Welcome to:

Introduction to machine learning

Introduction to machine learning

After completing this unit, you should be able to:

- Understand the history of machine learning
- Understand the advantages and drawbacks of using machine learning
- Learn the concept of how machines do work
- Gain an insight on the basic steps of machine learning
- Gain knowledge on the different types of machine learning approaches

Introduction

- Computer adopts a systematic approach, an algorithm.
  - Proven sequence of steps: transform the input to output.
  - Searching an element in a stored list of elements

- When the input data is not well defined, the model or algorithm cannot be predefined.

- Build a system by making it learn from the examples.
  - Weather prediction.
  - Person identification based on biometric.

Figure: Algorithm Economy, 2016

Introduction

Identifying Buying patterns:

It is hardy difficult for humans to learn and predict the customer's buying patterns, though the process is arbitrary

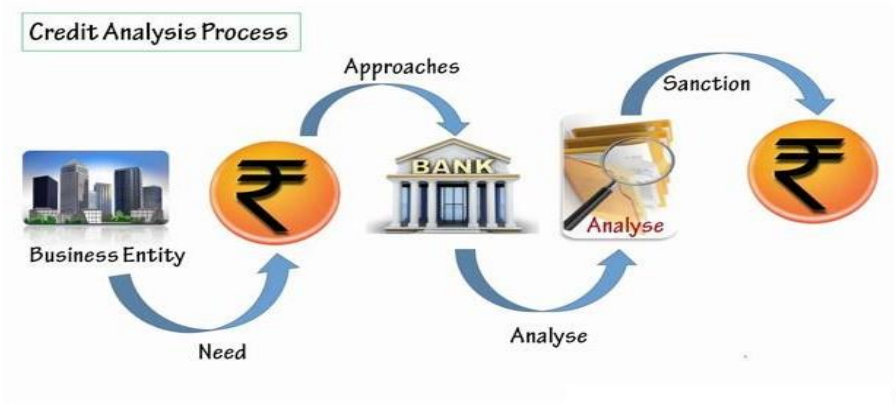
Machines perform better than humans!!!

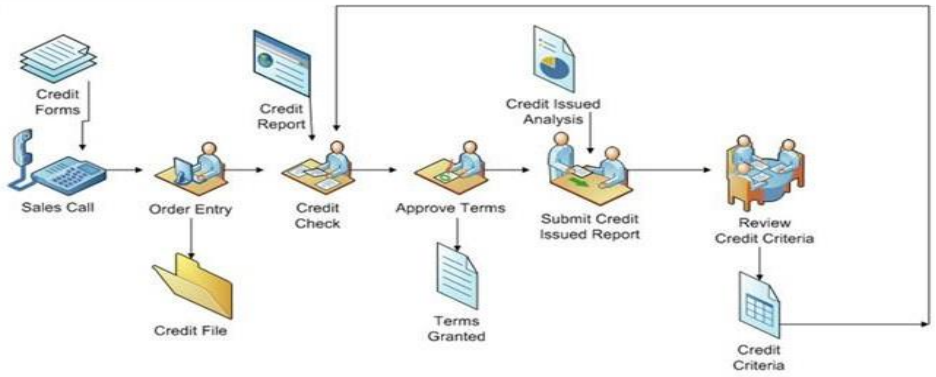
Motivation for machine learning

- The conventional techniques fail to recognize the process entirely, however we can get a good and useful approximation.
- These approximated patterns or regularities are the key factors of machine learning (ML), which help us in understanding the process and help us to make predictions.
- ML provides computers to learn and interpret without being explicitly programmed to do so.
- The computers also referred to as models are exposed to sets of raw data, they adapt independently and learn from earlier computations to interpret available data and identify hidden patterns.
- ML enables computers and computing machines to search for and identify hidden insights, without being programmed for where to look for, when exposed to new data sets.
- The main reason for resurging attention in machine learning is due to:
  - Powerful and affordable computational capability
  - Unceasingly rising volumes of massive data sets
  - Inexpensive data storage choices.

Applications of machine learning

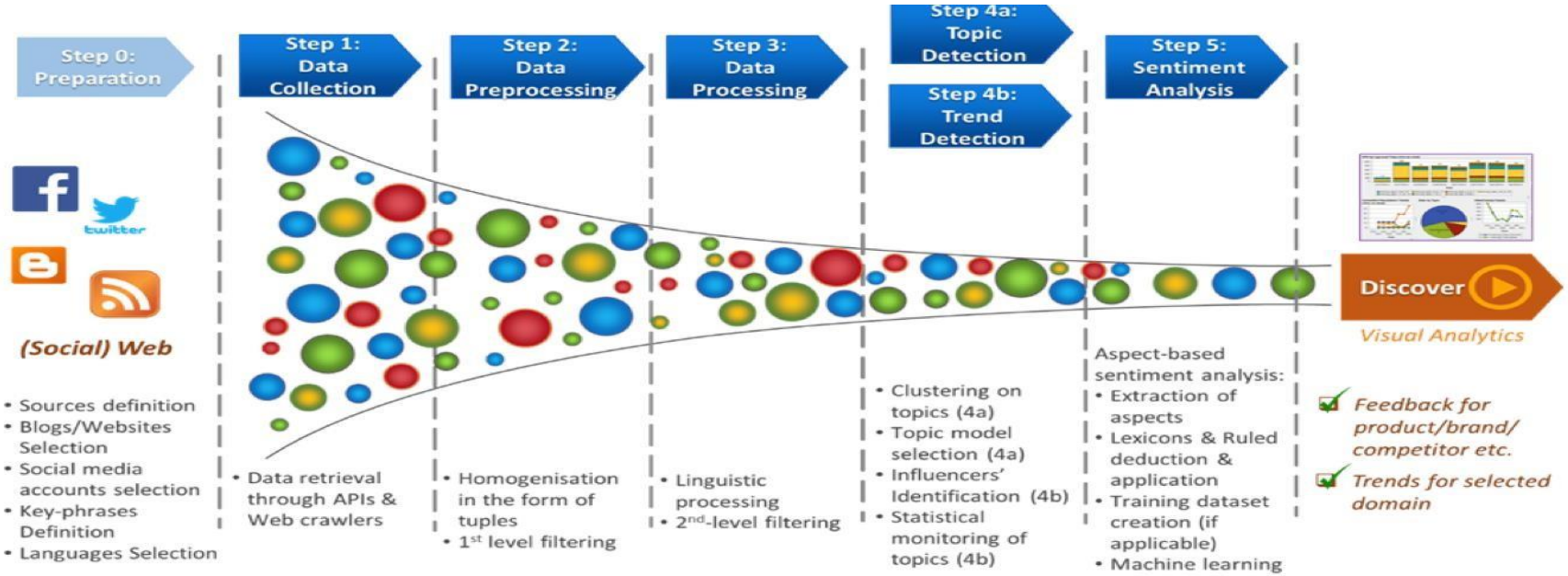
- Analyzing credit applications based on bank's past data
- Fraud detection
- Stock market prediction
- In manufacturing for optimization, control and trouble shooting
- In medicine, for medical diagnostics
- In telecommunications, for network optimization, call patterns.
- For information retrieval in www or social media





Motivation for machine learning

- By getting insights from their data, businesses can work more efficiently and can gain a competitive edge.
- Using ML organizations can deliver personalized services and differentiated products that precisely cater to the varying needs of the customers.
- It also helps companies to identify opportunities that can be profitable in the long run.

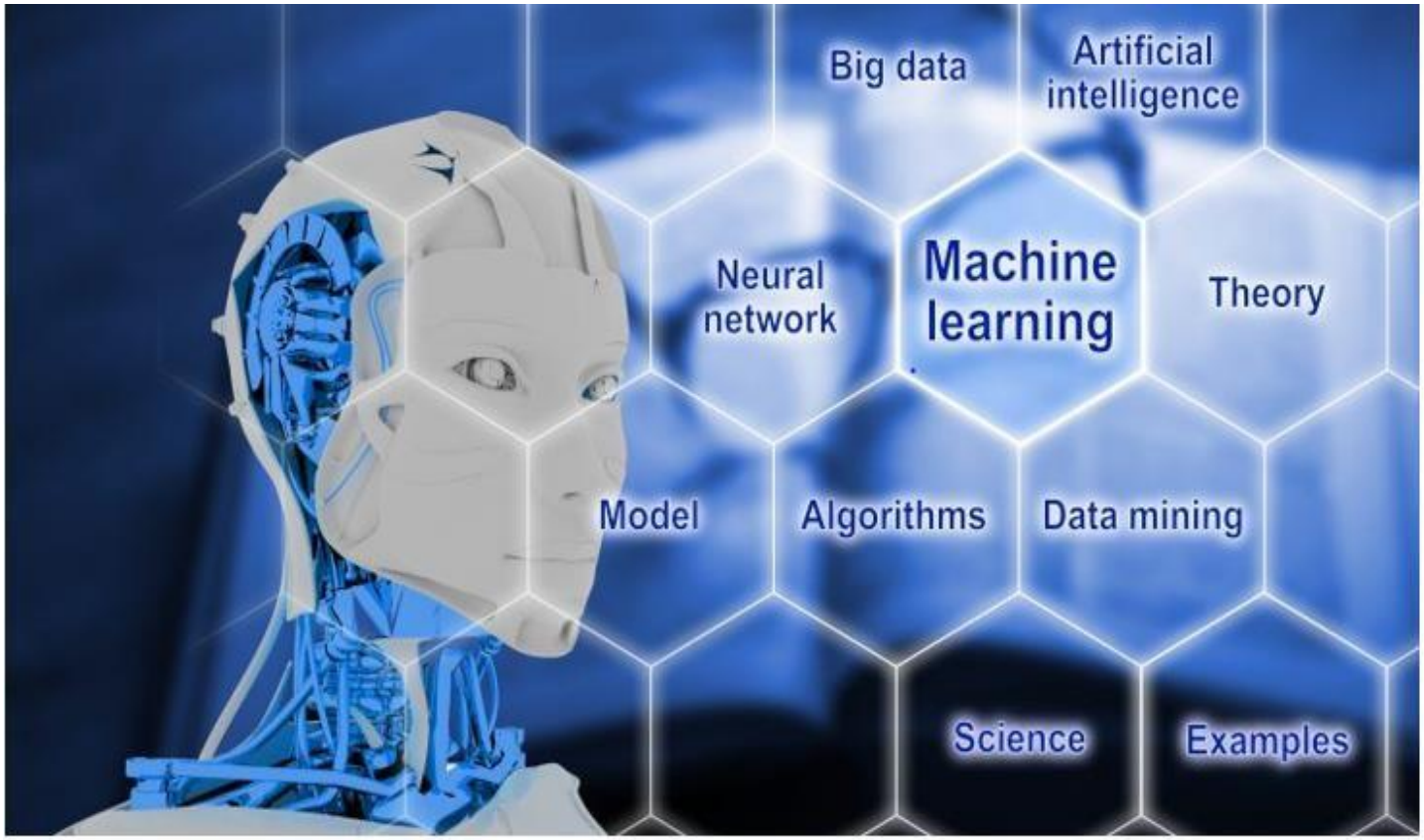


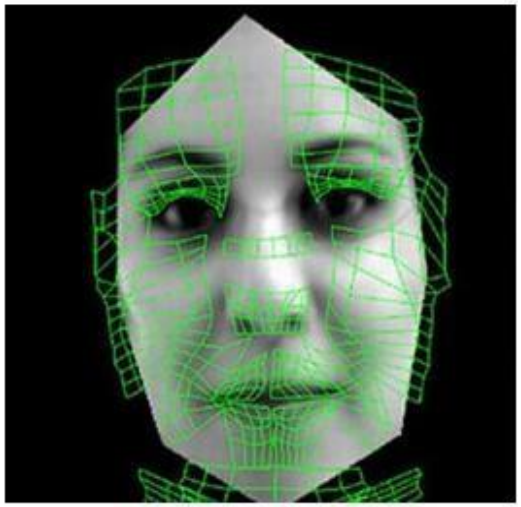
Source: https://i0.wp.com/vinodsblog.com/

Machine learning

- Machine learning is a part of artificial intelligence rather than being a simple database problem.

- It needs to learn from constantly changing environment.



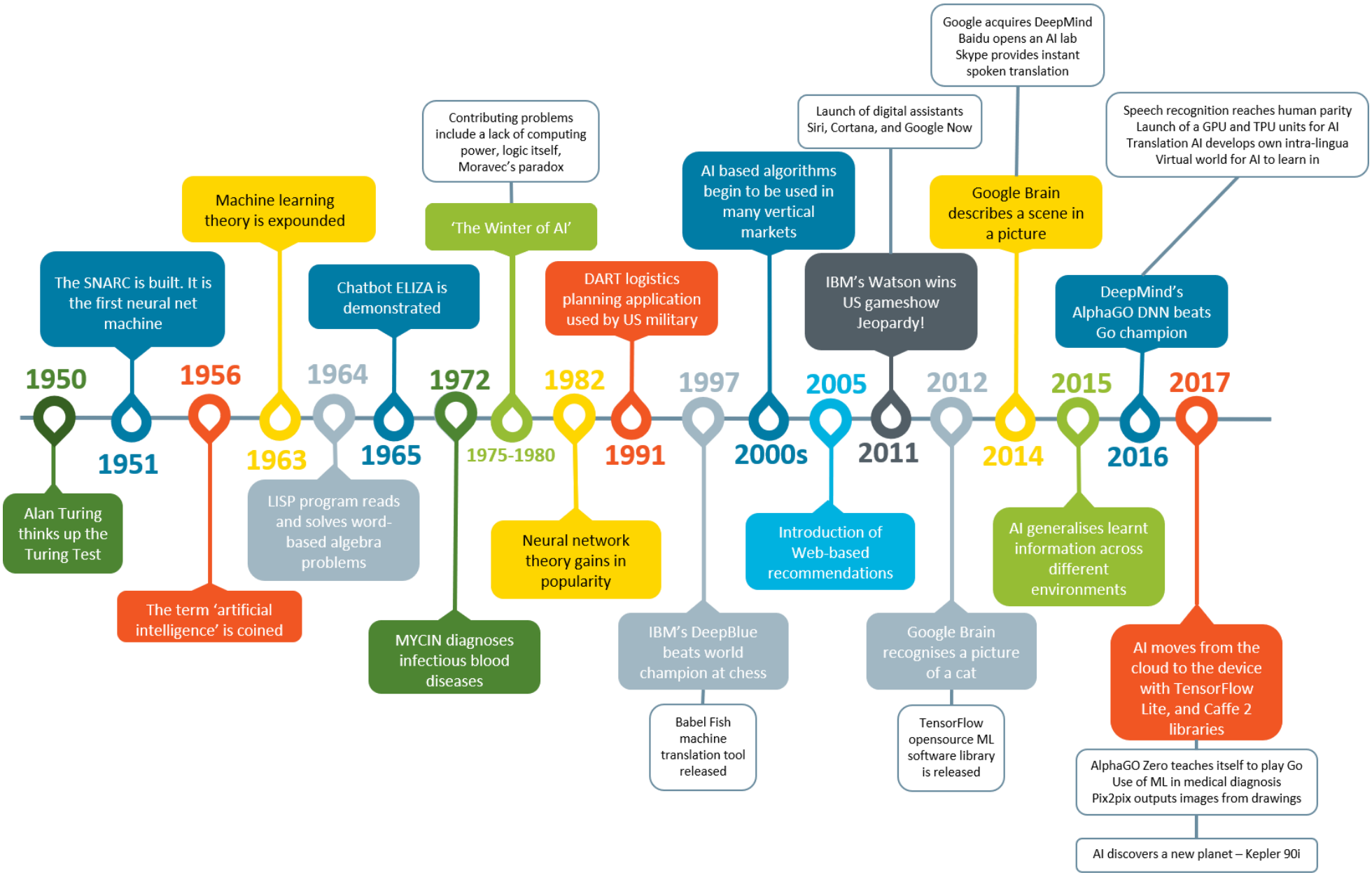


Source: https://www.guru.com/d/freelancers/q/machine-learning/

Machine learning

- ML is a process of programming computers to optimize a performance criterion using example data or past experience.
- We define a model up to some parameters, and learning is the execution of a computer program to optimize the parameters of the model using the training data or past experience.
- The model may be predictive to make predictions or descriptive to gain knowledge from data, or both.
- For e.g. identifying a horse from a given set of images provided to it. (some of which are horses and some of which are not horses)

The origin of machine learning



Source: https://www.researchgate.net

Time line of machine learning techniques

IBM ICE (Innovation Centre for Education)

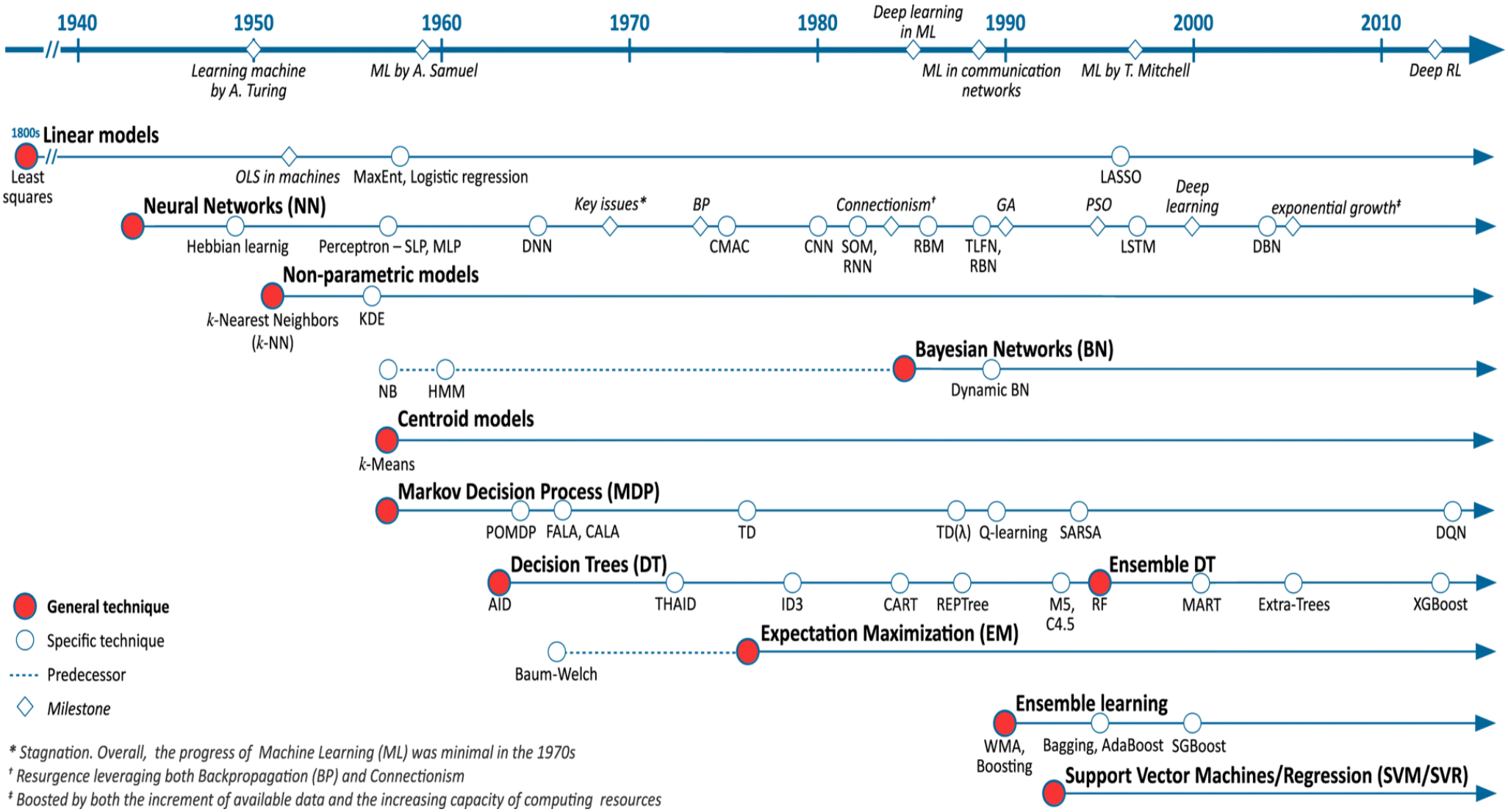


Figure: Boutaba, R., Salahuddin, M.A., Limam, N. et al. J Internet Serv Appl (2018) 9: 16

Source: https://doi.org/10.1186/s13174-018-0087-2

Uses and abuses of machine learning

- Machines are still relatively limited in their ability to thoroughly understand a problem.
- Machines have pure intellectual horsepower without guidance.
- Needs a human intervention to motivate the analysis and turn the result into meaningful action.
- Machine learning is highly successful when it augments with a system, rather than replacing the specialized knowledge of a subject-matter expert.
- Machine learning assists medical doctors at the forefront of the fight to eradicate cancer, assists engineers and programmers to create smarter homes and automobiles and helps social scientists build knowledge of how societies function.
- It is employed in numerous businesses, scientific laboratories, hospitals, and government organizations. Some machine learning algorithm are commonly employed among the organizations which generate or aggregate data make sense of it.

Success cases of machine learning

- Spam mail detection
- Segmentation of customer behavior for targeted advertising
- Forecasts of weather behavior and long term climate changes
- Reduction of fraudulent credit card transactions
- Actuarial estimates of financial damage of storms and natural disasters.
- Prediction of popular election outcomes
- Development of algorithms for auto-piloting drones and self driving cars.
- Optimization of energy use in homes and office buildings.
- Projection of areas where criminal activity is most likely.
- Discovery of genetic sequences linked to diseases.

Limitations of Machine Learning

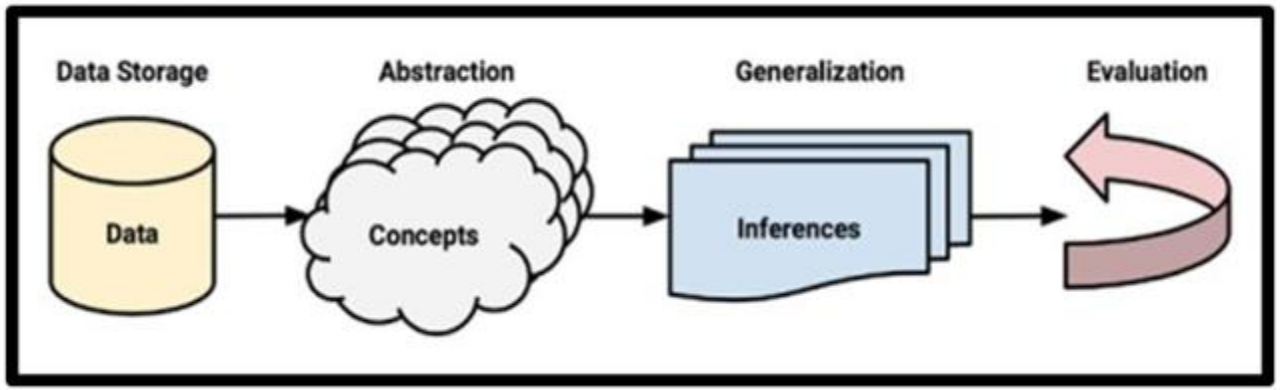
- Machine learning is in no way a substitute to a human brain yet.
- It has no freedom to extrapolate outside of the strict parameters it learned and does not have common sense.
- Unless trained with enormous past experience to build a model upon, computers can show limted common sense inferences about logical next steps.

- E.g. serach for a text book.
  - Even after you have bought the book, the banner adevertisements would keeping popping up on your browser.

- Even after you have bought a house, it would keep on showing advertisements of available options. On the contrary, it should now show you ptions for interior designing, furniture etc.

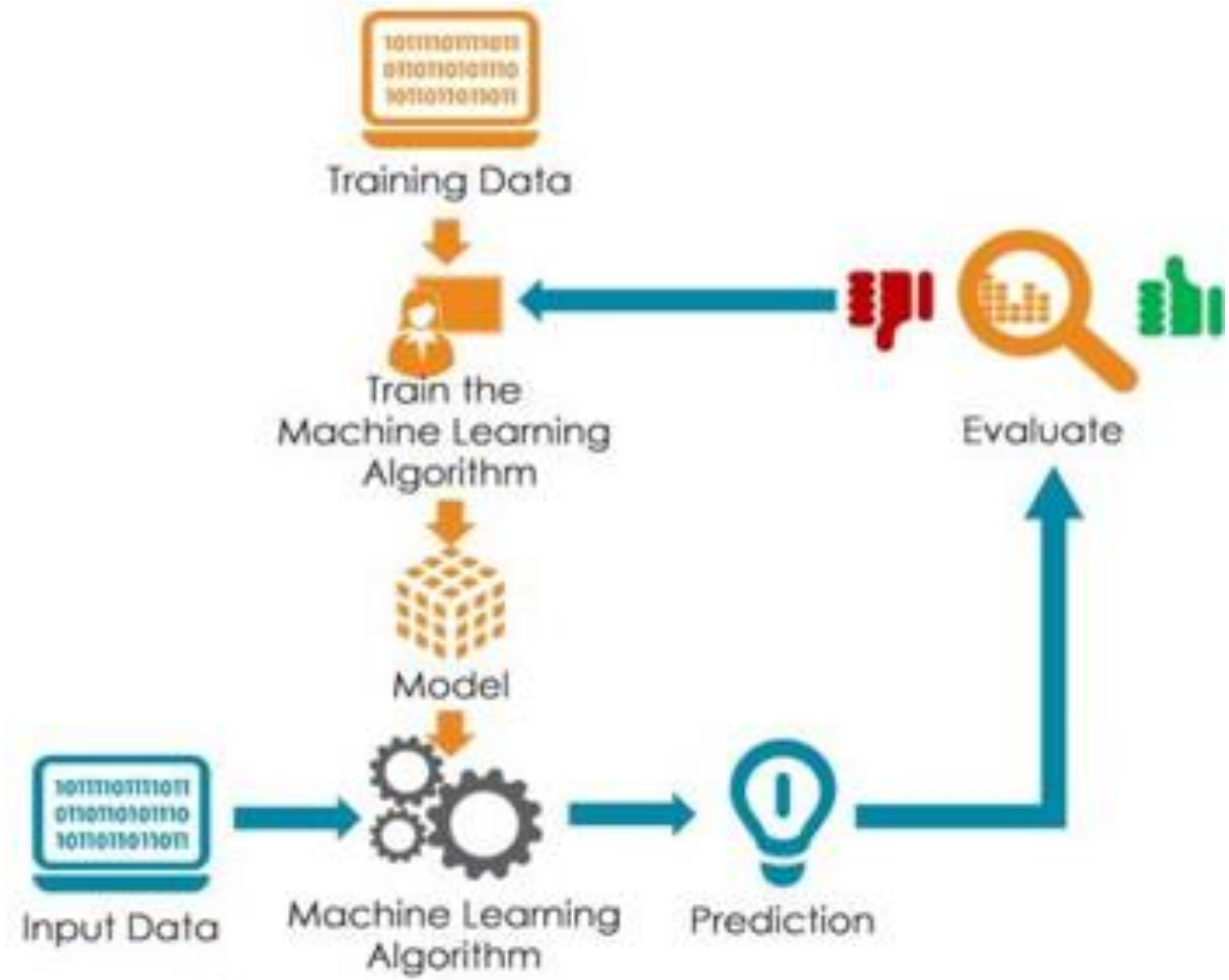
- There has been limited success in language translation, recognizing speech and handwriting.

How do machines learn?



- Data storage: Observed data and recalled data stored in is utilized to provide a factual basis to promote reasoning.
- Abstraction: Translate deposited data into wider representations and ideas.
- Generalization: explores abstracted data to form knowledge and implications that derive actions in new circumstances.
- Evaluations: delivers a feedback strategy to quantify the effectiveness of learnt knowledge and enlighten probable enhancements

How do machines learn?



How do machines learn?

How do machines learn?

- **Data storage**
  - All learning must begin with data.
  - Humans and computers alike utilize data storage as a foundation for more advanced reasoning.
  - Computers have capabilities of short and long term memory similar to human brain to store data in hard drives, flash memories, RAM etc.

How do machines learn?

Abstraction and knowledge representation

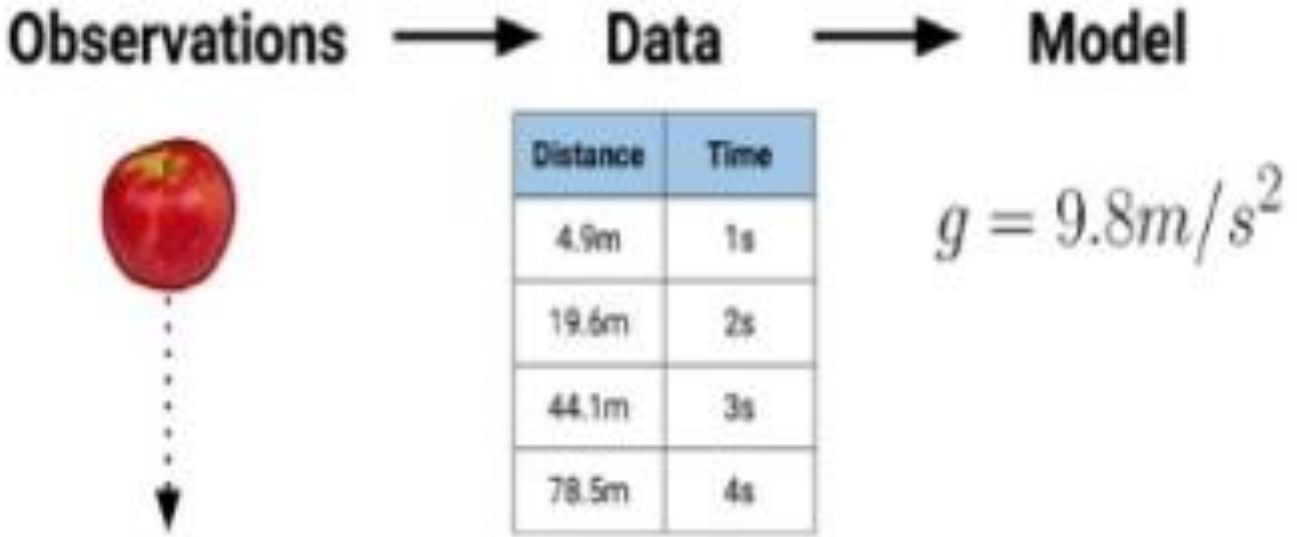
- Assigning meaning to stored data occurs during the abstraction process, in which raw data gets an abstract meaning.

- During a machine's process of knowledge representation, the computer summarizes the raw data stored using a model, an explicit description of the patterns within the data.
  - The model representation takes on a life beyond the raw data. It represents an idea greater than the sum of its parts.
  - There are different types of models, for example:
    - Mathematical equations.
    - Relational diagrams such as trees and graphs.
    - Logical if/else rules.
    - Groupings of data known as clusters.

How do machines learn?

Abstraction and knowledge representation

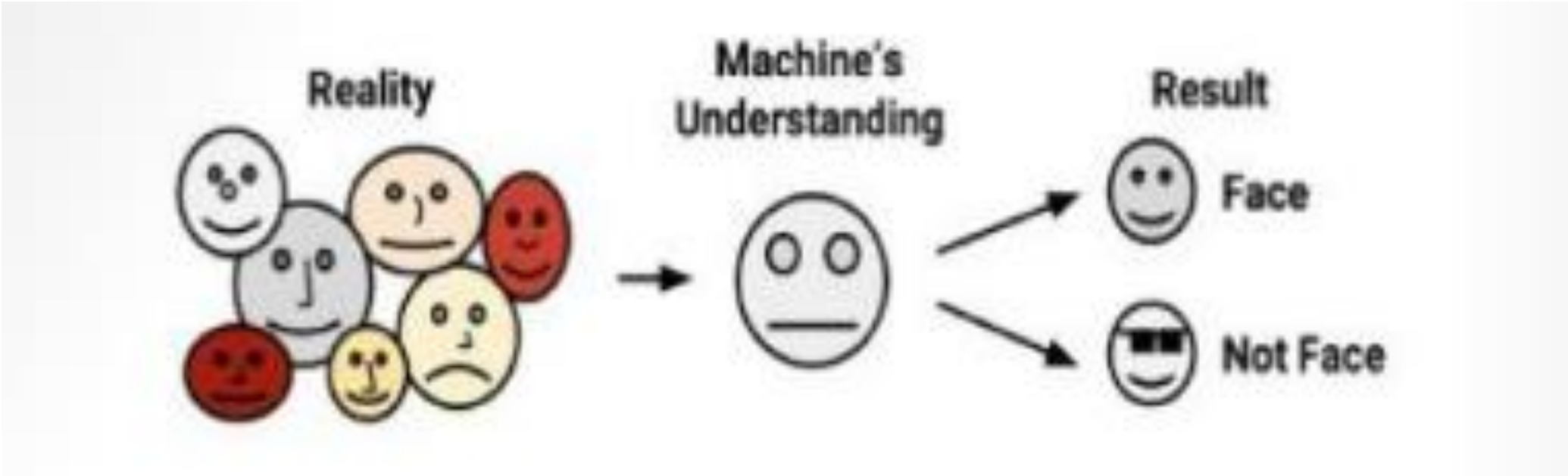
- The relationship among the data elements is established during the learning process.
- For instance, Sir Isaac Newton derived the gravity concept based on observational data.



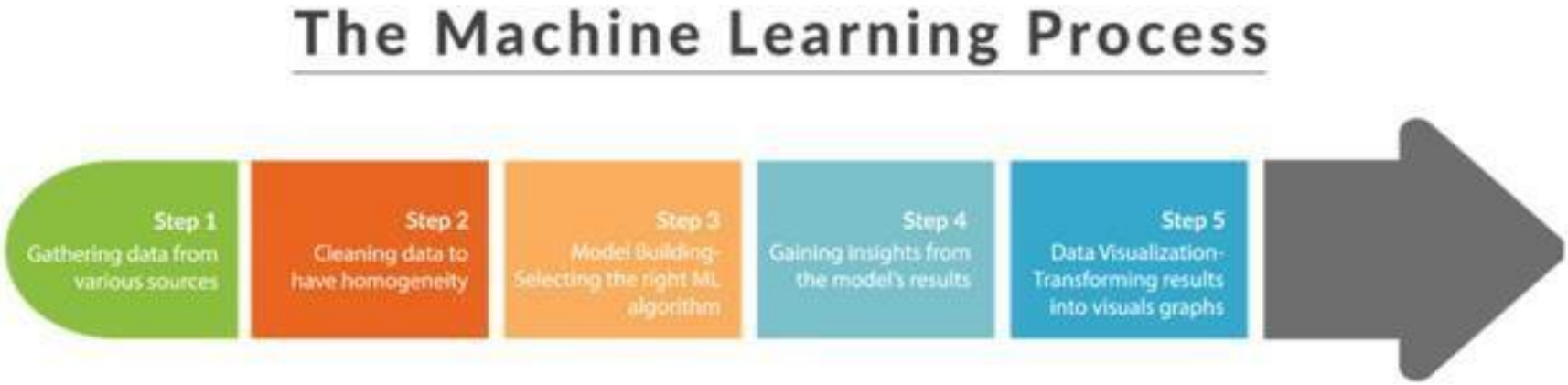
Generalization

- The learning process is not complete until the learner is able to use its abstracted knowledge for future action.
- Unless the production of abstractions is limited, the learner will be unable to proceed.
- It would be stuck where it started with a large pool of information, but no actionable insight.
- The term generalization describes the process of turning abstracted knowledge into a form that can be utilized for future action, on tasks that are similar, but not identical, to those it has seen before.
- Generalization is a somewhat vague process that is a bit difficult to describe.
- In generalization, the learner is tasked with limiting the patterns it discovers to only those that will be most relevant to its future tasks.
- It is not feasible to reduce the number of patterns by examining them one-by-one and ranking them by future utility.

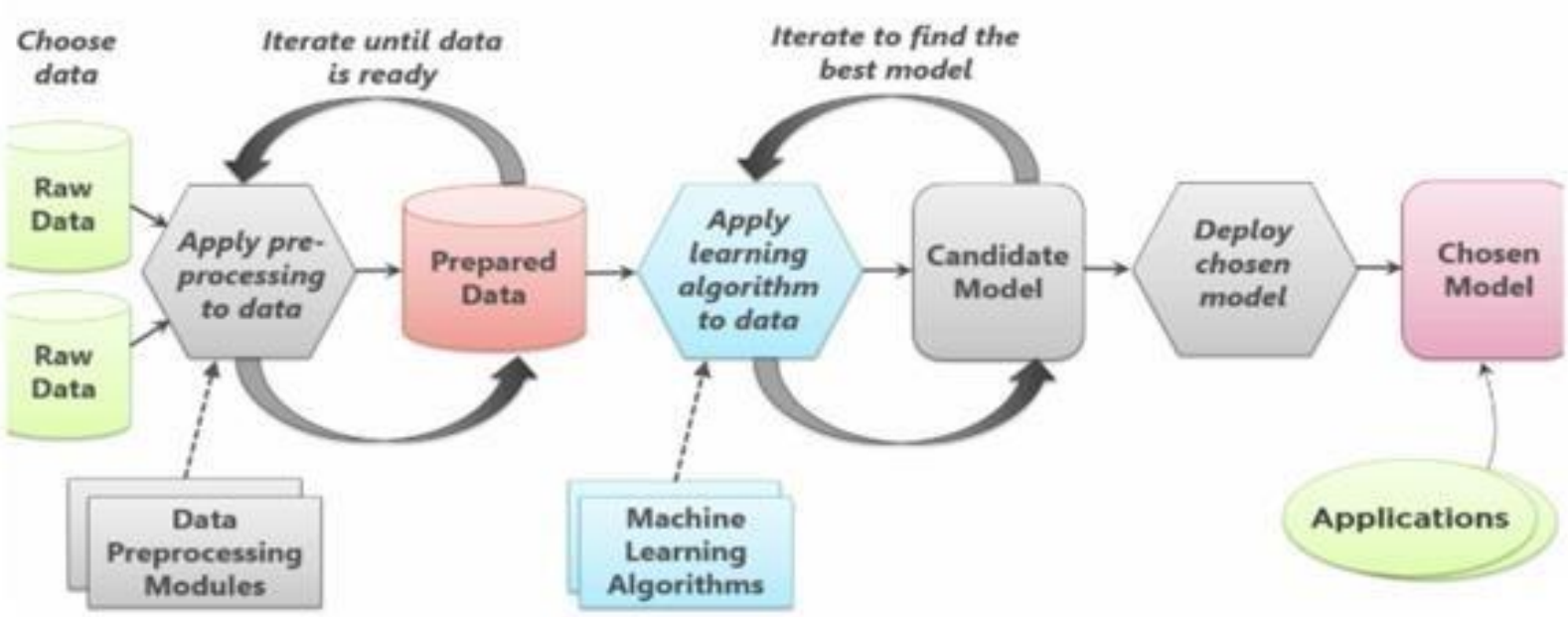
Generalization



Steps to apply machine learning to data



Source: https://www.dataschool.io/learn/



Source: www.researchgate.com

Steps to apply machine learning to data

- Representation
  - A classifier must be represented in some formal language.
  - Similarly, it is also equivalent to choosing the set of classifiers that it can possibly learn.
  - This set is called the hypothesis space of the learner.
  - If the classifier is not in the hypothesis space, it cannot be learned.
- Evaluation
  - An evaluation function (also called as objective function or scoring function) is required to distinguish good classifiers from bad ones.
- Optimization
  - The choice of the optimization technique is the key to the efficiency of the learner.

Input data and ML algorithm

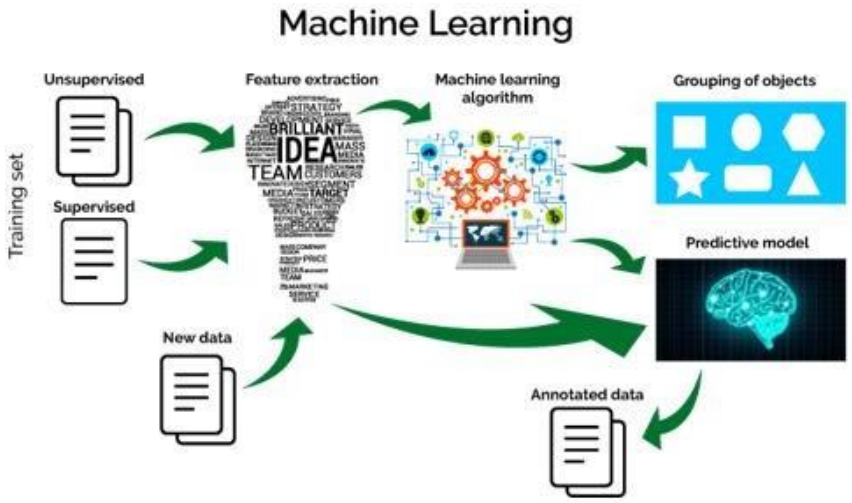
- The characteristics of input data.
- Understand the terminology that distinguishes among input datasets.
  - The unit of observation is in the form of persons, objects or things, transactions, time points, geographic regions, or measurements.
- Datasets that store the units of observation and their properties.
- Understand features and examples through real-world cases.
- Algorithms are categorized based on their purpose.
  - For example, a predictive model is employed on the cases of tasks which involve, the prediction of one value using other values in the dataset.
- Model the relationship between the target feature (the feature being predicted) and the other features.

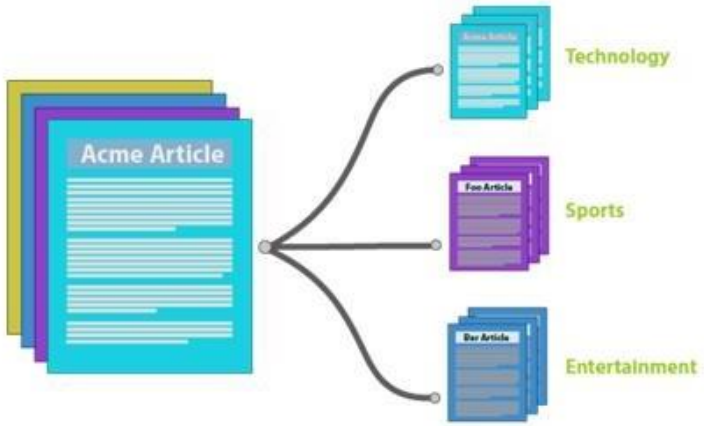
General ML architecture

- As the predictive models are well instructed regarding what they need to learn and how they are intended to learn it, the process of training a predictive model is known as supervised learning.

- The often used supervised machine learning task of predicting which category an example belongs to is known as classification.

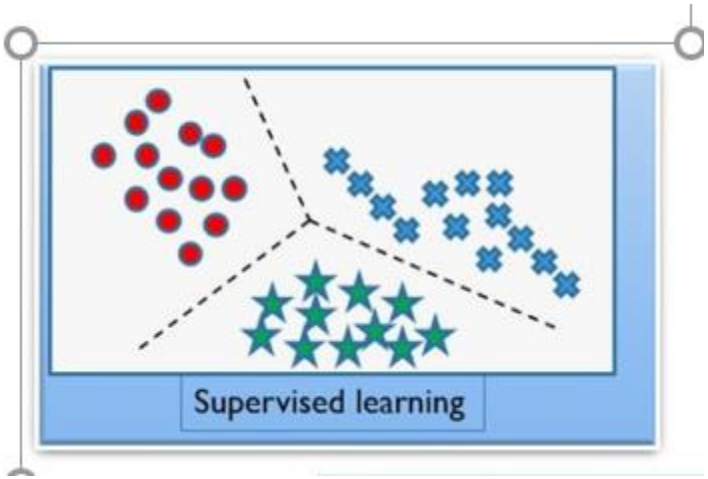
- In the case of classification, the target feature to be predicted is a categorical feature known as the class, and is divided into categories called levels.

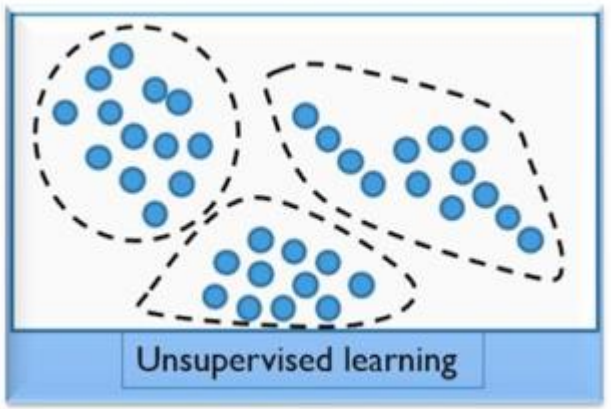


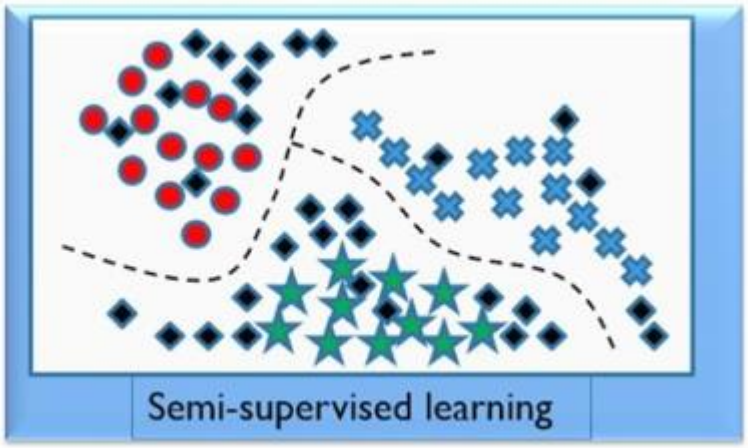


Source: https://www.xenonstack.com/blog/log-analytics-deep-machine-learning/

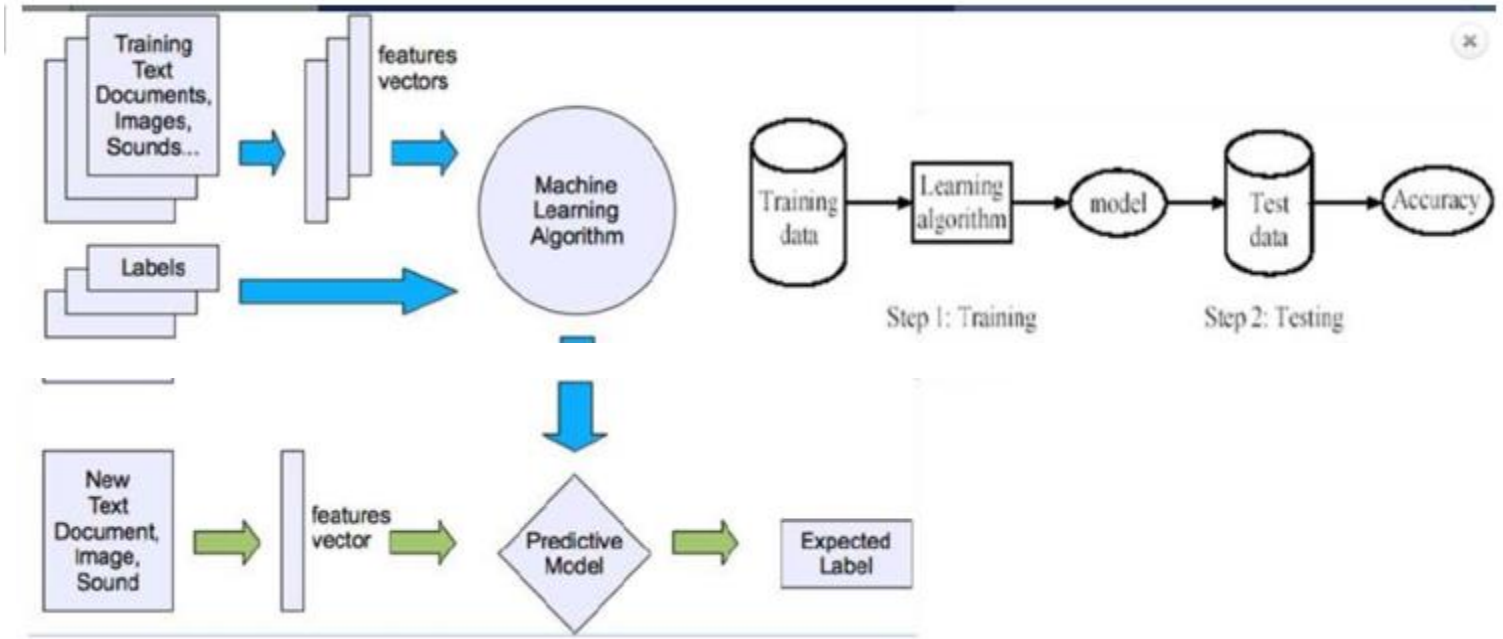
Machine learning methods







Supervised Learning



- Learning (training): Learn a model using the training data
- Testing: Test the model using unseen test data to assess the model accuracy

$$\text{Accuracy} = \frac{\text{Number of correct classifica tions}}{\text{Total number of test cases}}$$

Supervised Learning

- The steps for supervised learning algorithm
  - Decide the category of training examples.
  - Gather a training set
  - The training dataset should be the representative of the real-world situation.
  - Determining the input characteristic of the learning function, i.e. transforming the input to a feature vector
  - Compute the configuration of the learned function. E.g. designer may choose to use neural network or decision tree
  - Complete the design, accomplish the learning on the training dataset.
  - Calculate the precision of the learned function.

Supervised Learning

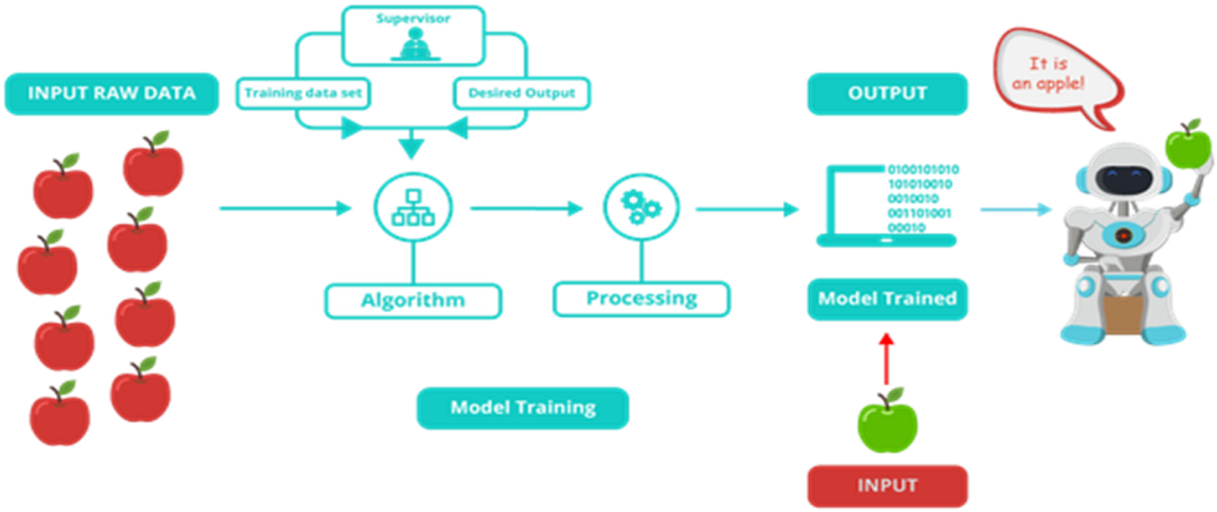
- Examples of supervised learning algorithms
  - Regression
    - Envisaging the age of a person
    - Guessing the nationality of a person
    - Predicting stock market trends
  - Classification
    - Separating mails as, spam and not-spam
    - Fraudulent and non-fraudulent data classification
    - Classifying images into M categories

Supervised learning

- In the case of supervised learning, input data is termed as training data and it has a known label uniquely mapping the data to a class.

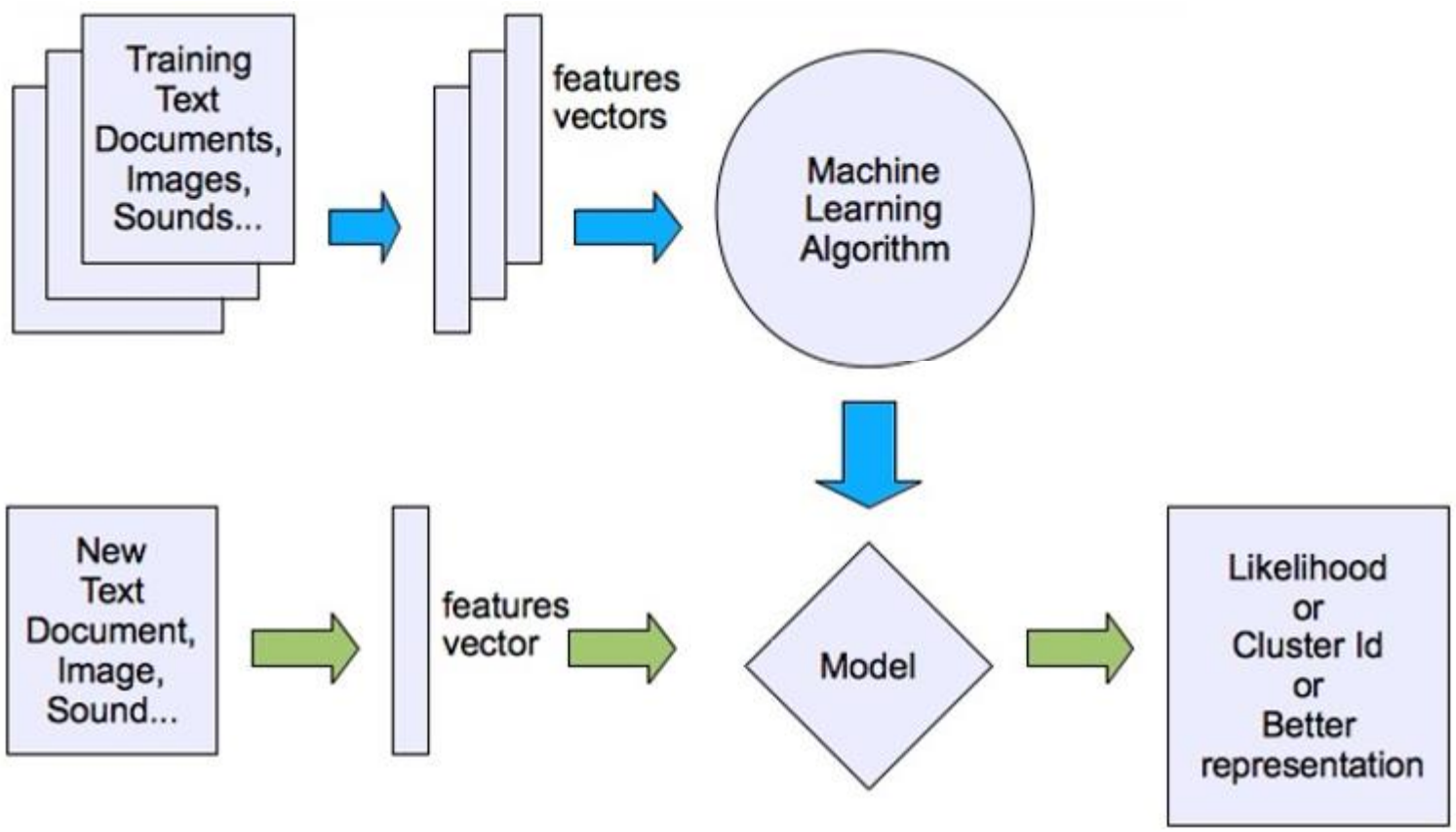
- Here a model is prepared through the training process in which it is required to make predictions and is corrected when those predictions are wrong.

- The process of training is continued until the model attains a satisfactory accuracy on the training data.



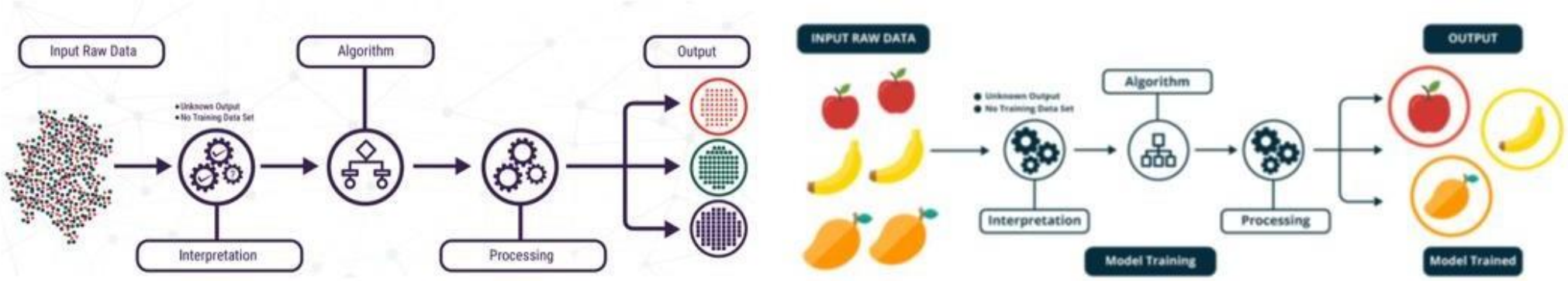
Source: https://www.edureka.co/blog/machine-learning-tutorial/

Unsupervised learning



Unsupervised learning

- Supervised learning, teaches a mapping from the input to an output where the correct values are provided, by a supervisor.
- In the cases of unsupervised learning, we are provided with only the data, without labels.
- The goal is to find the regularities in the input.
- The input space follows certain patterns, our goal is to build a model to identify these patterns.



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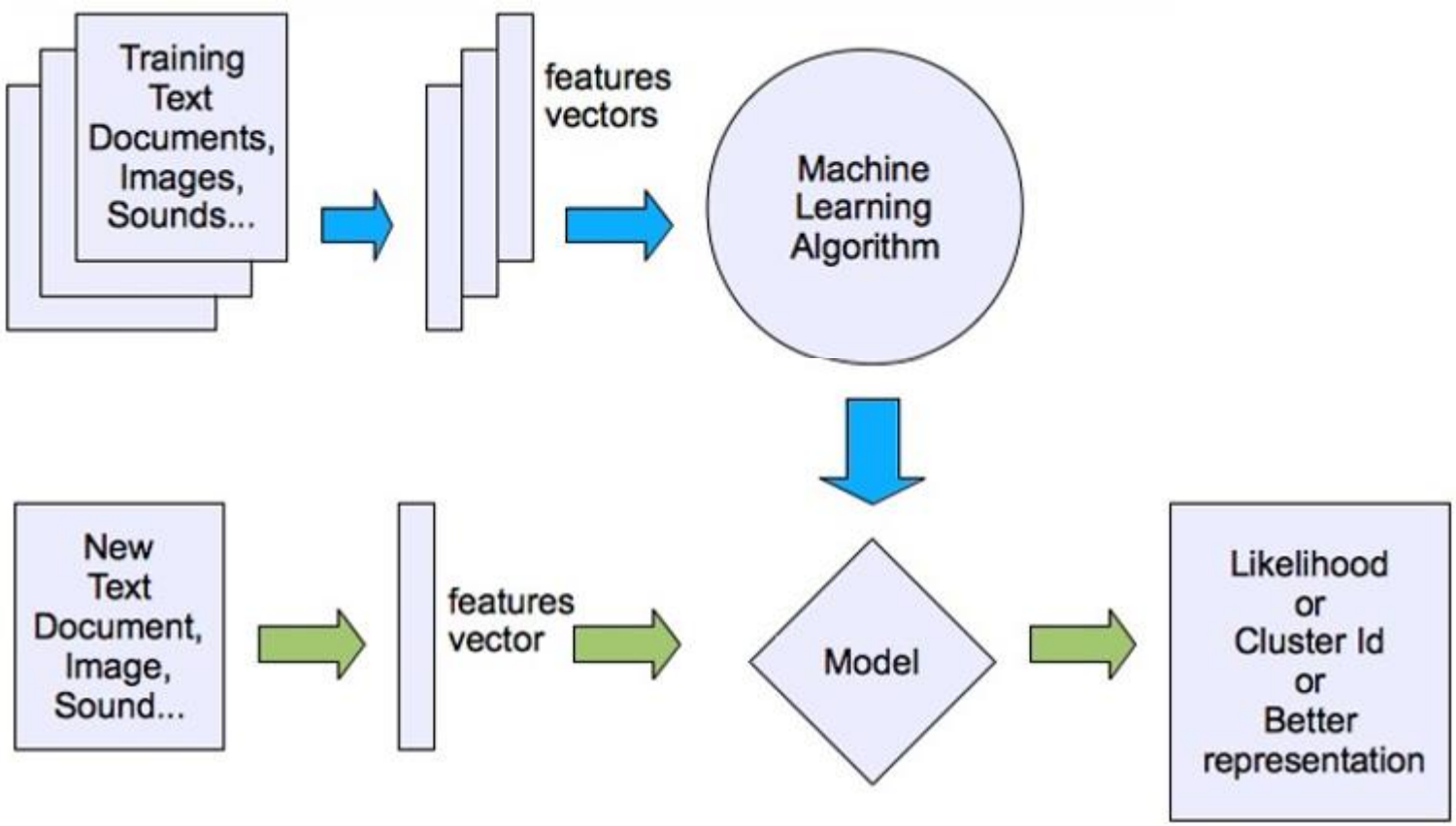
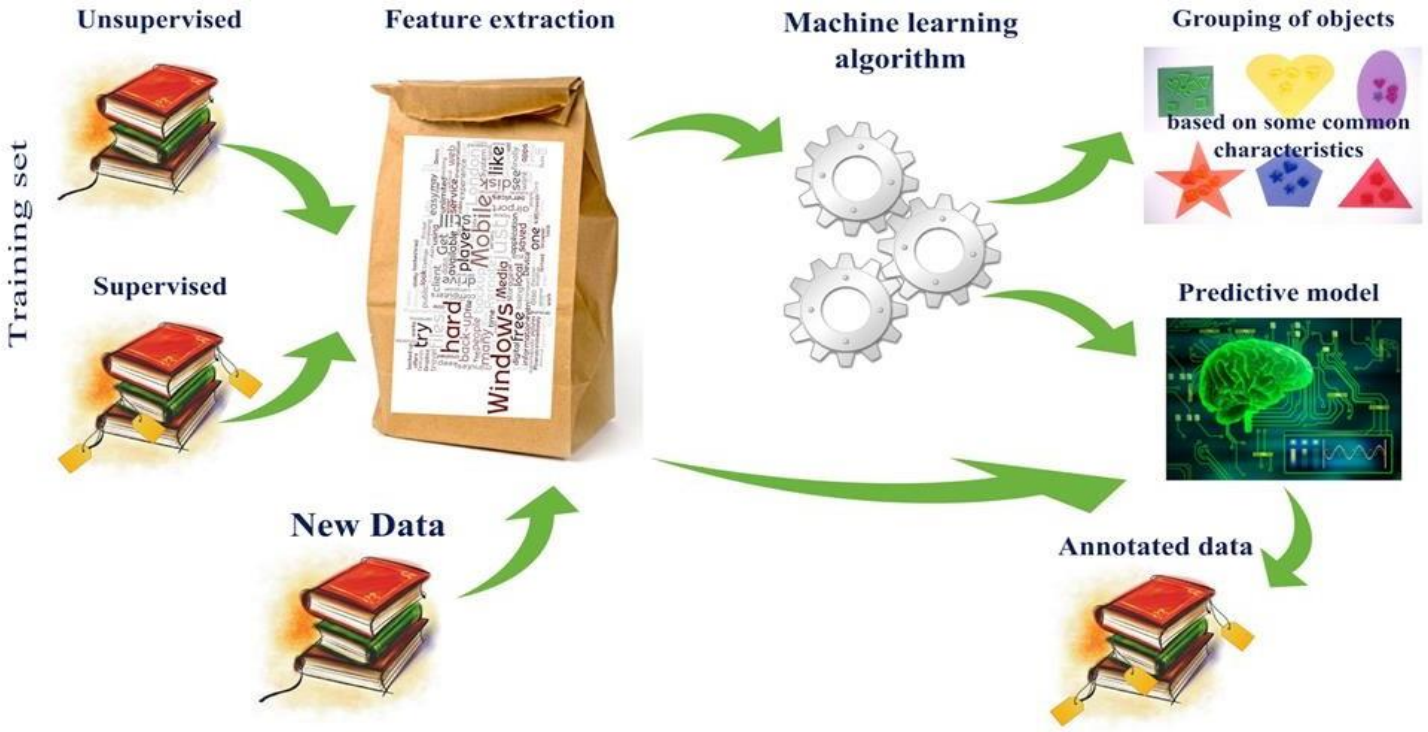
Semi-supervised learning



Semi-supervised learning

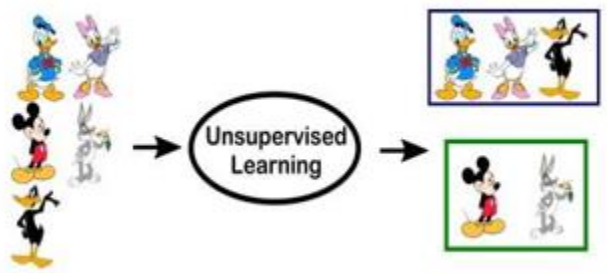
- In the case of Semi-supervised learning input data termed as training data, consists of both labeled and unlabeled collections of information.

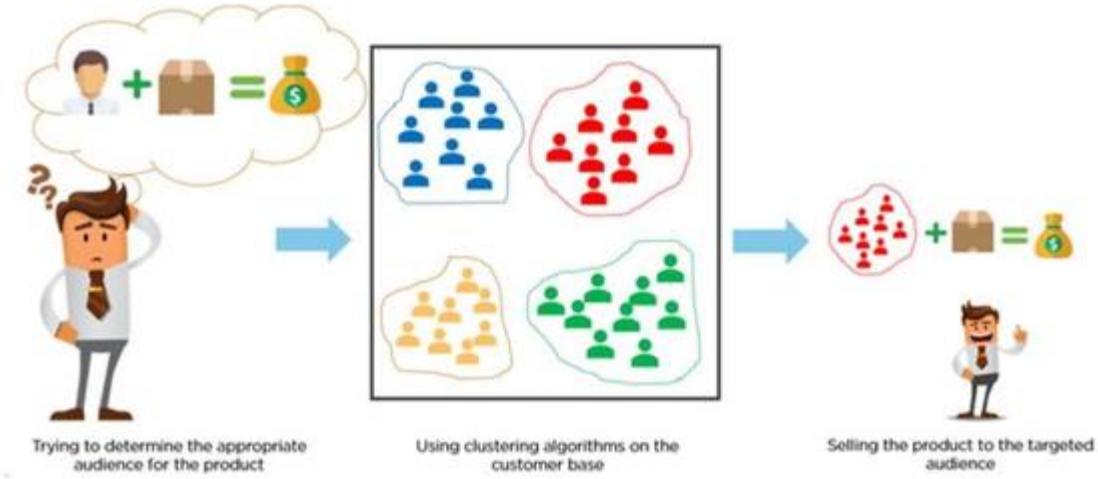
- There is a desired prediction problem but the model must learn the structures to organize the data as well as make predictions.



Source: https://d4datascience.wordpress.com/2016/03/31/difference-between-usual-machine-learning-and-deep-learning-explained/

Clustering


Unsupervised
Learning


Trying to determine the appropriate audience for the product
Using clustering algorithms on the customer base
Selling the product to the targeted audience

Clustering

- Clustering can be used in many applications
  - Marketing: finding groups of customers with similar behavior
  - Biology: classification of plants and animals
  - Libraries: book ordering
  - Insurance: identifying groups of motor insurance policy holders with high average clain cost, identifying frauds

Clustering algorithms

- Clustering approaches group the data based on certain similarity of features.
- Clustering methods generally use centroid-based and hierarchal kind of modelling approaches.
- Most of the methods tend to use the inherent structures in the data to best organize the data into groups, considering the maximum similarity in the data.

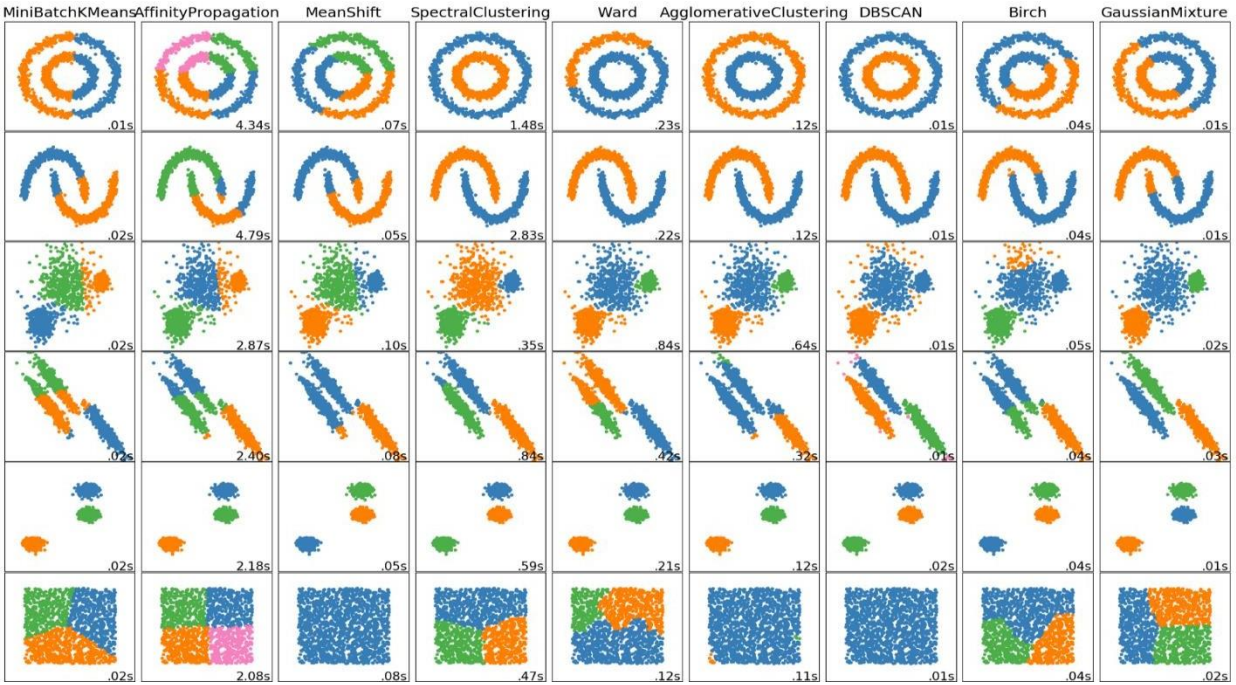
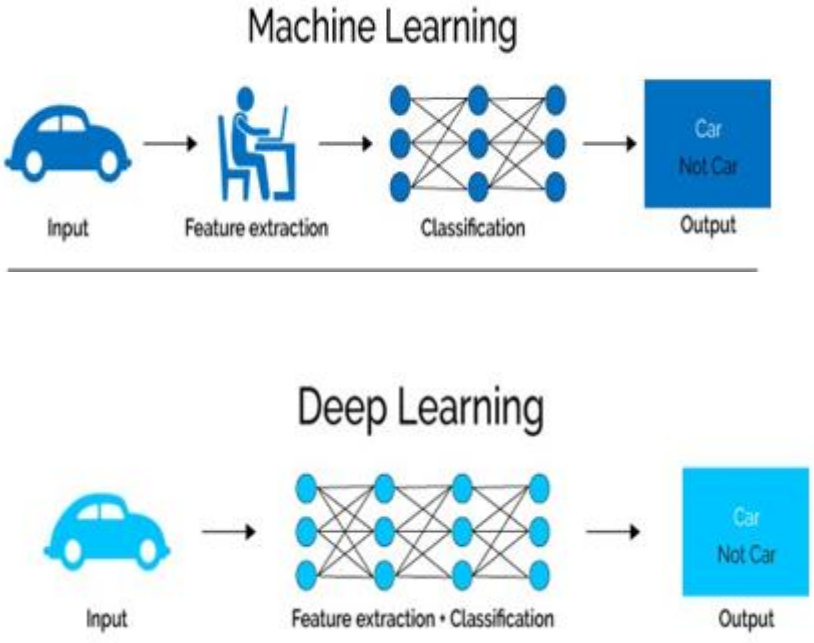


Figure: Machine Learning for Dummies

Deep learning algorithms

Deep learning methods are a modern extension to artificial neural networks with better efficiency.

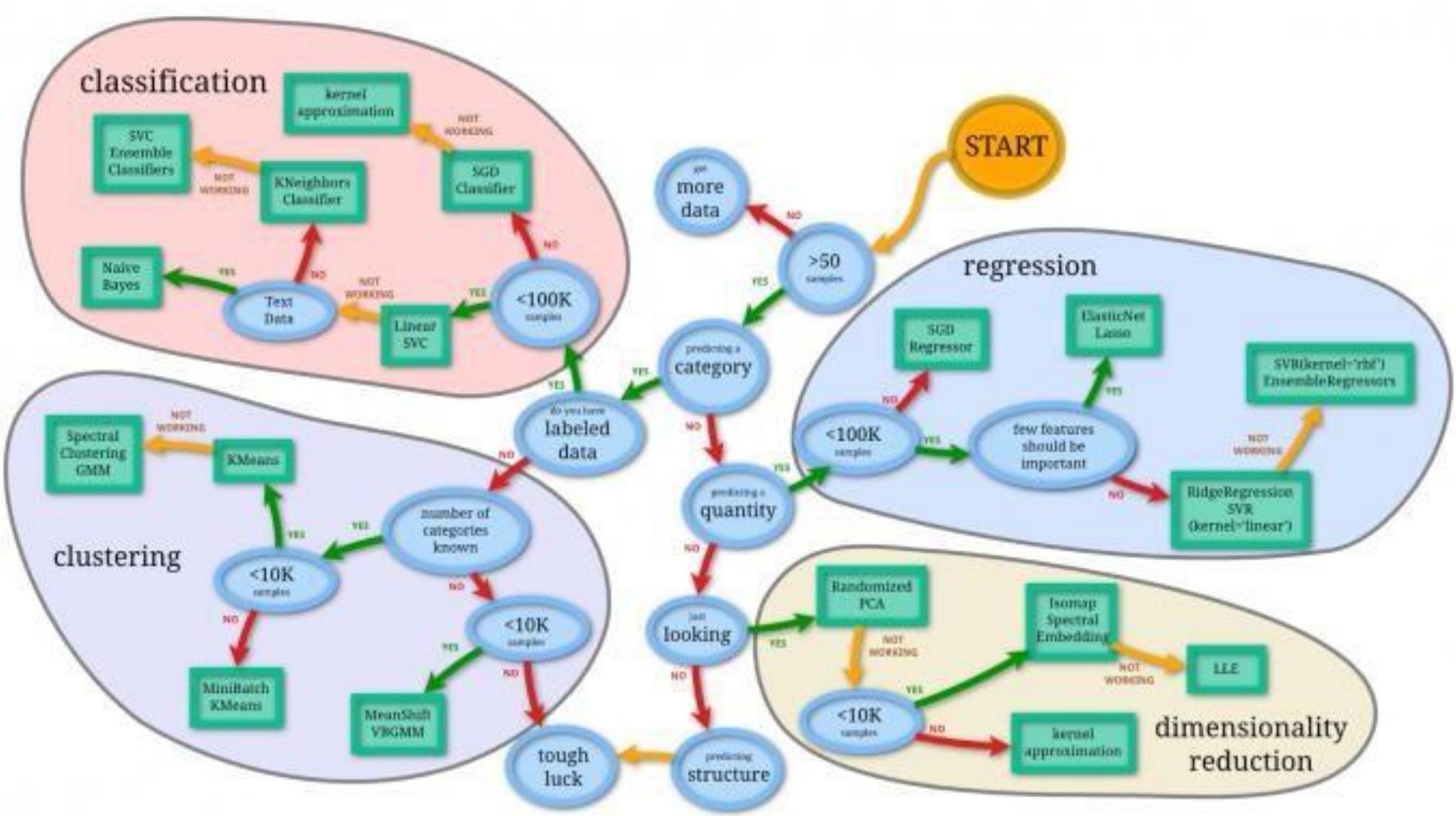
- Deep learning methods are concerned with building much larger and more complex neural networks and, as commented on above, many methods are concerned with semi-supervised learning problems where large datasets contain very little labeled data.



Ensemble learning

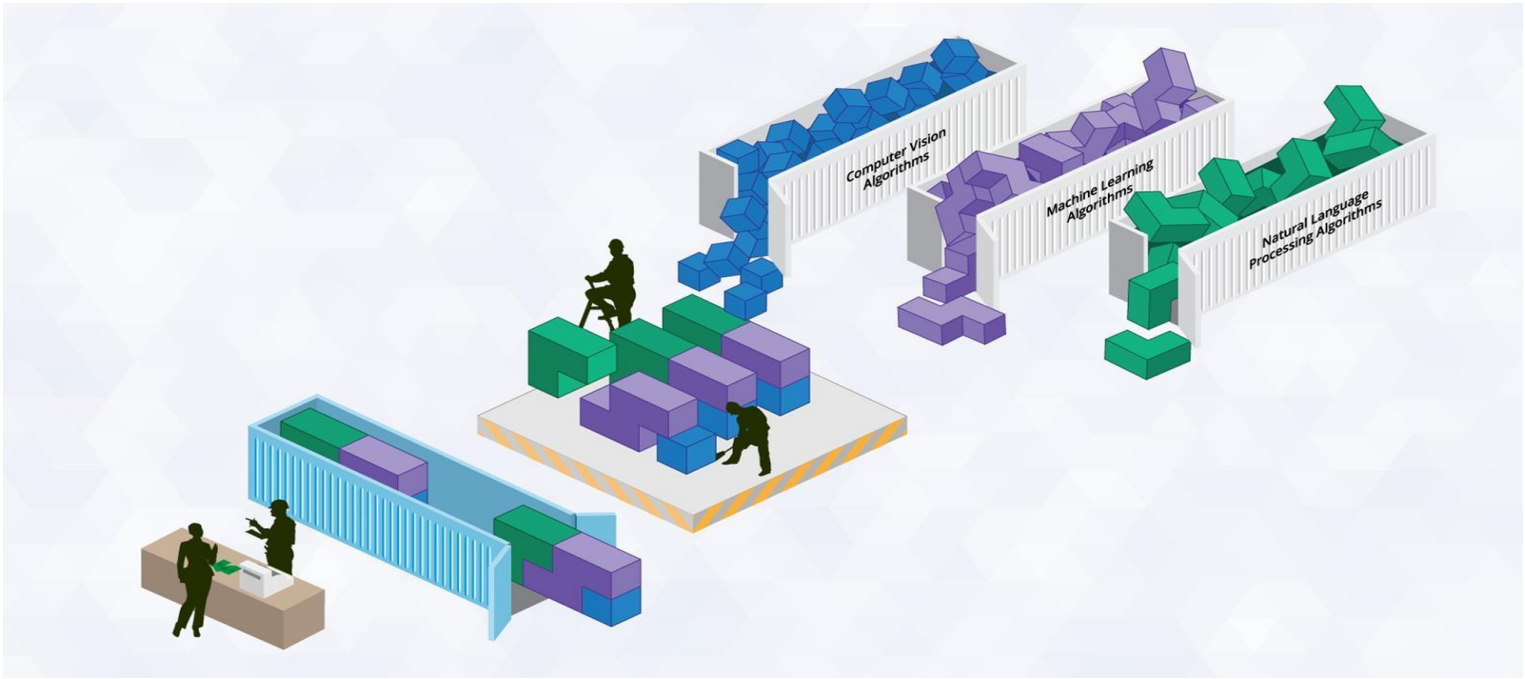
Source: https://www.aitrends.com/tag/ai-research

Matching data to an appropriate algorithm



Source: http://scikit-learn.org/stable/_static/ml_map.png

The algorithm Economy



The algorithm Economy

- Two fundamental shifts happening in technology today:
  - **The Algorithm Economy**
  - **Containers**

- The confluence of the algorithm economy and containers creates a new value chain, where algorithms as a service can be discovered and made accessible to all developers through a simple REST API.
- **Algorithms as containerized microservices** ensure both interoperability and portability, allowing for code to be written in any programming language, and then seamlessly united across a single API.
- Containerized algorithms shorten the time for any development team to go from concept, to prototype, to production-ready app.