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ROLE OF ARTIFICIAL INTELLIGENCE IN PHARMACY

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ABSTRACT

The field of pharmacy is undergoing a transformation due to the advancements in Artificial Intelligence (AI), which significantly enhance drug discovery, personalized medicine, and patient care. AI algorithms streamline the processes of drug development and diagnostics, while 3D printing technology allows for the creation of tailored medications to meet individual patient requirements. The use of robotics in pharmacy automates various tasks, leading to a reduction in errors and an increase in operational efficiency. Additionally, AI- powered biosensors enable continuous patient monitoring, which aids in the early detection of diseases and the customization of treatment plans. The convergence of AI, 3D printing, robotics, and biosensors is reshaping pharmaceutical practices, enhancing medication safety, and providing more accurate healthcare solutions. Notable statistics underscore their increasing influence on precision and patient outcomes.

KEYWORD:- Artificial Intelligence-3D printing Technology, Biosensors, Robotics.

Artificial Intelligence

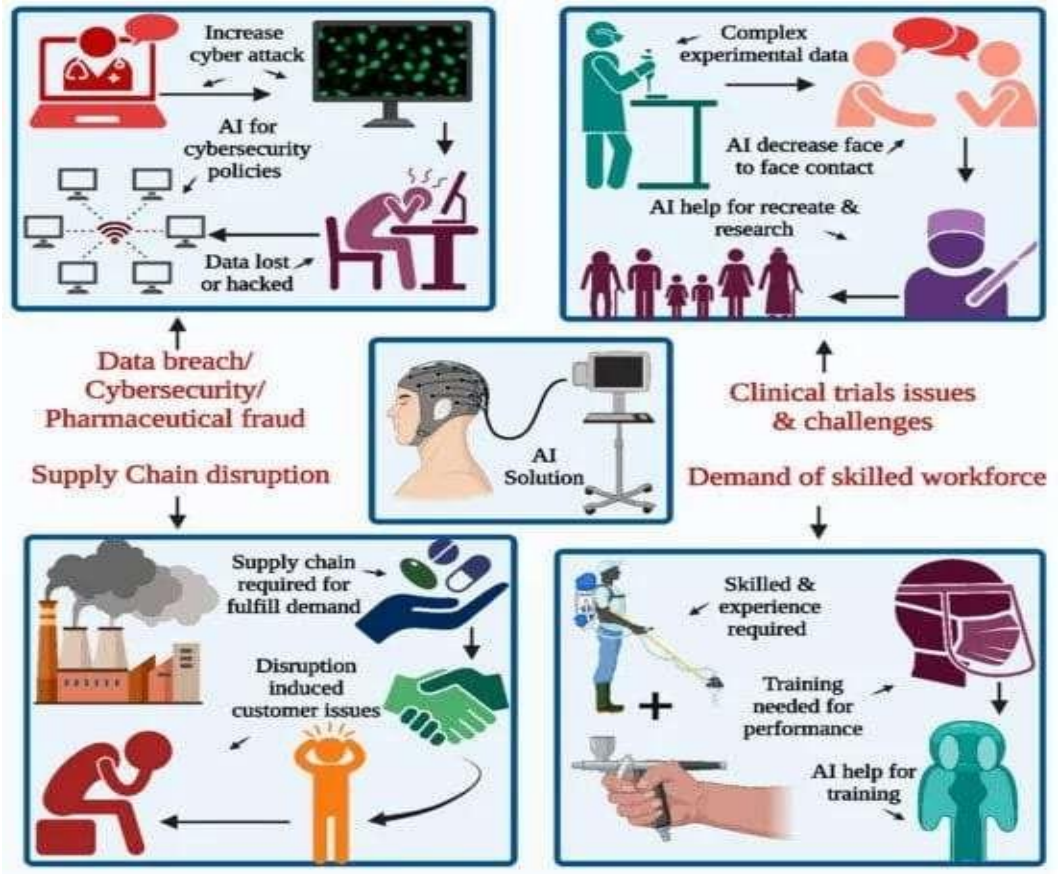
Artificial intelligence (AI) refers to computational technologies that replicate functions associated with human intelligence, including reasoning, deep learning, adaptability, interaction, and sensory perception. Certain systems are capable of performing tasks that usually require human judgment and decision-making. These methodologies adopt an interdisciplinary perspective and can be utilized across various domains, including healthcare and medicine. The integration of AI in medicine dates back to the 1950s, when doctors first endeavored to enhance their diagnostic capabilities through the use of computer-assisted programs.[1]

AI technology has recently became a crucial component within various industries, demonstrating its utility across numerous technical and research domains. The growing acceptance of AI applications in the pharmaceutical sector, encompassing areas such as drug discovery, formulation development for drug delivery, and other healthcare-related applications, has transitioned from mere speculation to genuine optimism. Furthermore, the implementation of AI models enables the prediction of in vivo responses, pharmacokinetic parameters of therapeutics, and appropriate dosing strategies.[2]

Artificial Intelligence (AI) is a fast emerging as a crucial tool for improving patient care and treatment outcomes; however, concerns persist among health professionals about potential compromises in quality care and loss of jobs. The availability of systematic evidence on health professionals' perspectives on AI in healthcare is limited. It is more important to use this technology safely, effectively, and equitably than in health and health care. Although artificial intelligence is quickly becoming a vital tool for bettering patient care and treatment.[3]

Typically, the aforementioned 3D models are created by humans utilizing specialized software to design and define various characteristics. This study, however, will explore an alternative approach to generating these models through the use of artificial intelligence (AI). AI facilitates machines in generating new insights via numerous iterations and inputs, learning and enhancing their performance based on the effectiveness of these iterations, thereby mimicking more human-like behaviour. The primary input types employed in the experiments are text-to-3D and image-to-3D. As the names suggest, the former enables the generation of 3D models from textual prompts, while the latter does so from image prompts.[4]

Applications of AI in pharmacy



1. 3D-Printing

It is newest emerging technology used in health care system for manufacturing of specific dosage forms for individual patients. Examples like This results in personalized medicine to the patient and overcomes the disadvantages of general dosage form thus leads for better optimization and control over the active medication.

This technology creates the 3D models for printing improves accuracy and reability.

2. Pharmaceutical manufacturing

Artificial intelligence tools (eg: meta-classifiers and tablet-classifiers) play a crucial role in maintaining the quality of pharmaceutical products by detecting potential manufacturing errors in tablets. These technologies assist in recognizing deviations from established quality standards during the production process, thereby minimizing the risk of defects and ensuring the safety and consistency of the final product. AI has the capability to forecast when equipment or machinery may fail, facilitating timely maintenance and reducing operational downtime.

3. Drug discovery

Artificial intelligence is pivotal in the discovery of promising compounds for drug development. Tools like machine learning and deep learning algorithms are used. Machine learning algorithms can sift through extensive chemical databases to predict which compounds are most likely to be effective against specific biological targets. AI-driven in silico methods (virtual screening and molecular modelling), thus accelerating the identification of potential drug candidates while minimizing the need for costly and time-consuming laboratory experiments.

4. Market Analysis and Digital Marketing

AI can enhance digital marketing and market analysis by employing MCDM methodologies. By collecting and analyzing both statistical and mathematical data, AI aids pharmaceutical companies in making informed decisions regarding product positioning, pricing, and promotional tactics.[6]

5. Patient education

Artificial intelligence serves a crucial function by converting complex medical information into formats that are easier to understand. Interactive chatbots, like Buoy Health, provide tailored guidance regarding medication usage, dietary adjustments, lifestyle changes, and treatment strategies, thereby enhancing patient comprehension and adherence.[7]

Recent trends in formulation of using AI 3 dimentional printing

3D printing has become a disruptive technology that has the potential to completely transform a number of industries, including pharmaceutics, aerospace, and energy and. Its capacity to precisely build intricate 3D

structures has great promise for the advancement of medical treatments. By producing precise and customised medications that are suited to each patient's need, 3D printing enhances therapeutic efficacy and patient outcomes. Nevertheless, 3D printing medications is still in its infancy and lags behind other well-established technologies, despite its immense promise. Realising the potential of 3D printed medications will need an elaborate research activity that will be both time- and cost-intensive.[8]

Three-dimensional (3D) printing is revolutionizing the field of pharmaceuticals and clinical pharmacy practice, moving away from conventional mass production methods towards the creation of customized drug products tailored to individual needs**.** This innovative approach holds the promise of delivering significant advantages for patients, pharmacists, and the pharmaceutical sector by facilitating the on-demand design and manufacturing of adaptable formulations with personalized dosages, shapes, sizes, drug release profiles, and combinations of multiple medications.[9]

The integration of advanced digital technologies, including artificial intelligence (AI), into 3D printing has the potential to bridge existing gaps in the pharmaceutical sector. Machine learning, a branch of AI, can effectively forecast drug dosages and optimize delivery methods, thereby enhancing human expertise. Furthermore, the incorporation of this transformative technology can lead to more efficient pharmaceutical management through innovative drug design and improved quality control.[10]

AI technology in Diagnostics

Medical diagnostics refers to the systematic evaluation of medical conditions or diseases through the analysis of symptoms, medical history, and laboratory test results. The primary objective of medical diagnostics is to identify the underlying cause of a medical issue and to establish an accurate diagnosis, which is essential for administering appropriate treatment. This process may encompass a range of diagnostic procedures, including imaging techniques (such as X-rays, MRI, and CT scans), blood analyses, and biopsy examinations.[11] Artificial intelligence can be applied across multiple stages of diagnostic imaging, including acquisition, reconstruction, analysis, and reporting.[12] The advancement of initial diagnostic instruments remains a persistent challenge, primarily due to the intricate nature of diverse disease mechanisms and their associated symptoms. Artificial Intelligence has the potential to transform numerous facets of healthcare, particularly in the realm of diagnosis. Machine Learning, a subset of AI, relies on data as a fundamental resource, with its accuracy significantly influenced by both the volume and quality of the input data, thereby addressing some of the complexities and challenges inherent in diagnosis.[13] Moreover, AI contributes significantly to the prompt detection of infections in chronic wounds. Through the analysis of wound exudate and other clinical data by machine learning algorithms, it can identify infection indicators before they are clinically noticeable. This timely detection permits swift treatment, thereby lowering the risk of serious complications and encouraging a faster recovery.[14] The application of artificial intelligence in medical diagnostics is gaining significant attention, especially in fields such as dermatology, where the automation of cancer detection is becoming increasingly prominent.[15] The development of artificial intelligence (AI)-enhanced tools and techniques for the effective identification and surveillance of atrial fibrillation (AF) is becoming more and more noticeable. The reliable diagnosis of this life-threatening cardiac condition necessitates the collaboration of both artificial intelligence and human intelligence. With the advancement of wearable technology, contemporary devices are outfitted with sophisticated embedded sensors such as optical sensors and accelerometers. As a result, photoplethysmography and ballistocardiograph signals could be investigated as a budget- friendly substitute for electrocardiography (ECG) signals in the detection of atrial fibrillation (AF), particularly in the design of economical and miniature screening and monitoring devices.[16]

Applications

1. **Lung cancer screening:** Artificial intelligence algorithms evaluate CT scans to detect early indicators associated with an increased likelihood of cancer development.

-Ex: Low-dose computed tomography scan

2. **Pneumonia detection:** These systems differentiate between COVID-related pneumonia and community-acquired pneumonia often achieving greater accuracy than human radiologists.

Ex: Chest X-rays, CT scans

3. **Cardiovascular diseases:** Models analyse data to reveal concealed patterns of heart disease, including early indicators of hypertrophic cardiomyopathy.

Ex: Electrocardiograms, MRIs

4. **Diabetes management:** Automated systems identify diabetic retinopathy with high sensitivity, facilitating timely and cost-effective treatment options.

Ex: Blood glucose meters, Continuous glucose monitors (CGMs)

5. **Breast cancer diagnosis:** AI applications in radiology assess mammograms, decreasing false positive rates from 11% to 5%, thereby assisting oncologists in identifying early-stage cancers.

Ex: Mammograms

6. **Neurological conditions:** AI technology can analyse intricate brain imaging to detect subtle signs of degeneration in conditions such as Parkinson's disease, ALS, and early Alzheimer's, often before clinical symptoms manifest.

Ex: Electroencephalogram, Brain machine interfaces

Statistics

Statistics represents a field within mathematics focused

on the collection, analysis, interpretation, presentation, and organization of data. The application of statistical methods is prevalent in artificial intelligence, enhancing both performance and accuracy.[17] SAS, founded in 1976, has become a leading developer of statistical software, widely adopted in academic, business, and government sectors. Since the 1980s, SAS has expanded its analytical capabilities to include forecasting, econometrics, data mining, text mining, and operations research. Currently, SAS utilizes these components to provide business analytics software and industry-specific solutions addressing challenges such as customer intelligence, fraud prevention, and risk management.[18] Stan is a programming language designed for probabilistic modelling, enabling the specification of statistical models. Stan is a probabilistic programming language that enables users to define a wide variety of statistical models with continuous parameters by coding their log posteriors or penalized maximum likelihood up to a certain proportion.[19] Statistical methodologies possess underutilized expanding resources and have created new avenues to enhance patient care through increased diagnostic precision, dependable prognosis forecasting, tailored treatment options, and improved operational efficiency within healthcare systems.[20]

- **Applications**

1. **Enhanced Accuracy and Precision:** The incorporation of statistics into artificial intelligence can significantly enhance the accuracy and precision of predictions generated by AI systems.
2. **Greater efficiency:** The integration of statistics within AI can lead to increased efficiency by minimizing errors and optimizing the time required for making predictions.
3. **Superior data management:** Statistics can improve data management in AI by uncovering patterns, trends, and relationships within the data.[17]
4. **Natural Language Processing (NLP):** It is a branch of artificial intelligence (AI) that explores how computers interact with human language. The use of statistical methods in NLP contributes to the development and refinement of models for processing, generating, and understanding language.[21]

Robotics

Robotic technologies and artificial intelligence (AI) in pharmacy and medicine presents a promising opportunity to revolutionize multiple areas of healthcare. These innovations aim to improve efficiency, enhance patient outcomes, and reduce costs, while also confronting urgent challenges such as personalized medicine and the quest for more effective treatment options.[22] Robotic technology and artificial intelligence (AI) are increasingly transforming the pharmacy and medicine sectors, ushering in a new era of healthcare that promises efficiency, accuracy, and improved patient outcomes. Robots are used to automate the process of testing potential drug compounds in high-throughput screening (HTS) facilities. These robotic systems can test thousands of compounds for effectiveness and safety, drastically speeding up the drug discovery process.[23] Furthermore, All these innovations driven by AI, Automation, and robotics also contribute to personalized medicine by extending tailored treatments based on individual patient data. This strategy increases workflow efficiency and ensures the delivery of consistent, high-level results that are free from errors and inventory management, leading to a reduction in human errors and a more efficient pharmacy workflow.[24] Robots equipped with computer-like capabilities can be programmed to replicate even the fundamental elements of human intelligence through various algorithms. The objective of artificial intelligence systems is to develop mechanisms that can address complex problems in a way that resembles human reasoning.[25] The use of robotics in the pharmaceutical sector is growing rapidly, facilitating the automation of specific tasks in drug development. These tasks may involve drug screening, production, and anticounterfeiting efforts. By leveraging Machine Learning and Artificial Intelligence, robotics can expedite the drug discovery process.[26]

Nanorobotics

Nanorobotics is a new subfield that has emerged from the field of robotics itself. This technique makes use of robots that are as small as nano- or micron-sized to diagnose diseases and deliver drugs to the targeted organ, tissue, or cell.[27] Nanorobots specifically designed to prevent and monitor blood-related diseases are carefully crafted to function efficiently within the intricate environment of the bloodstream.[28] Gain access to distant areas of human anatomy that are not operable during standard surgical procedures at the operating table.[29] like nanorobots are capable of continuously tracking blood pressure, cholesterol levels, and various cardiovascular metrics. They deliver real-time information that aids in the early identification of cardiovascular diseases, facilitating prompt intervention to avert heart attacks and strokes.[28] In considering the adverse effects of existing therapies, nanorobots are revealed to be a more innovative and supportive alternative for the treatment and diagnosis of critical health conditions.[29] They have gained recognition as a groundbreaking instrument within the biomedical sector. The domain of nanobotics is showing heightened interest in the ongoing initiatives aimed at developing small-scale automated systems capable of efficiently transforming energy into purposeful motion.[30]

Biosensors

A biosensor is a device that detects biological substances and translates their concentration into measurable signals. A biosensor functions as an integrated device that includes both a receptor and a transducer, enabling it to provide selective quantitative or semi- quantitative analysis of a particular analyte. This device is generally composed of bio-sensitive materials that act as the biorecognition element, in conjunction with a physical or

chemical aspect.[31] Biosensor-based technologies are groundbreaking in today's biomedical field and are expected to play a crucial role in the future of healthcare. The combination of artificial intelligence (AI) with biosensors for point-of-care (POC) diagnostics is an important and promising area of development.[32] The integration of biosensors and artificial intelligence enhances clinical practices and empowers patients to engage actively in their healthcare journey. Wearable biosensor devices equipped with AI capabilities enable users to monitor their skin health in real time, which supports timely interventions and preventive measures. This forward-thinking approach not only alleviates pressure on healthcare systems but also fosters a culture of wellness and self-care within the community.[33]

Applications

1. **Point-of-care (POC):** sensors are increasingly employed in bedside clinical environments for swift diagnostic evaluation and screening. These POC cardiac biosensors facilitate the monitoring of biomarkers, including troponin T, D-dimer, and pro-B-type natriuretic peptide (proBNP), enabling the proactive detection of cardiac events.[34]
2. AI-biosensors, facilitate the early detection of diseases, identification of bacteria, and measurement of harmful compounds. The application of machine learning improves the functionality of these biosensors and refines aspects such as electrode design and analyte selection.[35]
3. **Wearable biosensors:** when integrated with machine learning technologies, facilitate remote monitoring, diagnosis, and treatment of various health issues. These wearable devices are capable of collecting significant volumes of unlabelled data from biosensors, including Electrodermal Activity (EDA), Electrocardiography (ECG), and Electroencephalography (EEG).[36]

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