exhibit concern, belonging, or caring and cannot differentiate between individuals based on their work ethic. [30][31]

Pharmaceutical Market of AI:

Marketing is the activity of increasing sales of a business's goods and services. Pharmaceutical companies will employ artificial intelligence (AI) for marketing by 2023.

Additional benefits of using AI systems in the pharmaceutical industry include improved value propositions, effective resource allocation for higher market share gains, the capacity to maximize growth, and specialized sales and marketing information and channels. [32] AI along with various computer software can be used in drug discovery.[33]

Each year, the pharmaceutical industry spends enormous sums of money on the research and development of new pharmaceuticals and chemicals. With a high probability of failure during clinical trials, they are faced with the problem of screening around 10,000 compounds in search of a single successful molecule. Developing only one medicinal molecule costs businesses $2.6 billion on average.

Pharmaceutical firms are using big data and artificial intelligence (AI) to design clinical trials to address these issues and minimize failure rates while also lowering R&D expenditures. With a 40% compound annual growth rate between 2017 and 2024, the market for artificial intelligence is expected to rise fast and reach $5 billion by that time. [14]

CONCLUSION:

In conclusion, the integration of Artificial Intelligence (AI) into the pharmaceutical sector has introduced a new era of possibilities. From drug discovery and design to clinical trials and

marketing, AI's impact is multifaceted and transformative. It has the potential to accelerate drug development, enhance patient care, and optimize manufacturing processes. However, challenges such as the high cost of implementation and the need for refined data management systems must be addressed for AI to truly realize its potential. As AI continues to evolve and alter the pharmaceutical environment, it holds the key to unlocking novel solutions, enhancing efficiency, and ultimately transforming the way we approach healthcare and medical advancements.

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