INTRODUCTION TO MACHINE LEARNING

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Simple Definition of Machine Learning

Machine Learning is an Application of Artificial Intelligence (AI) it gives devices the ability to learn from their experiences and improve their self without doing any coding. For Example, when you shop from any website it's shows related search like:- People who bought also saw this.

What is Machine Learning?

Machine Learning is a subset of Artificial Intelligence. Machine Learning is the study of making machines more human-like in their behaviour and decisions by giving them the ability to learn and develop their own programs. This is done with minimum human intervention, i.e., no explicit programming. The learning process is automated and improved based on the experiences of the machines throughout the process. Good quality data is fed to the machines, and different algorithms are used to build ML models to train the machines on this data. The choice of algorithm depends on the type of data at hand, and the type of activity that needs to be automated.

Now you may wonder, how is it different from traditional programming? Well, in traditional programming, we would feed the input data and a well written and tested program into a machine to generate output. When it comes to machine learning, input data along with the output is fed into the machine during the learning phase, and it works out a program for itself. To understand this better, refer to the illustration below:

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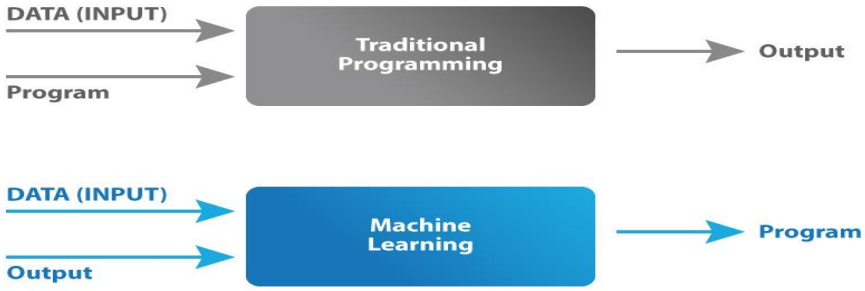


Why Should We Learn Machine Learning?

Machine Learning today has all the attention it needs. Machine Learning can automate many tasks, especially the ones that only humans can perform with their innate intelligence. Replicating this intelligence to machines can be achieved only with the help of machine learning.

With the help of Machine Learning, businesses can automate routine tasks. It also helps in automating and quickly create models for data analysis. Various industries depend on vast quantities of data to optimize their operations and make intelligent decisions. Machine Learning helps in creating models that can process and analyze large amounts of complex data to deliver accurate results. These models are precise and scalable and function with less turnaround time. By building such precise Machine Learning models, businesses can leverage profitable opportunities and avoid unknown risks.

Image recognition, text generation, and many other use-cases are finding applications in the real world. This is increasing the scope for machine learning experts to shine as a sought after professionals.

How to get started with Machine Learning?

To get started with Machine Learning, let’s take a look at some of the important terminologies used in Machine Learning:

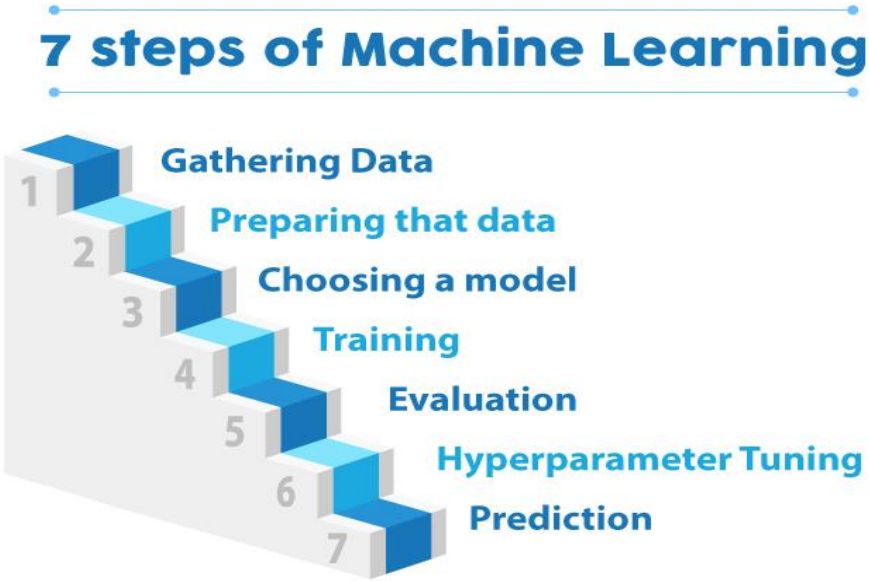
Some Terminology of Machine Learning

- **Model**: Also known as “hypothesis”, a machine learning model is the mathematical representation of a real-world process. A machine learning algorithm along with the training data builds a machine learning model.
- **Feature**: A feature is a measurable property or parameter of the data-set.
- **Feature Vector**: It is a set of multiple numeric features. We use it as an input to the machine learning model for training and prediction purposes.
- **Training**: An algorithm takes a set of data known as “training data” as input. The learning algorithm finds patterns in the input data and trains the model for expected results (target). The output of the training process is the machine learning model.

- **Prediction**: Once the machine learning model is ready, it can be fed with input data to provide a predicted output.
- **Target (Label)**: The value that the machine learning model has to predict is called the target or label.
- **Overfitting**: When a massive amount of data trains a machine learning model, it tends to learn from the noise and inaccurate data entries. Here the model fails to characterise the data correctly.
- **Underfitting**: It is the scenario when the model fails to decipher the underlying trend in the input data. It destroys the accuracy of the machine learning model. In simple terms, the model or the algorithm does not fit the data well enough.
  Here's a video that describes step by step guide to approaching a Machine Learning problem with a beer and wine example:

There are Seven Steps of Machine Learning

1. Gathering Data
2. Preparing that data
3. Choosing a model
4. Training
5. Evaluation
6. Hyperparameter Tuning
7. Prediction



It is mandatory to learn a programming language, preferably Python, along with the required analytical and mathematical knowledge. Here are the three mathematical areas that you need to brush up before jumping into solving Machine Learning problems:

1. Linear algebra for data analysis: Scalars, Vectors, Matrices, and Tensors
2. Mathematical Analysis: Derivatives and Gradients
3. Probability theory and statistics
4. Multivariate Calculus
5. Algorithms and Complex Optimizations

How does Machine Learning work?

The three major building blocks of a Machine Learning system are the model, the parameters, and the learner.

- Model is the system which makes predictions
- The parameters are the factors which are considered by the model to make predictions
- The learner makes the adjustments in the parameters and the model to align the predictions with the actual results

Let us build on the beer and wine example to understand how machine learning works. A machine learning model here has to predict if a drink is a beer or wine. The parameters selected are the colour of the drink and the alcohol percentage. The first step is:

Learning from the training set

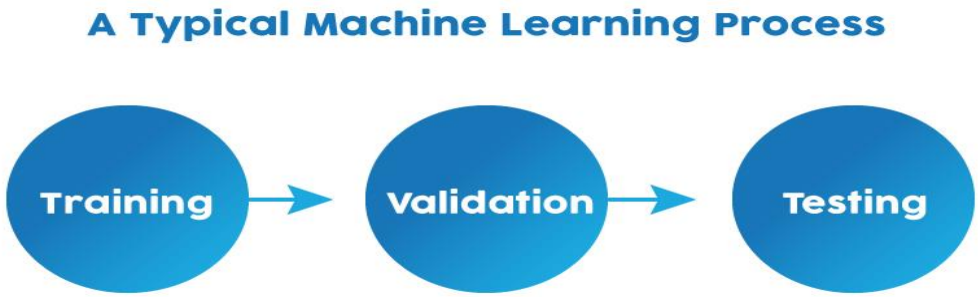
This involves taking a sample data set of several drinks for which the colour and alcohol percentage is specified. Now, we have to define the description of each classification, that is wine and beer, in terms of the value of parameters for each type. The model can use the description to decide if a new drink is a wine or beer.

You can represent the values of the parameters, ‘colour’ and ‘alcohol percentages’ as ‘x’ and ‘y’ respectively. Then (x,y) defines the parameters of each drink in the training data. This set of data is called a training set. These values, when plotted on a graph, present a hypothesis in the form of a line, a rectangle, or a polynomial that fits best to the desired results.

The second step is to measure error

Once the model is trained on a defined training set, it needs to be checked for discrepancies and errors. We use a fresh set of data to accomplish this task. The outcome of this test would be one of these four:

- True Positive: When the model predicts the condition when it is present
- True Negative: When the model does not predict a condition when it is absent
- False Positive: When the model predicts a condition when it is absent
- False Negative: When the model does not predict a condition when it is present



The sum of FP and FN is the total error in the model.

Manage Noise

For the sake of simplicity, we have considered only two parameters to approach a machine learning problem here that is the colour and alcohol percentage. But in reality, you will have to consider hundreds of parameters and a broad set of learning data to solve a machine learning problem.

- The hypothesis then created will have a lot more errors because of the noise. Noise is the unwanted anomalies that disguise the underlying relationship in the data set and weakens the learning process. Various reasons for this noise to occur are:
- Large training data set
- Errors in input data
- Data labelling errors
- Unobservable attributes that might affect the classification but are not considered in the training set due to lack of data

You can accept a certain degree of training error due to noise to keep the hypothesis as simple as possible.

Testing and Generalization

While it is possible for an algorithm or hypothesis to fit well to a training set, it might fail when applied to another set of data outside of the training set. Therefore, It is essential to figure out if the algorithm is fit for new data. Testing it with a set of new data is the way to judge this. Also, generalization refers to how well the model predicts outcomes for a new set of data.

When we fit a hypothesis algorithm for maximum possible simplicity, it might have less error for the training data, but might have more significant error while processing new data. We call this is **under-fitting**. On the other hand, if the hypothesis is too complicated to accommodate the best fit to the training result, it might not generalize well. This is the case of **over-fitting**. In either case, the results are fed back to train the model further.

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Which Language is Best for Machine Learning?

Python is hands down the best programming language for Machine Learning applications due to the various benefits mentioned in the section below. Other programming languages that could to use for Machine Learning Applications are R, C++, JavaScript, Java, C#, Julia, Shell, TypeScript, and Scala.

Python is famous for its readability and relatively lower complexity as compared to other programming languages. Machine Learning applications involve complex concepts like calculus and linear algebra which take a lot of effort and time to implement. Python helps in reducing this burden with quick implementation for the ML engineer to validate an idea. You can check out the Python Tutorial to get a basic understanding of the language. Another benefit of using Python in Machine Learning is the pre-built libraries. There are different packages for a different type of applications, as mentioned below:

- Numpy, OpenCV, and Scikit are used when working with images
- NLTK along with Numpy and Scikit again when working with text
- Librosa for audio applications
- Matplotlib, Seaborn, and Scikit for data representation
- TensorFlow and Pytorch for Deep Learning applications
- Scipy for Scientific Computing
- Django for integrating web applications
- Pandas for high-level data structures and analysis

Python provides flexibility in choosing between object-oriented programming or scripting. There is also no need to recompile the code; developers can implement any changes and instantly see the results. You can use Python along with other languages to achieve the desired functionality and results.

Python is a versatile programming language and can run on any platform, including Windows, MacOS, Linux, Unix, and others. While migrating from one platform to another, the code needs some minor adaptations and changes, and it is ready to work on the new platform.

Difference Between Machine Learning and Artificial Intelligence

AI manages more comprehensive issues of automating a system utilizing fields such as cognitive science, image processing, machine learning, or neural networks for computerization. On the other hand, ML influences a machine to gain and learn from the external environment. The external environment could be anything such as external storage devices, sensors, electronic segments among others.

Also, artificial intelligence enables machines and frameworks to think and do the tasks as humans do. While machine learning depends on the inputs provided or queries requested by

users. The framework acts on the input by screening if it is available in the knowledge base and then provides output.

Types of Machine Learning

In this section, we will learn about the different approaches towards machine learning and the variety of problems they can solve.

What is Supervised Learning?

The supervised learning model has a set of input variables (x), and an output variable (y). An algorithm identifies the mapping function between the input and output variables. The relationship is y = f(x).

The learning is monitored or supervised in the sense that we already know the output and the algorithm are corrected each time to optimise its results. The algorithm is trained over the data set and amended until it achieves an acceptable level of performance.
We can group the supervised learning problems as:

1. Regression problems – Used to predict future values and the model is trained with the historical data. E.g., Predicting the future price of a product.
2. Classification problems – Various labels train the algorithm to identify items within a specific category. E.g., Disease or no disease, Apple or an orange, Beer or wine.

What is Unsupervised Learning?

This approach is the one where the output is unknown, and we have only the input variable at hand. The algorithm learns by itself and discovers an impressive structure in the data.
The goal is to decipher the underlying distribution in the data to gain more knowledge about the data.
We can group the unsupervised learning problems as:

1. Clustering: This means bundling the input variables with the same characteristics together. E.g., grouping users based on search history
2. Association: Here, we discover the rules that govern meaningful associations among the data set. E.g., People who watch ‘X’ will also watch ‘Y.’

What is Semi-supervised Learning?

In semi-supervised learning, data scientists train model with a minimal amount of labelled data and a large amount of unlabelled data. Usually, the first step is to cluster similar data with the help of an unsupervised machine learning algorithm. The next step is to label the unlabelled data using the characteristics of the limited labelled data available. After labelling the complete data, one can use supervised learning algorithms to solve the problem.

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What is Reinforcement Learning?

In this approach, machine learning models are trained to make a series of decisions based on the rewards and feedback they receive for their actions. The machine learns to achieve a goal in complex and uncertain situations and is rewarded each time it achieves it during the learning period.

Reinforcement learning is different from supervised learning in the sense that there is no answer available, so the reinforcement agent decides the steps to perform a task. The machine learns from its own experiences when there is no training data set present.
Machine Learning algorithms help in building intelligent systems that can learn from their past experiences and historical data to give accurate results. Many industries are thus applying machine learning solutions to their business problems, or to create new and better products and services. Healthcare, defence, financial services, marketing, and security services, among others, use Machine Learning in their applications and processes.

Applications of Machine Learning

Facial recognition/Image recognition

The most common application of machine learning is Facial Recognition, and the simplest example of this application is the iPhone X. There are a lot of use-cases of facial recognition, mostly for security purposes like identifying criminals, searching for missing individuals, aid forensic investigations, etc. Intelligent marketing, diagnose diseases, track attendance in schools, are some other uses.

Automatic Speech Recognition

Abbreviated as ASR, automatic speech recognition is used to convert speech into digital text. Its applications lie in authenticating users based on their voice and performing tasks based on the human voice inputs. Speech patterns and vocabulary are fed into the system to train the model. Presently ASR systems find a wide variety of applications in the following domains:

- Medical Assistance
- Industrial Robotics
- Forensic and Law enforcement
- Defence & Aviation
- Telecommunications Industry
- Home Automation and Security Access Control
- I.T. and Consumer Electronics

Financial Services

Machine learning has many use cases in Financial Services. Machine Learning algorithms prove to be excellent at detecting frauds by monitoring activities of each user and assess that if an

attempted activity is typical of that user or not.
Financial monitoring to detect money laundering activities is also a critical security use case of machine learning.

Machine Learning also helps in making better trading decisions with the help of algorithms that can analyse thousands of data sources simultaneously. Credit scoring and underwriting are some of the other applications.
The most common application in our day to day activities is the virtual personal assistants like Siri and Alexa.

Marketing and Sales

Machine Learning is improving lead scoring algorithms by including various parameters such as website visits, emails opened, downloads, and clicks to score each lead. It also helps businesses to improve their dynamic pricing models by using regression techniques to make predictions.

Sentiment Analysis is another essential application to gauge consumer response to a specific product or a marketing initiative. Machine Learning for Computer Vision helps brands identify their products in images and videos online. These brands also use computer vision to measure the mentions that miss out on any relevant text. Chatbots are also becoming more responsive and intelligent with the help of machine learning.

Healthcare

A vital application of Machine Learning is in the diagnosis of diseases and ailments, which are otherwise difficult to diagnose. Radiotherapy is also becoming better with Machine Learning taking over.

Early-stage drug discovery is another crucial application which involves technologies such as precision medicine and next-generation sequencing. Clinical trials cost a lot of time and money to complete and deliver results. Applying Machine Learning based predictive analytics could improve on these factors and give better results.

Machine Learning technologies are also critical to make outbreak predictions. Scientists around the world are using these technologies to predict epidemic outbreaks.

Recommendation Systems

Many businesses today use recommendation systems to effectively communicate with the users on their site. It can recommend relevant products, movies, web-series, songs, and much more. Most prominent use-cases of recommendation systems are e-commerce sites like Amazon, Flipkart, and many others, along with Spotify, Netflix, and other web-streaming channels.

Machine Learning FAQs

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1. What exactly is machine learning?

Arthur Samuel coined the term Machine Learning in 1959. He defined it as “The field of study that gives computers the capability to learn without being explicitly programmed”. Machine Learning is a subset of Artificial Intelligence and it allows machines to learn from their experiences without any coding.

2. What is machine learning used for?

Machine Learning is used in our daily lives much more than we know it. These are areas where machine learning is used:

- Facial Recognition
- Self-driving cars
- Virtual assistants
- Traffic Predictions
- Speech Recognition
- Online Fraud Detection
- Email Spam Filtering
- Product Recommendations

3. What is difference between machine learning and artificial intelligence?

A technology that enables a machine to stimulate human behavior to help in solving complex problems is known as Artificial Intelligence. Machine Learning is a subset of AI and allows machines to learn from past data and provide an accurate output. AI deals with unstructured as well as structured data. Whereas, Machine Learning deals with structured and semi-structured data.

4. How Machine Learning works?

The typical machine learning process involves three steps: Training, Validation, and Testing. The first step is to learn from the training set provided, the second step is to measure error, the third step involves managing noise and testing all the parameters. These are the basic steps followed and a very broad description on how machine learning works.

5. What are the types of Machine Learning?

The broad types of machine learning are:

- Supervised Machine Learning
- Unsupervised Machine Learning
- Semi-supervised Learning
- Reinforcement Learning

6. What is the best language for machine learning?

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The best programming language to learn machine learning can be any of the following: Python, R, Java and JavaScript, Julia. However, in today's day and age, Python is the most commonly used programming language due to it's ease and simplicity. The number of programmers using Python as their primary coding language is increasing.

7. Is Alexa a machine learning?

Alexa is a virtual assistant that is created by Amazon and is also known as Amazon Alexa. This virtual assistant was created using machine learning and artificial intelligence technologies.

8. Is Siri a machine learning?

Similar to Alexa, Siri is also a virtual or a personal assistant. Siri was created by Apple and makes use of voice technology to perform certain actions. Siri also makes use of machine learning and deep learning to function.

9. Why is machine learning popular?

The amount of data available to us is constantly increasing. Machines make use of this data to learn and improve the results and outcomes provided to us. These outcomes can be extremely helpful in providing valuable insights and taking informed business decisions as well. Machine Learning is constantly growing, and with that, the applications of machine learning are growing as well. We make use of machine learning in our day-to-day life more than we know it. In the future, machine learning is only said to grow further and help us. Thus, it is popular.