EE6227 Genetic Algorithm and Machine Learning

Mao Kezhi

School of Electrical and Electronic Engineering
Nanyang Technological University

Tel: 6790 4284
Email: ekzmao@ntu.edu.sg
Office: S2-B2c-84

Lecture organization and assessments

- Machine learning lecture
  - ❑ Weeks 4-13

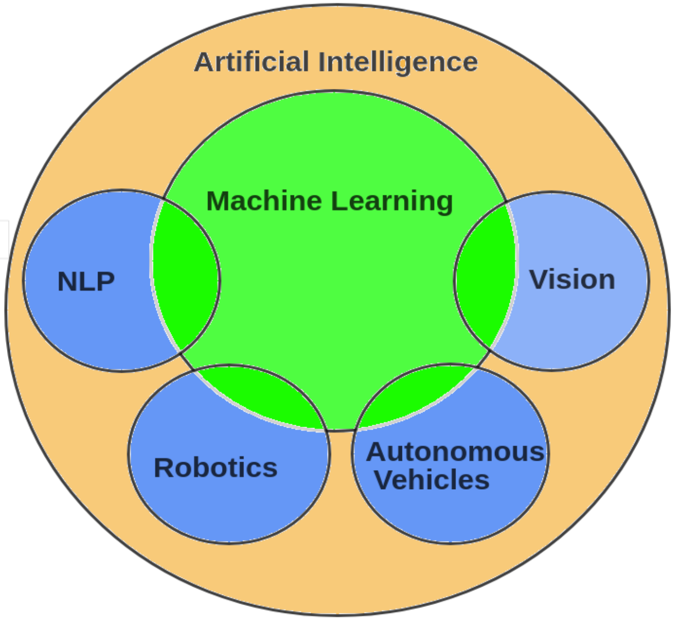
- Continuous Assessments (machine learning)
  - ❑ Total: 30%
  - ❑ Assignments :15% (Week 7)
  - ❑ Quiz:15%, in-class quiz on Week 13

- Exam
  - ❑ Total 60%
  - ❑ 4 questions, 3 from machine learning

AI, Machine Learning, Neural Networks and Deep Learning: at a Glance

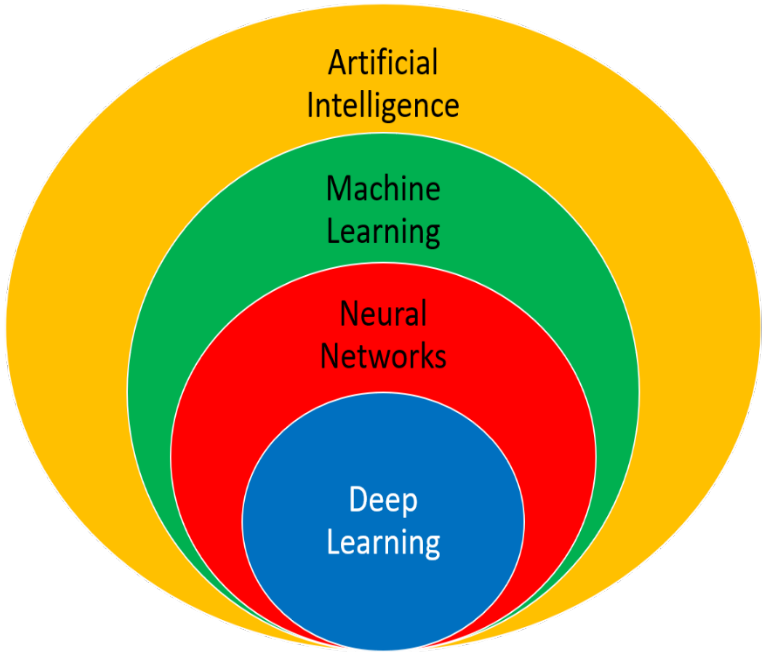
AI and Machine Learning

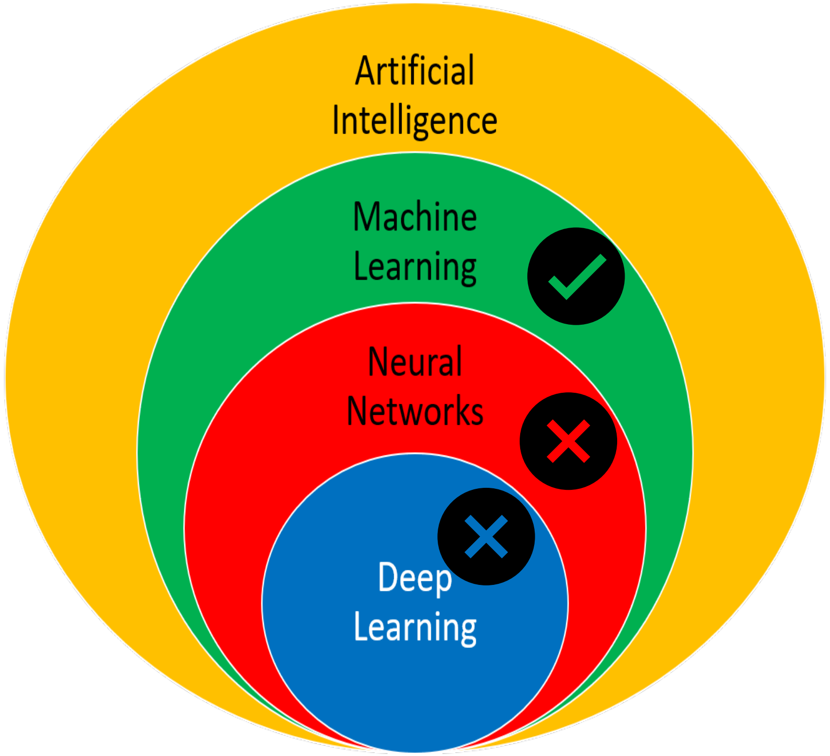
- AI is a broad term for techniques which enable machines to mimic human behaviours
- Machine learning is a sub-set of AI techniques which enable machines to learn from experience
  - Data-driven
  - Statistical algorithms



- **Machine Learning, Neural Networks and Deep Learning**

  - ❑ Neural networks is a sub-field of machine learning
  - ❑ Deep learning is a sub-field of neural networks




Artificial Intelligence
Machine Learning
Neural Networks
Deep Learning

References

- R. Duda, P. Harr and D. Stork, Pattern Classification, 2^{nd} edition, Wiley-Interscience.
- Subramanian Chandramouli, Saikat Dutt, Amit Kumar Das., Machine Learning, 1^{st} Edition, 2018, Pearson Education.
- Materials on the Internet.

Contents

- Introduction to machine learning
- Data preparation for machine learning
- Supervised learning
  - Bayesian decision rule
  - Linear discriminant analysis
  - Support vector machines
  - Decision Tree
  - Dimensionality reduction and feature selection
  - Evaluation of classification
  - Regression
- Unsupervised learning
  - Centroid-based clustering
  - Hierarchical clustering
  - Density-based clustering
  - Distribution-based clustering
  - Evaluation of clustering
  - Association analysis
- Other types of learning

1. Introduction to Machine Learning

The machine learning is an area of rapid development. This has triggered a question: Can machines learn better than human? To find its answer, the first step is to understand what learning is from a human perspective. Then, more light can be shed on what machine learning is. In the end, we need to know whether machine learning has already surpassed or has the potential to surpass human learning in every facet of life.

1.1 WHAT IS HUMAN LEARNING?

In cognitive science, learning is typically referred to as the process of gaining knowledge through observation. And why do we need to learn? In our daily life, we need to carry out multiple activities. It may be a task as simple as walking down the street or doing the homework. Or it may be some complex task like deciding the angle in which a rocket should be launched so that it can have a particular trajectory. To do a task in a proper way, we need to have prior knowledge on one or more things related to the task. Also, as we keep learning more or in other words acquiring more knowledge, the efficiency in doing the tasks keep improving. For example, with more knowledge, the ability to do homework increases. In the same way, knowledge from past rocket launches helps in taking the right precautions and makes more successful rocket launch. Thus, with more learning, tasks can be performed more efficiently.

1.2 TYPES OF HUMAN LEARNING

Thinking intuitively, human learning happens in one of the three ways:

(1) Somebody who is a domain expert directly teaches us, or

(2) We build our own notion indirectly based on what we have learnt from the expert in the past, or

(3) We do it ourselves, may be after multiple attempts, some being unsuccessful.

The first type of learning, we may call, falls under the category of learning directly under expert guidance.

The second type falls under learning guided by knowledge gained from experts

The third type is learning by self or self-learning.

Next, let's look at each of these types deeply using real-life examples and try to understand what they mean.

1.2.1 Learning under expert guidance

An infant may inculcate certain traits and characteristics, learning straight from his/her parents. He calls his hand, a ‘hand’, because that is the knowledge he gets from his parents. The sky is ‘blue’ because that is what his parents have taught him. We say that the baby ‘learns’ things from his parents.

The next phase of life is when the baby starts going to school. In school, he starts with basic familiarization of alphabets and digits. Then the baby learns how to form words from the alphabets and numbers from the digits. Slowly, more complex learning happens in the form of sentences, paragraphs, complex mathematics, science, etc. The baby is able to learn all these things from his teacher who already has knowledge in these areas.

Then starts higher studies where the person learns about more complex, application-oriented skills. Engineering students get skilled in one of the disciplines like civil, computer science, electrical, mechanical, etc. medical students learn about anatomy, physiology, pharmacology, etc. There are some experts, in general the teachers, in the respective field who have in-depth subject matter knowledge, who help the students in learning these skills.

Then the person starts working as a professional in some field. Though he might have gone through enough theoretical learning in the respective field, he still needs to learn more about the hands-on application of the knowledge that he has acquired. The professional mentors help newcomers in the field to learn on-job.

In all phases of life of a human being, there is an element of guided learning. This learning is imparted by someone, purely because of the fact that he/she has already gathered the knowledge by virtue of his/her experience in that field. So guided learning is the process of gaining knowledge from a person having sufficient knowledge due to the past experience.

1.2.2 Learning guided by knowledge gained from experts

An essential part of learning also happens with the knowledge which has been imparted by teacher or mentor at some point of time in some other form/context. For example,

(1) a baby can group together all objects of same colour even if his parents have not specifically taught him to do so. He is able to do so because at some point of time his parents have told him which colour is blue, which is red, which is green, etc.

(2) a grown-up kid can select one odd word from a set of words because it is a verb and other words being all nouns. He could do this because of his ability to label the words as verbs or nouns, taught by his English teacher long back.

(3) in a professional role, a person is able to make out to which customers he should market a campaign from the knowledge about preference that was given by his boss long back.

In all these situations, there is no direct learning. It is some past knowledge shared on some different context, which is used as a learning to make decisions.

1.2.3 Learning by self

In many situations, humans are left to learn on their own. A classic example is a baby learning to walk through obstacles. He bumps on to obstacles and falls down multiple times till he learns that whenever there is an obstacle, he needs to cross over it.

He faces the same challenge while learning to ride a cycle as a kid or drive a car as an adult. Not all things are taught by others. A lot of things need to be learnt only from mistakes made in the past. We tend to form a check list on things that we should do, and things that we should not do, based on our experiences.

1.3 WHAT IS MACHINE LEARNING?

Before answering the question “What is machine learning?”, there are more fundamental questions:

- Do machines really learn?
- If so, how do they learn?

It is important to formalize the definition of machine learning. This will itself address the first question, i.e. if machines really learn. There are multiple ways to define machine learning. But the one which is perhaps most relevant, concise and accepted universally is the one stated by Tom M. Mitchell, Professor of Machine Learning Department, School of Computer Science, Carnegie Mellon University. Tom M:

‘A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.’

What this essentially means is that a machine can be considered to learn if it is able to gather experience by doing a certain task and improve its performance in doing the similar tasks in the future.

When we talk about past experience, it means past data related to the task. This data is an input to the machine from some source.

In the context of the learning to play checkers, E represents the experience of playing the game, T represents the task of playing checkers and P is the performance measure indicated by the percentage of games won by the player.

The same mapping can be applied for any other machine learning problem, for example, image classification problem.

In the context of image classification, E represents the past data with images having labels or assigned classes (for example whether the image is of a class “cat” or a class “dog” or a class “elephant” etc.), T is the task of assigning class to new, unlabelled images and P is the performance measure indicated by the percentage of images correctly classified.

1.3.1 How do machines learn?

The basic machine learning process can be divided into three parts.

(1) Input Data: Past data or information is utilized as a basis for future decision-making

(2) Abstraction: The input data is represented in a broader way through the underlying algorithm

(3) Generalization: The abstracted representation is generalized to form a framework for making decisions

Let’s put the things in perspective of the human learning process and try to understand the machine learning process more clearly. Consider the situation of typical process of learning from classroom and books and preparing for the examination. It is a tendency of many students to try and memorize as many things as possible. This may work well when the scope of learning is not so vast. However, as the scope gets broader and the questions asked in the examination gets more complex, the strategy of memorizing doesn’t work well.

What we see in the case of human learning is that just by great memorizing and perfect recall, students can do well in the examinations only till a certain stage. Beyond that, a better learning strategy needs to be adopted:

(1) to be able to deal with the vastness of the subject matter and the related issues in memorizing it

(2) to be able to answer questions where a direct answer has not been learnt

A good option is to figure out the key points or ideas amongst a vast pool of knowledge. For example, a broad pool of knowledge may consist of all living animals and their characteristics such as whether they live in land or water, whether they lay eggs, whether they have scales or fur or none, etc. It is a difficult task for any student to memorize the characteristics of all living animals. It is better to draw a notion about the basic groups that all living animals belong to and the characteristics which define each of the basic groups:

(i) Invertebrate: Do not have backbones and skeletons, such as worm, insect etc.
(ii) Vertebrate
   1. Fishes: Always live in water and lay eggs
   2. Amphibians: Semi-aquatic i.e. may live in water or land; smooth skin; lay eggs
   3. Reptiles: Semi-aquatic like amphibians; scaly skin; lay eggs; cold-blooded
   4. Birds: Can fly; lay eggs; warm-blooded
   5. Mammals: Have hair or fur; have milk to feed their young; warm-blooded

Moving to the machine learning paradigm, the vast pool of knowledge is available from the data input. However, rather than using it in entirety, a concept map, is drawn from the input data. This is nothing but knowledge abstraction as performed by the machine. In the end, the abstracted mapping from the input data can be applied to make critical conclusions.

For example,

(i) if the group of an animal is given, understanding of the characteristics can be automatically made.

(ii) Reversely, if the characteristic of an unknown animal is given, a definite conclusion can be made about the animal group it belongs to. This is generalization in context of machine learning.

1.3.1.1 Abstraction

During the machine learning process, knowledge is fed in the form of input data. However, the data cannot be used in the original shape and form. As we saw in the example above, abstraction helps in deriving a conceptual map based on the input data. This map, or a **model** as it is known in the machine learning paradigm, is summarized knowledge representation of the raw data. The model may be in any one of the following forms:

(1) Computational blocks like if/else rules
(2) Mathematical equations
(3) Specific data structures like trees or graphs
(4) Logical groupings of similar observations

The choice of the model for a specific learning problem is a human task, based on multiple aspects, some of which are listed below:

(1) The type of problem to be solved: Whether the problem is related to forecast or prediction, analysis of trend, understanding the different segments or groups of objects, etc.
(2) Nature of the input data: How exhaustive the input data is, whether the data has no values for many fields, the data types, etc.
(3) Domain of the problem: If the problem is in a critical domain with a high rate of data input and need for immediate inference, e.g. fraud detection problem in banking domain.

Once the model is chosen, the next task is to fit the model based on the input data. Let's understand this with an example.

In a case where the model is represented by a mathematical equation, say $y = c_1 + c_2x$, based on the input data, we have to find out the values of c_1 and c_2. Otherwise, the equation (or the model) is of no use. So, fitting the model, in this case, means finding the values of the unknown coefficients or constants of the equation or the model.

This process of fitting the model based on the input data is known as **training or learning**. Also, the input data based on which the model is being finalized is known as **training data**.

1.3.1.2 Generalization

The first part of machine learning process is abstraction i.e. abstract the knowledge from the input data in the form of a model. However, this abstraction process, or training the model, is just one part of machine learning. The other key part is to tune up the abstracted knowledge to a form which can be used to take future decisions. This is achieved as a part of generalization.

The model is trained based on a finite set of data, which may possess a limited set of characteristics. But when we want to apply the model to take decision on a set of unknown data, usually termed as **test data**, we may encounter two problems:

(1) The trained model is aligned with the training data too much, hence may not portray the actual trend.

(2) The test data possess certain characteristics apparently unknown to the training data.

Hence, we has the risk of not making a correct decision – quite obviously because certain assumptions that are made may not be true in reality. But just like machines, same mistakes can be made by humans too when a decision is made based on intuition in a situation where exact reason-based decision-making is not possible.

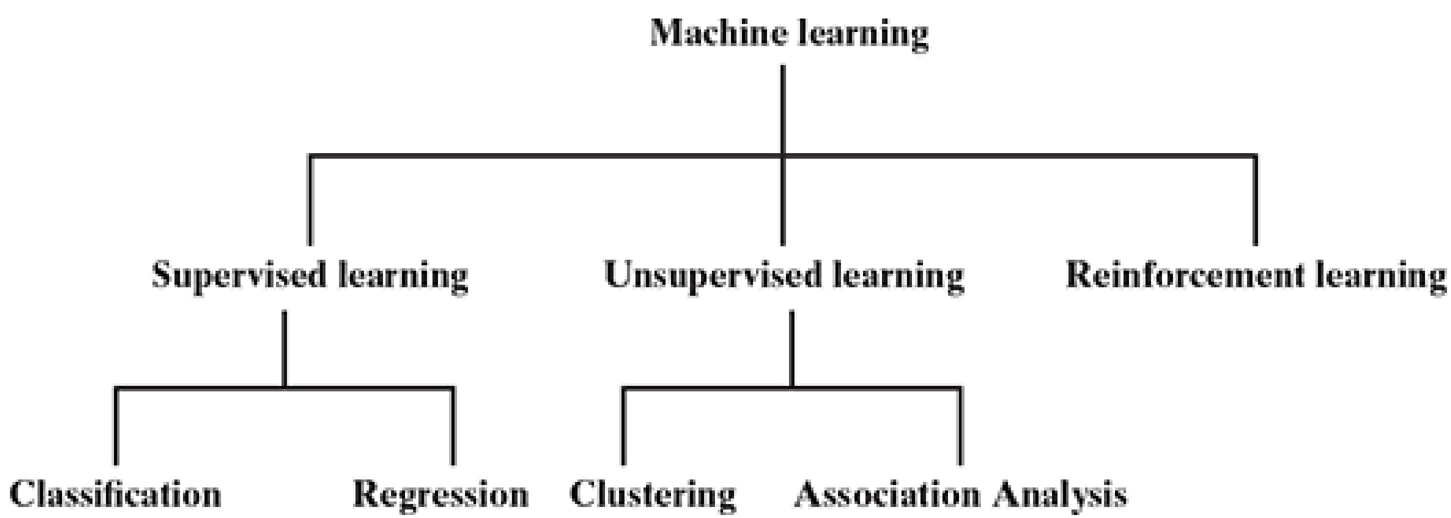
1.4 TYPES OF MACHINE LEARNING

Machine learning can be classified into three broad categories:

(1) Supervised learning – Also called predictive learning. A machine predicts the class of unknown objects based on prior class-related information of similar objects.

(2) Unsupervised learning – Also called descriptive learning. A machine finds patterns in unknown objects by grouping similar objects together.

(3) Reinforcement learning – A machine learns to act on its own to achieve the given goals.

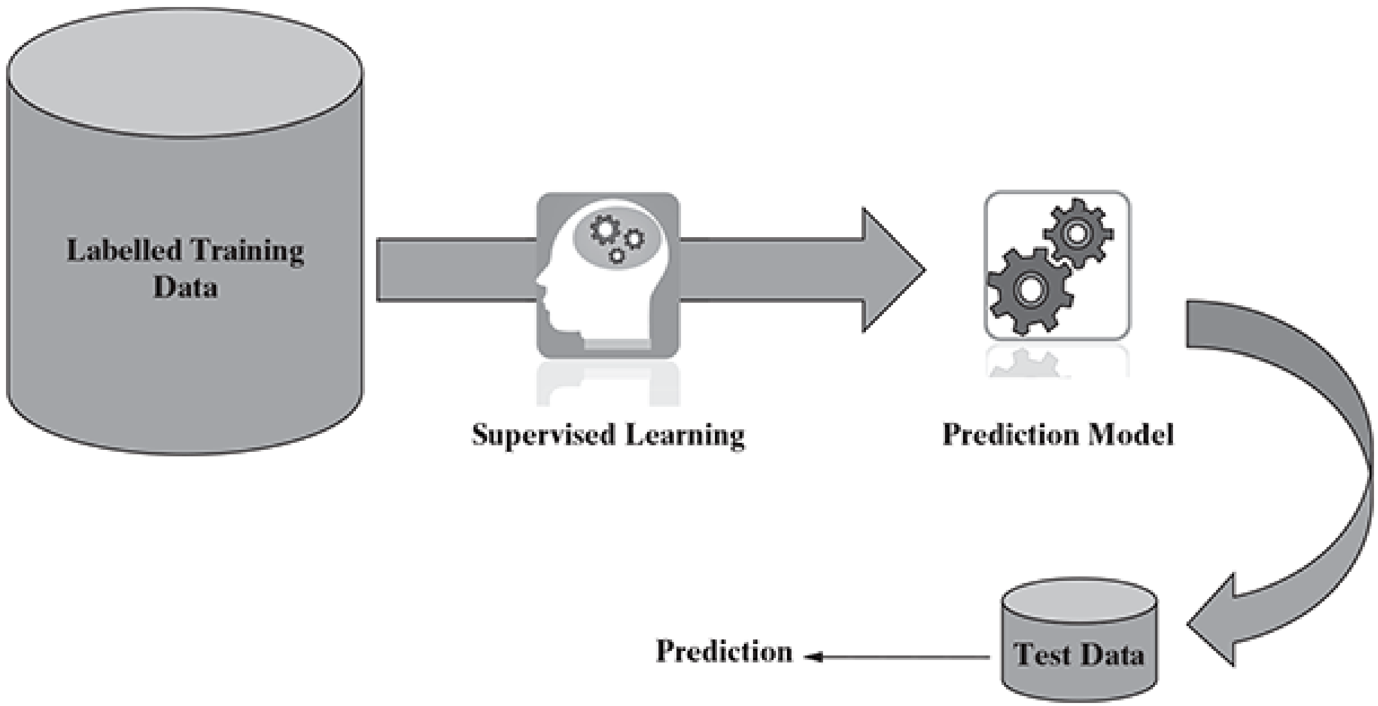


1.4.1 Supervised learning

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.



Supervised learning

Some examples of supervised learning are:

(1) Predicting the results of a game
(2) Predicting whether a tumour is malignant or benign
(3) Predicting the price of real estate, stocks, etc.
(4) Classifying texts such as classifying a set of emails as spam or non-spam

Now, let's consider two of the above examples, say 'predicting whether a tumour is malignant or benign', and 'predicting price of real estate'.

Are these two problems same in nature? The answer is 'no'.

Though both of them are prediction problems, in one case we are trying to predict which category or class an unknown data belongs to, whereas in the other case we are trying to predict a real value and not a class.

When we are trying to predict a categorical variable, the problem is known as a **classification** problem. Whereas when we are trying to predict a real-valued variable, the problem falls under the category of **regression.**

Let's try to understand these two areas of supervised learning, i.e. classification and regression in more details.

1.4.1.1 Classification

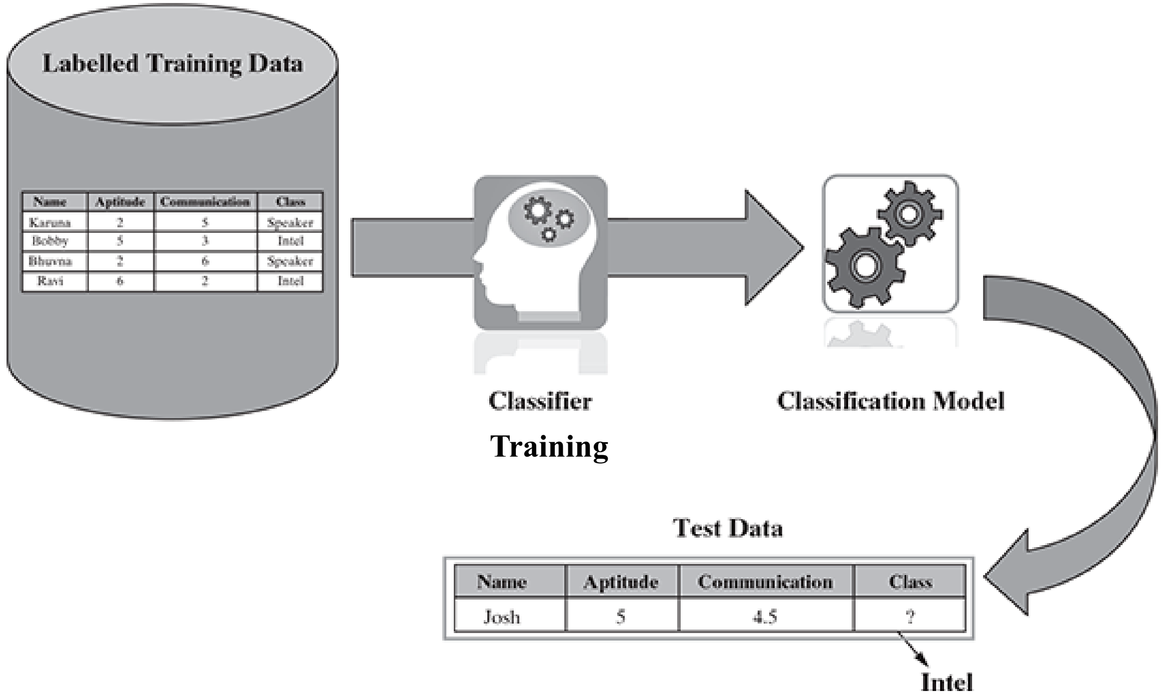
Let’s discuss how to segregate the images of objects based on the shape .

If the image is of a round object, it is put under one category, while if the image is of a triangular object, it is put under another category. In which category the machine should put an image of unknown category, also called a **test data** in machine learning, depends on the information it gets from the past data, which we have called as training data.

Since the training data has a label or category defined for each image, the machine has to map a new image or test data to a set of images to which it is similar to and assign the same label or category to the test data.

So we observe that the whole problem revolves around assigning a label or category or class to a test data based on the label or category or class information that is imparted by the training data. Since the target objective is to assign a class label, this type of problem is referred as classification problem. The following figure depicts the typical process of classification.

In summary, classification is a type of supervised learning where a target variable, which is categorical, is predicted for test data based on the information imparted by training data. The target categorical variable is known as **class**.



Some typical classification problems include:

(1) Image classification
(2) Prediction of disease
(3) Win-loss prediction of games
(4) Prediction of natural calamity like earthquake, flood, etc.
(5) Recognition of handwriting

1.4.1.2. Regression

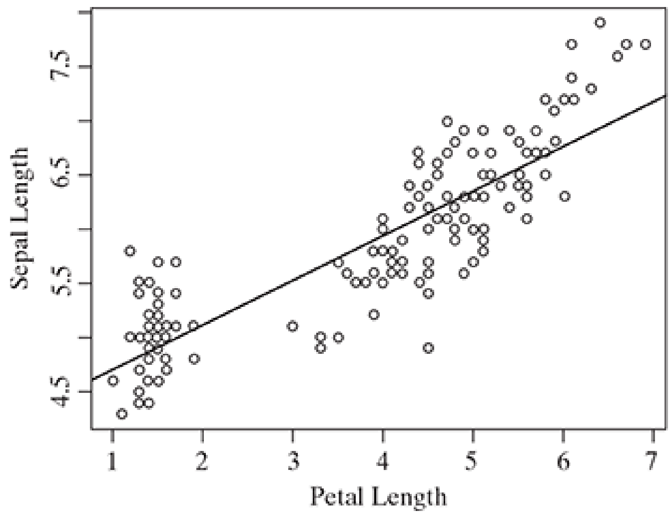
In regression, the objective is to predict numerical (real-valued) variables like real estate or stock price, temperature, marks in an examination, sales revenue, etc. The underlying predictor variable and the target variable are continuous in nature.

In case of linear regression, a straight-line relationship is fitted between the predictor variables and the target variables, using the statistical concept of least squares method.

In case of simple linear regression, there is only one predictor variable, whereas in case of multiple linear regression, multiple predictor variables can be included in the model.

Let's take the example of yearly budgeting exercise of the sales managers. They have to give sales prediction for the next year based on sales figure of previous years vis-à-vis investment being put in. Obviously, the data related to past as well as the data to be predicted are continuous in nature. In a basic approach, a simple linear regression model can be applied with investment as predictor variable and sales revenue as the target variable.

The figure below shows a typical simple regression model, where regression line is fitted based on values of target variable (i.e. sepal length) with respect to different values of predictor variable (i.e. petal length).



Typical applications of regression can be seen in

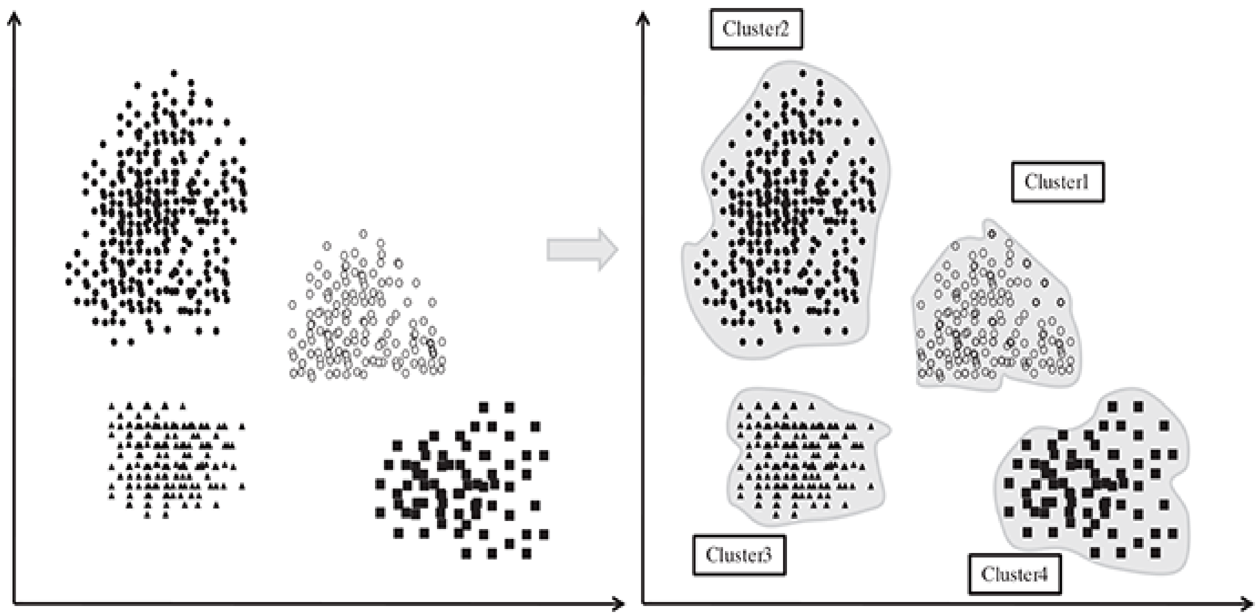
(1) Demand forecasting in retails
(2) Sales prediction for managers
(3) Price prediction in real estate
(4) Growth prediction in economics
(5) Enrol student number prediction in education

1.4.2 Unsupervised learning

Unlike supervised learning, in unsupervised learning, there is no labelled training data to learn from and no prediction to be made. In unsupervised learning, the objective is to take a dataset as input and try to find natural groupings or **patterns** within the data elements or records. Therefore, unsupervised learning is often termed as **descriptive learning** and the process of unsupervised learning is referred as **pattern discovery** or **knowledge discovery**.

One critical application of unsupervised learning is customer segmentation. **Clustering** is the main type of unsupervised learning. It intends to group or organize similar objects together. For that reason, objects belonging to the same cluster are quite similar to each other, while objects belonging to different clusters are quite dissimilar. Hence, the objective of clustering is to discover the intrinsic grouping of unlabelled data and form clusters, as depicted in the following figure.

Different measures of similarity can be applied for clustering. One of the most commonly adopted similarity measure is distance. Two data points are considered as a part of the same cluster if the distance between them is less. In the same way, if the distance between the data points is high, the items do not generally belong to the same cluster. This is also known as distance-based clustering.



Clustering

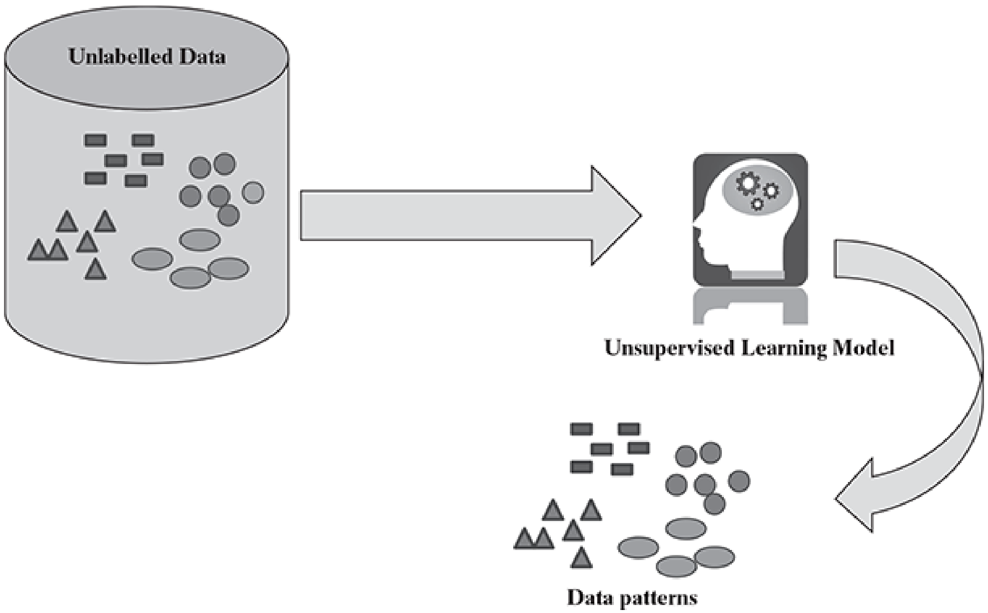
Other than clustering of data and getting a summarized view from it, one more variant of unsupervised learning is **association analysis**. As a part of association analysis, the association between data elements is identified. Let's try to understand the association analysis in context of market basket analysis as shown below. From past transaction data in a grocery store, it may be observed that most of the customers who have bought item A, have also bought item B and item C or at least one of them. This means that there is a strong association of the event 'purchase of item A' with the event 'purchase of item B', or 'purchase of item C'.

Identifying these sorts of associations is the goal of association analysis. Applications of association analysis include market basket analysis and recommendation etc.

TransID	Items Bought
1	{Butter, Bread}
2	{Diaper, Bread, Milk, Beer}
3	{Milk, Chicken, Beer, Diaper}
4	{Bread, Diaper, Chicken, Beer}
5	{Diaper, Beer, Cookies, Ice cream}
...	...

Market Basket transactions
Frequent itemsets ➔ (Diaper, Beer)
Possible association: Diaper ➔ Beer

Association analysis



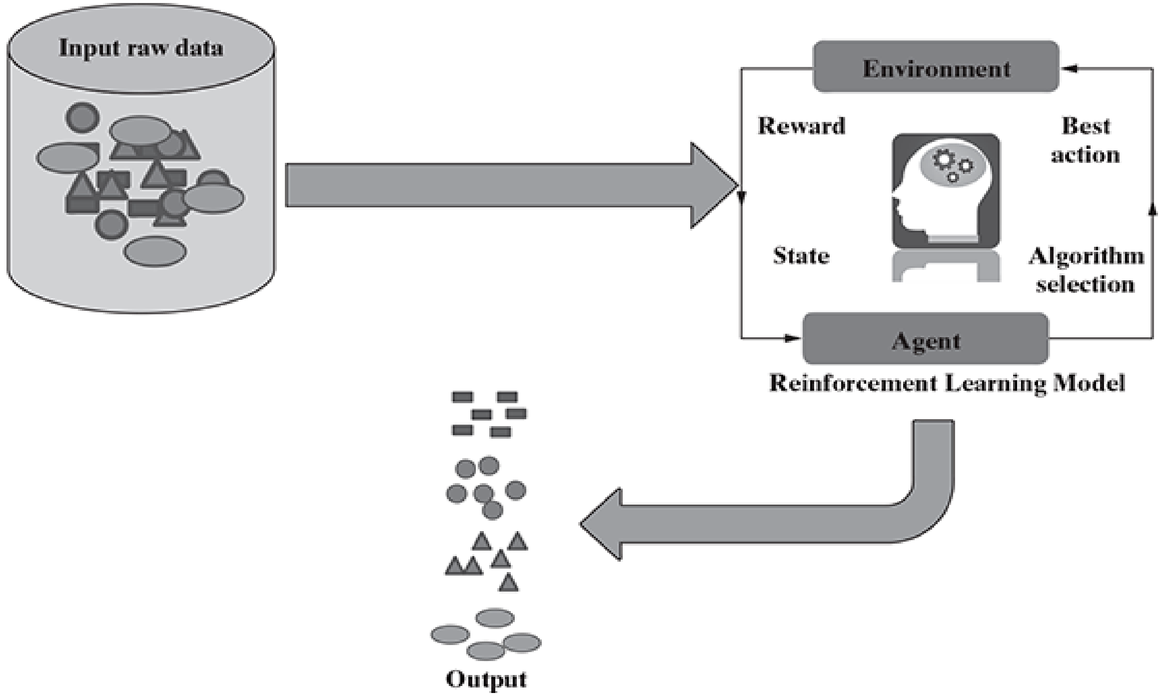
Process of unsupervised learning

1.4.3 Reinforcement learning

We have seen babies learn to walk without any prior knowledge of how to do it. Often we wonder how they really do it. They do it in a relatively simple way.

First they notice somebody else walking around, for example parents or anyone living around. They understand that legs have to be used, one at a time, to take a step. While walking, sometimes they fall down hitting an obstacle, whereas other times they are able to walk smoothly avoiding bumpy obstacles. When they are able to walk overcoming the obstacle, their parents are elated and appreciate the baby with loud claps / or may be a chocolates. When they fall down while circumventing an obstacle, obviously their parents do not give claps or chocolates. Slowly a time comes when the babies learn from mistakes and are able to walk with much ease.

In the same way, machines often learn to do tasks autonomously. Let’s try to understand in context of the example of the child learning to walk. The action tried to be achieved is walking, the child is the agent and the place with hurdles on which the child is trying to walk is the environment. It tries to improve its performance of doing the task. When a sub-task is accomplished successfully, a reward is given. When a sub-task is not executed correctly, obviously no reward is given. This continues till he is able to complete execution of the whole task. This process of learning is known as **reinforcement learning**. The following figure shows the high-level process of reinforcement learning.



Process of reinforcement learning

One contemporary example of reinforcement learning is self-driving cars. The critical information which it needs to take care of are speed and speed limit in different road segments, traffic conditions, road conditions, weather conditions, etc. The tasks that have to be taken care of are start/stop, accelerate/decelerate, turn to left / right, etc.

Further details on reinforcement learning are out of the scope of this course. If you are interested, please search and read relevant materials on the Internet.

1.5 APPLICATIONS OF MACHINE LEARNING

Wherever there is a substantial amount of past data, machine learning can be used to gain insight from the data. Though machine learning is adopted in multiple forms in every business domain, we have covered below three major domains just to give some idea about what type of actions can be done using machine learning.

1.5.1 Banking and finance

In the banking industry, fraudulent transactions, especially the ones related to credit cards, are extremely prevalent. Since the volumes as well as velocity of the transactions are extremely high, high performance machine learning solutions are implemented by almost all leading banks across the globe. The models work on a real-time basis, i.e. the fraudulent transactions are spotted and prevented right at the time of occurrence. This helps in avoiding a lot of operational hassles in settling the disputes.

Customers of a bank are often offered lucrative proposals by other competitor banks. Proposals like higher bank interest, lower processing charge of loans, zero balance savings accounts, no overdraft penalty, etc. are offered to customers, with the intent that the customer switches over to the competitor bank. Also, sometimes customers get demotivated by the poor quality of services of the banks and shift to competitor banks. Machine learning helps in preventing or at least reducing the customer churn. Both descriptive and predictive learning can be applied for reducing customer churn.

Using descriptive learning, the specific pockets of problem, i.e. a specific bank or a specific zone or a specific type of offering like car loan, may be spotted where maximum churn is happening. Quite obviously, these are troubled areas where further investigation needs to be done to find and fix the root cause. Using predictive learning, the set of vulnerable customers who may leave the bank very soon, can be identified. Proper action can be taken to make sure that the customers stay back.

1.5.2 Insurance

Insurance industry is extremely data intensive. For that reason, machine learning is extensively used in the insurance industry. Two major areas in the insurance industry where machine learning is used are risk prediction during new customer onboarding and claims management.

During customer onboarding, based on the past information the risk profile of a new customer needs to be predicted. Based on the quantum of risk predicted, the quote is generated for the prospective customer. When a customer claim comes for settlement, past information related to historic claims along with the adjustor notes are considered to predict whether there is any possibility of the claim to be fraudulent. Other than the past information related to the specific customer, information related to similar customers, i.e. customer belonging to the same geographical location, age group, ethnic group, etc., are also considered to formulate the model

1.5.3 Healthcare

Wearable device data form a rich source for applying machine learning and predict the health conditions of the person real time. In case there is some health issue which is predicted by the learning model, immediately the person is alerted to take preventive action. In case of some extreme problem, doctors or healthcare providers in the vicinity of the person can be alerted.

Suppose an elderly person goes for a morning walk in a park close to his house. Suddenly, while walking, his blood pressure shoots up beyond a certain limit, which is tracked by the wearable. The wearable data is sent to a remote server and a machine learning algorithm is constantly analyzing the streaming data. It also has the history of the elderly person and persons of similar age group. The model predicts some fatality unless immediate action is taken. Alert can be sent to the person to immediately stop walking and take rest. Also, doctors and healthcare providers can be alerted to be on standby.

Machine learning along with computer vision also plays a crucial role in disease diagnosis from medical imaging.

1.6 STATE-OF-THE-ART LANGUAGES/TOOLS IN MACHINE LEARNING

The algorithms related to different machine learning tasks are known to all and can be implemented using any language/platform. It can be implemented using a Java platform or C / C++ language. However, there are certain languages and tools which have been developed with a focus for implementing machine learning. Few of them, which are most widely used, are listed below.

1.6.1 Python

Python is one of the most popular, open-source programming language widely adopted by machine learning community.

Python has very strong libraries for advanced mathematical functionalities, algorithms and mathematical tools, and numerical plotting. Built on these libraries, there is a machine learning library named **scikit-learn**, which has various classification, regression, and clustering algorithms embedded in it.

1.6.2 R

R is a language for statistical computing and data analysis. It is an open-source language, extremely popular in the academic and industry – especially among statisticians and data miners.

R is a very simple programming language with a huge set of libraries available for different stages of machine learning.

1.6.3 MATLAB

MATLAB (matrix laboratory) is a licenced commercial software with a robust support for a wide range of numerical computing. MATLAB has a huge user base across industry and academia. MATLAB is developed by MathWorks. Being proprietary software, MATLAB is developed much more professionally, tested rigorously, and has comprehensive documentation.

MATLAB also provides extensive support of statistical functions and has a huge number of machine learning algorithms in-built. It also has the ability to scale up for large datasets by parallel processing on clusters and cloud.

1.7 ISSUES IN MACHINE LEARNING

Machine learning is a field which is relatively new and still evolving. Also, the level of research and kind of use of machine learning tools and technologies varies drastically from country to country. The laws and regulations, cultural background, emotional maturity of people differ drastically in different countries. All these factors make the use of machine learning and the issues originating out of machine learning usage are quite different.

The biggest fear and issue arising out of machine learning is related to privacy and the breach of it. The primary focus of learning is on analyzing data, both past and current, and coming up with insight from the data. This insight may be related to people and the facts revealed might be private enough to be kept confidential. Also, different people have a different preference when it comes to sharing of information. While some people may be open to sharing some level of information publicly, some other people may not want to share it even to all friends and keep it restricted just to family members. Some people share them with all in the social platforms like Facebook while others do not, or if they do, they may restrict it to friends only. When machine learning algorithms are implemented using those information, inadvertently people may get upset. For example, if there is a learning algorithm to do preference-based customer segmentation and the output of the analysis is used for sending targeted marketing campaigns, it will hurt the emotion of people and actually do more harm than good.

Even if there is no breach of privacy, there may be situations where actions were taken based on machine learning may create an adverse reaction. Let's take the example of knowledge discovery exercise done before an election campaign. If a specific area reveals an ethnic majority or skewness of a certain demographic factor, and the campaign pitch carries a message keeping that in mind, it might actually upset the voters and cause an adverse result.

So, a very critical consideration before applying machine learning is that proper human judgement should be exercised before using any outcome from machine learning. Only then the decision taken will be beneficial and also not result in any adverse impact.

1.8 SUMMARY

Machine learning imbibes the philosophy of human learning, i.e. learning from expert guidance and from experience.

(1) The basic machine learning process can be divided into three parts.

- Data Input: Past data or information is utilized as a basis for future decision-making.
- Abstraction: The input data is represented in a summarized way
- Generalization: The abstracted representation is generalized to form a framework for making decisions.

(2) Machine learning can be classified into three broad categories:

- Supervised learning: Also called predictive learning. The objective of this learning is to predict class/value of unknown objects based on prior information of similar objects. Examples: predicting whether a tumour is malignant or benign, price prediction in domains such as real estate, stocks, etc.
- Unsupervised learning: Also called descriptive learning, helps in finding groups or patterns in unknown objects by grouping similar objects together. Examples: customer segmentation, recommender systems, etc.
- Reinforcement learning: A machine learns to act on its own to achieve the given goals. Examples: self-driving cars, intelligent robots, etc.

(3) Machine learning has been adopted by various industry domains such as Banking and Financial Services, Insurance, Healthcare, Life Sciences, Engineering etc. to solve problems.

(4) Some of the most adopted platforms to implement machine learning include Python, R, MATLAB etc.

(5) To avoid ethical issues, the critical consideration is required before applying machine learning and using any outcome from machine learning.