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Pharmacy and Artificial Intelligence (AI): A Review of Recent Advancements

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ABSTRACT

The field of artificial intelligence (AI) arose as a solution to issues with data and numbers. This technical breakthrough has benefited engineering, architecture, education, accountancy, business, health, and countless others. Artificial intelligence (AI) has made great strides in the healthcare industry, particularly in the following areas: automated machines; software and computer applications like diagnostic tools like MRI radiation technology and CT diagnosis; and data and information storage and management, including patient medical histories, medicine stocks, sale records, and so on. Artificial intelligence has undoubtedly improved the efficiency and effectiveness of healthcare in general and the pharmacy industry in particular. A growing body of research in recent years has focused on the potential of artificial intelligence (AI) to improve our understanding of drug development, dosage form design, polypharmacology, and hospital pharmacy, among other vital areas of pharmacy. The article intends to put together a detailed report that any working pharmacist may use to comprehend the most significant advances made possible by deploying AI because of the field's increasing significance.

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Introduction

The term "Artificial Intelligence" (AI) describes computer programs that can mimic the intelligence of humans. Artificial intelligence (AI) aims to create a computer system that can simulate human intelligence and perform tasks such as perception, reasoning, learning, planning, prediction, and more [1].

The pharmacy industry has utilized automation to boost workflow efficiency, decrease operational costs, and ensure accuracy, efficiency, and safety in all pharmacy settings. Thanks to automated dispensing, pharmacists can improve health outcomes and spend more time with more patients [2]. The initial use of a computer in a pharmacy was likely in the 1980s. Since then, computers have found numerous uses in the pharmacy industry, including data collection, retail pharmacy management, clinical research, drug storage, pharmacy education, clinical pharmacy, and many more [3]. Drug interactions, drug therapy monitoring, and formulary selection are all guided by artificial intelligence. Pharmacists must consider how artificial intelligence (AI) can change various parts of the pharmaceutical industry since these changes could become accepted standards.

Topics about artificial intelligence were the focus of this article. This course aims to raise awareness of artificial intelligence (AI) as a future component of pharmacy practice, to encourage pharmacists to embrace this advancement, and to help them acquire the necessary skills to contribute to this much-desired development by covering topics such as AI general overview and classification, AI uses in hospitals, the pharmaceutical industry, and retail pharmacies.

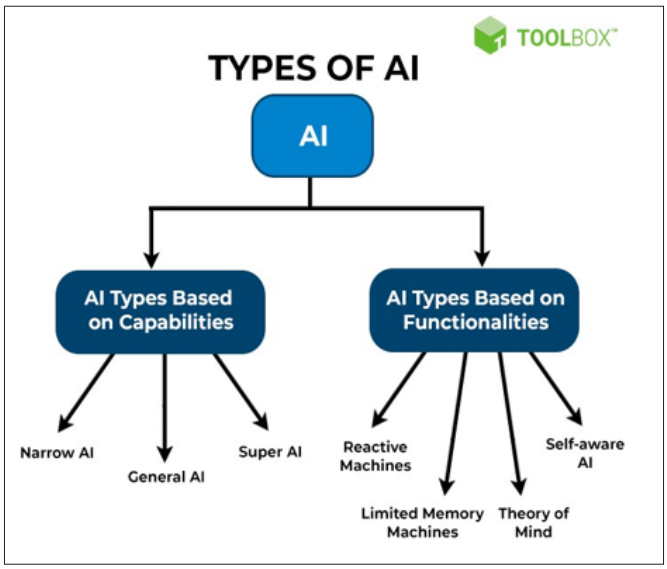
General Overview- Artificial Intelligence

Artificial Intelligence (AI) involves the application of machine learning algorithms to simulate intelligent behavior, requiring minimal human involvement [4]. Artificial intelligence is an interdisciplinary field that integrates computer science with comprehensive datasets to facilitate problem-solving. Natural language processing (NLP) is a branch of artificial intelligence focused on comprehending and producing language.NLP focuses on creating algorithms and constructing models that utilize language similarly to humans. Natural Language Processing (NLP) is crucial for harnessing the power of Artificial Intelligence (AI) in biomedical sciences since it is the primary method for gathering and sharing knowledge in public health and medicine. Contemporary NLP platforms rely on models enhanced using machine learning methods. Machine learning methods rely on four key elements: a model, data, a loss function to evaluate model fit, and a training procedure to enhance the model. Advancements in various model types like recurrent neural networks (RNN), convolutional neural networks (CNN), and attention-based models have enabled contemporary natural language processing (NLP) systems to comprehend and represent intricate linguistic relationships and concepts beyond essential word presence. [5].

The year 1956 is often considered the birth year of AI, as it was during this year that Dartmouth College hosted the renowned conference. In 1955, Allen Newell and Herbert A. Simon developed the first AI system, called Logic Theorist. This technique was used to prove over 40 theorems of Principia Mathematica by Alfred N. Whitehead and Bertrand Russell. Nevertheless, the system's designers were unable to have it published [6].

Classification of Artificial Intelligence [7]
AI can be classified in two different ways.

- AI-based on capability.
- AI-based on functionality.



AI-based Capability is Further Divided into Three Categories

• **Narrow AI:** Narrow AI, also known as narrow artificial intelligence, refers to a specialized form of artificial intelligence wherein a learning algorithm is created to carry out a singular task. It is important to note that any knowledge acquired during the execution of this work is not automatically transferred or applied to other tasks [8]. Instances of narrow artificial intelligence (AI) encompass Apple's Siri and IBM's Watson supercomputer.

• **General AI:** Artificial general intelligence (AGI) refers to the cognitive abilities of computers, enabling them to understand, acquire knowledge, and execute intellectual activities in a manner similar to humans [9].

• **Super AI:** Superintelligence refers to the state of artificial intelligence where a computer's intelligence much exceeds that of a human by multiple magnitudes [10]. A machine equipped with super AI can engage in cognitive processes such as thinking, reasoning, puzzle-solving, judgment-making, learning, and independent communication. Super AI is a theoretical idea that symbolizes the future of artificial intelligence.

AI-based on Functionalities are Further Divided into Four Categories

• **Reactive Machines:** Reactive machines are fundamental types of artificial intelligence that do not possess the capability to retain past experiences or memories for future actions. These systems focus on present situations and respond to them by taking the most optimal action. Notable instances of reactive machines are IBM's Deep Blue system and Google's AlphaGo.

• **Limited Memory Machines:** Limited memory capacity AI refers to machine learning models extracting knowledge from previously obtained information, historical data, or past occurrences [11].

• **Theory of Mind:** The term "theory of mind" describes an artificial intelligence system that mimics human reasoning and emotional intelligence. This variety of AI is still in the conceptual stages and could be a game-changer in the future.

• **Self-Aware AI:** Developing AI systems with the capacity for self-awareness is the essence of self-aware AI. In other words, this would mean that AI might understand its reality, have an identity, and be conscious of its feelings and ideas. With the ability to reflect on its actions, AI could mimic human empathy by engaging in more profound and meaningful interactions with the environment [12].

Application of AI in Pharmacy

By providing a more streamlined and individualized method of patient care, artificial intelligence (AI) may cause a dramatic shift in the pharmaceutical industry. Artificial intelligence (AI) language models that utilize deep learning to produce convincingly human responses are one approach to this problem. There are a number of areas in which AI could completely transform the pharmacy system. These include medication management, communication with patients, data analytics, electronic health records, medicine interactions, adverse drug reactions, and patient monitoring. Improved patient outcomes and lower healthcare expenses are possible when healthcare practitioners use AI's capabilities in these areas. In this study, we'll look at how artificial intelligence (AI) can enhance patient care by analyzing factors in pharmaceutical systems. Criteria for pharmacy system parameters administered by AI include [13].

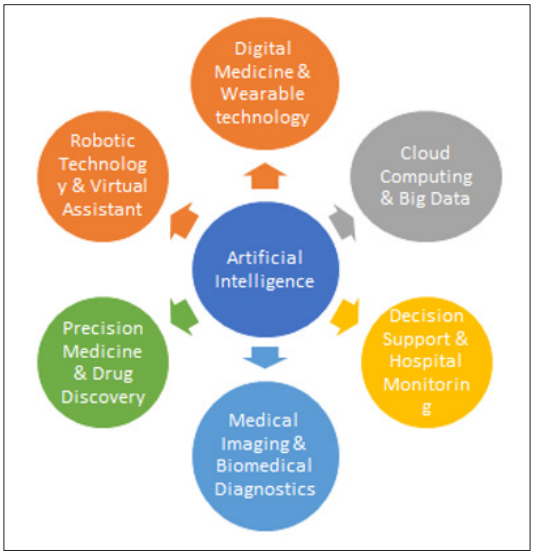
Medication Management

Pharmacists now have a far heavier burden to prevent adverse medication reactions and drug-drug interactions due to new prescriptions due to the rising prevalence of polypharmacy. Artificial intelligence (AI) has the potential to significantly assist clinical teams and pharmacists in the following ways: Artificial intelligence (AI) can sort through mountains of public data, and prediction algorithms based on machine learning can reliably identify hazards related to toxicity along with potential threats to efficacy.

With the help of AI, pharmacists can cross-verify patient data, prescription data, and pharmacy inventory to manage medications better and reduce the likelihood of medication errors. It can help spot problems, including double therapies, improper dosages, drug-drug interactions, and drug-disease contraindications.

Communication with Patients

AI-powered systems can generate medication reminders that are automatically sent to users' phones, texts, or voice assistants. These reminders help patients keep track of their prescription schedules, improve adherence, and significantly reduce the likelihood of missed doses. Artificial intelligence technology has revolutionized healthcare by making drug adherence easier and enhancing health outcomes and patient satisfaction [14].



Electronic Health Record

The electronic medical record (EMR) stores patients' medical records, including their diagnosis, medications, lab results, allergies, vaccines, treatment programs, individualized care, and progress toward better health outcomes while reducing risks [15]. An algorithm for managing cardiac arrest was developed by analyzing three years of Electronic Medical Record (EMR) data. This algorithm considers Essential health indicators, including blood pressure, heart rate, breathing rate, and body temperature [16].

Data Analysis

Due to advancements in Machine Learning (ML) and Artificial Intelligence (AI), the likelihood and efficiency of automated programs detecting and diagnosing diseases early is higher than the manual technique of recognizing diabetes [17]. Pharmacy budgeting and efficiency can both be enhanced with data analytics. Gaining access to your company's supply chain data could help you spot improvement opportunities that would otherwise go unnoticed. Improvements in supply chain efficiency, rate negotiation, and patient demand forecasting are all part of this effort [18].

Adverse Drug Reaction

AI systems depend significantly on high-quality data to detect ADRs accurately. By combining various data sources, including EHRs, patient reports, and medical literature, AI algorithms can detect possible ADRs very accurately. The detection of ADRs powered by AI relies heavily on machine learning methods. These systems can improve their ADR prediction and identification capabilities by learning from past data. With the help of AI, adverse drug reactions can be detected early on [19].

Possible Challenges to using AI in Pharmacy

A lack of understanding and familiarity with AI's potential pharmaceutical industry uses may slow its acceptance. Concerns about the security and privacy of personal information are another major roadblock to the widespread use of AI. Since AI systems rely on personal data to do the necessary tasks, there is a risk that they may violate patients' privacy and security. Artificial intelligence has yet to attain perfect privacy protection and safety. The financial burden of integrating AI systems in the pharmacy environment might be exceptionally high due to the high expenses of AI technology. In addition, many pharmacists may be resistant to change and hesitant to embrace AI because they fear it will take their employment. This is probably because they aren't unaware of how AI may improve their pharmacies [20].

Conclusion

In conclusion, artificial intelligence (AI) has made significant advancements in the pharmacy industry, improving efficiency and effectiveness in various areas such as drug development, dosage form design, polypharmacology, and hospital pharmacy. AI has the potential to enhance medication management, communication with patients, electronic health records, data analysis, and the detection of adverse drug reactions. However, there are challenges to the widespread use of AI in pharmacy, including a lack of understanding, concerns about privacy and security, high costs, and resistance to change. Despite these challenges, AI has the potential to benefit significantly the pharmacy industry and improve patient care.

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