REVIEW ARTICLE

Artificial Intelligence: The Beginning of a New Era in Pharmacy Profession

Manish Vyas[1], Sourav Thakur[2], Bushra Riyaz[3], Kuldeep K Bansal[4], Bhupendra Tomar[2], Vijay Mishra[3]*

[1]Department of Ayurveda, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab, India, [2]Department of Quality Assurance, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab, India, [3]Department of Pharmaceutics, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab, India, [4]Pharmaceutical Sciences Laboratory, Faculty of Science and Engineering, Abo Akademi University, 20520 Turku, Finland

Abstract

Artificial intelligence (AI) is a branch of computer science that deals with the problem-solving by the aid of symbolic programming. It has greatly evolved into a science of problem-solving with huge applications in business, health care, and engineering. One of the pivotal applications of AI is the development of the expert system. With the advent of big data and AI, robots are now becoming more trustworthy for doctors, and a large number of institutions are now employing robots along with human supervision to carry out activities that were previously done by humans. The major advantage of AI is that it reduces the time that is needed for drug development and, in turn, it reduces the costs that are associated with drug development, enhances the returns on investment and may even cause a decrease in cost for the end user. A large number of researches are being carried out to improve the current available AI technology to make the pharmacy profession more efficient. The present article briefly describes the importance of AI in the process of drug development and then looks at the various AI tools that are available at the disposal of a modern-day pharmacist to aid in a more efficient functioning.

Key words: Artificial intelligence, drug discovery, tug robots, Watson for oncology

INTRODUCTION AND HISTORY

Artificial intelligence (AI) is a branch of computer science that deals with the problem-solving by the aid of symbolic programming. It has greatly evolved into a science of problem-solving with huge applications in business, health care, and engineering. One of the pivotal applications of AI is the development of the expert system.[1]

The year 1956 is usually considered to be the year when AI was born, as it was in 1956 that Dartmouth College had organized the famous conference. However, the preceding year, that is, 1955, saw its first AI system that was called Logic Theorist and the people who developed it was Allen Newell, Herbert A. Simon. Nearly, 40 theorems of *Principia Mathematica* by Alfred N. Whitehead and Bertrand Russell were proved using this system. However, the designers of the system could not get it published.[2]

In an interview with the BBC, theoretical physicist, Professor Stephen Hawking, had said that human efforts to create machines that can think are a huge threat to the existence of human race and that the race to develop a complete AI could mean that the human race would come to an end in the future. This warning was given by Professor Hawking after he was asked about revamping the technology that is used by him to communicate. The technology used by him involves AI of a basic nature.[3] However, the warning of Professor Stephen Hawking has not been taken seriously by the world. Throughout the world, innumerable researches are being carried out on AI. A large amount of money is being invested to create a system that can function far more efficiently and at a much less time than a normal human being. Be it an educational institute, a manufacturing firm,

Address for correspondence:
Dr. Vijay Mishra, Department of Pharmaceutics, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab, India.
Email: vijaymishra2@gmail.com

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a government office, or a research organization; AI finds its application in every field.

It has been forecasted that the revenue from AI market will be increasing by as much as ten-fold between the years 2017 and 2022. Natural language processing market, which has several applications including text prediction, and speech and voice recognition has been said to achieve a growth of 28.5% in the year 2017. Worldwide revenue from big data and business analytics was US$ 122 billion in the year 2015 and it is being expected that the figures will rise to more than US$ 200 billion by the year 2020.[4]

IMPORTANCE OF AI IN PHARMACY

According to a U.S. News survey that was carried out on 150 professionals, pharmacists are the 13th best-paid professionals. The average salary of a pharmacist was found to be $120950, and the unemployment rate was found to be 1.6%. The job of a pharmacist, for decades, has been to ensure that the prescriptions that are received by the pharmacy are filled with the right medicine in the right amount and to also ensure that in case of multiple medications, the medicines do not show any adverse drug-drug interactions. However, the scenario has drastically changed over the past 5 years. With the advent of big data and AI, robots are now becoming more trustworthy for doctors, and a large number of institutions are now employing robots along with human supervision to carry out activities that were previously done by humans.[5]

A large number of compounds that could have the potential to combat a large number of specific diseases are available with pharmaceutical companies. However, the companies have no tools at their disposal for their identification as such. Drug development and production is not an easy task, and it may cost a pharmaceutical company as much as $2.6 billion along with a time frame of as long as 12–14 years for completion. This is where AI becomes a boon for pharmaceutical companies. AI reduces the time that is needed for drug development and, in turn, it reduces the costs that are associated with drug development, enhances the returns on investment and may even cause a decrease in cost for the end user.[6]

The major benefit of AI is that it is much more superior to humans in analyzing data and it can analyze large number of data that would normally not fit into any of the conventional computers. AI is being mostly used in research areas currently. The processing power of AI is greater than any other tools available at anyone's disposal and in research, especially on gene mutation; it can go through piles of data and pick out the necessary information.[7]

AI IN DRUG DISCOVERY

Klopman introduced a new program to study the structure-activity relationship (SAR) of organic molecules. The program meant for structure evaluation is computer-automated, and it recognizes structures of molecules from the KLN code, which is a linear coding routine of the molecule, automatically and then further identifies, tabulates, and analyzes biophores, which are substructures that are actually responsible for the biological activity of the molecules, statistically. The method was applied for studying the carcinogenicity of polycyclic aromatic hydrocarbons, ketoxime carbamates' pesticides activity, and to study the carcinogenicity of *N*-nitrosamine in rats.[8]

Cherkasov *et al*. came up with the idea to prepare small peptides having broad-spectrum antibiotic activity using information on chemical biology that has been accumulated. With the use of peptide array technology and utilizing the composition of the amino acid of the peptides that are more active, they randomly prepared two large libraries of 9-amino-acid peptides. The data that were obtained were used in combination with Artificial Neural Networks, which are electronic models of the brain's neural structure, thus creating *in silico* models that represented antibiotic activity. On carrying out random sampling, these models turned out to be very successful in the prediction of 1,00,000 virtual peptides' activity. The peptides that were predicted as top candidates were also shown to be highly effective against a large number of "Superbugs" that are multidrug-resistant and had activities equal to or even better than four of the most frequently used antibiotics. They were even more effective than the antimicrobial peptide that is the most advanced clinical candidate, and also active against *Staphylococcus aureus* infections when tested in animal models.[9,10]

Aliper *et al.* recently presented a novel approach of utilizing deep neural networks (DNNs) for predicting pharmacological activities of several drugs. The group of scientists trained DNNs such that it could be utilized for the prediction of the therapeutic use of several drugs using data of gene expression. These data were gained from experimentations on human cell lines. The total number of drug samples involved in the study was 678 and the cell lines used were A549, PC-3, and MCF-7. DNN was found to be highly accurate in classifying drugs into different therapeutic categories. For the very first time, it was shown that DNN could be used for the recognition of pharmacological properties of several drugs.[11]

TOOLS OF AI

A large number of AI tools have been created to meet the current need of the pharmaceutical industry. These tools have shown promising outcomes. Some of the AI tools that have gained huge popularity in pharmaceutical sector have been described below:

IBM Watson for oncology

IBM has developed a supercomputer and named it Watson, which is a combination of AI and sophisticated analytical

software designed basically to answer questions.[12] Watson for oncology has been designed to assist oncologists in taking better decisions for the treatment of cancer. It works by analyzing the medical information of a patient from a vast network of data and expertise and then providing treatment options based on the evidence obtained. Watson for oncology is capable of analyzing both the meaning and context of any data present in clinical notes or reports, be they properly structured or unstructured. It can easily collect critical information regarding the patient and write it in plain English which can turn out to be a very critical step in providing the correct treatment plan for the patient. It combines critical attributes from the file of a patient with external research, clinical research, and data and then decides the most effective treatment plans that can be implemented for a patient. Watson has a huge array of information from literature and rationales curated by MSK, over 200 textbooks, 12 million text pages, and over 290 medical journals.[13]

Recently, an Indian software engineer, aged 37 years, was diagnosed with breast cancer of a rare form and it was spreading across both her breasts very fast which was posing a threat of both breast removals. Her medical records along with her genomics data were fed into Watson by Dr. Somashekhar, an oncologist in Bengaluru, and Watson provided viable treatment options within 60 s.[14]

Robot pharmacy

With the objective of improving the safety of patients, UCSF Medical Center uses robotic technology for the preparation and tracking of medications. According to them, the technology has prepared 3,50, 000 medication doses without any error. The robot has proved to be far better than humans both in size as well as its ability to deliver accurate medications. The abilities of the robotic technology include preparation of oral as well as injectable medicines which include chemotherapy drugs that are toxic. This has given freedom to the pharmacists and nurses of UCSF so that they can utilize their expertise by focusing on direct patient care and working with the physicians.[15]

Within the automated system of the pharmacy, the computers first receive medication orders electronically from the physicians and pharmacists of UCSF. After this, individual doses of pills are picked, packaged, and dispensed by the robotics. This is followed by machines assembling the doses onto a bar-coded plastic ring. The thin plastic ring contains all medications that have to taken by a patient within a period of 12 h. Adding to the capabilities of the automated system is their ability to prepare sterile preparations that are meant for chemotherapy along with filling of intravascular syringes with the right medications.[15]

The automated facility also consists an inventory management system that keeps track of every product along with a refrigerated and two non-refrigerated pharmacy warehouses for providing with storage and withdrawal of supplies and medications. All these facilities are fully automated.[15]

MEDi robot

MEDi is a short form for Medicine and Engineering Designing Intelligence. The pain management robot was developed as part of a project led by Tanya Beran, professor of Community Health Sciences at the University of Calgary in Alberta. She got the idea after working in hospitals where children scream during medical procedures.[16] The robot first builds a rapport with the children and then tells them what to expect during a medical procedure. During the medical procedure, it guides them on what should be done, how to breathe during the procedure, and how to cope.[17] Although the robot cannot think, plan, or reason, it can be programmed such that it shows to have AI.[18]

MEDi, manufactured by Aldebaran Robotics, having inbuilt facial recognition technology, can speak 20 different languages and is highly adaptable to different situations. The retail price of the robot is $9000, however, the cost rises to $15000–$30000 when the applications needed for the robot to help in medical procedures are installed.[17] The robot was initially developed for pain management, but with time its use has expanded to comfort between procedures, physical rehabilitation, and fundraising.[18]

Erica robot

Erica is a new care robot that has been developed in Japan by Hiroshi Ishiguro, a professor at Osaka University. It was developed in collaboration with the Japan Science and Technology Agency, Kyoto University, and the Advanced Telecommunications Research Institute International (ATR). It can speak Japanese and has a blend of European and Asian facial features.[7] Like any normal human being, it likes animated films, desire to visit south-east Asia, and wants a life partner who would chat with it. The robot cannot walk independently; however, it has been developed with the ability to understand and answer questions with human-like facial expressions. Erica is the "most beautiful and intelligent" android as Ishiguro fixed up the features of 30 beautiful women and used the average for designing the robot's nose, eyes, and so on.[19]

TUG robots

Aethon TUG robots are designed to autonomously travel through the hospital and deliver medications, meals, specimens, materials, and haul carry heavy loads such as linen and trash. It has two configurations, i.e., fixed and secured carts as well as exchange base platform that can be used to carry racks, bins, and carts. The fixed carts are used for delivering medications, sensitive materials, and laboratory specimens, whereas, the exchange platform is employed to

transport materials that can be loaded on different racks. The TUG can deliver several types of carts or racks thus making it a very flexible and utilizable resource.[20] During working, a touchscreen that is simple to use, allows users to determine where the TUG has to make deliveries or from where it has to pick up supplies or materials. In the case of multiple destinations, the TUG automatically computes the best path. It has sensors that overlap to ensure 180° coverage while navigation and to detect obstacles. The array of sonar and infrared sensors called "Light whisker" are able to detect low lying obstacles. The benefits of using TUG include 24/7 improved productivity, improved patient experience, worker safety, employee satisfaction, and patient safety.[20]

MANUFACTURING EXECUTION SYSTEM (MES)

A MES is a control system that is designed to manage, monitor, and track the various manufacturing information in real time by receiving minute by minute data from various sources which include robots, employees, and machine monitors. In today's world, MES is being widely integrated with enterprise resource planning systems.[21] MES facilitates compliance with regulatory guidelines along with ensuring that drug makers get high-quality products in their manufacturing processes.[22]

The benefits of using MES include compliance with guaranteed legal regulations, minimized risks, increased transparency, shortened production cycles, optimized resource utilization, controlled, and monitored production steps, and optimized up to batch release.[23]

AUTOMATED CONTROL PROCESS SYSTEM (ACPS)

The objective of an ACPS is to ensure that a process is carried out in a safe and profitable manner. This is achieved by continually monitoring the various process variables which include temperature, pressure, flow, vacuum, and concentration and as and when required, taking necessary actions such as slowing down pumps, opening valves, and turning the heaters up so as to ensure that the process variables are maintained at the required values. The advantages of ACPS are good quality achieved at low cost, saving of material, assured personnel, plant, and processes safety, increased yield, and reduced labor cost.[24] The elements of ACPS include (1) sensing process variables' value, (2) transmission of signal to measuring element, (3) measure process variable, (4) presenting the value of the measured variable, (5) set the value of the desired variable, (6) comparison of desired and measured values, (7) control signal transmission to final control element, and (8) control of manipulated value

Berg

Berg is Boston-based biotech and is one of the key players employing AI in its various processes. It has an AI-based platform for drug discovery, which has a huge database of patients and this is used to find as well as validate the various biomarkers responsible for causing diseases and then decides therapies according to the obtained data. The motto of the company is to speed up the process of drug discovery and to bring about a reduction in the cost with the aid of AI as it obliterates guesswork that is involved in the process of drug development. The steps that are followed by Berg include procurement of sequencing data from samples of human tissue, finding information regarding metabolites, and protein formation, and testing of data using algorithms of AI to correctly determine the actual cause of disease.[25]

CONCLUSION AND FUTURE PERSPECTIVES

It is said that a human being is the most sophisticated machine that can ever be created. Everyone would have agreed to this line a few decades ago. However, the scenario, today, has changed drastically. Humans are no longer considered the most sophisticated machines. The human brain, which is believed to be the most complex network of knowledge, is working hard to create something that is much more efficient than a human being in doing any given task and it has succeeded to a great extent in doing so. The AI is slowly becoming a very integral part of pharmaceutical industry as well as health-care team. With innumerable researches being carried out throughout the world to improve the efficiency of manufacturing and other health-care related activities, researchers are looking into the prospect of employing AI for every activities carried out. The AI tools like Watson for oncology, tug robot and robotic pharmacy has changed the face of the profession considerably. These tools are capable of functioning at a much faster rate and the chances of error that may occur with the use of these tools are negligible. The bigger the health-care sector gets the more sophisticated and more technologically advanced infrastructure it will need. This means that the sector is going to rely heavily on AI for most of its future works. This is good news from the point of view of productivity and efficiency. AI not only increases efficiency but also minimizes errors that are much more frequent when a human is handling the task. This in turn will mean a reduced wastage, better quality of product, and a larger profit margin for companies. This is one of the prime reasons why the industry is getting more and more technologically advanced day by day. However, if we look at this from the point of view of human employment, then we will be forced to think that substituting humans for machines will mean large-scale unemployment and soon all the activities that were once a human job will be a part of AI's job. As Stephen Hawking said, "this may mean the end of human race". Hence, AI should be brought into health care

but AI should be made such that it works in coordination with humans.

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