Artificial intelligence in pharmacy: A review

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Abstract
Artificial intelligence is the future of every field. It can be applied in any field for the better or efficient performance. AI can automate the tasks which will save time as well as resources. AI also known as man-made brain power is an integral part of software engineering that has hugely developed in critical thinking with vast applications in business, social insurance, engineering & designing. Many researches are being conducted to improve AI technology so that pharmacy profession can be more efficient. AI has the major advantage that it reduces the time required for drug development & also the cost of drug development thereby reducing the cost for end user. AI plays an important role in various fields of pharmacy like drug discovery, drug delivery formulation development, polypharmacology, hospital pharmacy, etc.AI has an important role in developing an expert system. This article deals with the importance of AI in drug development process and the availability of AI tools to pharmacist to aid in a more efficient functioning.

Introduction
Artificial Intelligence (AI) is a branch of science concerned with intelligent machine learning, specifically intelligent computer learning programmes that produce outcomes in the same way that the human attention process does. The majority of the time, this procedure entails getting data, and the development of effective mechanisms for the usage of collected data in a precise way or a rough estimate of conclusions and self-corrections/adjustments. AI is, in general, a tool for assessing machine learning where individual's cognitive tasks are imitated. Artificial intelligence (AI) is used to complete tasks with more precise analysis, as well as achieving useful interpretations. In AI technology various statistical models & computational intelligences are combined [1-3]. Now, AI is the fundamental part of industry for applications in many technical and research areas.AI has been initiated in pharmacy drug discovery, drug delivery formulation development and other healthcare applications [4, 5]. A lot of money is being put into developing a system that can work significantly more efficiently and in a fraction of the time that a regular human can. AI has applications in every industry, whether it's a government agency or a research institution, educational institute or a manufacturing company [6 7]. Artificial Intelligence (AI) is a difficult technology in both nature and application. It is a complex blend of mathematics, computer science, and other disciplines. The intricacy of programming assists machines in replicating human cognitive capacities [8–10].

Need of AI in Pharmacy
Pharmaceutical companies have access to a large number of compounds that have the potential to combat a wide range of specific diseases. However, the companies do not have any tools to identify themselves as such. Drug development and production are difficult tasks that can cost a pharmaceutical company up to $2.6 billion and take up to 12–14 years to complete. This is where artificial intelligence can help pharmaceutical companies [11, 12].

AI reduces the time required for drug development, which reduces the costs associated with drug development, improves the returns on investment, and may even result in a decrease in cost. Moreover, pharmacists are the 13th best-paid professionals, according to a poll of 150 professionals conducted by U.S. News. A pharmacist's job is to ensure that prescriptions received by pharmacy are filled with right medicine in right amount & the medicines do not show any adverse drug reactions. However, scenario has changed since last 5 years with robots are becoming more intelligent as a result of the emergence 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 [13-16].

Milestones in AI
The name "artificial intelligence" was coined in 1956, and the notion was coined in 1950 under the headings "problem solving" and "symbolic approaches."[17]

The timeline of events in AI research is depicted in Figure 1 depicted the timeline of events in AI research, while the milestones are listed in Table 1 [18, 19].


a. Neural networks (1950- 1970's)

b. Machine learning (ML) (1980-2010's)

c. Deep learning
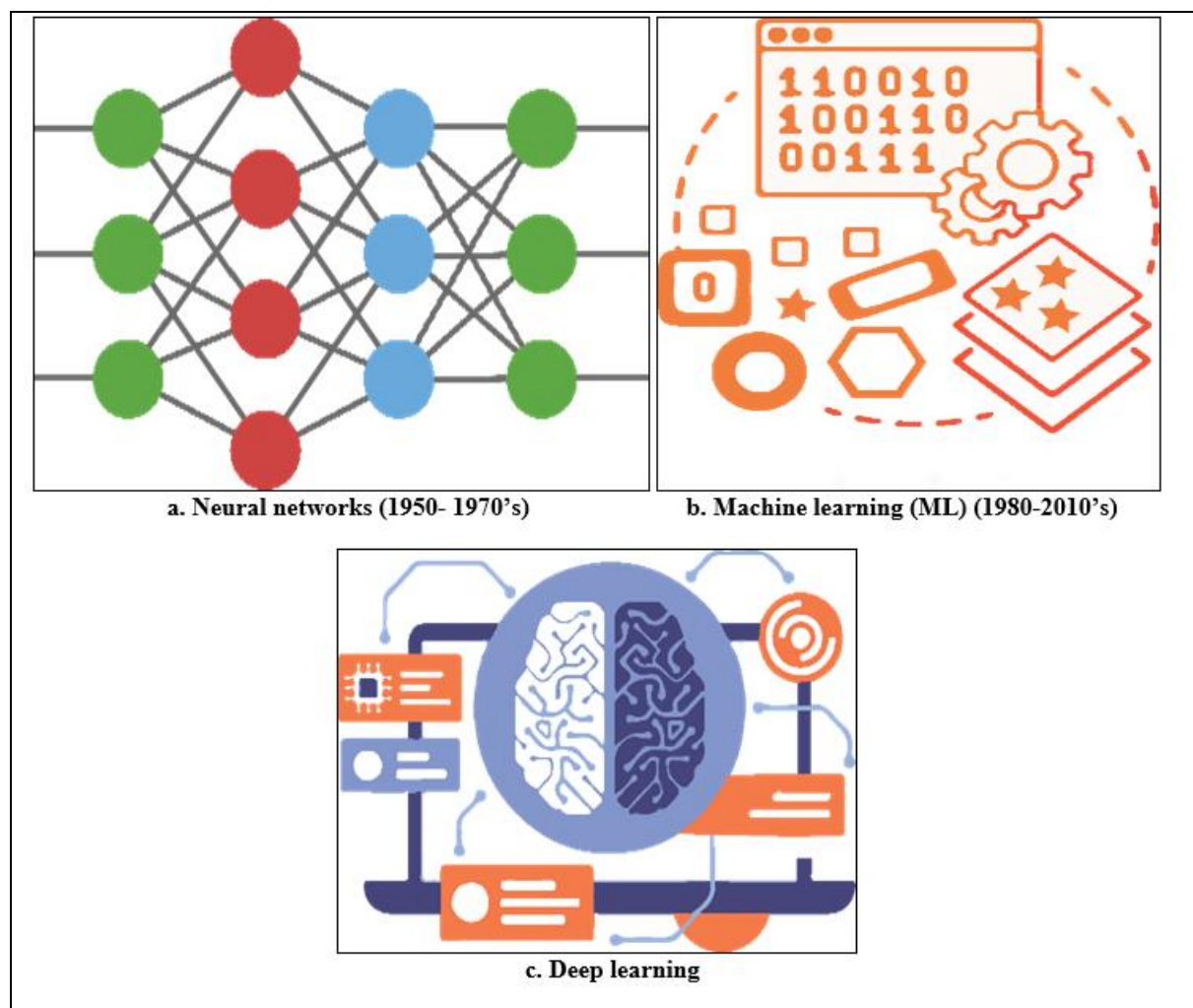
Fig 1: Computer programming stages

Table 1: Mile stones in the artificial intelligence process

Year	Milestones
1943	Neurons can do logical operations like "and", "or" or "not", when they are connected as a network. This process was proved by Walter Pitts and Warren McCulloch.
1951	First neuronal network, which solved a problem from the real world i.e. SNARC (Stochastic Neural Analog Reinforcement Computer) was by Marvin Minsky.
1956	At Dartmouth college conference the term "Artificial Intelligence" was coined.
1958	Perceptrons (neuronal networks that transmit information in one direction) was created by the Frank Rosenblatt which is the origin for todays AI progress.
1969	Minsky supported the symbolic representation of problems in his book - "Perceptrons".
1974 -1980	During this period, interest on AI was dropped, which is called as "First AI Winter".
1986	Back propagation algorithm design was developed by Georey Hinton which is widely using in deep learning nowadays.
1987 -1993	This phase is called as "AI winter"
1997	This year IBM Deep blue defeated the Garry Kasparov (Russian grandmaster).
2013	Google used the British technology to perform efficient research on photos.
2016	Google DeepMind, software AlphaGo defeated the Go Champion Lee Sedol.
2018	First AI release deep learning library, Google released Tensor Processing Unit (TPU)
2021	Proliferation of AI continues

Classification of AI
AI can be classified in two ways: based on its caliber and its presence [20, 21].
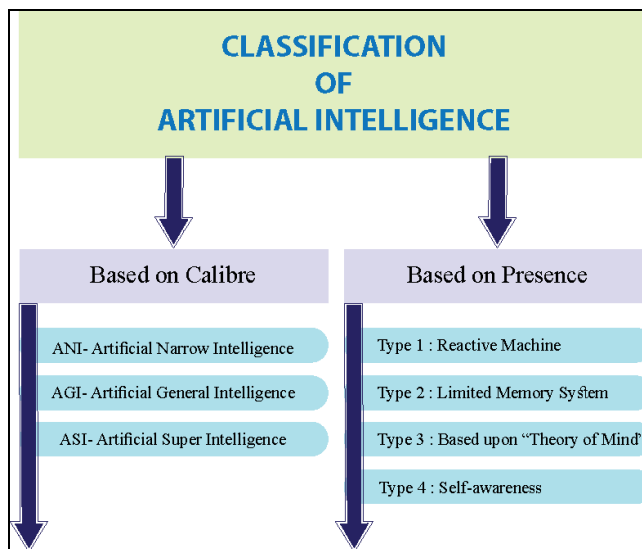
Fig 2: Classification of artificial intelligence

AI can be classified into the following categories based on their capabilities
 Artificial Narrow Intelligence (ANI) or Weak AI: It performs a limited set of tasks, such as facial recognition, car steering, chess practice, traffic signaling, and so on.
ii) Artificial General Intelligence (AGI) or Strong AI: This type of AI performs all of the tasks that humans do, and is also referred to as human-level AI. It has the ability to simplify human cognitive capacities and do unfamiliar tasks.
iii) Artificial Super Intelligence (ASI): It is smarter than humans and does many more tasks than humans, such as sketching, mathematics, and space exploration.
AI can be divided into the following categories based on their existence and absence:
Type 1: This is the most common type. It's designed for single-purpose apps that can't make use of previous experiences because it lacks a memory system. It's referred to as a reactive machine. Some instances of this memory include an IBM chess programme that can recognize the checkers on a chess board and make predictions.
Type 2: It has a limited memory system that can only utilize prior experiences to solve difficulties. This system is capable of making decisions in automatic cars, and there are some recorded observations that are utilized to record subsequent actions, but these records are not saved permanently.
Type 3: It is based on the concept of "Theory of Mind." It means that human beings make decisions based on their own preferences which are influenced by their own thoughts and goals and aspirations This is a non-existent AI system.
Type 4: It has self-awareness, or a feeling of self & consciousness. This is also a non-existent AI system [18]
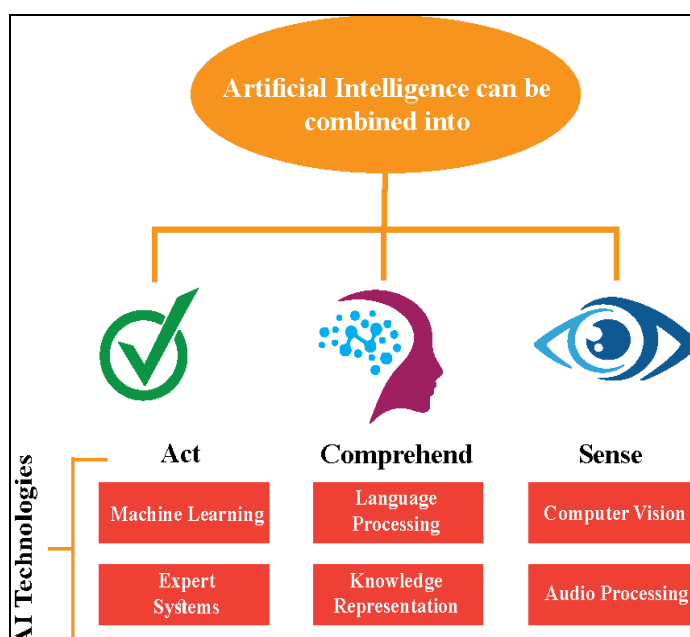
Fig 3: AI representation

Advantages of artificial intelligence technology
The following are the potential benefits of AI technology:

Error Reduction
AI assists humans in reducing errors and increasing the likelihood of achieving greater accuracy and precision. Because intelligent robots have metal bodies, they are more resistant to the harsh atmospheric conditions of space and have a stronger ability to withstand them.

Difficult Exploration
It can be applied to the mining and oil and gas industries. By programming the robots, they will be able to do more difficult tasks. Strenous work can be done with ease and without exhaustion [22]

Daily Application
AI can be used in everyday situations. The GPS system is extensively used, and it is especially useful for travelling long distance drives. Because AI is installed in androids, it predicts what the user will enter and corrects any spelling mistakes [23, 24].

Artificial Intelligence (AI) systems are digital assistants
Advanced corporations utilize 'avatars,' which are digital assistant models, to decrease the requirement for human resources. Because the avatars are emotionally liberated, they think logically and make sound decisions. Human emotions are commonly related with moods, which impair judgement and reduce human productivity. This issue was not seen with artificial intelligence [25]

Repetitive tasks:
Humans can generally only complete one task at a time. Machines, unlike humans, can multitask and interpret data faster. Various machine characteristics, such as speed and duration, can be modified to meet the needs of the user.

Medical applications
With the help of AI, physicians may examine the status of patients and study the side effects and other health hazards linked with medication. AI programmes such as numerous artificial surgery simulators (for example, gastrointestinal simulation, heart simulation, brain simulation, and so on) can help trainee surgeons gain expertise [26–28]

No breaks:
Unlike humans, who can work for 8 hours a day with breaks, machines are programmed to conduct work in a continuous manner for long periods of time without becoming confused or bored.

Increased technological growth rate:
Artificial intelligence (AI) is widely used in the majority of modern technical developments around the world. It is capable of creating a variety of computer modelling programmes and strives to develop new compounds. Drug delivery formulations are also being developed using AI technology [29]

Risk free
When working in a high-risk environment, such as a fire station, there is a significant risk of harming the employees involved. If a disaster occurs with machine learning programmes, the broken sections can be repaired.

Assistive devices
AI technology has served a different purpose by being available 24 hours a day, seven days a week to both children and the elderly. It can be used as a teaching and learning tool for anyone [30]

Endless functions
Machines have no limitations in terms of their capabilities. Humans cannot do everything as efficiently as soulless machines can. They can also create more accurately than humans [6, 31]

Disadvantages of AI Technology
The following are the major drawbacks of AI technology

Expensive
The introduction of AI results in a significant financial outlay. Machine design, maintenance, and repair are all extremely cost effective. It takes a long time to develop one AI machine for R & D section. The software programmes for the AI machine must be updated frequently. Reinstallations and recovery are possible with AI machine but it takes a long time and costs a lot of money.

No human replication
AI-enabled robots are connected with the ability to think like a person and to be emotionless, since these provide certain advantages in terms of doing a task more correctly and without making any judgments. When unknown difficulties develop, robots are unable to make decisions and may deliver incorrect information.

With experience, there is no improvement
With experience, human resources can be improved. Machines that use AI technology, on the other hand, cannot be improved via experience. They are unable to distinguish between those who work hard and those who do not.

No original creativity
Machines with AI technology have neither sensitivity nor the emotional intelligence. Humans have the ability to hear, see, feel and think. They can use their creativity as well as thoughts. These features are not achievable by the uses of machines.

Unemployment
The widespread uses of AI technology in all the sectors may cause large scale unemployment. Because of the undesirable unemployment, human workers may lose their working habits and creativity.

Lack of creativity
Machines with AI technology lack sensitivity and emotional intelligence, resulting in a lack of unique creativity. Hearing, seeing, feeling, and thinking are all abilities that humans possess. They have the ability to employ both their creativity and their thoughts. These characteristics are not possible to achieve with the use of machinery.

Unemployment
The extensive application of AI technology in all areas has the potential to result in widespread unemployment. Human workers may lose their working habits and creativity as a result of unemployment [32]

Tools of AI
To suit the present needs of the pharmaceutical sector, a great variety of AI technologies have been developed. These tools have yielded good results. The following are some of the AI tools that have gained a lot of popularity in the pharmaceutical industry:

Artificial intelligence in the pharmacy of a hospital
In a hospital pharmacy-based health-care system, AI can be used to organize dosage forms for particular patients, choose the best or most available administration routes, and create treatment strategies [33, 34]

Maintaining medical records
Keeping track of a patient's medical records is a difficult task. Implementing an AI system simplifies data collection, storage, normalization, and tracing. The Google Deep Mind health project (created by Google) aids with the rapid excavation of medical records. As a result, this project is beneficial to better and faster health treatment. This project is assisting the Moor fields Eye Hospital NHS in improving eye treatment [35–37]

Artificial intelligence in Retail Pharmacy
Artificial intelligence is becoming more widely used every day. Artificial intelligence is being used in all fields to improve results and performance. AI is advantageous to every area or institution, including finance and healthcare. The biggest benefit of utilizing the artificial intelligence allows people to save time and money. Various tasks can be completed without the involvement of humans. These tasks can be completed by artificial intelligence computers. in a timely manner. The researchers proposed a software for the (Donepudi, 2016) manufacturers who will assist in the delivery of medicines in a cost-effective and timely manner [12, 38]

Designing treatment plans
AI technology can help with formulating treatment plans. If the patient's situation is critical, the AI system is useful because it is tough to choose an appropriate treatment strategy. It takes into account patient reports, clinical expertise, and historical data to recommend appropriate treatment plans to physicians, e.g., IBM Watson established a programme to assist oncologists [39, 40].

Aiding in repetitive tasks
AI technology can assist in repetitive tasks such as analyzing X-ray pictures, radiography, ECG, and ECHO for the purpose of detecting and identifying abnormalities.
Medical Sieve is a new algorithm developed by IBM. It functions as a "cognitive helper" with excellent analytical and thinking abilities. It's ideal for analyzing radiological images, locating abnormalities, and detecting them quickly. To improve a patient's condition, a medical start-up can integrate deep learning and medical data. Until recently, computer systems for diagnosis were created based on existing data of disease-specific characteristics. As a result, each portion of the body has its own specialized programme for a limited

number of medical situations. Deep learning, on the other hand, is useful for a wide range of disorders affecting the entire body, as well as all sorts of imaging, including as CT scans, X-rays, Echo, ECG, and so on [41–43].

Using technology to speed up drug discovery:
New technologies assist scientists identify prospective drugs by providing systematic insights into disorders. Compound design, a larger chemical space, and selecting the best chemical molecule are all aided by technology. It can also aid with concerns like compound selection based on efficacy, safety, and patient selection for clinical trials. To select the best therapeutic candidate, pharmaceutical companies now screen a large number of compounds. The software, which Insilico taught, develops new chemical structures by combining attributes of existing medications. Using the CUDA parallel computing platform, NVIDIA Tesla K80 GPU accelerators, and TITAN X GPUs with cuDNN on the Theano and TensorFlow deep learning frameworks, Aspuru-Guzik trained his deep learning software to study 250,000 drugs like molecules, but AI drug discovery was unable to replace scientists. The discoveries made by AI must be verified by humans [21, 44]. AI may be used to discover new therapeutic targets as well as improve medications, diagnostics, and biomarkers. Repurposing pharmaceuticals to identify new uses for existing drugs or late-stage drug prospects is one of the most common applications. If this occurs, there is no need to repeat all of the phase I tests and toxicity testing; instead, a phase II trial for a different indication can be conducted immediately. As a result, the creation of medicines can be significantly accelerated [45-48].

Artificial Neurons
AI research focuses on how machines can be programmed to mimic features of intelligence. The mechanical brain known as the Perceptron (containing neural networks) was invented by psychologist Frank Rosenblatt in the 1950s. The perceptron system is made up of layers of neurons, with each neuron functioning as a single unit. Every neuron, like physiological neurons, is coupled to other neurons in the surrounding layers. After reaching the threshold point, each layer transmits a signal to the next layer [49, 50] Scientists put forth a lot of effort to create dependable, efficient neutral networks. They built a network with several layers. The capacity to convey information from a device's output backwards through successive layers is essential for managing input weight. Separating the layers of neurons throughout the learning process can prevent weight adjustments from being disrupted. Figure 3 depicts the machine learning steps in order [51, 52]

Fig 4: Steps involved in machine learning process

AI and machine learning
Machine learning technology is supporting research and development scientists in analysing large amounts of scientific data in order to obtain important new information. Eg. They developed the "Judgement Correlation System" (JACS) to conduct research on Amyotrophic Lateral Sclerosis (ALS), which can check billions of phrases and paragraphs from various abstracts, research and review papers. As known facts, JACS developed a direct link between data and the regulatory procedure. These facts can be used to build a hypothetical number of hypotheses, ranging from 200 to 250, based on the theories made by scientists. The expert team of scientists confirms the hypothesis. The valuable hypotheses have been finalised. Among those, only about 5 hypotheses are used to create experiments as well as the creation of novel chemical molecules or formulas [53].

In-person and online consultation
Babylon, a British subscription-based online medical consultation and health service, provides medical consultation based on patient information, medical knowledge and history. The users must give the information regarding symptoms of their health concerns which are then entered into the app and monitored. The information is then matched to the facts on the ailment logged into the database and recommends the best line of action. The

app serves as a reminder to patients about their prescription regimen. The application reduces the waiting time for doctors [5]

Health support and pharmaceutical aid:
Artificial intelligence (AI) can help with health support and drug administration. Molly, a virtual nurse created by a start-up, has a lovely voice and a friendly expression. Its objective is to aid people in keeping track of their finances, ailment and therapy. It aids people who are suffering from a long-term illness. Another app, AiCure, can be found in the webcam of a smartphone & watches patients to see if they follow the prescription and assists them in coping with their ailments. This app is beneficial for patients who are on a lot of medication and patients who participate in clinical studies [18]

Medical precision
AI has a positive impact on genomes and genetic development. Deep Genomics is an AI system that can spot patterns in genetic data and medical records. Records will be used to discover mutations and their links to diseases. This system alerts doctors regarding what's going on inside a cell when a person's DNA gets changed as a result of genetic variation. The father of the human genome project Craig Venter's created an algorithm that provides information about a patient's physical condition based on their DNA. AI for "Human Longevity" can be used to pinpoint the specific site of a cancerous tumour & vascular disorders that are still in the early stages [54]

Drug development
The development of pharmaceuticals takes more than a decade and costs billions of rupees. "Atomwise," an AI system that employs supercomputers, is useful for locating medicines in a molecular structure database. It launched a virtual quest for a safe and effective solution for Ebola virus with the existing technological advancements identified two medicines responsible for Ebola infection. This investigation was accomplished in one day compared to months to years with manual examination [55]

Analyzing a healthcare system
In a healthcare system, if all of the data is computerised, data retrieval is simple. In the Netherlands, 97 percent of bills are in digital format and include treatment data, physician names, and hospital names. Consequently, these may be retrieved easily. Zorgprisma Publiek, a local company evaluates the bills with the help of IBM Watson cloud technology. If an error happens, it is instantly recognised and the appropriate action is taken. As a result, patient outcome improves and hospitalisation is avoided [56]

Diagnostic and imaging
This is a very important and busy area in the healthcare industry, where AI technology must be implemented. 50 AI-based healthcare startups have been created thus far. They are primarily concerned with mental health, cancer, coronary artery disease, and patient wearable technology. Figure 6 depicts a list of AI-related enterprises and start-ups in the healthcare diagnostics field [57–59]
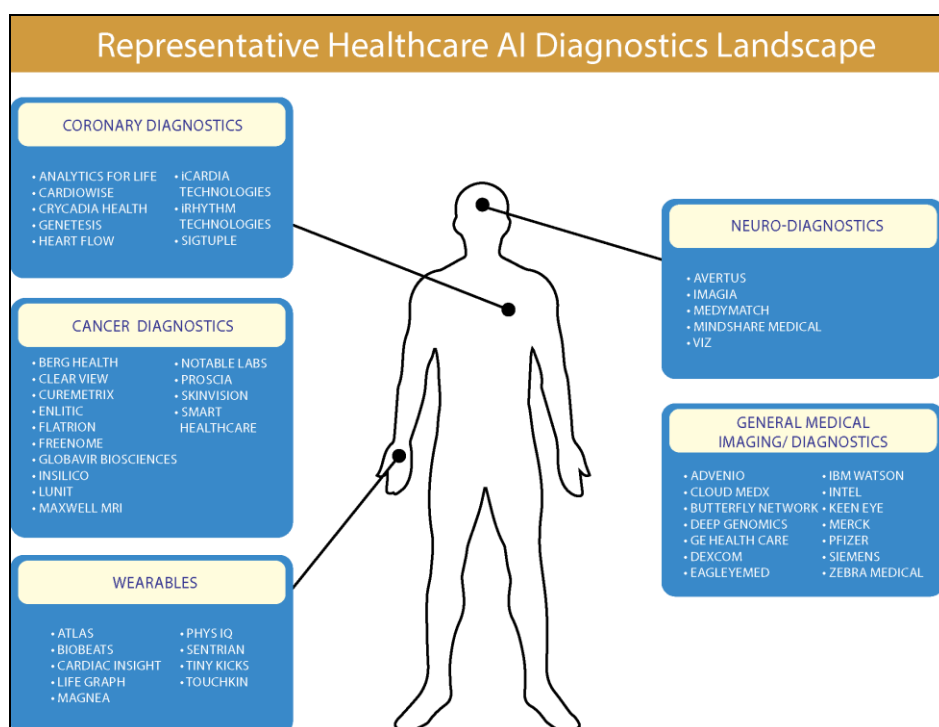

Fig 5

Prognosis
In the healthcare system, predicting suitable treatment strategies is critical. It is critical to correctly identify high-risk individuals in the healthcare system & boost their chances of survival. ANNs have the capacity to take advantage of the relationship between variables in order to analyse complex cancer data. Neural networks can predict breast and colorectal cancer survival rates in patients. They can also be used to check the outputs of the lungs and other organs [60]

Conclusion
When compared to other industries, the pharmaceutical business still lags behind in terms of modernity and execution of its production network. The industry is beset by the rising multifarious nature that comes with new pharmaceuticals, complex generation advances, patent expiration, and fluctuating demand. The wastefulness of the manufacturing network is coming under more scrutiny as the cost of physician-recommended pharmaceuticals continues to rise. These incentives, together with the impending imposition of administrative measures, are persuading pharmaceutical companies to modify their supply chains and shift to more community-oriented models. Pharmaceutical companies have begun researching AI in order to achieve this goal. To achieve this purpose, pharmaceutical companies have begun researching artificial intelligence and have advanced inspection technologies in their system of production.

It is believed that a person is the most advanced machine that has ever been created. It was a couple of decades ago. Whatever the case may be, the current condition has changed. People are never again regarded as the most important refined machines. The human mind, which is widely considered to be the source of all knowledge, most perplexing information system, is attempting to create something that is far more efficient than a person in completing any particular task. AI is evolving into a self-driving car as a vital component of the pharmaceutical business, in addition to the medical services group.

With endless research being done all around the world to increase the efficiency of assembling and other medical services-related activities, experts are looking at the prospect of using AI to finish each action. AI gadgets such as Watson for oncology, the pull robot, and the automated medicine store have drastically changed the face of the profession. These apparatuses are capable of working at a much faster rate, and the chances of making a mistake when using this apparatus are minimal. The more modern and mechanically propelled the human services field becomes, the more advanced and mechanically propelled foundation it will require.

However, if we examine at this from the standpoint of human business, we are going to substitute humans for machines which will result in widespread joblessness, and that all activities that were done by humans will soon become a part of Simulated intelligence's activity. "This may be the end of the human race," Stephen Hawking said. Henceforth, AI should be integrated into human services; nevertheless, AI should be designed in such a way that it collaborates with people.

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