# CHAPTER 1

# ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

## What is Artificial Intelligence

Artificial intelligence is a field of computing that focuses primarily on the transmission of anthropomorphic intelligence and thinking into machines that can assist humans in many ways. Artificial intelligence was a term that John McCarthy used in 1956. AI has slowly sprung up and grown stronger in many fields such as engineering, mathematics, physics, technology all of which have led to the current tremendous shift in this field which we are witnessing now. This is an idea that proposes that machinery can acquire intelligence. It encompasses areas like machines can learn on their own, adapt to a specific circumstance and self-correct their own mistakes. i.e., Machinery may think on their own without being encoded with commands. The AI programs will have cognitive skills: reasoning, problem-solving, learning, perception, and self-correction, as given below:

* **Reasoning process:** The AI program here focuses on selecting the most appropriate algorithm to achieve the required results. It is the process that is used for making judgments, decisions, and predictions. Reasoning processes are mainly categorized as inductive reasoning and deductive reasoning.
* **Learning process:** Its function is acquiring data and creating rules in order to devise actionable information from data. Learning improves understanding of the subjects under study. The rules, also called algorithms, help provide sequences of instructions to perform a task using computing devices. It involves acquiring knowledge by way of study, practice, and gaining experience. Humans, some animals, and AI-based systems have the ability to learn
* **Problem-solving process:** It is used to get the required solution from the current situation by taking another approach. Problem solving may include decision-making, i.e., selecting the best out of several possible alternatives to get the objectives.
* **Perception process:** It includes selecting, acquiring, interpreting, and ultimately analyzing the information. In case of humans, perception is supported by sensory organs. Perception mechanisms in AI place the sensors data together in a useful manner.
* **Self-correction process:** It is designed to continually refine the algorithm so that it determines the most accurate results.

The concept of building computers that are capable of thinking and acting with expertise and comprehension in the same way which we, as people, do in our day-to-day lives was the spark that ignited the field of artificial intelligence (AI) research. A select sample of these early philosophical conceptions are depicted in Figure 1.2. Over the course of time, these concepts have developed into a wide variety of subfields.

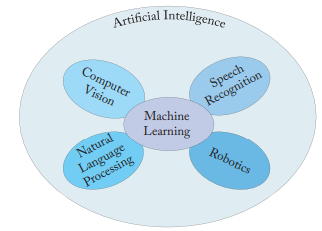


Figure 1.2: AI and example subfields (Enright Jerger *et al.*, 2020)

The field of speech recognition investigates many approaches of converting spoken language into written text. Similarly, natural language processing (NLP) includes the development of a comprehension of language, which enables capacities that include automatic translation (for example, Google Translate). The goal of artificial intelligence applications in robotics is to improve control and decision-making by learning from experience rather than routines that have been meticulously developed. Computer vision is a discipline that is connected to computer science that enables machines to interact with the actual world and acquire knowledge from it based on visual input. Machine learning (ML), which has been quickly embraced not only in other subfields of artificial intelligence but also in architecture, is one of the most important aspects of the subject. The application of ML to architecture will, in point of fact, be the major focus of our attention in subsequent chapters. likewise do not intend for the reader to make the assumption that artificial intelligence in architecture would persistently concentrate on such tactics. One example of what may be accomplished in the future is the use of NLP and automated code generation to the design of architecture. This would make it possible for a building and simulation tool to carry out automatic verification based on defined goals.

### Advantages of AI

The use of AI has the potential to decrease the amount of labor performed by humans. This is because robots can take over tasks formerly performed by humans.

* Individuals who are suffering from a disease can be diagnosed with it at an earlier stage with the use of technologies that are developed using AI.
* A new kind of help is available because of AI, and it's quite useful during operations since the AI system allows for the most exact motions to be performed.
* To acquire a better and clearer picture of all the facts, AI may keep all the patient data in an organised manner.
* People who live in rural regions, who typically struggle owing to their absence of availability of technology, can profit from artificial intelligence. Artificial intelligence helps to cut down on the amount of time needed to complete a task.
* Multitasking is possible with the assistance of artificial intelligence, which helps decrease the amount of work that has to be done and is extremely effective.
* Artificial intelligence helps eliminate human mistake, and as a result, it is employed in a broad variety of contexts since it is very reliable.
* Artificial intelligence enables us to complete time-consuming tasks that, after a certain amount of time, one would put off because of a loss of interest or boredom.
* Novel developments be done with the assistance of artificial intelligence, and AI systems are constantly available.
* AI systems are able to respond appropriately to situations and do not experience emotions like humans do.

On the other hand, if they are correctly programmed, computers wouldn't commit these kinds of errors. Using artificial intelligence, the decisions are made based on the knowledge that was obtained in the past and are then applied to a certain set of equations. Therefore, the likelihood of achieving accuracy with a higher degree of precision is increased, and as a result, the probability of achieving accuracy is increased. Throughout our workday, we will be responsible for a variety of tasks that are repetitious in nature, such as writing a thank-you letter, checking specific papers for problems, and a great deal of other tasks. Using artificial intelligence, we will be able to automate these routine chores productively. They need to be able eliminate "boring" duties for people, which will free them up to be more creative. In order to engage with people, some of the most technologically proficient organisations have begun to deploy digital assistants, which eliminates the need for traditional human resources. The digital assistants are also utilised in a variety of websites in order to provide consumers with the stuff that they desire. We may have a conversation with them about the things that we are looking for. From time to time, we have conversations with chatbots that make it hard to tell them apart from real people. Using artificial intelligence in conjunction with additional technologies, we will be able to have computers make decisions and carry out activities more quickly than a person could. In the process of making a decision, a person will consider a wide range of elements, both emotionally and practically. However, a machine driven by AI will be more efficient since it will only accomplish its intended tasks. Programs like OK Google, Apple's Siri, and Microsoft's Cortana are a part of our daily lives. These applications are utilised for a variety of purposes, including looking for a location, snapping selfies, making phone calls, responding to emails, and many other tasks (Bhbosale, Pujari and Multani, 2020).

## Understanding Machine Learning

The concept of machine learning and deep learning has been around for a long time. However, in recent years, these technologies have been revolutionized with the availability of big data and advancements in computing power. Machine learning and deep learning have become increasingly popular in various industries, including healthcare, finance, retail, and more. The aim of this article is to provide a comprehensive understanding of machine learning and deep learning and how they differ from each other. This article also aims to examine the applications of these technologies in various industries and their impact on society. Machine learning (ML) is used to teach machines how to handle the data more efficiently. Sometimes after viewing the data, we cannot interpret the extract information from the data. In that case, we apply machine learning. With the abundance of datasets available, the demand for machine learning is in rise. Many industries apply machine learning to extract relevant data. The purpose of machine learning is to learn from the data. Many studies have been done on how to make machines learn by themselves without being explicitly programmed. Many mathematicians and programmers apply several approaches to find the solution of this problem which are having huge data sets. Machine Learning relies on different algorithms to solve data problems. Data scientists like to point out that there‟s no single one-size-fits-all type of algorithm that is best to solve a problem. The kind of algorithm employed depends on the kind of problem you wish to solve, the number of variables, the kind of model that would suit it best and so on. Here‟s a quick look at some of the commonly used algorithms in machine learning (ML).

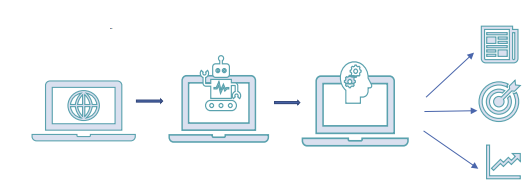


FIGURE 1.1: machine learning (Alam, 2023)

On the basis of their prior experiences, machines are able to construct a model that may be utilised for the purpose of predicting future values. Machines learn from previous instances and historical trends they have encountered. In situations when the amount of data and questions involved is too great for natural solutions to be found, ML may be utilised to assist in the discovery of answers to these issues through the analysis of the data. It can assist individuals in searching for significant stuff in a shorter amount of time. As a result of robots' ability to learn more quickly, even complex issues may be readily addressed, and in certain areas, they can even outperform humans. As a consequence of this, the demand for it is consistently growing. While big data and cloud computing are becoming increasingly important, ML is also becoming more important because of the various challenges that it solves with its computational capacity. It has use in a wide variety of contexts. It can be of assistance in the process of drug discovery, and it can enable medical professionals to make accurate diagnoses, which can lead to the early prediction of a variety of diseases. It does this by targeting consumers on social media and segmenting them according to age, gender, geography, and other factors, which allows it to analyse the purchase habits of those customers. Online scams are simple to identify and identify. The identification of faces and voices, automated trading, NLP, automotive, aerospace, and other fields are all areas in which it is quite valuable.

The learning process, whether by a human or a machine, can be divided into four components, namely, data storage, abstraction, generalization and evaluation. Figure 1.1 illustrates the various components and the steps involved in the learning process.



Figure 1.1: Components of learning process (Iv and Sem, 2020)

**Data storage:** Facilities for storing and retrieving huge amounts of data are an important component of the learning process. Humans and computers alike utilize data storage as a foundation for advanced reasoning.

* In a human being, the data is stored in the brain and data is retrieved using electrochemical signals.
* Computers use hard disk drives, flash memory, random access memory and similar devices to store data and use cables and other technology to retrieve data.

**Abstraction**: The second component of the learning process is known as abstraction. Abstraction is the process of extracting knowledge about stored data. This involves creating general concepts about the data as a whole. The creation of knowledge involves application of known models and creation of new models. The process of fitting a model to a dataset is known as training. When the model has been trained, the data is transformed into an abstract form that summarizes the original information.

**Generalization:** The third component of the learning process is known as generalisation. The term generalization describes the process of turning the knowledge about stored data into a form that can be utilized for future action. These actions are to be carried out on tasks that are similar, but not identical, to those what have been seen before. In generalization, the goal is to discover those properties of the data that will be most relevant to future tasks.

**Evaluation:** Evaluation is the last component of the learning process. It is the process of giving feedback to the user to measure the utility of the learned knowledge. This feedback is then utilised to effect improvements in the whole learning process.

### Machine learning Life cycle

Machine learning has given the computer systems the abilities to automatically learn without being explicitly programmed. But how does a machine learning system work? So, it can be described using the life cycle of machine learning. Machine learning life cycle is a cyclic process to build an efficient machine learning project. The main purpose of the life cycle is to find a solution to the problem or project. Machine learning life cycle involves seven major steps, which are given below:

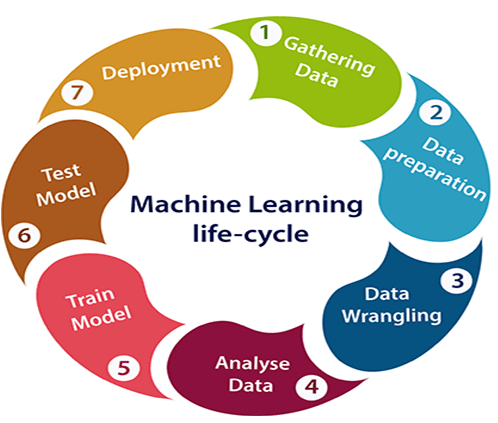


Figure 1.2: life cycle of machine learning (javatpoint, 2024)

The most important thing in the complete process is to understand the problem and to know the purpose of the problem. Therefore, before starting the life cycle, we need to understand the problem because the good result depends on the better understanding of the problem. In the complete life cycle process, to solve a problem, we create a machine learning system called "model", and this model is created by providing "training". But to train a model, we need data, hence, life cycle starts by collecting data.

1. **Gathering Data**

Data Gathering is the first step of the machine learning life cycle. The goal of this step is to identify and obtain all data-related problems. In this step, we need to identify the different data sources, as data can be collected from various sources such as files, database, internet, or mobile devices. It is one of the most important steps of the life cycle. The quantity and quality of the collected data will determine the efficiency of the output. The more will be the data, the more accurate will be the prediction.

1. **Data preparation**

After collecting the data, we need to prepare it for further steps. Data preparation is a step where we put our data into a suitable place and prepare it to use in our machine learning training. In this step, first, we put all data together, and then randomize the ordering of data.

1. **Data Wrangling**

Data wrangling is the process of cleaning and converting raw data into a useable format. It is the process of cleaning the data, selecting the variable to use, and transforming the data in a proper format to make it more suitable for analysis in the next step. It is one of the most important steps of the complete process. Cleaning of data is required to address the quality issues. It is not necessary that data we have collected is always of our use as some of the data may not be useful. In real-world applications, collected data may have various issues.

1. **Data Analysis**

The aim of this step is to build a machine learning model to analyze the data using various analytical techniques and review the outcome. It starts with the determination of the type of the problems, where we select the machine learning techniques such as Classification, Regression, Cluster analysis, Association, etc. then build the model using prepared data, and evaluate the model.

1. **Train Model**

Now the next step is to train the model, in this step we train our model to improve its performance for better outcome of the problem. We use datasets to train the model using various machine learning algorithms. Training a model is required so that it can understand the various patterns, rules, and, features.

1. **Test Model**

Once our machine learning model has been trained on a given dataset, then we test the model. In this step, we check for the accuracy of our model by providing a test dataset to it. Testing the model determines the percentage accuracy of the model as per the requirement of project or problem.

1. **Deployment**

The last step of machine learning life cycle is deployment, where we deploy the model in the real-world system.

### Perspectives And Issues In Machine Learning

One useful perspective on machine learning is that it involves searching a very large space of possible hypotheses to determine one that best fits the observed data and any prior knowledge held by the learner. For example, consider the space of hypotheses that could in principle be output by the above checkers learner. This hypothesis space consists of all evaluation functions that can be represented by some choice of values for the weights wo through w6. The learner's task is thus to search through this vast space to locate the hypothesis that is most consistent with the available training examples. The LMS algorithm for fitting weights achieves this goal by iteratively tuning the weights, adding a correction to each weight each time the hypothesized evaluation function predicts a value that differs from the training value. This algorithm works well when the hypothesis representation considered by the learner defines a continuously parameterized space of potential hypotheses. Many of the chapters in this book present algorithms that search a hypothesis space defined by some underlying representation (e.g., linear functions, logical descriptions, decision trees, artificial neural networks). These different hypothesis representations are appropriate for learning different kinds of target functions. For each of these hypothesis representations, the corresponding learning algorithm takes advantage of a different underlying structure to organize the search through the hypothesis space. Throughout this book we will return to this perspective of learning as a search problem in order to characterize learning methods by their search strategies and by the underlying structure of the search spaces they explore. We will also find this viewpoint useful in formally analyzing the relationship between the size of the hypothesis space to be searched, the number of training examples available, and the confidence we can have that a hypothesis consistent with the training data will correctly generalize to unseen examples. Our checkers example raises a number of generic questions about machine learning.

## Historical Overview of ML

1. **History of ML**

The word Machine learning was first coined by Arthur Samuel in 1952. In 1957, Frank Rosenblatt – at the Cornell Aeronautical Laboratory – combined Donald Hebb's model of brain cell interaction with Arthur Samuel's Machine Learning efforts and created the perceptron. In 1967, the nearest neighbor algorithm was conceived, which was the beginning of basic pattern recognition. This algorithm was used for mapping routes and was one of the earliest algorithms used in finding a solution to the traveling salesperson’s problem of finding the most efficient route. In the 1960s, the discovery and use of multilayers opened a new path in neural network research. It was discovered that providing and using two or more layers in the perceptron offered significantly more processing power than a perceptron using one layer. machine learning grew out of the quest for artificial intelligence. Already in the early days of artificial intelligence as an academic discipline, some researchers were interested in having machines learn from data. They attempted to approach the problem with various symbolic methods, as well as what were then termed neural networks; these were mostly perceptron and other models that were later found to be reinventions of the generalized linear models of statistics. Probabilistic reasoning was also employed, especially in automated medical diagnosis. From the 1950s to now, machine learning has significantly developed. Below is a brief history of machine learning within the AI field. We show how the algorithms we described are motivated by the need to solve very simple automation tasks, such as the recognition of spoken words or written digits, and how AT&T showed strong leadership in this process.

* **The Turing Test 1950 In 1950:** Alan Turing created the “Turing Test” to determine whether or not a computer was capable of real intelligence. In order to pass the test, the computer had to be able to fool another human into believing it was also human.
* **The First Computer Program 1952:** Arthur Samuel created the first implementation of machine learning, the game of checkers, in 1952. The computer improved at the game the more it played by determining which moves resulted in winning strategies, and incorporating those strategies into the game.
* **Neural Networks for Computers 1957:** Frank Rosenblatt designed the first neural network for computers in 1957, which was meant to simulate the human brain's thought process.
* **“Nearest Neighbor” Algorithm 1967:** The “nearest neighbor” algorithm was written in 1967, allowing computers to begin recognizing basic patterns. This could be used as a mapping route for traveling salesmen.
* **Explanation Based Learning 1981:** EBL, or Explanation Based Learning, was created in 1981 by Gerald Dejong. This concept allowed a computer to analyze training data and create a general rule it can follow by discarding unimportant data.
* **Machine Learning Research Group 1985:** Researchers from AT&T created the first research group for machine learning in 1985. They also began a series of machine learning meetings that eventually turned into NIPS, the leading conference on machine learning. This group was representative of the early machine learning community, breaking away from a computer science field still mostly interested in expert systems. These theoreticians were confronted with real world problems where machines had to replace humans in recognizing noisy written digits: mainly check amounts and zip codes.
* **Automated Speech Recognition 1992:** In 1992, Jay Wilpon (SVP of Natural Language Research at Interactions) and a team of researchers at AT&T deployed the first nationwide automated speech recognition (ASR) using a machine learning approach called Hidden Markov Models (HMMs). This saved billions of dollars in operating costs by spotting things like collect calls.
* **Support Vector Machines 1992:** Researchers at AT&T invented Support Vector Machines (SVMs) in 1992, a technique that revolutionized large scale classification because of its predictable performance.
* **Convolutional Neural Network 1996:** Patrick Haffner (Lead Inventive Scientist at Interactions) and researchers from AT&T proposed the first convolutional neural network (CNN) in 1996, with a large-scale application to check recognition. The influence of this technology was not appreciated until 10 years later when it became rebranded as deep learning, and machine learning researchers began to focus on another technique developed by the same group at AT&T: Support Vector Machines
* **The Adaboost Algorithm 1997 In 1997:** another group of researchers from AT&T invented the Adaboost algorithm. This algorithm allowed unstructured data to be handled through decision trees, making it wildly popular among a wide range of applications.
* **Natural Language Understanding 2001:** AT&T deployed natural language understanding in Interactive Voice Response (IVR) systems in 2001, combining 3 of its machine learning technologies: SVMs, HMMs, and Adaboost.
* **Deep Learning 2006**: The concept of deep learning was successfully promoted, increasing the power and accuracy of neural networks.
* **Deep Neural Networks 2011:** A group of researchers began to work on deep neural networks (DNNs) in 2011 and new algorithms were discovered that made it possible to train a model on millions of examples, outcompeting other techniques previously used in computer vision and speech recognition. Large DNNs trained on massive amounts of data also allowed ASR to reach ‘super-human’ performance in controlled settings.

## Applications of AI and ML

AI has wide applications. More and more industries, such as education, health care, travel, entertainment, finance, and marketing, rely heavily on its ability to solve complex problems and perform complex functions efficiently (Sharma and Garg, 2020). It is also being used in military planning, intelligent vehicle movement, credit card transaction monitoring, robots, credit card fraud detection, automobiles, etc. The AI is trying to make users’ daily lives much more easy and comfortable. The following are some areas having potential applications of AI:

1. **AI as a Service (AIaaS)**

The deployment of an AI platform may be expensive, as it involves the cost of hardware, software, and staff. Therefore, many firms are incorporating AI in their products to provide access to AIaaS platforms. The AIaaS allows to experiment with various AI platforms for businesses and applications before investing heavily in an AI platform. Popular AI-based cloud offerings include IBM Watson Assistant, Amazon AI, Google AI, Microsoft Cognitive Services, etc.

1. **Automobiles**

Many automobile industries are providing AI-based virtual assistants to their users for better driving performance, such as TeslaBot by Tesla. The AI is now being applied toward development of driverless cars. These cars, with the help of AI systems would be able to apply brakes, change lanes, navigate, etc. Such cars will study the patterns of other surrounding cars moving on the road and implement the moves necessary for safe driving autonomously. Autonomous vehicles use computer vision, image recognition, and DL to navigate a vehicle in a given lane and at the same time avoid obstructions like dividers, pedestrians, light-poles, animals, etc

1. **Agriculture**

The AI is emerging in the fields of agriculture, which requires various resources for obtaining the best yields. Agriculture robotics is being applied in agriculture for crop monitoring and predictive analysis to help farmers. The AI techniques for farming help increase productivity and yield.

1. **Banking**

Banks are using chatbots to provide services and offers to their customers, and to deal with the transactions without human involvement. The AI virtual assistants improve the services and cut down the costs of establishments. Financial organizations make use of AI to improve decision-making for loans, keep track of approved loans, set credit limits, as well as highlight the investment opportunities to their customers.

1. **Business**

Business can use AI-based solutions to assess the weaknesses and strengths in order to improve its financial and customer relationship management (CRM), among other things. AI can help in automating the works, saving considerable time and manpower requirements. The ML algorithms that can better serve customers are integrated into analytics and CRM platforms to. Manufacturing units can improve the quantity and quality of its production by using AI required to assess the demand and supply, assembling the parts, etc AI is being used in the e-commerce business in a big way to provide competition to e-commerce industry. It is helping its customers to find out the related products with suggested size, color, or brand. Chatbots are being used in websites of companies to provide almost instant customer service. For example, McDonald’s has been using AI to analyze customers’ ordering trends. Further, customers can place orders directly by using kiosks or interactive terminals instead of dealing with a live cashier; this has reduced order errors and increased sales.

1. **Data security**

In digital worlds, cyberattacks are growing very fast, and the security of data has become crucial for all organizations. AI is being used to make this data safer and more secure. AI and ML in cybersecurity products are providing added value to identify malware attacks. The AI is capable of assessing new malware attacks much faster than the human operators. The AI-based security technology gives organizations advanced information to take precautions against threats before real damage occurs. The technology, such as AEG bot or AI2 platform, is playing an important role in helping organizations fight with cyberattacks; they can also be used to determine software bugs that allow cyberattacks to happen.

1. **Education**

AI can adapt the learning as required by each student, and deliver a good learning experience. In addition, it provides universal access to all students, as well as helps them work at their own pace. The system also automates examination grading systems by reducing the involvement of educators, providing them more time to teach. An AI chatbot, as a teaching assistant, can communicate effectively with students. An AI tutor can teach the subject as required by the students. The AI can work as a personal virtual tutor for students in future, which will be easily accessible to students at anywhere any time.

1. **Entertainment**

AI-based applications such as Netflix or Amazon are providing entertainment services all over the world. With the help of ML-based AI algorithms, these services also recommend specific programs or shows for its users.

1. **Finance**

Finance applications require collection of personal data of individuals and provide help, advice, and suggestions related with finances, and can even help doing securities trading. Today, trading on Wall Street is done through AI software. The finance industries are employing ML in the automation, chatbot, adaptive intelligence, algorithm trading, etc. into financial processes. The AI systems, such as Intuit Mint or TurboTax, are being used by financial institutions for personal financial applications, while other programs, such as IBM Watson, are being used to buy homes.

1. **Gaming**

AI can be used for gaming purpose to generate alternative solutions in a game based on decisions taken by the users in the game, such as player movements, pathfinding, etc. AI-based programming is used by many video games today, such as Minecraft and Tom Clancy’s Splinter Cell. The AI machines can play crucial roles in games, such as poker, chess, etc.

1. **Government**

Governments are using AI to draw suitable policies and services, analyze road accidents, and find solutions for many other problems. The AI-based applications are reducing costs, minimizing errors, taking heavy workloads, and helping bust the backlogs.

1. **Health care**

AI is assisting doctors in many ways and providing faster recovery to the patients. AI can help doctors and patients with diagnoses and inform the latest conditions to the patients, and, if the condition is serious, ensuring medical help reaches patients faster. AI has several advantages and is expected to have a positive impact on the health care industry. AI robots are being developed that will be able to care for the elderly and remind them to take their medicine and even locate misplaced items like eyeglasses. Various AI applications may include use of online virtual health assistants and chatbots by the patients, collection of medical history, fixing of appointments, and helping with administrative tasks. The AI technologies are also helpful to understand pandemics, such as COVID-19. For example, BlueDot, a Canadian company, used AI technology to detect COVID-19 outbreak in Wuhan, China, soon after the first few cases were detected. The IBM Watson can understand the natural language and provide responses to the queries. The system can mine the data of patients to develop a framework for presenting the results with a relative score. But while the predictive algorithms could be helpful in controlling pandemics or other global threats, the ultimate impact of AI is impossible to predict. It is known that robots are increasingly assisting the surgeons in an operating room. Specialized robots are being manufactured to carry out experimentation and provide life-like experiences without carrying out any hands-on experimentation on patients. For example, Gaumard, a health care education company, is now producing robots that can be used to perform various experiments by medical students and medical professionals to do practical learning. These life-like robots can interact with care providers and simulate facial expressions and other physical responses to the questions and actions of doctors or medical students when prompted, spoken to, or touched. Not only can medical professionals interact with the robots, but the robots also can be operated on to teach the procedure and also to take corrective steps if any errors are made during an operation. Using such AI-based system, medical students can easily make incisions, conduct surgeries, draw blood, monitor breathing, etc.

1. **Law**

The use of AI is proving to be time-saving to automate the labor-intensive processes of the legal industry, and thus help improve the services of clients. Law firms and professionals make use of ML-based AI to analyze the data and predict the outcomes. In addition, computer vision is used to extract information and the NLP is used to interpret requests for information.

1. **Natural language processing**

The NLP utilizes the capabilities of machines to understand natural languages. Two of the most commonly used examples of NLPs, available in many smartphones and computer software, are spell check and autocorrect. In 2019, two AIs created by Alibaba and Microsoft defeated a team of persons in a Stanford reading-comprehension test. The algorithms could “read” a series of Wikipedia entries on the topic, and successfully answered a number of questions about the topic more precisely than the human participants could do.

1. **Personal assistant**

An AI-based personal assistant can perform several tasks based on verbal or written commands, such as navigating the records or assessing if some person suffered a heart attack during an emergency call services. This is a good example of weak AI, as the algorithm has been created to perform a specific task. The best-known examples of AI assistants are Google, Alexa, and Siri. One of the most advantageous points about an AI assistant is that it serves as a great help in various applications of AI. As more and more consumers are using Virtual Personal Assistants, speech recognition has become essential in our lives. Phones, computers, and home appliances are increasing our dependence on AI and ML through voice. According to recent statistics, the AI assistant market is going to expand further and will become worth USD 25 billion by 2025.

1. **Robotics**

AI has a remarkable role in robotics. Manufacturing industries are adapting to incorporate the use of robots into their workflows. Earlier, the industrial robots were separated from human workers and programmed to perform single tasks. Today industrial robots function as cobots, which are smaller and multitasking robots. Such cobots can be used to take up the jobs in warehouses, industries, and other workspaces. Normally, robots are programmed to perform tasks that are repetitive in nature, but AI-based robots are used to perform several tasks with their own previous experience, and even without preprogramming. Humanoid robots are best examples of AI-based intelligent robots; like Erica and Sophia can talk and behave like humanbeings. Their sensors can detect physical data from the real world, such as light, sound, temperature, movement, and pressure, and these systems can learn from their past and apply that knowledge to the new environment. Industrial robots are used in the manufacturing fields as an alternative to humans. For example, such robots have been in use in the automobile manufacturing sector for quite some time, as some processes in car making may not be safe for humans. In 1961, Unimate, the first-ever industrial robot, was used by General Motors on an assembly line. Currently, the robots are used in warehouses for many other duties also. In 2014, Amazon has deployed Kiva robots in their centers’ warehouses, which are helping employees to fill orders very quickly (15 minutes) that humans alone can manage (90 minutes). These robots can pick up the items and transport the inventory directly to human workers. Programmed with object detection technology, these robots can move freely throughout the warehouse, avoiding potential collisions with other Kiva robots or human workers.

1. **Social media**

AI can be used to organize and manage large volumes of data efficiently. Social media sites like Facebook, Twitter, and Snapchat may contain profiles of large number of users, which are required to be stored and managed efficiently. The AI can analyze this huge block of data to identify the latest trends, hashtags, and requirements, among other things, of different users.

1. **Supermarkets (retail)**

Some large industries in the retail sector have started using AI-based robots to handle the tasks previously carried out by human customer associates. Stock inventories generally are time-consuming and require multiple employees to track items that need to be restocked so they can be reordered. Several supermarkets and other retail markets are now using robots to take stock inventory. For example, Walmart, a retail industry giant, and Bossa Nova, a robotics company, have teamed up to create a supermarket application. The Bossa Nova robot would be used to scan the shelves in real time to collect product data, doing so much faster than a human employee could. Such a robot aims to improve product availability, enhance customer experience, and reduce the workload of customer associates.

1. **Transportation and travel**

Demand for AI is also growing in travel industries. In addition to AI being used in autonomous vehicles, it is used to manage traffic, estimate flight delays, and many other tasks. It is also used in the travel insurance sector to file claims faster and more efficiently after the accidents. The AI can be used for making travel arrangements and suggesting accommodations, flights and best routes to its customers. Travel companies are employing AI-powered chatbots for faster response and better service for their customers.

1. **Vision systems**

Vision based algorithms are being developed to predict future actions of individuals. Machine vision can capture and analyze visual information using a camera and video and digital signal processing. These systems can understand, interpret, analyze, and display visuals. For instance, doctors can utilize expert system to operate on patients. Police can use them to recognize the faces of criminals based on drawings done by a forensic artist.

1. **Speech recognition**

Some AI-based systems can be used for hearing and comprehending the sentences and their meanings while a person is talking. These systems are capable of handling a variety of accents, slang words, background noise, change in a person’s voice due to an illness, and many more aspects.

1. **Handwriting recognition**

The algorithm is able to read the text written on paper using a pen or on screen using a stylus. In addition, it can also recognize letter shapes and convert them into editable text (Russel and Norvig, 2016).

**Modern Application of Machine Learning**

There is an increasing influence of machine learning applications in everyday life spanning from information technology, Healthcare, sports, banking and a lot more with many solutions already implemented and many more being explored. This study seeks to outline some key areas of machine learning applications as follows:

1. **Virtual personal**

A virtual assistant, also called AI assistant or digital assistant, is an application program that understands natural language voice commands and completes tasks for the user. Such tasks, historically performed by a personal assistant or secretary, include taking dictation, reading text or email messages aloud, looking up phone numbers, scheduling, placing phone calls and reminding the end user about appointments. Popular virtual assistants currently include Amazon Alexa, Apple's Siri, Google Assistant and Microsoft's Cortana and the digital assistant built into Windows Phone 8.1 and Windows 10. The capabilities and usage of virtual assistants are expanding rapidly, with new products entering the market and a strong emphasis on both email and voice user interfaces. Apple and Google have large installed bases of users on smartphones. Microsoft has a large installed base of Windowsbased personal computers, smartphones and smart speakers. Amazon has a large install base for smart speaker.

1. **Robot Control**

Robotic control is the system that contributes to the movement of robots. This involves the mechanical aspects and program systems that makes possible to control robots. A machine learning algorithm is used in a variety of robot control system. For instance, recently, several types of research have been working to gain control over stable helicopter flight and helicopter aerobatics. Another good example of robotic control is the Darpa-sponsored competition- a robot driving for over one hundred miles within the desert was won by a robot that used machine learning to refine its ability to notice distant objects.

1. **Online Customer Support**

Online Customer Services are automated services that helps customers solve problems. Such a service is usually connected to a business or brand which sells products and offers support. There are different types of online customer service, depending on the type of industry involved. Recently almost all websites allow the customer to chat with the website representative. However, not website has an executive. Basically, they develop a chat-bot to chat with the customer to know their opinion. This is possible only for the machine learning approach. It’s just a beauty of machine learning algorithm.

1. **Video Surveillance**

The video surveillance system nowadays are powered by Artificial Intelligence which is part of machine learning. This makes it possible to detect crime before they happen. They track unusual behaviour of people like standing motionless for a long time, stumbling, or napping on benches etc. The system can thus give an alert to human attendants, which can ultimately help to avoid mishaps. And when such activities are reported and counted to be true, they help to improve the surveillance services. This happens with machine learning doing its job at the backend. A small video file contains more information compared to text documents and other media files such as audio, images. For this reason, extracting useful information from video, i.e., the automated video surveillance system has become a hot research issue. With this regard, video surveillance is one of the advanced application of a machine learning approach. A system with the ability to gather information about the presence of the same person in a different frame of a video is highly demanding. There are several methods of machine learning algorithm to track the movement of human and identifying them.

1. **Medical Services**

Machine learning methods, tools are used extensively in the area of the medical-related problem. As an instance to detect a disease, therapy planning, medical-related research, prediction of the disease situation. The value of machine learning in healthcare is its ability to process huge datasets beyond the scope of human capability, and then reliably convert analysis of that data into clinical insights that aid physicians in planning and providing care, ultimately leading to better outcomes, lower costs of care, and increased. Some of the notable areas of applications in medical services include Identifying diseases and diagnosis, drug discovery and manufacturing, medical imaging diagnosis, personalized medicine, machine learning-based behavioral modification, smart health records, clinical trial and research and crowdsourced data collection.

1. **Email Spam and Malware Filtering**

There are a number of spam filtering approaches that email clients use. To ascertain that these spam filters are continuously updated, they are powered by machine learning. When rule-based spam filtering is done, it fails to track the latest tricks adopted by spammers. To classify email and filter the spam in an automatic way machine learning algorithm is employed. There are many techniques such as multilayer perception, C4.5 decision tree induction etc. used to filter the spam. The rule-based spam filtering has some drawbacks to filter the spam, whereas spam filtering using the machine Learning approach is more efficient.

1. **Speech Recognition**

One of the applications of Machine Learning is speech recognition. Speech recognition is the ability of a machine or program to identify words and phrases in spoken language and convert them to a machine-readable format. Alternatively referred to as, voice recognition is a computer software program or hardware device with the ability to decode the human voice. Voice recognition is commonly used to operate a device, perform commands, or write without having to use a keyboard, mouse, or press any buttons. All commercial purpose speech recognition system uses a machine learning approach to recognize the speech. This is because the speech recognition system using machine learning approach outperforms better than the speech recognition system using a traditional method.

1. **Online Fraud Detection**

Machine learning is proving its potential to make cyberspace a secure place and tracking monetary frauds online is one of its good applications. Online fraud detection is an advanced application of machine learning algorithm. This approach is practical to provide cybersecurity to the users efficiently. Recently, PayPal is using a machine learning and artificial intelligence algorithm for money laundering. This advanced machine learning and artificial intelligence example helps to reduce the loss and maximize the profit. Using machine learning in this application, the detection system becomes robust than any other traditional rule-based system.

1. **Image Recognition**

Image Recognition is one of the most significant Machine Learning and artificial intelligence applications. It is the process of identifying and detecting an object or a feature in a digital image or video. This concept is used in many applications like systems for factory automation, toll booth monitoring, and security surveillance. Typical image recognition algorithms include Optical character recognition, Object Recognition, Face Recognition, Scale-invariant Feature Transform, Speeded Up Robust Features, Principal Component Analysis and Linear Discriminant Analysis. This technique can be used for further analysis, such as pattern recognition, face detection, face recognition, optical character recognition, and many more.

1. **Social Media Services**

One key area of application of machine Learning is in Social media. Social Media Services also known as social networking site or social media are online platforms which people use to build social networks or social relationships with other people who share similar personal or career interests, activities, backgrounds or real-life connections. Common examples of social media services include Facebook, Twitter, Pinterest, Instagram, LinkedIn etc. Social media is using the machine learning approach to create attractive and splendid features, i.e. people you may know, suggestion, react options for their users. These features are just an outcome of the machine learning technique. Social media is using the machine learning approach to create attractive and splendid features, i.e. people you may know, suggestion and react options for their users.

## Importance and Impact of AI and ML

Every organization is challenged to remain competitive in the market, increasing revenue and reducing operating costs. AI is the single most powerful tool that organizations are using to make informed decisions, drive new lines of revenue, attract new customers and optimize costs of business operations. As you look forward to your organization's goals for 2021, implementing AI/ML systems might be something to consider. They provide the following benefits not just for this year but in the future as well:

1. **Increase organizational performance**

In the context of AI increasing organizational performance, a question to consider is, "How is AI automating a manual process or improving interdepartmental processes?" There are several use cases of AI-related technologies — such as ML, deep learning and natural language processing (NLP) — that could be used to produce reliable, relevant, dynamic and intelligent information that can help with decision making. One example is the use of NLP-based chatbots in customer service that can be used to answer most questions by a customer and, in case of a complex query, can seamlessly pass it on to a human representative. They also offer backend integrations with APIs with their case management or ERP systems.

1. **Launch innovative products**

Being competitive in the marketplace is imperative for every commercial organization in the post-pandemic world. One way enterprises are using AI is to launch new product lines to capture market share or establish new lines of revenue. Under Armour, the fitness brand, uses machine learning to automatically identify precise user segments to create highly customized fitness recommendations. This gives Under Armour a competitive edge in the marketplace in terms of new and innovative product offerings.

1. **Reduce operational costs**

As companies work toward regaining their foothold in a post-pandemic world, one of the key focus areas would be to reduce operating costs. In general, the increased adoption of AI can be attributed to automating manual or statistics-driven tasks that save time on repetitive tasks and increases focus on high-value jobs. Use cases of machine learning that most commonly led to cost decreases are optimization of inventory or pricing, contact-center automation and claims processing.

1. **Meet customer expectations**

The benefits of AI/ML in analytics are also prevalent in customer-focused initiatives. Let’s face it, the modern average customer comes to expect a more personalized experience. Machine learning and artificial intelligence solutions can help to personalize offerings. With the benefits of AI/ML, these personalized offerings are able to attract and retain customers more than traditional selling. Advanced analytics with AI/ML are essential to digital marketing, with the realization that customers are actually more likely to purchase products if they’re personalized. Transforming the customer experience is not the only benefit of AI/ML in analytics. Companies can use these tools to set dynamic pricing automation and even train chatbots to answer customer questions.

1. **Introduce new lines of revenue**

While most enterprises benefit from the cost savings that machine learning applications provide, there are some examples of ML systems that can bring in new revenue lines. One such example is Australia's leading energy company, AGL. For the past three years, AGL has been using machine learning in various innovative ways to manage and analyze its 3.7 million customers' energy usage. They used this to enable a new product called "virtual power plant" to allow customers to give back energy to the grid. This product has helped AGL generate additional revenue. AI and ML applications provide incredible opportunities — both in cost savings and revenue growth, depending on the use case. Organizations that have implemented machine learning algorithms in the last three to five years see a return on investment today. If your enterprise has not included AI/ML in your business strategy, it is time to consider focusing on it in 2021 to remain competitive in the marketplace as well as generate new lines of revenue while meeting customer expectations.

### AI and ML in Customer Service and Marketing

AI and machine learning (ML) are transforming the way businesses interact with their customers, particularly in the areas of customer service and marketing. Here are some of the ways that AI and ML are being used in these areas:

* **Chatbots and Virtual Assistants:** AI-powered chatbots and virtual assistants can provide 24/7 customer support, handle a high volume of customer inquiries, and support multiple languages. This can improve the customer experience and reduce the workload of human customer support representatives.
* **Personalization and Targeting:** AI and ML algorithms can analyze customer data and personalize product recommendations and marketing campaigns, resulting in improved customer engagement and satisfaction.
* **Predictive Analytics:** AI and ML can be used to analyze large amounts of customer data and predict future trends and behaviors, allowing businesses to make informed decisions and optimize their marketing strategies.
* **Sentiment Analysis:** AI and ML can be used to analyze customer feedback and sentiment, allowing businesses to better understand their customers and make improvements to their products and services.

Overall, AI and ML are enabling businesses to provide a more personalized and efficient customer experience, as well as gain valuable insights into customer behavior and preferences. This is helping companies to build stronger relationships with their customers and drive long-term growth and success.

### Disrupting Traditional Industries with AI and ML

AI and machine learning (ML) have the potential to disrupt traditional industries in a big way, by transforming the way that businesses operate and compete. Here are some examples of how AI and ML are disrupting traditional industries:

* Healthcare: AI and ML are being used to improve patient outcomes by analyzing vast amounts of medical data to develop new treatment options and predict patient outcomes.
* **Finance:** AI and ML algorithms are being used to detect fraud, automate back-office tasks, and personalize financial products and services, improving the customer experience and reducing costs.
* **Retail:** AI and ML are being used to personalize product recommendations, automate supply chain processes, and improve the customer experience, enabling retailers to compete more effectively in an increasingly digital marketplace.
* **Manufacturing:** AI and ML are being used to optimize production processes, reduce waste, and improve product quality, helping manufacturers to stay competitive and drive innovation.
* **Date Labelling and Annotation:** At the heart of these advancements in AI and ML lies the critical process of data labeling and annotation. High-quality image annotation services are fundamental in training AI systems to recognize patterns and make informed decisions. By accurately labeling and annotating images, businesses can significantly improve the performance of their AI models, leading to more precise predictions and outcomes. This is especially relevant in industries like healthcare, where AI-driven image analysis can revolutionize diagnostics and treatment plans, and in autonomous vehicle technology, where accurate image interpretation is critical for safety.

Overall, AI and ML are enabling businesses to transform traditional industries by optimizing operations, improving the customer experience, and driving innovation. This is leading to new business models, increased competition, and improved outcomes for customers.

### Overcoming Challenges in Adopting AI and ML

While the potential benefits of AI and machine learning (ML) are significant, there are also many challenges that organizations must overcome in order to successfully adopt these technologies. Here are some of the biggest challenges and ways to overcome them:

* **Data Quality and Availability:** AI and ML algorithms require large amounts of high-quality data to be effective. Ensuring that data is accurate, complete, and consistent is a critical first step in successfully adopting these technologies.
* **Technical Skills and Expertise:** AI and ML technologies are complex, and organizations often struggle to find the technical skills and expertise required to implement and operate these systems. Investing in training and upskilling employees can help organizations overcome this challenge.
* **Integration with Existing Systems:** AI and ML systems must be integrated with existing systems and processes in order to deliver value. Ensuring that these systems are compatible and can work together is a critical step in successful adoption.
* Ethical and Regulatory Concerns: There are ethical and regulatory concerns associated with AI and ML, particularly with regards to data privacy and bias. Organizations must be mindful of these concerns and implement appropriate safeguards to mitigate risks.
* **Resistance to Change:** Change is always difficult, and many organizations may be resistant to adopting new technologies like AI and ML. Communicating the benefits and addressing concerns is key to overcoming this challenge and driving successful adoption.

Overall, while the challenges of adopting AI and ML are significant, they can be overcome through careful planning, investment in skills and expertise, and a commitment to driving positive change. With the right approach, organizations can reap the significant benefits of these technologies and transform their operations and compete more effectively in the marketplace.

## The Importance of Ethical AI

1. **Societal Impact**

The omnipresence of AI systems and their far-reaching societal implications cannot be overstated. They wield the potential to revolutionize economies, influence political landscapes, and reshape cultural norms. Such transformative power necessitates a concurrent commitment to the ethical governance of AI, for its unchecked proliferation can inadvertently breed unintended consequences, often impacting marginalized communities disproportionately.

1. **Responsible Innovation**

Ethical AI is not merely a moral compass but a prerequisite for responsible innovation. The notion of 'dual use' technology underscores the duality of AI's capabilities - a tool that can be harnessed for societal good or wielded for nefarious purposes. With responsible innovation, we seek to harness AI's potential while mitigating its potential for harm.

1. **Ethical vs. Unethical AI**

Distinguishing between ethical and unethical AI entails a nuanced exploration of the principles governing AI development and application. Ethical AI adheres to fundamental tenets such as fairness, transparency, accountability, and privacy. These principles guide AI systems to maximize benefits while minimizing harm. Conversely, unethical AI disregards these principles, resulting in dire consequences, often manifesting as bias, discrimination, and disregard for individual liberties.

### Ethical Principles and Frameworks

1. **Fairness**

Fairness in AI is a foundational ethical principle, obliging AI systems to treat all individuals equitably. Achieving fairness, however, is a complex endeavor, marred by challenges in data collection, algorithmic bias, and defining fairness metrics. The concept of algorithmic fairness necessitates critical examination, as it seeks to rectify the deeply entrenched biases present in many AI systems.

1. **Transparency and Explainability**

Transparency and explainability are vital prerequisites in AI ethics. The black-box nature of deep learning models demands greater scrutiny, for opaque AI systems can lead to a lack of accountability and trust. Thus, the pursuit of model transparency and explainability is not only ethically imperative but also essential for fostering public acceptance of AI technologies.

1. **Accountability**

In the realm of AI, accountability extends beyond legal liability to encompass a moral obligation to rectify harm caused by AI systems. Defining accountability in AI is a multifaceted challenge, owing to the distributed nature of decision-making in machine learning models. Ethical frameworks such as consequentialism and deontology provide valuable perspectives on AI accountability.

1. **Privacy and Data Protection**

Privacy, a fundamental human right, confronts profound ethical challenges in the age of AI. Data collection, storage, and utilization by AI systems raise intricate questions about consent, anonymization, and data protection. Legal instruments like the General Data Protection Regulation (GDPR) represent significant steps toward safeguarding individual privacy in AI applications.

### Ethical Challenges in AI and Machine Learning

* **Bias and Discrimination:** The phenomenon of bias in AI represents a grave ethical challenge. This bias can emerge from historical data, encoding societal prejudices into algorithms, and leading to discriminatory outcomes. These issues manifest in contexts as diverse as employment decisions, lending practices, and criminal justice systems, necessitating ethical considerations to rectify systemic disparities.
* **Job Displacement and Economic Impact:** The ethical implications of AI extend to economic dimensions, particularly job displacement. Automation driven by AI threatens certain job sectors, raising questions about societal responsibility for displaced workers. Approaches like universal basic income (UBI) and robust retraining programs emerge as potential ethical solutions to mitigate these impacts.
* **Autonomous Decision-Making:** AI's growing role in autonomous decision-making, whether in medical diagnoses or autonomous vehicles, poses intricate ethical dilemmas. The 'trolley problem' in autonomous vehicles and the ethical quandaries of AI in healthcare underscore the urgency of defining ethical boundaries for AI's autonomous decision-making processes. The alignment of AI's values with human values is at the heart of these challenges (Torshin, 2023).

**PART-1: VERY SHORT QUESTIONS**

1. What is AI and how does it differ from traditional computing?
2. Can you explain the concept of ML in simple terms?
3. What are some key milestones in the historical development of ML?
4. How is AI and ML applied in real-world scenarios such as healthcare or finance?
5. What are the significant impacts of AI and ML on industries like manufacturing and transportation?
6. How do ethical considerations come into play when designing AI and ML systems?
7. What are some examples of bias or discrimination that can arise in AI algorithms?
8. How do regulations and policies address the ethical concerns surrounding AI and ML?
9. In what ways can AI and ML contribute positively to society and the environment?
10. What steps can be taken to ensure responsible deployment and use of AI and ML technologies?

**PART-2: SHORT QUESTIONS**

1. What is the fundamental concept behind Artificial Intelligence?
2. How does Machine Learning differ from traditional programming approaches?
3. Can you provide a brief historical overview of Machine Learning development?
4. What are some real-world applications of Artificial Intelligence?
5. How do Artificial Intelligence and Machine Learning impact various industries?
6. What ethical considerations should be taken into account in the development and deployment of AI and ML technologies?
7. How do AI and ML influence job markets and employment patterns?
8. What are some potential risks associated with the widespread adoption of AI and ML?
9. How can AI and ML be used to address societal challenges such as healthcare or climate change?
10. In what ways can individuals and organizations ensure responsible and ethical use of AI and ML systems?

**PART-3: LONG QUESTIONS**

1. In the realm of "What is Artificial Intelligence," could you delve into the philosophical and technical underpinnings that distinguish narrow AI from general AI, and how advancements in each contribute to our understanding of intelligence?
2. When exploring "Understanding Machine Learning," can you elaborate on the various types of machine learning paradigms such as supervised, unsupervised, and reinforcement learning, and how they differ in their approaches to problem-solving and decision-making?
3. Could you provide a comprehensive "Historical Overview of ML," tracing the evolution of machine learning from its inception to modern breakthroughs, highlighting key milestones, influential researchers, and pivotal moments that have shaped its development?
4. Within the domain of "Applications of AI and ML," can you elucidate on the diverse range of sectors and industries where AI and ML technologies are making significant impacts, including but not limited to healthcare, finance, autonomous vehicles, and natural language processing?
5. Considering the "Importance and Impact of AI and ML," could you discuss the transformative potential of these technologies in reshaping economies, labor markets, and societal structures, while also addressing concerns such as job displacement, privacy breaches, and economic inequality?

**PART-4: MCQ QUESTIONS**

1. What is the primary goal of Artificial Intelligence (AI)?
2. To replicate human intelligence entirely
3. To automate tasks using computers
4. To develop robots with emotions
5. To create self-aware machines
6. Which of the following best defines Machine Learning (ML)?
7. A subset of AI focused on building intelligent systems that can learn from data
8. A branch of computer science solely dedicated to robotics
9. An approach to mimic human behavior in machines
10. A technique for programming computers to think logically
11. In the historical context of Machine Learning, what was the significance of Arthur Samuel's work in the 1950s?
12. He developed the first neural network model.
13. He coined the term "Machine Learning."
14. He created the first chatbot.
15. He designed the first self-driving car prototype.
16. Which of the following is an application of Artificial Intelligence and Machine Learning in healthcare?
17. Autonomous vehicles
18. Social media platforms
19. Predictive analytics for disease diagnosis
20. Online shopping recommendations
21. What is the importance of Artificial Intelligence and Machine Learning in business?
22. They eliminate the need for human workers.
23. They reduce operational costs and increase efficiency.
24. They solely focus on generating profits without considering ethical implications.
25. They limit innovation and creativity in decision-making processes.
26. What ethical considerations should be taken into account in the development of Artificial Intelligence and Machine Learning systems?
27. Bias in algorithms, data privacy, and societal impact
28. Speed of computation, hardware specifications, and software licensing
29. Corporate profits, market dominance, and product branding
30. Intellectual property rights, patents, and copyright infringement
31. Which of the following is an example of bias in AI and ML algorithms?
    1. Providing personalized recommendations based on user preferences
    2. Facial recognition systems misidentifying individuals with darker skin tones
    3. Autonomous vehicles reducing traffic accidents
    4. Natural language processing improving customer service interactions
32. What impact does the widespread adoption of Artificial Intelligence and Machine Learning have on the job market?
    1. It leads to mass unemployment due to the replacement of human workers by machines.
    2. It creates new job opportunities in the field of AI and ML but requires upskilling and reskilling.
    3. It guarantees job security for all workers regardless of their skill level.
    4. It doesn't affect the job market significantly as AI and ML are still in experimental stages.
33. How do Artificial Intelligence and Machine Learning contribute to environmental sustainability?
34. By increasing energy consumption through data centers
35. By optimizing resource usage and reducing waste in various industries
36. By accelerating deforestation and habitat destruction
37. By promoting overconsumption and unsustainable production practices
38. What role do regulatory bodies and policymakers play in governing the ethical use of Artificial Intelligence and Machine Learning?
39. They have no influence on the development and deployment of AI and ML systems.
40. They establish guidelines and regulations to ensure ethical practices and mitigate potential risks.
41. They prioritize technological advancement over ethical considerations.
42. They solely rely on industry self-regulation without intervention.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| b | a | b | c | b | a | b | b | b | b |

# CHAPTER 2

# FOUNDATIONS OF MACHINE LEARNING

## Basic Concepts in Machine Learning

Machine Learning is continuously growing in the IT world and gaining strength in different business sectors. Although Machine Learning is in the developing phase, it is popular among all technologies. It is a field of study that makes computers capable of automatically learning and improving from experience. Hence, Machine Learning focuses on the strength of computer programs with the help of collecting data from various observations. In this article, ''Concepts in Machine Learning'', we will discuss a few basic concepts used in Machine Learning such as what is Machine Learning, technologies and algorithms used in Machine Learning, Applications and example of Machine Learning, and much more. So, let's start with a quick introduction to machine learning. Machine Learning is defined as a technology that is used to train machines to perform various actions such as predictions, recommendations, estimations, etc., based on historical data or past experience. Machine Learning enables computers to behave like human beings by training them with the help of past experience and predicted data. There are three key aspects of Machine Learning, which are as follows:

* **Task:** A task is defined as the main problem in which we are interested. This task/problem can be related to the predictions and recommendations and estimations, etc.
* **Experience:** It is defined as learning from historical or past data and used to estimate and resolve future tasks.
* **Performance:** It is defined as the capacity of any machine to resolve any machine learning task or problem and provide the best outcome for the same. However, performance is dependent on the type of machine learning problems.

## Supervised Learning: Algorithms

The major motivation of supervised learning is to learn from past information. So what kind of past information does the machine need for supervised learning? It is the information about the task which the machine has to execute. In context of the definition of machine learning, this past information is the experience. Let’s try to understand it with an example Say a machine is getting images of different objects as input and the task is to segregate the images by either shape or colour of the object. If it is by shape, the images which are of round-shaped objects need to be separated from images of triangular-shaped objects, etc. If the segregation needs to happen based on colour, images of blue objects need to be separated from images of green objects. But how can the machine know what is round shape, or triangular shape? Same way, how can the machine distinguish image of an object based on whether it is blue or green in colour? A machine is very much like a little child whose parents or adults need to guide him with the basic information on shape and colour before he can start doing the task. A machine needs the basic information to be provided to it. This basic input, or the experience in the paradigm of machine learning, is given in the form of training data . Training data is the past information on a specific task. In context of the image segregation problem, training data will have past data on different aspects or features on a number of images, along with a tag on whether the image is round or triangular, or blue or green in colour. The tag is called ‘ label’ and we say that the training data is labelled in case of supervised learning.

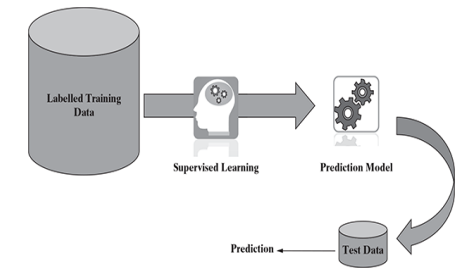


Figure 2.1: supervised learning (Eni, 1967)

Figure 1.4 is a simple depiction of the supervised learning process. Labelled training data containing past information comes as an input. Based on the training data, the machine builds a predictive model that can be used on test data to assign a label for each record in the test data.

**Algorithm:**

Many classification algorithms have been proposed in the machine learning and data science literature. In the following, summarize the most common and popular methods that are used widely in various application areas.

1. **Naive Bayes (NB)**

The naive Bayes algorithm is based on the Bayes’ theorem with the assumption of independence between each pair of features. It works well and can be used for both binary and multi-class categories in many real-world situations, such as document or text classification, spam filtering, etc. To effectively classify the noisy instances in the data and to construct a robust prediction model, the NB classifier can be used. The key benefit is that, compared to more sophisticated approaches, it needs a small amount of training data to estimate the necessary parameters and quickly. However, its performance may affect due to its strong assumptions on features independence. Gaussian, Multinomial, Complement, Bernoulli, and Categorical are the common variants of NB classifier.

1. **Linear Discriminant Analysis (LDA)**

Linear Discriminant Analysis (LDA) is a linear decision boundary classifier created by fitting class conditional densities to data and applying Bayes’ rule. This method is also known as a generalization of Fisher’s linear discriminant, which projects a given dataset into a lower-dimensional space, i.e., a reduction of dimensionality that minimizes the complexity of the model or reduces the resulting model’s computational costs. The standard LDA model usually suits each class with a Gaussian density, assuming that all classes share the same covariance matrix. LDA is closely related to ANOVA (analysis of variance) and regression analysis, which seek to express one dependent variable as a linear combination of other features or measurements.

1. **K-nearest neighbors (KNN)**

K-Nearest Neighbors (KNN) is an “instance-based learning” or non-generalizing learning, also known as a “lazy learning” algorithm. It does not focus on constructing a general internal model; instead, it stores all instances corresponding to training data in n-dimensional space. KNN uses data and classifies new data points based on similarity measures (e.g., Euclidean distance function). Classification is computed from a simple majority vote of the k nearest neighbors of each point. It is quite robust to noisy training data, and accuracy depends on the data quality. The biggest issue with KNN is to choose the optimal number of neighbors to be considered. KNN can be used both for classification as well as regression.

1. **Support vector machine (SVM)**

In machine learning, another common technique that can be used for classification, regression, or other tasks is a support vector machine (SVM) [56]. In high- or infinite-dimensional space, a support vector machine constructs a hyper-plane or set of hyper-planes. Intuitively, the hyper-plane, which has the greatest distance from the nearest training data points in any class, achieves a strong separation since, in general, the greater the margin, the lower the classifier’s generalization error. It is effective in high-dimensional spaces and can behave differently based on different mathematical functions known as the kernel. Linear, polynomial, radial basis function (RBF), sigmoid, etc., g (1) (z) = 1 1 + exp(−z) . are the popular kernel functions used in SVM classifier. However, when the data set contains more noise, such as overlapping target classes, SVM does not perform well.

1. **Decision tree (DT)**

Decision tree (DT) is a well-known non-parametric supervised learning method. DT learning methods are used for both the classification and regression tasks. ID3, C4.5, and CART are well known for DT algorithms. Moreover, recently proposed BehavDT, and IntrudTree by Sarker are effective in the relevant application domains, such as user behavior analytics and cybersecurity analytics, respectively. By sorting down the tree from the root to some leaf nodes. DT classifies the instances. Instances are classified by checking the attribute defined by that node, starting at the root node of the tree, and then moving down the tree branch corresponding to the attribute value.

1. **Random forest (RF)**

A random forest classifier is well known as an ensemble classification technique that is used in the field of machine learning and data science in various application areas. This method uses parallel ensembling” which fts several decision tree classifiers in parallel, on different data set sub-samples and uses majority voting or averages for the outcome or final result. It thus minimizes the over-ftting problem and increases the prediction accuracy and control. Therefore, the RF learning model with multiple decision trees is typically more accurate than a single decision tree based model. To build a series of decision trees with controlled variation, it combines bootstrap aggregation (bagging) and random feature selection. It is adaptable to both classification and regression problems and fts well for both categorical and continuous values.

1. **Logistic regression (LR)**

Another common probabilistic based statistical model used to solve classification issues in machine learning is Logistic Regression (LR). Logistic regression typically uses a logistic function to estimate the probabilities, which is also referred to as the mathematically defined sigmoid function. It can overfit high-dimensional datasets and works well when the dataset can be separated linearly. The regularization (L1 and L2) techniques can be used to avoid over-ftting in such scenarios. The assumption of linearity between the dependent and independent variables is considered as a major drawback of Logistic Regression. It can be used for both classification and regression problems, but it is more commonly used for classification.

### Advantages of Supervised Learning

The power of supervised learning lies in its ability to accurately predict patterns and make data-driven decisions across a variety of applications. Here are some advantages listed below:

* Labeled training data benefits supervised learning by enabling models to accurately learn patterns and relationships between inputs and outputs.
* Supervised learning models can accurately predict and classify new data.
* Supervised learning has a wide range of applications, including classification, regression, and even more complex problems like image recognition and natural language processing.
* Well-established evaluation metrics, including accuracy, precision, recall, and F1-score, facilitate the assessment of supervised learning model performance.

### Disadvantages of Supervised Learning

Although supervised learning methods have benefits, their limitations require careful consideration during problem formulation, data collection, model selection, and evaluation. Here are some disadvantages listed below:

* **Overfitting:** Models can overfit training data, which leads to poor performance on new, unseen data due to the capture of noise.
* **Feature Engineering:** Extracting relevant features from raw data is crucial for model performance, but this process can be time-consuming and may require domain expertise.
* **Bias in Models**: Training data biases can lead to unfair predictions.
* Supervised learning heavily depends on labeled training data, which can be costly, time-consuming, and may require domain expertise.

## Unsupervised Learning: Principles and Algorithms

In unsupervised learning, a machine is trained with some input samples or labels only, while output is not known. The training information is neither classified nor labeled; hence, a machine may not always provide correct output compared to supervised learning. Although Unsupervised learning is less common in practical business settings, it helps in exploring the data and can draw inferences from datasets to describe hidden structures from unlabeled data. Unsupervised learning works by analyzing unlabeled data to identify patterns and relationships. The data is not labeled with any predefined categories or outcomes, so the algorithm must find these patterns and relationships on its own. This can be a challenging task, but it can also be very rewarding, as it can reveal insights into the data that would not be apparent from a labeled dataset.

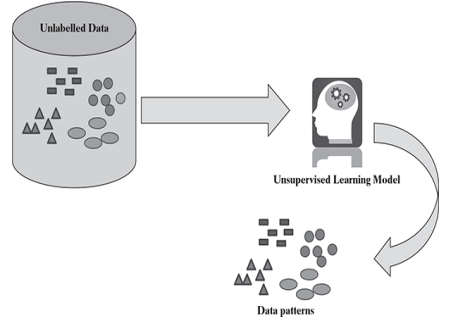


Figure 2.2: unsupervised learning (Eni, 1967)

Unsupervised learning’s primary objective is to obtain a deeper understanding of the data by recognising its basic structure or pattern of distribution. The algorithm tries to represent a specific detected input pattern while reflecting it on the general structure of input patterns as it learns on its own. As a result, the various inputs are grouped depending on the features that were taken from each input item. Unsupervised learning is used to solve association and clustering issues. Unsupervised learning is used to extract features from unlabelled data and categorise or label them when the input data are not labelled. Many unsupervised algorithms are currently being used in the digital advertising and marketing space. They are used to analyse the available customer-centric data and adapt services to individual customers. Further, it might help identify potential customers. There are mainly 3 types of Algorithms which are used for Unsupervised dataset.

1. **Clustering**

Clustering in unsupervised machine learning is the process of grouping unlabeled data into clusters based on their similarities. The goal of clustering is to identify patterns and relationships in the data without any prior knowledge of the data’s meaning. Broadly this technique is applied to group data based on different patterns, such as similarities or differences, our machine model finds. These algorithms are used to process raw, unclassified data objects into groups. For example, in the above figure, we have not given output parameter values, so this technique will be used to group clients based on the input parameters provided by our data.

1. **Association Rule Learning**

Association rule learning is also known as association rule mining is a common technique used to discover associations in unsupervised machine learning. This technique is a rule-based ML technique that finds out some very useful relations between parameters of a large data set. This technique is basically used for market basket analysis that helps to better understand the relationship between different products. For e.g. shopping stores use algorithms based on this technique to find out the relationship between the sale of one product w.r.t to another’s sales based on customer behavior. Like if a customer buys milk, then he may also buy bread, eggs, or butter. Once trained well, such models can be used to increase their sales by planning different offers.

1. **Dimensionality Reduction**

Popular algorithms used for dimensionality reduction include principal component analysis (PCA) and Singular Value Decomposition (SVD). These algorithms seek to transform data from high-dimensional spaces to low-dimensional spaces without compromising meaningful properties in the original data. These techniques are typically deployed during exploratory data analysis (EDA) or data processing to prepare the data for modeling. It’s helpful to reduce the dimensionality of a dataset during EDA to help visualize data: this is because visualizing data in more than three dimensions is difficult. From a data processing perspective, reducing the dimensionality of the data simplifies the modeling problem. When more input features are being fed into the model, the model must learn a more complex approximation function. This phenomenon can be summed up by a saying called the “curse of dimensionality.”

1. **Principal Component Analysis (PCA)**

The PCA (principal component analysis), which is one of the most popular and common methods for decreasing dimensionality, is probably the best known. The algorithm intend to is the reduction of the data dimensional range by removing contributions of singular variance source. Karl Pearson launched it in 1901, and it has now been used intensively in many areas of science, such as signal processing and image processing. It is also frequently used in the medical field where only a few cases and a large number of factors are available in order to studying patients data sets. In PCA the initial variables are managed by a set of linear combinations called principal components, which are obtained orthogonally. Among them, they include the elements of the factors that can not be ignored in observing the Full range of the data. The primary aim in the first principal component is to take the largest portion of the variance, and the subsequent components will follow in this order.

1. **Kernel Principal Component Analysis (KPCA)**

Kernel KPCA is an upgrade to PCA that avoids the problems with linear methods by nonlinearly mapping data onto a higher-dimensional feature space. Since its proposal in 1998 KPCA has become widely used in several fields, including as signal processing, bioinformatics, and computer vision. Using the dataset's nonlinear patterns and interactions, KPCA attempts to discover a low-dimensional representation of the data. It does this by using a technique known as the kernel trick.

1. **Linear Optimal Low-Rank (LOL)**

One dimensionality reduction method that builds on PCA by adding class-conditional means is Linear Optimal Low-Rank (LOL). This approach outperforms existing dimensionality reduction techniques and has demonstrated effectiveness with imaging and genetics data. LOL and SLMVP represent few of the supervised techniques that have been developed. When dealing with input data that has a small number of features (less than 100 million) and a big number of features (hundreds of millions), LOL was created to improve LDA's accuracy and efficiency. This is known as the "large p, small n" problem, and it negatively affects the performance of classifiers, often making them overfit.

1. **Locality Preserving Projection (LPP)**

One way to reduce the number of dimensions is by using LPP. This method attempts to keep the local relationships and structure of the data in a lower-dimensional environment. Using the data set's surrounding areas as building blocks, it constructs a graph that we'll call a similarity matrix W. An image of the graph's Laplacian is used to calculate a transformation matrix that assigns each data point to a spatial subspace. This linear translation keeps all the information about the immediate area.

1. **Locally Linear Embedding (LLE)**

An effective nonlinear dimensionality reduction method, Locally Linear Embedding (LLE) seeks to maintain the data's local structure in a space with less dimensions. Many areas have taken an interest in LLE since its introduction in 2000 by Sam T. Roweis and Lawrence K. Saul. These areas include manifold learning, data visualisation, computer vision, and computer vision.

### Challenges of Unsupervised Learning

Here are the key challenges of unsupervised learning

* **Evaluation:** Assessing the performance of unsupervised learning algorithms is difficult without predefined labels or categories.
* **Interpretability:** Understanding the decision-making process of unsupervised learning models is often challenging.
* **Overfitting:** Unsupervised learning algorithms can overfit to the specific dataset used for training, limiting their ability to generalize to new data.
* **Data quality:** Unsupervised learning algorithms are sensitive to the quality of the input data. Noisy or incomplete data can lead to misleading or inaccurate results.
* **Computational complexity:** Some unsupervised learning algorithms, particularly those dealing with high-dimensional data or large datasets, can be computationally expensive.

### Applications of Unsupervised learning

Most executives would have no problem identifying use cases for supervised machine learning tasks; the same cannot be said for unsupervised learning. One reason this may be is down to the simple nature of risk. Unsupervised learning introduces much more risk than unsupervised learning since there’s no clear way to measure results against ground truth in an offline manner, and it may be too risky to conduct an online evaluation. Nonetheless, there are several valuable unsupervised learning use cases at the enterprise level. Beyond using unsupervised techniques to explore data, some common use cases in the real-world include:

* **Customer segmentation:** Unsupervised learning can be used to segment customers into groups based on their demographics, behavior, or preferences. This can help businesses to better understand their customers and target them with more relevant marketing campaigns.
* **Fraud detection:** Unsupervised learning can be used to detect fraud in financial data by identifying transactions that deviate from the expected patterns. This can help to prevent fraud by flagging these transactions for further investigation.
* **Recommendation systems:** Unsupervised learning can be used to recommend items to users based on their past behavior or preferences. For example, a recommendation system might use unsupervised learning to identify users who have similar taste in movies, and then recommend movies that those users have enjoyed.
* **Natural language processing (NLP):** Unsupervised learning is used in a variety of NLP tasks, including topic modeling, document clustering, and part-of-speech tagging.
* **Image analysis:** Unsupervised learning is used in a variety of image analysis tasks, including image segmentation, object detection, and image pattern recognition.

## Reinforcement Learning: Principles and Applications

Recently, reinforcement learning has exploded through the birth of many challenging projects. Robotic arm manipulation, 1v1 Dota, and vintage Atari games are one of the most important implementations using reinforcement and deep reinforcement learning. Moreover, the winnings of supervised deep learning have continued to cumulate, giving the example of the ImageNet classification challenge in 2012. In addition, researchers from many areas have been involved in deep neural networks to solve an important range of new projects such as comprehending intelligent attitudes and actions within a convoluted dynamic environment. Reinforcement learning is considered as a subfield of machine learning and is considered one of the most favorable and helpful orientations to attain a high level of intelligence in robotics behavior. Nearly every researcher uses supervised learning in machine learning projects and application, where an input is given to the neural network model while knowing exactly what output the model should produce, subsequently, gradients will be calculated by utilizing the backpropagation method to train the network to output the results. Unfortunately, by using supervised learning elements should be collected in the created dataset. This step of the process is not always easy for doing, regarding the amount number of elements that should be gathered in the dataset. Furthermore, the neural network will be trained to straightforwardly emulate the human player records and actions, knowing that an agent can never perform well at playing compared to a human. Thereafter, reinforcement learning remains the idealistic choice to handle the issue of an agent being a better player than a human gamer, and also to learn how to play it by itself with no human interaction. Reinforcement learning and the normal framework of supervised learning are similar, we constantly have an input frame that is run through certain neural network models, and afterward, the network generates an output action. In reinforcement learning, and owing to the absence of a dataset it’ll be impossible to recognize the target label, unlike supervised learning. Likewise, a Policy Network is defined as a network that modifies input frames to output actions, and among the uncomplicated ways or techniques to train the Policy Network is by employing the Policy Gradient. Moreover, the output of the network will consist of two numbers, the probability of each decision, and what to do while training. In reinforcement learning we want to authorize the agent to acquire knowledge completely by itself, the only given feedback, in this case, is the scoreboard. The agent in this process receives a reward of (+1) whenever it achieves to mark or score a goal, or else, in the case when the opponent was the first to score the goal, the agent is then rewarded with a penalty of (-1). The noteworthy aim of the agent is to optimize its policy to increase the amount received rewards. The policy network will be trained by first of all gathering a bunch of experiences by running a whole set of game frames through the network. Then, pick out random actions and feed them back into the system as shown in Figure 1.

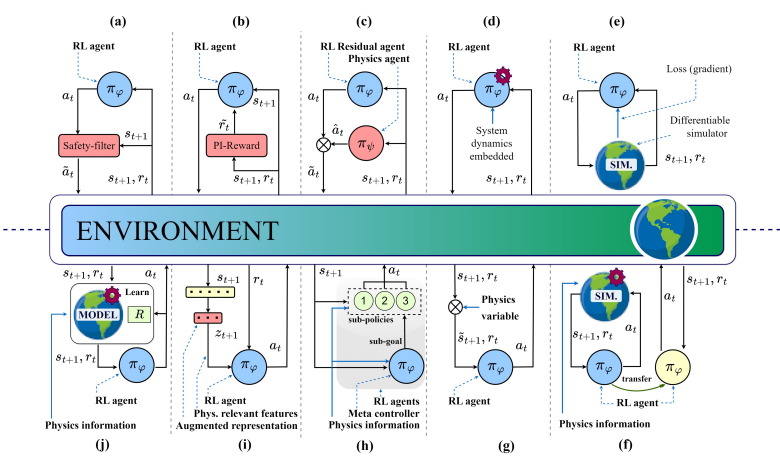


Figure 2.2: Reinforcement learning architecture (Banerjee *et al.*, 2023)

The agent is randomly going to select a whole succession of actions that lead to scoring a goal. Multiple sequences of actions will be selected randomly by the agent to score goals, subsequently, it will receive a reward. A key thing to retain here is that for each episode, and in any case, we can calculate the gradients to make the agent’s action, either we need a positive or a negative reward. Ordinarily, the normal gradients are chosen to increment the likelihood of the taken actions in the future. The same gradient will also be used but this time multiplied by (-1) whenever we obtain an unfavorable reward. In this case, and by using this minus sign, every action that is taken in a bad episode will be less likely. Consequently, during the policy network training all the actions that lead to an unfavorable or negative reward will be filtered out, thereafter, the positive ones will be more likely. However, the problem with policy gradients is that if in an episode the agent was lucky by taking good actions, it did badly in the last one. In this case, the gradient policy is going to presume that since that episode is missed, every taken action must be bad and reduce the probability of taking those actions in the future. In reinforcement learning, this is called the “Credit Assignment problem”.

This issue is entirely related to the fact that we have what it’s called a “Sparse Reward setting”. Rather than gaining a reward for every single action, we only acquire a reward posterior to an entire episode, and the agent needs to find out in what part of its action sequence the reward has been created. In reinforcement learning, algorithms, must have a training time before they can learn some useful behavior. In some extreme cases, the sparse reward setting fails; a famous example is the Montezuma’s Revenge game, where the main motivation of the agent is to navigate a bunch of stairs, leap over the skull, snatch a key and navigate to the way out to get to the following stage. The problem here is that by taking random actions, the agent is never going to see a singular reward; and that is due to the succession of actions that it needs to take to get that reward that is so complicated. That means that the policy gradient is never going to see a single positive reward. The traditional approach to solve this issue of sparse rewards has been the employment of ‘Reward Shaping’ which is the process of manually designing the reward function which needs to guide the policy to some required attitude. For the Montezuma’s game, the agent could be rewarded every single time it manages to avoid the skull or reach the key. Posteriorly, these additional rewards will guide the policy to some desired behavior. Nevertheless, there are some significant downsides to reward shaping. Firstly, reward shaping is a custom process that needs to be redone for every novel environment, and the second problem is that reward shaping suffers from what is called alignment.

**REINFORCEMENT LEARNING ALGORITHMS**

One of the most important perspectives in reinforcement learning is that of an agent. In certain circles, it is also referred to as the learner and the decision maker. All things that are not under the control of the agent are regarded to fall into the agent's realm. Combining this area of the Reinforcement Learning architecture with trial-and-error encounters makes it a powerful tool for translating all situations to actions. Through the use of the single-agent and multi-agent frameworks, which are distinct from one another in terms of their characteristics, these actions are carried out. The traditional single agent is dependent on the Markov property; however, in the multi-agent framework, additional adjusting agents are also utilised, which causes the environment to become unstable. This violates the Markov property. Multiple reinforcement methods are used in multi-agent systems, some of them are listed below:

1. **Minimax-Q Learning Algorithm**

In the case of zero-sum games, the Minimax-Q learning algorithm is utilised for instances in which the learning player is able to increase its payoffs regardless of the circumstances. On the other hand, the player's enthusiasm for the game is completely different. In the beginning, it is important to have the capacity to enable learning calculation. Using this approach, the player makes an effort to increase its usual incentive, even if the opponent executes the worst possible activity decision that could ever be made.

1. **Nash-Q Learning Algorithm**

A zero-sum game framework of Minimax-Q learning algorithm was suggested by Hu and Wellman in 2003. This framework was intended to be used for general-aggregate games. Additionally, a Nash-Q learning calculation algorithm was developed for multi-agent reinforcement learning approaches. When it comes to expanding Q-learning to the many different multi-agent learning domains, it is necessary to take into consideration a number of activities that include the participation of several agents working together, rather than focusing just on the behaviours of individual agents. This approach must keep using the Q values for both single-agent and multi-agent Reinforcement learning agents because of the significant difference between the two. the learner itself and other participants also. In order to get Nash equilibrium techniques for the purpose of modifying the Q values, the primary reason to identify Nash equilibria at each state as described above. It is not until the Nash Q-value has been specified that the Nash-Q learning method is implemented. The predicted total of constrained rewards in an instance where all agents are required to obey the policies that are stated to be in Nash equilibrium is described by this specified value. Further, Hu and Wellman brought attention to the fact that this learning process, when applied to a multi-player scenario, interacts with Nash equilibrium techniques under specific conditions and adds additional expectations to the payout structures.

1. **Friend-or-Foe Q-Learning (FFQ) Algorithm**

There are two possible labels for each agent in the FFQ method: "friend" and "foe." It is possible to categorize the equilibria in this situation as either harmonious or antagonistic. The FFQ-learning method can provide a stronger convergence guarantee when compared to the Nash-Q learning method.

1. **rQ-Learning Algorithm**

A technique known as rQ-learning was developed to address problems with a large search space. For this method to work, the r-state and r-action sets must be explicitly declared from the get-go. The collection of pre- and post-conditions with a generalised action initialises an r-action, whereas a set of first-order relations, such as "goal" in the front and "team robot" to the left, etc., initialises an r-state. If an r-action is suitable for one instance of an r-state, it follows that it must also be suitable for all instances of that state in order for its proper definition to be satisfied. An r-state and an r-action set may be difficult to represent in an acceptable way for problems with a large search space, but this technique gives a reasonable solution. This is particularly the case when there is a lack of data. Furthermore, it is worth noting that Morales (2003) argues that in the r-state space, there is no assurance that the quantity of clearly specified r-actions is adequate to discover the best configuration of fundamental operations and challenging methods that could be explored.

1. **Fictitious Play Algorithm**

When finding the results of Nash equilibria becomes challenging in Nash-equilibrium-based learning, the fake play method is employed. When used in conjunction with a multi-agent architecture, this method provides an extra means of management. According to Cao and Suematru, this method's other approaches include exploratory dissemination, and each participant must maintain a Q value that is weighted by their conviction appropriation and corresponds to all operations. Furthermore, each player must supply their Q-values. For both stationary and non-stationary player approaches, the made-up play method can transform the variation of individual Q-learning. Both modest games (known as rival modelling) and combined games (named Joint Action Learner) make use of this fictional play method, with the former allowing players to demonstrate their antagonistic opponents and the latter allowing them to learn the Q values of their joint activities.

1. **Multi-Agent SARSA Learning Algorithm**

The off-strategy Reinforcement Learning algorithms include Nash-Q and Minimax-Q. This is because, as a result of their dominating reaction, also known as the Nash equilibrium policy, the algorithms used for learning change the max operator of a certain Q-learning algorithm. As a general rule, off-approach learning algorithms in Reinforcement Learning will always seek out the best Q values of the optimum strategy, regardless of approach. An example of a policy reinforcement learning approach is the SARSA algorithm, which strives to find the optimal Q values for the present approach. To address these issues with Minimax-Q and Nash-Q, Suematru presented research that led to the development of EXORL (Extended Optimal Response Learning), a SARSA-based multi-agent method.

1. **Policy Hill Climbing (PHC) Algorithm**

This approach maintains the mixed policy, also called the stochastic policy, by performing hill-climbing in the space of these policies, and it updates the Q values in the same way as the creative play algorithm. WoLF (Win or Learn Fast), a PHC technique that draws on the ideas of Win or Learn Fast and the variable learning rate. When this technique is applied, the agent quickly learns to be more careful and effective. The convergence will benefit from this shift in learning rates as it will prevent the agents' emerging tactics from becoming overfit.

### Applications of Reinforcement Learning

* **Robotics:** Robots with pre-programmed behavior are useful in structured environments, such as the assembly line of an automobile manufacturing plant, where the task is repetitive in nature.
* A master chess player makes a move. The choice is informed both by planning, anticipating possible replies and counter replies.
* An adaptive controller adjusts parameters of a petroleum refinery’s operation in real time.

### Advantages of Reinforcement learning

* + Reinforcement learning can be used to solve very complex problems that cannot be solved by conventional techniques.
  + The model can correct the errors that occurred during the training process.
  + In RL, training data is obtained via the direct interaction of the agent with the environment
  + Reinforcement learning can handle environments that are non-deterministic, meaning that the outcomes of actions are not always predictable. This is useful in real-world applications where the environment may change over time or is uncertain.
  + Reinforcement learning can be used to solve a wide range of problems, including those that involve decision making, control, and optimization.
  + Reinforcement learning is a flexible approach that can be combined with other machine learning techniques, such as deep learning, to improve performance.

### Disadvantages of Reinforcement learning

* Reinforcement learning is not preferable to use for solving simple problems.
* Reinforcement learning needs a lot of data and a lot of computation
* Reinforcement learning is highly dependent on the quality of the reward function. If the reward function is poorly designed, the agent may not learn the desired behavior.
* Reinforcement learning can be difficult to debug and interpret. It is not always clear why the agent is behaving in a certain way, which can make it difficult to diagnose and fix problems.

## Evaluation and Metrics in Machine Learning

An additional crucial aspect of ML is the challenge of how a computer programme can identify accurate and incorrect outcomes. This would not be an issue for the method, for instance, in a programme that attempts to forecast whether an online shopper would make a buy. In order to measure the method's efficacy, the data entry will be recorded along with the provided information on whether the customer made a purchase or not. Evaluation of document translations is one example of a study subject that faces more challenging conditions due to the lack of or restricted access to real-world data. To compare the final results from the computer programme, it is necessary to rank the offered translations into classes, which needs extra human labour. To evaluate classification tasks, it is common practice to divide the dataset into a training set and a test set, as explained in the paragraph. Next, the ML algorithm is taught to utilise the first one, and to gauge its efficacy, performance metrics are computed using the test data set. When there isn't enough data available for testing and training, ML techniques often struggle. Consequently, overfitting poses a significant challenge when assessing these programmes. X-Fold Cross Validation is a popular method for dealing with this issue. In cross-validation, the entire dataset is partitioned into X equal parts, with each portion serving as the test data set in turn, while the remaining parts are used to train the model. Once all validation steps have been completed, the outcome metrics are averaged. In terms of evaluating ML methods, there is no one-size-fits-all indication because every one has its own set of pros and cons. The following are the most crucial aspects of a ML program's efficiency evaluation:

1. The misclassification rate quantifies the proportion of erroneously labelled data within a dataset. The term misclassification is used when the actual label is yi and the forecast for data point i is yˆi .

A major issue with misclassification is that the accuracy of the findings is very sensitive to the data distribution among the class labels and the number of labels. It may not seem difficult to attain a misclassification rate of 0.03 in the preceding example, where 97% of the data set is labelled with class a and 3% with class b, however this can be misleading without more information. Dissimilarities in the number of possible classes have the same effect. An obviously superior ML system for a three-class dataset compared to a two-class one would have a misclassification rate of 20% or below. The usage of benchmarking helps to circumvent this problem.

1. The practice of comparing an indicator's value to a reference value to enhance its assertion is called benchmarking. As an example, a classifier that consistently forecasts the most prevalent class might serve as the benchmarking method for a binary classification problem in a supervised learning situation. The misclassification rate might thereafter be defined by the standard. In this example, an increase of 20% above the benchmark of 30% would lead to an equal distribution of classes.
2. the proportion of cases that were properly identified as true out of all the instances that have been categorised as true is termed the precision value, which is also known as the positive prediction value. The aforementioned example of online shopping might be used to demonstrate this point. Every single consumer who is marked as making a purchase actually does so when the accuracy value is 1. It should be mentioned that this does not affect the number of customers who are categorised as "no purchase" but make purchases.
3. The proportion of correctly identified examples to the total number of true occurrences is the recall value, which is also known as sensitivity. In the above scenario, a recall value of 1 indicates that all customers who made a transaction have been appropriately tagged. You may simply attain a recall value of 1 by purchasing each instance of the data set and categorising it accordingly.
4. By utilizing the harmonic mean of the two, the F-Measure attempts to merge the recall and precision statements:
5. The confusion matrix, also known as a contingency table, is a great way to show how well ML programs are doing. It separates predictions into four categories: true positives, false positives, true negatives, and false negatives.

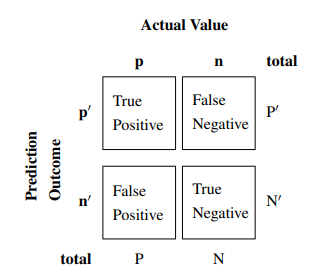


figure 3.10: Example of a confusion matrix (Luckert and Schaffer-Kehnert, 2015)

The need for interpretation by humans is the confusion matrix's primary drawback.

**PART-1: VERY SHORT QUESTIONS**

1. What is the fundamental goal of machine learning?
2. Name two types of machine learning algorithms.
3. What distinguishes supervised learning from unsupervised learning?
4. Explain the concept of labeled data in supervised learning.
5. Can you give an example of a popular supervised learning algorithm?
6. What is the primary objective of unsupervised learning?
7. Provide a brief overview of clustering algorithms in unsupervised learning.
8. How does reinforcement learning differ from supervised and unsupervised learning?
9. Offer an application scenario where reinforcement learning could be utilized effectively.
10. Why are evaluation metrics crucial in assessing the performance of machine learning models?

**PART-2: SHORT QUESTIONS**

1. What is the fundamental difference between supervised and unsupervised learning?
2. Can you explain the key principles behind supervised learning algorithms?
3. How do unsupervised learning algorithms identify patterns in data?
4. What are some common types of supervised learning algorithms?
5. Give an example of a real-world application where reinforcement learning is used.
6. What are the primary objectives of reinforcement learning?
7. How do we evaluate the performance of a machine learning model?
8. What metrics are commonly used to assess the accuracy of a classification model?
9. Describe a scenario where clustering is applied in unsupervised learning.
10. What role do reward functions play in reinforcement learning applications?

**PART-3: LONG QUESTIONS**

1. In the realm of machine learning, what are the fundamental differences between supervised, unsupervised, and reinforcement learning paradigms? How do these paradigms differ in terms of the type of data they utilize and the objectives they aim to achieve?
2. Could you elaborate on the principles underlying supervised learning algorithms? Discuss the key components involved in supervised learning processes and illustrate with examples how algorithms such as decision trees, support vector machines, and neural networks operate within this framework.
3. Unsupervised learning algorithms operate without labeled data. Could you explain the principles governing unsupervised learning and provide insights into how algorithms like k-means clustering, hierarchical clustering, and principal component analysis (PCA) function to uncover patterns and structures within unlabeled datasets?
4. Reinforcement learning has gained prominence in various domains, including robotics and game playing. What are the foundational principles of reinforcement learning, and how do algorithms such as Q-learning and deep Q-networks (DQN) navigate the trade-off between exploration and exploitation to learn optimal policies?
5. Evaluation and metrics play a critical role in assessing the performance of machine learning models. Could you elucidate the various evaluation metrics used in classification, regression, and clustering tasks? Furthermore, how do metrics like accuracy, precision, recall, F1-score, and silhouette coefficient help in gauging the effectiveness and generalization capability of machine learning models?

**PART-4: MCQ QUESTIONS**

1. Which of the following is not a type of machine learning algorithm?
   1. Supervised Learning
   2. Unsupervised Learning
   3. Reinforcement Learning
   4. Descriptive Learning
2. In supervised learning, what is the primary task of the algorithm?
   1. Discovering hidden patterns in data
   2. Making predictions based on labeled data
   3. Exploring the environment to maximize rewards
   4. Clustering similar data points together
3. Which of the following algorithms is commonly used for classification tasks in supervised learning?
   1. K-means clustering
   2. Linear regression
   3. Decision trees
   4. Principal Component Analysis (PCA)
4. What is the main objective of unsupervised learning algorithms?
   1. Predicting future outcomes based on historical data
   2. Minimizing errors between predicted and actual values
   3. Finding hidden structures or patterns in unlabeled data
   4. Maximizing rewards by interacting with an environment
5. Which algorithm is often utilized for dimensionality reduction in unsupervised learning?
   1. Naive Bayes
   2. Support Vector Machines (SVM)
   3. K-nearest neighbors (KNN)
   4. Singular Value Decomposition (SVD)
6. Reinforcement learning is primarily concerned with:
   1. Making predictions based on labeled data
   2. Discovering hidden patterns in data
   3. Learning to make sequential decisions to maximize rewards
   4. Clustering similar data points together
7. What is the role of a reward signal in reinforcement learning?
   1. It helps in clustering similar data points together
   2. It guides the learning agent towards better actions in an environment
   3. It discovers hidden patterns in data
   4. It minimizes errors between predicted and actual values
8. Which evaluation metric is commonly used for classification tasks in machine learning?
   1. Mean Squared Error (MSE)
   2. F1-score
   3. R-squared
   4. Mean Absolute Error (MAE)
9. When evaluating a regression model, which metric measures the average deviation of predictions from actual values?
10. Precision
11. Recall
12. Mean Absolute Error (MAE)
13. F1-score
14. Which of the following is NOT a measure used for evaluating clustering algorithms?
15. Silhouette Coefficient
16. Adjusted Rand Index
17. Root Mean Squared Error (RMSE)
18. Davies–Bouldin Index

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| d | b | c | c | d | c | b | b | c | c |