IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Artificial intelligence (AI) in advanced pharmacy.

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Abstract: Artificial intelligence (AI) is Pharma's next frontier in life sciences. This article analyze about the recently techniques of AI that aims to imitate human intelligence functions i.e. with the help of Artificial intelligence & Robots 'Automation become the result of Industrialization', driven by the need to increase productivity, to achieve consistent quality products & to remove hazardous and heavy work from workers. Recent trends of AI in pharmacy are PAT, CFD, Pharmaceutical automation in research & development which give detailed information about techniques that has already been used in healthcare such as inhaler designs, drug absorption & dissolution and is disease focused. A robot for pharmaceutical applications has a bright future but with the rapidly aging population that urgently requires sophisticated medical devices & newer drugs, robotics systems are increasingly adopted for improved productivity and efficiency to meet this growing demand. However, robots manufacturers face several challenges in their effort to establish themselves in pharmaceutical applications. AI with robotics in the life of mankind has several advantages & disadvantages. Despite the increasingly rich AI literature from the drug discovery to care options AI techniques are used such as in ANN [artificial neural network], machine learning, AI in healthcare, AI in clinical practice. This research mainly concentrates around a few disease types: Cancer, Nervous system and cardiovascular diseases as they are life threatening. The future is always hard to predict, but it will be determined by AI as it would become the next frontier in pharmacy.

The next frontier In life sciences for pharma is artificial intelligence (AI). This article examines the most modern AI strategies that try to replicate human intellectual functions, namely with the aid of robots and AI. Industrialization led to the rise of automation, which was fueled by the desire to boost output, produce items of consistently high quality, and free workers from dangerous and taxing jobs. PAT, CFD, and pharmaceutical automation are recent advancements in AI in pharmacy that provide in-depth information regarding methods that have already been employed in healthcare, such as inhaler designs, drug absorption & dissolution, and are disease oriented. Robotics systems have a promising future in the pharmaceutical industry, but with an ageing population that urgently needs sophisticated medical equipment and innovative medications, robotics systems are becoming more common.

Keywords: Artificial intelligence [AI]; Chatbots; Computational fluid dynamics [CFD]; Robots, Artifical neural network; Applications of AI

1.General Overview: The present pharmaceutical industry is beset by costly and protracted drug discovery cycles as well as pricing pressure from Payers and Consumers. It is not enough to merely analyse drug discovery data; Pharma must also take

note of the analytics in order to stay competitive. Artificial intelligence, another disruptive technology, is used to achieve this [1]. AI can be defined as "the study of ideas that enable computers to do the things that make people seem intelligent" in just a few words. Artificial intelligence (AI) can be defined as the branch of science that deals with research, projects, and applications that seek to use knowledge or computer-based solutions to support and enhance human carer performance in decision-based medical tasks [7].

In order to address the needs of society and patients in the twenty-first century, the current drug discovery process must undergo a significant transformation. The pharmaceutical sector may speed up innovation by utilising new technologies. One of the few top industries where the development of artificial intelligence will have the biggest positive effects on human health, the foundation of evolution, is pharmacy.

2.Artificial intelligence and Robotics:

Robotics and artificial intelligence share a shared origin and a long history of interaction and scholarly debate.One could counter that not all machines are robots, and that artificial intelligence is also interested in 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 a wide range of robotics applications[2]. Patients will also look into potential drug options as they become more involved in their healthcare decision. Pharmaceutical companies can further ensure that the appropriate information is delivered at the appropriate time to allow informed dialogues between providers and patents through target audience marketing [1].

The era of linked pharma has arrived.

However, advancement is not always smooth and is most likely to be "lumpy." The vast reach of AI technology is well on its way to becoming omnipresent, boosting technology on many levels, and resulting in much better, quicker patient outcomes.

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However, advancement is not always smooth and is most likely to be "lumpy."AI technology is well on its way to becoming widely used and has a vast range of applications that can enhance technology at many different levels and produce far better, quicker patient outcomes.

3. 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 viable data analytics solution [1, 3].

Adoption of AI enables learning from current data.

1) Selecting the appropriate participants for clinical trials.
2) Analysing immediate patient feedback.
3) Integrating partner data exchanges.
4) Providers and distributors.

Here 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 [4]:

- Wireless
- Nanotechnology
- Advance storage and memory
- Sensors and analyzers
- Advance software algorithms
- Artificial intelligence

Here are a few instances of ways to enhance drug discovery outcomes while coordinating operational efficiency to give patients with better treatment. Often, getting the appropriate medication to the appropriate patient at the appropriate time actually boils down to having the appropriate information in front of healthcare providers. With complete real-time drug insights at their disposal, clinicians may select the optimal prescription for the greatest result. Automation applications are still expanding thanks to enabling technology as [4]:

- Wi-Fi
- Nanotechnology
- Extraordinary memory and storage
- Sensing and analysis devices

- Sophisticated computer algorithms
- Computerised intelligence

4.Recent trends:

4.1. Pharmaceutical automation in Research and Development: The development of artificial intelligence is more recent. Although lab automation systems have been around since the 1990s, it has only been in the last few years that they have really taken off, thanks in large part to labs focused on high-throughput screening, combinatorial chemistry, automated clinical and analytical testing diagnostics, and large-scale biorepositories. Robotics and other technological advancements have made completely automated libraries a reality [3]. A strong automated information system is required due to the sheer volume of measurements and data generated by the high speed and big quantity processing of samples. LIMS (laboratory information management system) is an example.

In the pharmaceutical sector, automation's base is firmly in place. With incremental advancements from the typical cycle of technological innovation, the functions that have already adopted automation will continue to dominate [3].

4.2. PAT (Process analytical technology: PAT is another innovative trend. This is crucial in assisting pharmaceutical firms to concentrate on ongoing innovation and be more creative to enhance their production procedures. This results in better product yields, better utilisation, and reduced waste, which saves money for the patients. Instrumentation is simply one aspect of PAT. In order to comprehend crucial process parameters, it needs to be able to interact with and gather data from a variety of equipment and analyzers [3]. It also needs to execute complicated multivariable calculations and modelling.

4.3. Computational fluid dynamics: With the use of computational fluid dynamics, product designers can quickly and affordably compare several ideas. Method operates by employing numerical techniques to resolve equations governing fluid flow. The fundamental equation (Navier-stokes) for fluid flow is automatically solved to yield an overall solution. A domain to be studied is first determined and divided into millions of little 3-D cells known as a computational mesh. The following problems can be resolved by CFD, allowing for quick and cost-effective examination of various drug delivery strategies utilising a 3D model of human physiology.

- Animal experimentation has traditionally been used to assess drug discovery processes, but results are not seen to be suffi ciently accurate when applied to humans, whose physiology, for example, can differ substantially from animals'.Because of t his, it is frequently the case that significantly different dosages are released from the same original sample, making valid co mparison difficult.
- The law requires that animal testing be minimised and that the amout of testing permitted be constrained.

5. Applications of CFD: Below is a list of some of the CFD's potential and existing applications in the creation of medication delivery systems.

5.1. Inhaler design: Inhalation therapy is widely used to treat lung conditions like cystic fibrosis and asthma.This technique allows for quick and simple drug delivery and allows for the use of smaller quantities. In the lung, the alveolar epithelial is the site of the majority of drug absorption. Particle size and inspiration rate affect the rate of medication deposition. Metered

dose inhalers and dry powder inhalers are two types of inhalers that are readily available. Since a few years ago, MDIs that incorporate CFC gases have been the most commonly recommended inhalation system. However, MDIs have two primary flaws:

- The aerosol's operation.
- Low dose concentration (usually 10% of usual dose).

Modes:

Pharmaceutical industry started researching inhaler design to improve factors such as:

- Ease of use.
- Efficiency of drug disposition.
- Reproducibility of drug dosage.

Drug delivery systems normally involve the transportation of additional phase material to the area being treated. These materials may be medicated particulate, liquid drops, a gaseous species or a mixture of these. A variety of established modeling methodologies is available to the CFD practitioner to scrutinize design variations.

This makes it possible to characterise a device that is efficient for delivering a certain dosage concentration, dose variation, and particle dispersion. Any particle-causing factor can also be found, and any ensuing design changes can be checked to make sure the issue is solved.

5.2. Drug Absorption and Dissolution: There are many other ways to give medications, including subcutaneously, rectally, orally, nasally, and more. Through the use of CFD, it is possible to simulate these channels and forecast how a drug will dissolve and be absorbed under specific conditions [5].

For instance, drugs destined for inhalation or absorption via the alveolar epithelium and into the capillaries are commonly micronized to form microparticles that are small enough to be inhaled and targeted at a particular location of the lung.

These particles create an unstable cohesive system because of their high surface area and high charges. This implies that the particles may stick to any surface en route to the respiratory system's target area. To make sure the correct dosage is given, CFD can be used to track a drug particle's movements from the nasal cavity to the lung, where it is finally deposited.

6. Pharmaceutical Applications: The pharmaceutical sector may speed up innovation by utilising new technology. Artificial intelligence immediately springs to mind as a recent development. AI has the potential to save lives by saving time, money, and human effort by analysing data and providing conclusions that would aid in decision-making [8].

6.1. Drug Repositioning : To determine the appropriate molecular starting points for a study that involves re-purposing an existing medicine or combination to investigate if it can treat additional related or unrelated disorders based on its mode of action, targets, or genomic or proteomic fingerprint[3].

6.2. Alternative Indication Identification : What are the most recent and encouraging indicators for a certain class of inhibitors? By reviewing all available information on indications and classifying it according to the quantity, quality, and relevance of published studies and trials [11].

6.3. Epidemic outbreak prediction : With the use of AI, it is possible to analyse social media activity and the history of epidemic breakouts in order to accurately anticipate where and when an epidemic will strike.

There are a tonne more use cases like the ones stated above as well!

- Customising the course of action
- Assist in creating new tools for patients, doctors, etc.

6.4. Robotics in pharmacy : Robotics play a significant part in the dispensing system [5].

- **Safety and quality -** It reduces dispensing errors and frees up workers in the pharmacy to assist with direct patient care [2, 4].
- **Financially-** 1)More efficient stock rotation.

2) Less wastage of expired stock.

- **Process efficiencies-** 1. A quicker dispensing method to cut down on patient waiting times. 2. After-hours activities

- **Reliability -** The Food and Drug Administration mandates that every medication be documented and traced from conception to completion. Pharmaceutical businesses can more easily meet these standards thanks to robots. In a similar vein, robots reduce waste and accidents [1].

- **Production-** is significantly impacted by the increased throughput speed that robots provide! Robots have the capacity to create more than a human worker since they can operate continuously without taking breaks, rest breaks, or vacations [10].

- **Reduced danger of contamination and potential for dropped samples while handling samples in labs –** Removing individuals from the screening process minimises the risk of contamination and potential for dropped samples. These duties are carried out much more quickly and accurately by robots

- **Boost efficiency –** Robots can boost efficiency, which makes medicine prices themselves more competitive. People are less productive than machines while producing pharmaceuticals, even when they are using safety gear [4].

6.5. AI in Healthcare : Prior to being used in health care applications, AI systems must first be educated using data produced by clinical operations like screening, diagnosis, therapy, and so on. A significant percentage of AI literature, specifically in the diagnosis stage, analyses data from electrodiagnosis, genetic testing, and diagnosis imaging [6].

6.6. Disease focus: Despite the growing body of AI research in healthcare, the majority of the study focuses on just a few illness types: cardiovascular, nervous system, and cancer.

Cancer: Through a double-blinded validation research, Somashekharet et al. showed that IBM Watson for oncology would be a trustworthy AI system for assisting the diagnosis of cancer.

Neurology: Bouton et al. created an AI system to help quadriplegic patients regain control over their motions. Farina et al. evaluated the effectiveness of an offline man/machine interface that connects upper-limb prosthesis to the timing of spinal motor neuron discharge.

Cardiology: Dilsizian and Siegel talked about the potential use of an AI system to detect heart problems using cardiac images. It is not entirely surprising that there is a concentration around this illness [9].

All three of these illnesses are the main causes of death, so it is essential to get a diagnosis as soon as possible to keep the patient's condition from declining.

6.7. AI in various techniques : The most intriguing artificial intelligence method is the artificial neural network, which is most frequently employed in medicine. Non-linear Mapping, a mathematical system that activates biological brain networks, is a component of this potent technique. It simulates the brain's neural networks' capacity for pattern recognition. Due to their capacity to discern even non-linear relationships from noisy data, ANN are highly effective in the data analysis of pharmacological research [7]. They can identify patterns from complex sets of analytical data.

6.7.1. Applications include –

- o Drug simulation
- o Dosage planning
- o The makeup of proteins
- o Prediction of function
- o Modelling of pharmacokinetic and pharmacodynamic effects
- o Correlation between in vitro and in vivo results.

6.7.2. Machine learning-

To extract features from data, machine learning creates data analysis algorithms. Age, gender, disease history, gene expression, clinical symptoms, and medication are among the 'traits' and occasionally the medical outcomes of interest that go into machine learning algorithms [6].

6.7.3. Deep learning- contemporary improvement on the traditional neural network method is deep learning. Deep learning can be seen as a multi-layered neural network. Deep learning is able to construct neural networks with a huge number of layers, which is impractical for classical neural networks due to the rapid development of modern computing.

6.8. AI in clinical practice -

The gathering, storing, normalising, and tracking of data is a significant use of AI in the healthcare industry. Deep genomics searches for mutations and connections to the disease by looking for patterns in massive databases of genetic data and medical records [11]. A new generation of computational methods is being developed to show doctors what will happen inside a cell when genetic variation, whether natural or therapeutic, modifies the DNA. Clinical trials for the creation of drugs can take more than a decade and cost billions of dollars. [9, 10].

7. Advantages:

- Artificial intelligence offers the pharmaceutical sector the chance to find solutions to issues that were previously intractable by straightforward data analysis [8].
- AI can do particular activities with greater accuracy, which lowers costs while boosting efficiency.
- AI provides useful insights that will significantly enhance the results of clinical trials.
- In-depth understanding of market dynamics, consumer behaviour, and how they interact.
- Tailoring enhanced and distinctive value offers, both real and intangible, to unmet client demands.
- It encourages the development of new artificial intelligence algorithms and enhances antiviral detection systems' efficacy.
- It also makes it easier for businesses to choose the right patients for clinical trials and allows them to spot problems with chemicals considerably earlier in terms of safety and efficacy.
- If properly coded, AI would have a lower mistake rate than humans. They would be incredibly quick, accurate, and precise.
- Future robotic surgery will be able to perform additional types of surgery with more precision than humans.
- AI is revolutionising the drug development process by utilising deep learning and natural language processing to comprehend and examine enormous amounts of bioscience data [7,8].

8. Disadvantages –

- Since AI lacks the ability to think for itself and can simply follow instructions, it primarily lacks the human touch.
- It can effectively taint the next generation.
- Can be altered to mass devastation as the first option.
- Joblessness will result if robots begin to replace humans in all occupations.
- Can be expensive to construct, repair, and rebuild.
- If machines are in the wrong hands, they can quickly cause havoc. At the very least, many people fear that.
- AI machines may be able to outperform people, subjugating mankind.

9. Current challenges –

The largest issue facing healthcare is its historical clogged infrastructure brought on by decades-old legacy systems. Pharmaceutical companies are also faced with the problem of creating new medications that are more effective and have fewer side effects while doing so in a setting that promotes faster drug development, higher success rates, lower discovery costs, and better access to patients in need[6].

Increasing client expectations The business landscape is becoming more challenging as healthcare payers place new financial restrictions on healthcare providers and closely examine the benefits that medications bring. They want innovative treatments that are clinically and financially superior to the alternatives already available, along with concrete real-world outcomes data to support any claims about the superiority of medicine [7].

- **Low scientific productivity:** For the past ten years, Pharma's output has been steady. There is little reason to believe that it will suddenly lose productivity if the same discovering and developing techniques are used.

- **Cultural sclerosis:** Despite being replaced by new business models, the management culture, mental models, and methods that are currently in use are the same as they have historically been.

These difficulties are lessened by potential developments in the gathering and analysis of medical data along with machine learning skills. The R&D process itself, patient EHRs, and carer input all contribute to the exponential growth of data in the pharmaceutical and healthcare industries[6,7]. Pharmaceutical companies will be better able to find new prospective drug candidates, develop them successfully, and eventually get new treatments approved and reimbursed more swiftly if they make efficient use of these data points.

10. Future Directions –

❖ AI is Pharma's next frontier in life sciences

Research and development – Pharmaceutical businesses must build portfolios in order to manage risk. To achieve this, they must make sure that R & D funds are allocated appropriately to allow for decision-making[1,6].

a)By raising the probability of effective drug discoveries.
b) Produce a sizable increase in revenue.
c)To gain advantages from a production, sales, and marketing environment that is integrated with research and development.

Clinical Trial Research: AI-enabled clinical trials have the potential to revolutionise clinical trials and enhance the efficacy and security of life-improving treatments. It is substantially more accurate than other methods for predicting drug activity. It takes around 15 years to develop a product that is ready for the market; clinical studies take too long and are exceedingly expensive. The odds are not in our favour; the current drug discovery approach is losing its viability [11].

Pharmaceutical businesses will soon be able to construct bots for doctors that function similarly to apps in terms of artificial intelligence [7].

➢ **For example –**

- A bot that responds to all patient questions concerning a certain ailment for that disease. A special form of treatment is about to go into effect that involves educating patients in this way.
- Chatbots are created for a certain treatment, giving patients and doctors access to all the pertinent information about the brand they need to prescribe or begin treatment.
- Now that a treatment choice has been recommended, several Chatbots can assist with patient adherence. It can alert patients to potential side effects and how to handle them, serve as a reminder of when therapy should be given, and even serve as a preventative measure by providing videos on how to correctly administer dose and treatment.

11. Conclusion :

AI would benefit the globe by finding a pharmacore for drug research & development to healthcare like ANN, CFD, & Robotics thanks to the sophisticated current difficulties and futuristic path. Insights from artificial intelligence can be used to more accurately describe patients and anticipated results. These insights are produced from real-world data. As a result, pharmaceutical companies that are working on a new generation of computational technologies that can inform doctors what will happen inside a cell when DNA is altered by genetic variation have a tempting potential thanks to artificial intelligence. By utilising deep learning and natural language processing to comprehend and analyse enormous amounts of bioscience data, AI is redefining the drug discovery process.

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