Introduction to Artificial Intelligence

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Introduction to Artificial Intelligence

Moumita Ghosh and A. Thirugnanam

Abstract Artificial Intelligence (AI) is the branch of computer science, which makes the computers to mimic the human behavior to assist humans for better performance in the field of science and technology. Replicating human intelligence, solving knowledge-intensive tasks, building machines, which can perform tasks, that require human intelligence, creating some system which can learn by itself are the few specific goals of AI. Machine learning and deep learning are two subsets of AI which are used to solve problems using high performance algorithms and multilayer neural networks, respectively. With the help of machine learning process, structured data like genetic data, electrophysical data, and imaging data are properly investigated in medical diagnosis. AI provides advanced devices, advanced drug designing techniques, tele-treatment, physician–patient communication using Chatbots and intelligent machines used for analyzing the cause and the chances of occurrence of any disease in the field of health care.

Keywords Artificial intelligence · Machine learning · Deep learning · Drug development · Healthcare systems

1 Introduction

Artificial Intelligence (AI) is a domain of computer science which deals with the development of intelligent computer systems, which are capable to perceive, analyze, and react accordingly to the inputs [1, 2]. It is well-known fact that humans are considered as the most intelligent and smart species on earth. The features which have helped them to bag this title include the ability to think, apply logic, do reasoning, understand the complexity, and make decisions on their own. They can also do planning, innovation, and solve problems to a greater extent. Since the era of invention of fire to reaching the Mars, man has invented many things for the benefit of humans. One such

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invention is the computer, which plays a significant role in reducing the workload of humans and solving many complex mathematical and logical problems. However, for researchers, it can be considered that sky is not the limit for new inventions. So, they tried to create a "man-made homosapien" species, which can be related to the world of computers in the form of AI (which are *Artificial,* i.e., manmade, and *Intelligence,* i.e., has thinking power). If a system can have the basic skills like learning, reasoning, self-improvement (by learning from experience), language understanding, and solving problems, then it can be assumed that there is the existence of AI. The AI has been used and implemented in many fields especially in technological domain and is expected to provide 2.3 million jobs by 2020. It is a cutting-edge technology which has its impact in almost every field, be it business, defense, aerospace, or health care systems. It can also be denoted as the method of simulation of human intelligence designed or programmed by humans. With the help of AI, a well-equipped life is generated where the automated machines work for humans, saving their time and energy. Basically, two types of assistants are considered for humans, manual (in the form of robots), and digital (Chatbots) which can perform risky, repetitive, and troublesome tasks. The task of developing such machines is accomplished by minutely studying the human behavior and implementing the logic in the form of algorithms resulting in inventions of software, devices, robots, etc., making human race smarter.

There are many areas which contribute to artificial intelligence which includes mathematics (used for developing algorithms), biology, philosophy, psychology, neuroscience (for studying human mind and its behavior), statistics (for handling huge data), and last but not the least, computer science (to run the algorithm for implementing the concepts). The basic aim of AI is to provide more transparent, interpretable, and explainable systems which can help to establish a better-equipped system used as an intelligent agent. The concept of trusting machine as a replica of human started with the invent of turing test in which the machine is tested irrespective of the knowledge of examiner upon the instructions given considering it as human and if it passes the test, the machine is considered as intelligent. No wonder AI has affected many aspects of the society and presented a new modern era in this digital revolution.

1.1 *Types of AI (Based on Capabilities)*

The various types of artificial intelligence based on the capabilities can be classified as

– Weak or narrow AI
– General AI
– Strong AI.

Weak or narrow AI: it is a type of AI which can perform a predefined narrow set of instructions without exhibiting any thinking capability. It is the most widely used type of AI in this world. Some famous examples are Apples's Siri, Alexa, Alpha Go, IBM's Watson supercomputer, Sophia (the humanoid) all belong to the weak AI type [3].

General AI: it is the type of AI which can perform the tasks like what human can do. Till now it is not achieved, there are no such machines which works like human or can think as perfectly as human, but it may happen in near future.

Strong AI: it is the type of AI in which it is expected that the machine will surpass the capacity of human. It will perform better than humans, though it is tough, but it is not impossible. It may be the situation when it can be said that the machines will be the master and overtake humans. It has been considered as a great threat to the society by scientists including Stephen Hawking.

1.2   Types of AI (Based on Functionality)

Based on the functionality, artificial intelligence can be classified as per the following types:

 (i)   Reactive machines
 (ii)   Limited memory
(iii)   Theory of mind
(iv)   Self-awareness.

Reactive machines: these are the machines which works on the data available in the form of predefined dataset. It does not have the facility of data storage for storing the past and future data. It completely depends on the present data. IBM's chess program which defeated famous champion Garry Kasparov and the deep blue system, Google's AlphaGo are some of the examples for reactive machines [3].

Limited memory: these are the machines which can store the past experience or store the memory for limited period of time. An example for limited memory AI is the self-driving cars (it can store the information like speed, distance, speed limit required for the navigation of the car).

Theory of mind: these are types of machines, which are expected to understand the psychological and emotional aspects of human mind and work accordingly. So far such machines are a dream but scientists are working to develop such machines in near future.

Self-awareness: these machines belong to a hypothetical concept that will be considered as super-intelligent machines, which can think, act, and will be self-aware as they will have consciousness and sentiments like humans. Research is carried out to develop such machines and considered as future AI.

1.3 Domains of AI

The major domains of AI (Fig. 1) are neural network, robotics, expert systems, fuzzy logic systems, natural language processing (NLP).

Neural networks: these can be described as the representation of human neural system, i.e., neurons and dendrites in the form of layers and nodes representing data. It comprises algorithms that understand the relationships between the data while mimicking the human brain. These are widely used in AI in the form of machine learning and deep learning. Some of the typical examples are pattern recognition of face and image recognition in medical diagnosis.

Robotics: it is the domain of AI which is mostly associated with the development of intelligent machines in the form of robot which obeys human instructions. The use of robots or humanoids is a new trend and is being appreciated and adopted worldwide. Robots used in industry, medical surgery, restaurants, etc., are classified under this category.

Expert system: these are systems which make decisions with the help of data present in the knowledge base and getting guidance by an expert. These are basically computer applications developed to solve complex problems with intelligence and expertise.

Fuzzy logic system: this domain is considered as resembling the human thinking method and decision-making. It is quite similar to the way humans decide between 0 and 1, but it also deals with all the possibilities between 0 and 1. Examples of fuzzy logic systems used are in consumer electronics, automobiles, comparison of data, etc.
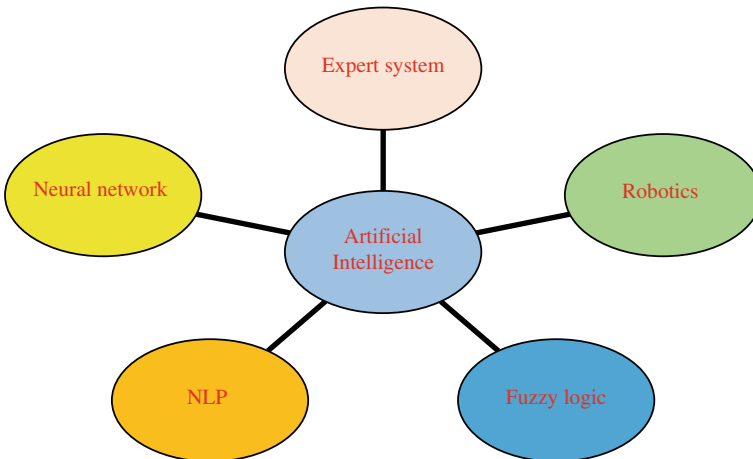

Fig. 1 Various domains of Artificial Intelligence

Natural language processing (NLP): this domain deals with bridging the gap of communication between the computer and human languages. It is basically the inter-action between computer and human in a smart way. Google translator and spell check are some of the examples under NLP domain.

2 Subsets of Artificial Intelligence

Artificial intelligence has emerged as a boon for the society for the furtherance of advanced techniques to deal with the real-life problems. The major two subsets of AI are Machine Learning (ML) and Deep Learning (DL). ML is considered as the subset of AI and DL is considered as the subset of ML. The pictorial representation of the relationship between AI, ML, and DL is shown in Fig. 2.

2.1 Machine Learning

As humans can think, improve by self-improvement cycle, and learn from the past experiences, AI machines can also learn from the past experiences with the help of the concept known as Machine Learning (ML). The machine learning deals with the development of algorithms that enables the computer to learn from its data and past experiences on their own [4]. In this method, the machine analyzes the available data set which is also known as training data and with the help of the algorithms predict the possible output over the given input. More the data (information) is provided, more perfect is the performance or prediction. In other words, the relationship between the data and efficiency is that the machine can improve its efficiency by gaining

Fig. 2 Relationship between AI, ML, and DL
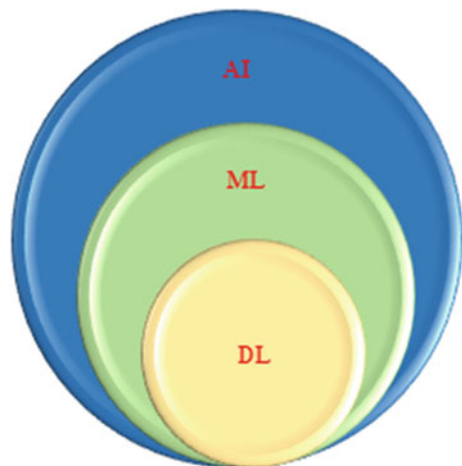
more and more data. It can learn from the data and improve automatically. This is very much helpful for dealing with huge data of complex problems, which are difficult for humans to deal with and they also consume more time in solving. In this process of computing the machine receives data as input and provides result using an appropriate algorithm.

Classification of Machine Learning

Based on the nature of the learning signal or response that the machine gets; machine learning can be classified into following categories:

(i)   Supervised learning
(ii)   Unsupervised learning
(iii)   Reinforcement learning.

Supervised learning: according to the literal meaning, this method correlates with the method of learning of student under the supervision of a teacher. As a teacher illustrates the student with many good examples to help in grasping the concept perfectly, the machine is provided with many labeled data to help in obtaining the perfect output from the given input. The algorithms under this method are classified into two categories, i.e., regression and classification. One example of this method is spam filtering [5, 6].

Unsupervised learning: in this method the machine has to train itself without any supervisor, i.e., the data provided at the input are not labeled or classified. The algorithm has to train itself by searching the degree of similarities among the given data and figure out the appropriate output for the given problem. The algorithm helps to refine the data which can be correlated with the desired output. The algorithms are classified into clustering and association types [6, 7].

Reinforcement learning: this method is typically a feedback-based learning method. In this method the machine is given a reward for every right action taken by it and a penalty for any wrong action, so it is a self-learning method done by analyzing its past performances. The objective of the algorithm is to achieve maximum reward points. Examples for reinforcement learning is a robotic dog learning by its own mistakes and performances, computer playing video games by their own.

The machine learning algorithm is widely being used in multiple fields such as medical diagnosis, image processing, web search engines, photo tagging applications, finance and marketing sector, fraud detection, weather forecasting, and many more. The main advantage is the repetitive process and self-learning methods that it applies to find the output.

2.2 Challenges and limitation of ML

The basic challenge and limitation for ML are that it requires huge amount of data. Without quality data, ML algorithm cannot provide accurate results for further analysis. The prediction can be considered best if the analysis is done over a large amount of data. Another point is that the data need to be heterogeneous as well. With wide range of inputs or datasets, the efficiency of the algorithm will be enhanced with appropriate output. It is similar to that of a new entrant in an organization making mistakes as junior and eventually improves by self-learning and provides output with required accuracy and efficiency.

2.3 Deep Learning

Deep Learning (DL) is considered as the subdomain of ML and thereby the subset of AI. In ML, the system is provided with given input data sets and subjected to self-learning from the past experiences and give predictions as output. Deep learning can be denoted as the next level of machine learning where the system is similar to human nervous system and mimic the working of the neurons. In ML the system is mostly put either in supervised or unsupervised learning method with multilayers of algorithms undergoing such learning methods. As the number of layers increases, it is called as deep learning or Deep Neural Network (DNN) [8]. The initial layer is denoted as the input layer, the last layer is called the output layer and the intermediate layers are termed as the hidden layer, where all the layers are interconnected [9]. The amount of the depth of the network in terms of layers decides how efficient the algorithm can do the dense representation of any data (for example, in an image, the edge, boundaries, etc., are the required data needed for representation). This method has the capability of working upon unstructured data and provides efficient results. This includes intake of large amount of data known as bigdata and assures better performance with respect to the complex data [10]. It helps in enhanced feature extraction, pattern recognition of complex dataset and high-level data extraction. The main advantage is that it can learn without any predefined data and does not require explicit programming by the programmers. The process of deep learning begins with the understanding the problem given, identifying the data, selecting the proper algorithm followed by training and testing the model.

2.3.1 Types of Neural Networks

Basically neural networks can be classified into two categories, namely,

I. **Shallow neural network** (in which there is only one single hidden layer between the input and output layer) as shown in Fig. 3a [11].
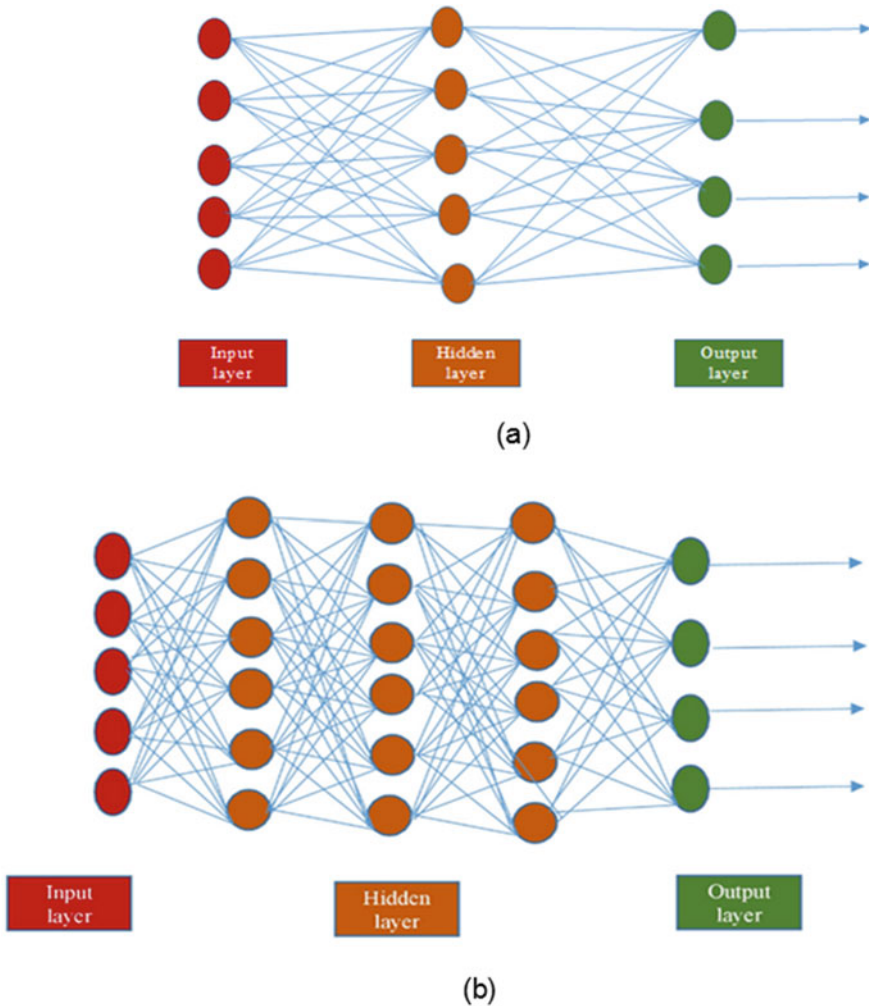
Fig. 3 Schematic diagram of **a** simple and **b** deep learning neural network

II.　**Deep neural network** (in which there are multiple hidden layers between the input and output layer and it is the most widely used network) as shown in Fig. 3b.

The deep neural networks are further broadly classified into three categories:

(a)　*Feed-forward neural networks*: it is the single way data transmission type of network in which the data moves towards the output layer through the input layer. It does not contain any recurrent movement of information.

(b)　*Recurrent neural networks*: in Recurrent Neural Networks (RNN), there is a recurrent flow of data from the output to the input to generate the memory for

the system, learn from the data and produce results. Some of the major applications of the RNN are the Chatbots, fraud detection algorithms in monetary transaction, providing caption for images, and many more [11].

(c) *Convolutional neural networks*: the Convolutional Neural Networks (CNN) are the most widely used neural networks which have multi-layered neural network. The CNN is considered to be the most efficient form of neural network which is basically used for feature extraction of images and pattern recognition. It has a wide range of application in the field of medical diagnosis and has helped in medical image analysis. Deep CNN has its great usage in radiology and pathology as well. For instance, it can help in esophageal endoscopy for detecting esophageal cancer [12]. The schematic diagram (Fig. 4) describes how the image recognized by the network [13, 14]. The CNN network is widely used method and algorithm in the application of deep learning and is basically used for image identification and classification. The algorithms are developed in a manner to deal with the pixel data. The basic CNN network consists of two parts, i.e., feature extractor and classifier. The feature extractor contains the convolutional and pooling layers whose purpose is to extract the minute features from the image in terms of pixel data. The convolutional layer deals with the feature extraction of the image and preserving the relevant data about the pixels. It reveals the information like edge, boundaries of a image. The pooling layers reduce the dimensionality of an image while retaining the important information. As CNN is a multilayer neuron network, the role classifier part of the network is to classify the information obtained from convolution and pooling layers. This role is played by the fully connective layer whose motive is to connect each node of a layer with other nodes. As a result, whatever image
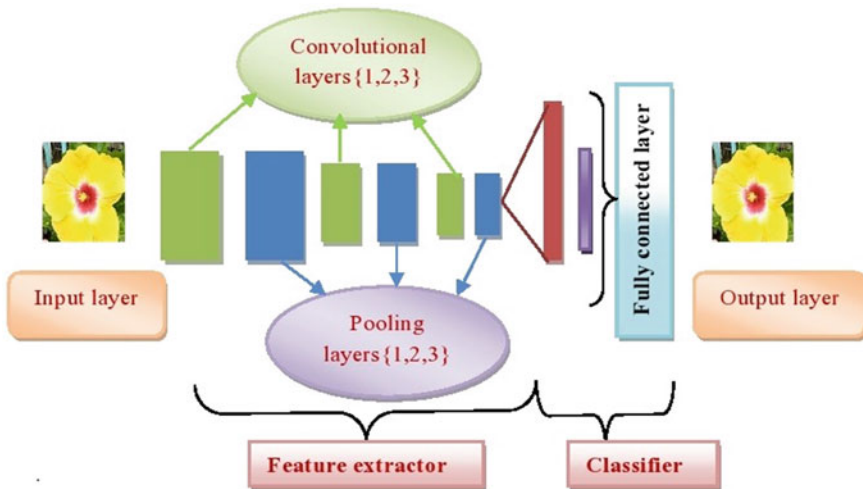

Fig. 4 Schematic diagram depicting the image recognition of the input image using CNN

is placed in the input layer is produced in the output layer if passed through a simple image detection CNN network.

The biggest challenge and limitation of DL is to acquire large amount of data and label it accurately to help the machine while learning the data. Another challenge that could arise is the degree of interpretability which should be high and accurate.

3 Applications of Artificial Intelligence in Modern World

Artificial intelligence has been evolved as one of the most important technology in this world, with its impact on almost every field of human endeavor. It was all started in the year 1950s, after its invention by John McCarthy (the father of AI). With time, it has played a significant role in helping the human generation to become more advanced and equipped than ever before. It can be mentioned that it has spread the broad spectrum of its application from "the soil to the space". The 24×7 Internet facility, the invention of cloud technology, the concept of big data, sensors, and other technological advancements have turned up as a boon for the development of AI. Although AI has not yet replaced humans completely, it has assisted humans to a great extend in solving and handling the problems which are difficult and risky. In the form of intelligent machines, it has played the role of representative of human beings. Today, AI has found wide applications in agriculture, business, education, entertainment industry, medical, defense, and space technology where it has crucial and admirable effects. It has a great impact in the health sector which has helped to bridge the gap between technology and medicine, in diagnosing the patients. It requires data accuracy and security and the trust of the patients on the system. It has also many amazing applications of robotics in the form of robots performing surgery or assisting in diagnosis. Basically, AI deals with large amount of data to obtain the required results, and accordingly the algorithms are designed to reduce the chances of error and provide accurate results. As already mentioned, the spectrum of its application has spread from soil to space as a booming technology for the betterment and development of human life. Following are few of the application areas of AI and data based on some case studies.

3.1 Agriculture

The agriculture is the backbone of any country and hence improving this sector with the help of technology is essential. Considering the world scenario, the agriculture sector shall be capable of producing almost 50% more food than being produced now. The implementation of AI and its technologies has significantly played its role in improving the situation of agriculture industry. Going with the phases of farming, AI is used in the analysis of soil and its monitoring, advancement in crop sowing phase,

moving forward in the pest/weed control methods and lastly to the crop harvesting and supply of produce to the right place and at justifiable rate [15, 16]. With the advent of AI, sensor technology and Internet this industry has benefitted to a large extent. In soil analysis and monitoring, AI can help us to know about the soil and seed relationship. In this regard, it tells which seed should be opted for specific type of soil. It predicts in reducing the use of harmful chemical fertilizers used to enhance the plant growth and monitors the irrigation method thereby saving water. According to a study done in Alfalfa, California, the use of Geographic Information System (GIS), in the irrigation method has helped to enhance the crop output by 35% and reduction in the amount of water used for irrigation. AI-based apps, basically with the help of sensors, pictures, and infrared rays help to determine the quality and properties of soil. Hence it helps in improving the agriculture process assuring better yield and profit for the concerned farmers.

Moving to the next application is the sowing process enhancement by the use of AI sowing app. According to a study in 2016, pilot project with 175 farmers was initiated by ICRISAT (The International Crop Research Institute for the Semi-Arid Tropics) with partnership of Microsoft in Kurnool district of Andhra Pradesh, India whose objective was to increase the level of output (about 30%) with decrease in the investment done prior to the farming. It was equipped with the alert messages provided to the farmers regarding the most suitable dates for cropping, land preparation, and usage of fertilizer using this app which works and gives required results by taking the images uploaded by the farmers from the user end. In another study, the development of machine learning technology along with integrated computer vision applications by Blue River Technologies aimed to optimize the herbicide and pest control. This technology helps to distinguish between the affected and normal parts of the plant. The "see and spray" project of Arkansas, USA, using this technology, got reduction in the required amount of expenses for weedicides per acre of land. In a different study done on the crop harvesting, it was found that the time taken by AI-based robots in tomato farms in Japan, is lesser than the time taken by the human.

3.2   Business, Banking, and Finance

This industry or sector is very important and delicate to protect the data and records of millions of customers. The prime factor is the trust, data transparency, and security of the customers. But unfortunately, till date, AI is unable to stop any fraud cases. However, with the help of AI many fraud detection methods and technologies are now offered to make the system more robust. Similarly, the business and retail market are also getting benefited by improvised methods of customer handling and providing faster and safer services. The world of e-commerce is highly affected by its high-level of customer interaction.

In the finance and banking sector, AI has come up with many technological aids either in form of apps or methods to prevent from frauds, enhance better customer data storage/retrieval, and many more. A study by a bank helped online fraud detection

solution provider, i.e., Teradata which helps to manage the false positive cases and detection of real frauds. Another study revealed that the payment fraud over anomaly of data is nicely dealt by a client bank using the software Feedzai, using which the bank got a hike of 78% of new customers. DataVisor software helped a bank in USA to detect the fraud in loan and repayments and get profit by 30% with a high accuracy of 90%. Similarly, in business sector, AI has helped many IT firms like Deloitte, IBM, Infosys to bloom in the market as a better technological service provider. Elsevier undergone a digital transformation from being a publisher to a tech with the help of big data and machine learning.

3.3 Education

This is the sector of any nation which transforms the nation after all students are the future of the nation. Considering India only where it is assumed that almost more than half of the population is of age lesser than 25, therefore, it is much more crucial to protect the data shared by the students and provide the best form of education. In this pandemic year, it is not unknown how technology has equipped the education sector to continue the process of education be it in schools, colleges, or research. Apps like Zoom, Microsoft Teams have made it possible or easy to impart knowledge online and from distance. AI has helped the students worldwide to get access to the huge amount of data in the forms of syllabus, curriculum, textbooks, research articles and papers, and e-learning to a greater extent [17].

   According to Content Technologies Inc., which is an AI research and development company, smart, and customized educational content can be created and developed which help the students to get access of the customized study materials. It basically uses the concept of deep learning. In a hackathon (organized by NITI Ayog), ReadEx was featured which helped to generate real-time questions using natural language processing and also provided content recommendations and flashcard creation. In a recent study, the Andhra Pradesh government (India) was aided by a predictive analysis done with the assistance of Microsoft using some Azure machine learning process to find the dropouts of students in an academic institution. It successfully detected 19,500 students record who are more likely to dropout in Visakhapatnam district for the year (2018–2019) so that precautionary counseling sessions could be arranged to counsel the students. Not only the students, teachers also got benefitted from these technologies as it optimized searches in Wikipedia or e-learning courses from various organizations. A case study depicts the use of Pearson's Write-To-Learn app for the betterment of writing skills. This app provides tips, hints, and personalized feedbacks to improve the writing skills of the learner be it student or any teacher. In another study, AI has put the fact of how Wikipedia handled the situation of decreased level of content writers by 40% and the problem of controlling abusive comments by the users. It uses AI and associate technology to deal with it and now its AI who writes for Wikipedia which has really changed the world.

3.4 Entertainment and Gaming

This industry does not need much introduction and effect of AI in this. The highly efficient digitally strong technologies have provided awesome movies and work pieces which includes high power editing, imaging, and sound effects. It has transformed the media industry. Starting from the camera effects to the action effects everything has been improved. Probably the superpowers having a huge fan following are nothing using technology. The famous Netflix uses AI and big data to manage the search and provides the better content recommendation and many more ways to help users for better access of data. Gaming industry also uses AI to improve the quality of the game and secure the data provided by the users. It has made the online game in social media possible with multiple participants. Ludoking, PUBG, and many other games have touched and captured the hearts of millions of teenagers.

3.5 Health Care

Artificial intelligence has its maximum effect in this sector and has totally transformed the way of treatment and diagnosis. The goal of having a very effective healthcare system of a nation can now be achieved in many way by difficult task accomplishments with the help of technology and AI. The three basic steps of treatment which are detection, diagnosis and analysis, and treatment are now improvised and enhanced with the advent of artificial intelligence in this sector. The main two factors which are of major concerned are the patient's data privacy and security. Any technology which is introduced mainly focus on these two factors. This includes development of different apps including data collection apps, digital Chatbots for consultation on primary basis, image detection, and analysis using specific algorithms. Since the broad discussion has been done later in this chapter here the focus is on the role of AI in COVID-19 pandemic in India and worldwide.

Role of AI in Handling COVID-19 Pandemic

The role of AI in medical field is tremendous as the planet witnessed a pandemic due to Corona outbreak, which has affected the entire human population with huge number of death cases. In this scenario, AI has come with its technologies to help the people from getting infected with the virus. It cannot assure to avoid death but can assure prevention and precaution by the following ways:

(i)   *It has served as high-level data mining tool*: with the help of AI, researchers can get help to fight the disease. Information like the nature of the virus, the symptoms, crucial data from other research papers, and records of past incidents are available by data mining methodologies.

(ii) *As a predictor*: the Corona outbreak was reported in Wuhan, China. The fact that it turned into a pandemic and all such related information were predicted

with help of AI and ML. It is being identified that BlueDot and Metabiota uses AI and ML to predict the pandemic outbreak.

(iii)   ***Quick diagnosis***: it is true that AI alone cannot treat patients but has assisted a lot for the quick diagnosis in terms of image analysis of the lungs (CT scan) of suspected and positive cases.

(iv)   ***Tracking the patients***: it is the most prevalent job that is being done to keep the record of the active, recovered, and death cases. Microsoft developed a Corona online tracker to track the status of the virus and its possible predictions based on the present data. Similarly, the Indian government also developed its own website to track Corona infected persons. The very famous *Aarogya Setu* App developed by the Ministry of Telecommunication and Information Technology, Government of India, helped to guide citizens in tracking the nearby affected patients and to take necessary preventive measures. AI has helped to fight back the pandemic from this deadly virus.

3.6   *Smart Cities and Transportation*

This is the area in which the application of AI has its specific and unique role. Smart city is a term, which has become a point of measure of urbanization of a nation. A smart city can be described as the city with technologies to make the life of people much easier and advanced. Similarly, smart transportation signifies the way of handling the transportation and controlling the traffic and accidents which is really a matter of concern due to large number of deaths on highways and roads [18]. As people in smart cities are more likely to use smart technologies, it is obvious that the data security will become a major concern. Be it smart homes, parks, robotic equipped restaurants, or the home delivery of food, it is all because of AI. They also play a crucial role in crowd management and cybersecurity in smart cities.

Considering smart mobility and transportation, AI has given autonomous vehicles the power to detect the chances of accidents and protect the person. It may be the automated airbags or the water splashes to the alarming sounds if the driver gets to sleep while driving. The broader applications of intelligent transportation systems are the use of CCTV cameras installed in the highways to keep track and record of all the activities. Google map needs no extra explanation how it is helping in tracking the one who is traveling and tracing the places one needs to travel. It also helps in suggesting different routes to control the congestion. Based on a study it was found that almost more than 500 train accidents occurred from 2012 to 2017 in India, out of which 53% was due to the derailment. So, the Ministry of Railways, India used AI technology to help in detecting the problems in the track and avoided many such accidents. These technologies are being used and will be used further for the betterment of the nation and the world.

3.7 Space Exploration

In the present scenario it has become almost impossible to imagine the world without technology and the effects of AI in space exploration. The world is aware of the space mission of Chandrayan-2 and the mission to Mars of ISRO which is not possible without the help of AI and its application. Starting from the satellite communication to the rovers moving around the Mars surface many activities needs to be performed by its own or without any instruction from the space station. Be it NASA or ISRO or any other space organization, no one can deny the use of AI in space exploration and how it has enhanced the quality of space exploration. The satellites sending the images from space are decoded and extraction of useful information from the images is done with the help of machine and deep learning. As per a study in 2015, it has been known that the space mission of SpaceX Falcon 9 was accomplished with the help of machine learning which helped it for successful landing at the Cape Canaveral Air Force Station. Application of deep learning has assured the automatic landing of many aircrafts, accurate data collection and transmission without minimum chances of human error.

From another study it was reported that SKICAT (Sky Image Cataloging and Analysis Tool) performed beyond the expectations of human and was able to classify many images having lower resolution during the span of second Palomer Sky Survey. With the help of AI, NASA and Google discovered two obscure planets in 2017 [Kepler-90i and Kepler-90 g]. From these studies, it can be assumed how strongly AI and its subset-based technologies have changed the world in the space exploration and definitely, many more to come with the strengths of AI technology in creating a world of intelligent machines.

4 Artificial Intelligence for Advanced Medical Diagnosis

Medical field is the area where the AI has put its most important impact which has changed the way of medical diagnosis. It has made the diagnosis process much more effective, efficient, faster, and much more reliable. It never aims to replace the doctors but to help them in making their service easier. It basically acts as an assistant to the physician. The role of AI in medical diagnosis is classified into two types, i.e., virtual and physical. Virtual branch deals with clinical data management and the physical branch mostly deals with the use of robots [19]. It has many applications such as assisting in diagnosis, in surgery, with the help of specifically designed robots and equipment helping in guiding the patients about the particular disease. It also helps to aware them and restricts them from getting affected with the help of Tele-treatment technologies. It is also used in signal and image processing along with some crucial predictions regarding the organs. It has also assisted the physicians in maintaining their daily schedule by acting as a reminder to them. It also helps the patients in keeping track with the doctor regarding their pre- and post-surgery

conditions. The medical data and records maintenance, the payment facility, and many more applications are used in the healthcare system. Since healthcare system is one of the most important sectors for any nation, it really needs to be improved a lot to facilitate the people and enhance quality treatment in this sector. All this has been possible due to the introduction of AI, cloud technology (for data storage and fast retrieval), the concept of big data, and the use of mobile computing in the healthcare system. Eventually the combination of AI, Robotics, Internet of Things (IoT), and Internet of Medical Things (IoMT) is the new era of healthcare solution system and an important milestone in the process of fourth industrial revolution. Following image (Fig. 5) depicts the most important use cases of AI and robotics as a whole in the healthcare system [20].

As per the data from a case study a project named as the project DeepDream which was developed by Google in 2015 helped to create images of given input and also imagine all possible features that the image should have. This method includes the training of the neural network-based software with millions of images as an input and then asked to produce images from the selected. Based on some case studies on the combating technologies for the most common deadly disease which is cancer a software was introduced by the IBM, namely, Watson for oncology, including both ML and NLP technologies, in 2016. It helped the patients to get to know about the correct
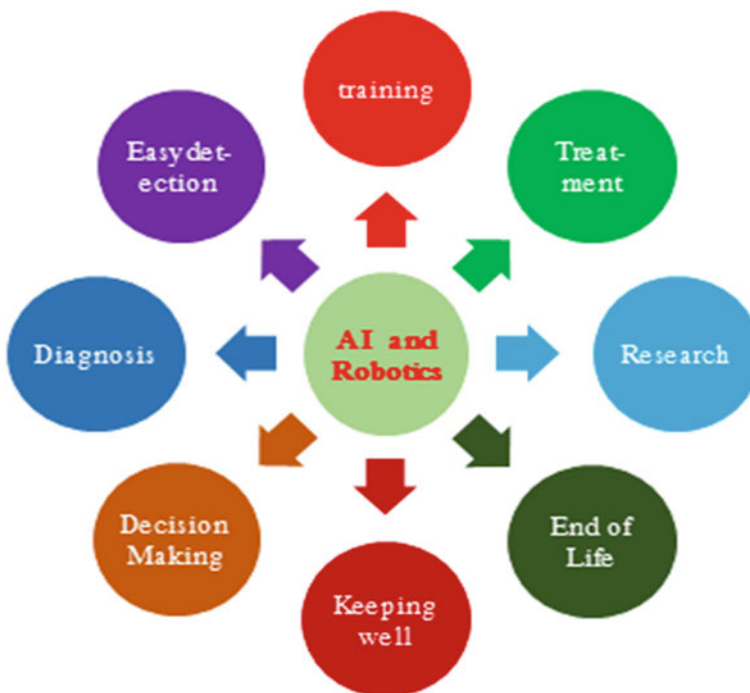

Fig. 5 Use cases of AI for healthcare system

mode of treatment required for them based on their symptoms and health conditions. A similar project for fastening the cancer therapy process is the AI developed by NITI Ayog organization of Indian government which is named as Digital Pathology which contained the images of annotated and curated pathology images. Another ongoing project is the Biobank for cancer patients which helped to bridge the gap between the imaging done by radiologists and by the machine and find out some very minute details. One more case study talks about the e-healthcare and consultation service provided by the UK-based AI Babylon in 2018. In a case study, it explains how the nurse robot Molly which helps the physician in organizing the patients' symptoms and follow up the treatment process. An app developed by National Institutes of Health named as AI AiCure to manage the patient's prescriptions and manage the health condition of patient.

The basic things on which any AI developer put focus are the data generation, data management, and disease detection and management. There are many examples of medical imaging being improved by the implementation of deep learning algorithms be it in detecting the correct disease at the right time or throughout the diagnosis process like eye diseases such as diabetic retinopathy, diabetes detection, risk prediction and control, and also the heart disease monitoring systems [21, 22]. There are also many cases where the drug discovery is done with the help of AI, machine learning, and deep learning technologies and help to find the best solution for a disease. There is no limit to its application under proper implementation and ideologies. But there are few challenges that AI must face in the field of medicine and health care such as the data accuracy, security, integrity, and the interpretability. These factors are very much important for any technology to be trusted and used by the general public. Another factors includes the rate of availability of the services to the people in need at correct time which aims at the digitizing the nation totally because it is known that the rural areas lack the facilities and also the doctors move to town and cities for their improvement. So, the rural remains the same in most of the cases, thereby the prime job is to provide the service where it is much needed. Still, with all these challenges AI has been working with much accuracy in health care and not only diagnosis or treatment it has gone beyond that and provided with some advanced level of medical applications which are being discussed later in this chapter.

4.1 Database Management

In healthcare system, the application of AI, ML, DL, cloud computing, and IoMT has created excellent technologies for the development and services to the healthcare system. Currently, the whole world is going digitized at a higher rate and is in the grip of technology assisted services. With the help of technologies, such as cloud storage and devices based on mobile computing methods, the digital universe is existing and working efficiently. It provides lots of data to store, keep track of and retrieve at a higher speed. Based on a report by the International Data Corporation (IDC), the

data size of this digitized universe will be almost 40,000 Exabytes (EB) by the end of 2020. Similarly, by the use of AI and relevant technologies in healthcare system, it is generating large amounts of data in the form of EHR (Electronic Health Record), EMR (Electronic Medical Record), PHR (Personal Health Record), MPM (Medical Practice Management software), and other digital records related to the patients and physicians. The biggest challenge is to manage, maintain the privacy and security norms of all these data. In such cases, an advanced level of algorithms by AI and ML are required to handle big data efficiently ensuring no loss of security and integrity of the data. For instance, the AI and ML approaches have been used to find useful information from the "data lakes" which are large data sets of information extracted from Electronic health records [23]. This huge amount of data is stored in the data warehouse and then analysis is done to produce the effective and feasible outcomes. One of the important features of the healthcare big data is that it is unstructured and heterogeneous type which again becomes more challenging in terms of proper management.

In this scenario ML, DL, and NLP works as a boon to this sector which helps to solve many problems related to database management. Whether it is the data extraction from various medical images (CT, MRI, X-ray, ECG, EMG, PET, and EEG) or to manage the medical records; is very easy with use of advanced level of algorithms [24]. But it must accept the challenges for the proper management of database and accomplish the task of managing the healthcare big data. Some of the basic challenges are data storage, accuracy, availability, data cleaning, data integrity, data sharing, and security. With proper data management and data analysis, AI helps to manage the analytics of the huge data and provides better access to patients and doctors.

4.2 Advanced Medical Devices

In medical and healthcare services, AI and its related technology has spelled its magic in the development of medical devices used for treatment. Talking about the devices, it is only the machinery and equipment that come into our mind which mostly includes surgical equipment, image capturing, and analyzing devices. But to a large extent, software is the most essential medium used in the device to analyze, interpret, and solve health-related problems in diagnosis and treatment of diseases. The classification of medical devices is primarily based on three basic categories (Fig. 6) and all the recent developments are classified based on these major classifications.

In 2016, Medtronic a leading medical device company, in collaboration with IBM Watson developed the SugarIQ App including the AI technology. This app helps the diabetic patient to monitor the sugar levels along with the proper guidance for food habits and all the information regarding healthy eating habits. In 2017, the Medtronic again introduced a device asserting automatic insulin control and stabilization in the body throughout the day. The device named as MiniMed 670G system was launched with the approval of Food and Drug Administration (FDA). In 2017, computerized

Fig. 6 Image depicting three main categories of medical devices development

New trends of medical devices
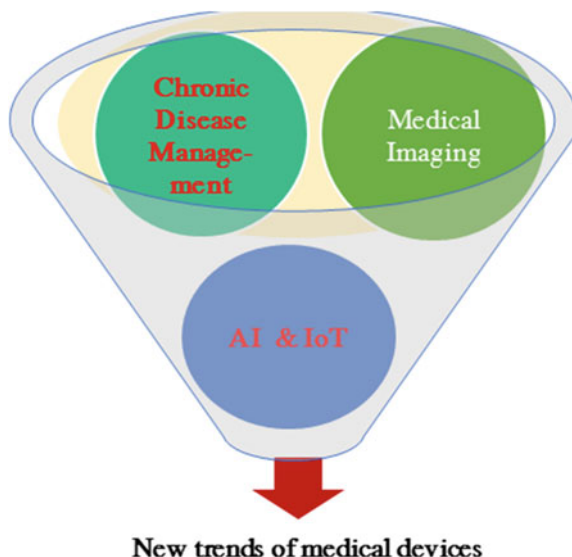
CT scans was introduced by the GE health care in collaboration with NVIDIA. It enhanced the medical imaging process and ensures the capture of minute details of affected body parts which is not possible to get by physically looking at the scan data.

The invention of IoT and AI has given many devices in form of various mobile apps to monitor the body required to maintain good health. Patient monitoring system is also a device or system for monitoring the patients' detailed activity and helps to control the deterioration of the body by giving feedback and suggestions. One such development is IntelliVue Guardian Solution, which was done by Philips Healthcares which uses the concept of artificial intelligent and makes appropriate predictions for effective and early managing of health status of a patient.

4.3 Drug Design

Artificial intelligence has already marked its significance in drug discovery and now drug design is also becoming a chief application of AI in drug development process. The basic drug development process includes various steps such as the drug target identification and validation, new drugs design, repurposing of drugs, improvement in research and development, asserting biomedicine conformation, and finally the clinical trials on patients [25]. AI has also successfully helped in the drug discovery method by determining the correct drug molecule and the information about the reaction of proteins in the body before going for design. For drug design, AI is used to determine the proper candidate molecules from the reduced graph of the drug

to be designed. This type of job was performed by the company Tessella. AI can also help in differentiating the non-suitable compounds for the drug design which are not suitable for the patient body. It also takes the help of computer-aided design techniques to design the drugs for specific requirements [26].

4.4   Digital Consultation

AI provides digital consultation to the whole world in the form of healthcare chatbots. These are AI-based software solution which provides customized service in form of messages to the patients or the users without making them realize that they are talking to any person or any device [27]. These basically make use of the natural language processing methods and help the healthcare industry to provide digitized service. They also provide consultation regarding food habits, exercise, and other tips to stay healthy. It helps to take necessary preventive measures by the users in order to protect themselves from getting affected with any disease and keep track of their health. Many services companies like Sensely, Your.MD, Babylon HealthTap+ , Pact., Woebot, and others provide a platform for digital consultation to the patients with the help of AI and related technologies like ML, NLP, and DL.

4.5   Genome Editing

This is totally a different aspect of AI application in which the focus is on the features of genetic composition of a person. They try to get the relationship between the occurrence of the disease and the changes it made to the genes. Using the AI and ML techniques, scientists are now able to know the genomic data using gene editing and sequencing techniques. Gene editing can be described as the technique involved in DNA mutations with some alterations in the target sequence such as insertion, deletion, and substitutions [28]. It is known that the gene sequence consists of base pairs made up of (A, T, C, G); general DNA sequencing took much time but after the invent of a technology called as high throughput sequencing (HTS) which helps to perform the DNA sequencing in less than a day. The alterations done in that sequence is termed as gene editing. Many AI platforms have been developed to enhance the HTS for a better representation of genome such as DeepVariant. Overall, AI has efficiently aided the healthcare system and expected to do more in near future related to genome editing and more advancements including the genetic screening tools for the infants.

5 Conclusion

Artificial intelligence and its related technology like machine learning, deep learning, natural language processing has invaded the world undergoing fourth phase of industrial revolution in a very strong manner. It has put its incredible and efficient impacts on almost every sector, from agriculture to education and even to the space technology. It has greatly assisted the healthcare system for making it more efficient in providing the services to the patients and being affordable and feasible for use. The use of machine learning in health care has really modified the scenario in the healthcare system and still there is more scope for research and development. The various application of deep learning and machine learning has helped in better disease detection and diagnosis process. Furthermore, the use of deep learning in image analysis and data extraction from medical images has helped in detecting some deadly diseases. It has also its impact in radiology and the use of robots in medical diagnosis process has its own significance. Artificial intelligence has also spread its spectrum to advance level of medical application and many more research results are leading to a new venture of application in health sciences. It has greatly changed the daily activities by digitalizing the universe and getting benefits from the predictive analysis. The common advantages of AI include reducing the workload of humans and making it easier for them to get much lesser error-prone results for any given set of problems. But considering the assumption of AI creating new employment opportunities it also predicts the risk of increase in unemployment. Furthermore, the cost of implementation and the complexity of the used algorithms if can be reduced will be of much use in health care systems. In conclusion, it can be said that AI is the new way of living with and making it the assistance of human.

References

1. Spector, L.: Evolution of artificial intelligence. Artif. Intell. **170**(18), 1251–1253 (2006)
2. Kamble, R., Shah, D.: Applications of artificial intelligence in human life. Int. J. Res. **6**(6), 178–188 (2018)
3. Singh, H.: Artificial intelligence revolution and India's AI development: challenges and scope. Int. J. Sci. Res. **3**(3), 417–421 (2017)
4. Simeone, O.: A brief introduction to machine learning for engineers. Found. Trends Signal Process. **12**(3–4), 200–431 (2018)
5. Wang, X., Lin, X., Dang, X.: Supervised learning in spiking neural networks: a review of algorithms and evaluations. Neural Netw. **125**, 258–280 (2020)
6. Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, Hao:, Ma, Sufeng: , Wang, Yongjun:, Dong, Q., Shen, H., Wang, Y.: Artificial intelligence in healthcare: Past, present and future. Stroke Vasc. Neurol. 2(4), 230 - 243 (2017).
7. Simeone, O.: A very brief introduction to machine learning with applications to communication systems. IEEE Trans. Cogn. Commun. Netw. **4**(4), 648–664 (2018)
8. Herzog, S., Tetzlaff, C., Wörgötter, F.: Evolving artificial neural networks with feedback. Neural Netw. **123**, 153–162 (2020)
9. Reggia, J.A.: Neural computation in medicine. Artif. Intell. Med. **5**(2), 143–157 (1993)

10. Lobo, J.L., Del Ser, J., Bifet, A., Kasabov, N.: Spiking Neural Networks and online learning: an overview and perspectives. Neural Netw. **121**, 88–100 (2020)
11. Schmidhuber, J.: Deep Learning in neural networks: an overview. Neural Netw. **61**, 85–117 (2015)
12. Kiryu, S., Akai, H., Yasaka, K.: Deep learning application in the oesophageal endoscopy. J. Med. Artif. Intell. **2**, 22–22 (2019)
13. Yamashita, R., Nishio, M., Do, R.K.G., Togashi, K.: Convolutional neural networks: an overview and application in radiology. Insights Imaging **9**(4), 611–629 (2018)
14. Tian, C., Xu, Y., Zuo, W.: Image denoising using deep CNN with batch renormalization. Neural Netw. **121**, 461–473 (2020)
15. Barbedo, J.G.A: Detecting and Classifying Pests in Crops Using Proximal Images and Machine Learning: A Review. Artif.Intell. 1(2), 312 - 328 (2020).
16. Talaviya, T., Shah, D., Patel, N., Yagnik, H., Shah, M.: Artificial Intelligence in Agriculture Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. Artif. Intell. Agric. **4**, 58–73 (2020)
17. Hernández-Blanco, A., Herrera-Flores, B., Tomás, D., Navarro-Colorado, B.: A Systematic Review of Deep Learning Approaches to Educational Data Mining. Complexity, 2019, (2019).
18. Dickmanns, E.D.: Vehicles capable of dynamic vision. IJCAI Int. Jt. Conf. Artif. Intell. **2**, 1577–1592 (1997)
19. Hamet, P., Tremblay, J.: Artificial intelligence in medicine. Metabolism **69**, S36–S40 (2017)
20. Mani Sekhar, S.R., Siddesh, G.M., Tiwari, A., Anand, A.: Bioinspired Techniques for Data Security in IoT. In: Alam M., Shakil K., K. S. (eds) Internet of Things (IoT):Concept and Applications(2020). pp. 167 - 187, Springer, Cham (2020).
21. Xu, Q., Wang, L., Sansgiry, S.S.: A systematic literature review of predicting diabetic retinopathy, nephropathy and neuropathy in patients with type 1 diabetes using machine learning. J. Med. Artif. Intell. **3**, 1–13 (2020)
22. Riihimaa, P.: Impact of machine learning and feature selection on type 2 diabetes risk prediction. J. Med. Artif. Intell. **3**, 1–6 (2020)
23. Shah, F., Kendall, P., Khozin, N., Goosen, S., Hu, R., Laramie, J., Ringel, J., Schork, M.: Artificial intelligence and machine learning in clinical development: a translational perspective. npj Digit. Med. **2**, 69 (2019)
24. Abbod, M.F., Linkens, D.A., Mahfouf, M., Dounias, G.: Survey on the use of smart and adaptive engineering systems in medicine. Artif. Intell. Med. **26**(3), 179–209 (2002)
25. Mak, K.K., Pichika, M.R.: Artificial intelligence in drug development: present status and future prospects. Drug Discov. Today. **24**(3), 773–780 (2019)
26. Tang, C., Ji, J., Tang, Y., Gao, S., Tang, Z., Todo, Y.: A novel machine learning technique for computer-aided diagnosis. Eng. Appl. Artif. Intell. **92**(February), 103627 (2020)
27. Colace, F., De Santo, M., Lombardi, M., Pascale, F., Pietrosanto, A., Lemma, S.: Chatbot for e-learning: a case of study. Int. J. Mech. Eng. Robot. Res. **7**(5), 528–533 (2018)
28. Manghwar, H., Lindsey, K., Zhang, X., Jin, S.: CRISPR/Cas system: recent advances and future prospects for genome editing. Trends Plant Sci. **24**(12), 1102–1125 (2019)