Types of machine learning problems

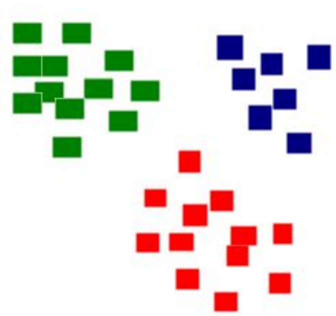
There are various ways to classify machine learning problems. Here, we discuss the most obvious ones.

1. On basis of the nature of the learning “signal” or “feedback” available to a learning system

- **Supervised learning**: The computer is presented with example inputs and their desired outputs, given by a “teacher”, and the goal is to learn a general rule that maps inputs to outputs. The training process continues until the model achieves the desired level of accuracy on the training data. Some real-life examples are:
    - **Image Classification:** You train with images/labels. Then in the future you give a new image expecting that the computer will recognize the new object.
    - **Market Prediction/Regression:** You train the computer with historical market data and ask the computer to predict the new price in the future.
- **Unsupervised learning**: No labels are given to the learning algorithm, leaving it on its own to find structure in its input. It is used for clustering population in different groups. Unsupervised learning can be a goal in itself (discovering hidden patterns in data).
    - **Clustering:** You ask the computer to separate similar data into clusters, this is essential in research and science.
    - **High Dimension Visualization:** Use the computer to help us visualize high dimension data.
    - **Generative Models:** After a model captures the probability distribution of your input data, it will be able to generate more data. This can be very useful to make your classifier more robust.

- **Semi-supervised learning**: Problems where you have a large amount of input data and only some of the data is labeled, are called semi-supervised learning problems. These problems sit in between both supervised and unsupervised learning. For example, a photo archive where only some of the images are labeled, (e.g. dog, cat, person) and the majority are unlabeled.
- **Reinforcement learning**: A computer program interacts with a dynamic environment in which it must perform a certain goal (such as driving a vehicle or playing a game against an opponent). The program is provided feedback in terms of rewards and punishments as it navigates its problem space.
    - https://www.youtube.com/watch?v=spfpBrBjntg
- **Classification**: Inputs are divided into two or more classes, and the learner must produce a model that assigns unseen inputs to one or more (multi-label classification) of these classes. This is typically tackled in a supervised way. Spam filtering is an example of classification, where the inputs are email (or other) messages and the classes are “spam” and “not spam”.
- **Regression**: It is also a supervised learning problem, but the outputs are continuous rather than discrete. For example, predicting the stock prices using historical data.
- **Clustering**: Here, a set of inputs is to be divided into groups. Unlike in classification, the groups are not known beforehand, making this typically an unsupervised task.

  As you can see in the example below, the given dataset points have been divided into groups identifiable by the colors red, green and blue.



- **Density estimation**: The task is to find the distribution of inputs in some space.
- **Dimensionality reduction**: It simplifies inputs by mapping them into a lower-dimensional space. Topic modeling is a related problem, where a program is given a list of human language documents and is tasked to find out which documents cover similar topics.

Some commonly used machine learning algorithms are Linear Regression, Logistic Regression, Decision Tree, SVM(Support vector machines), Naive Bayes, KNN(K nearest neighbors), K-Means, Random Forest

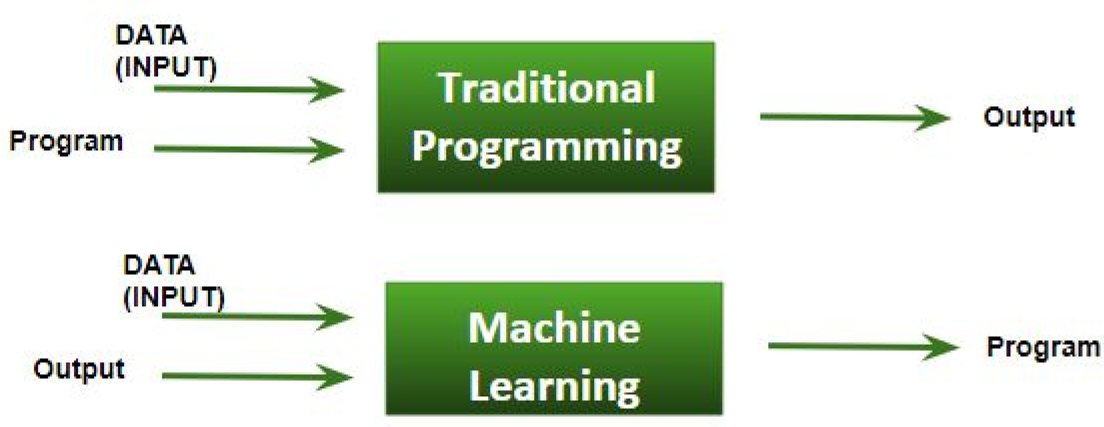
Terminologies of Machine Learning

- **Model**
  A model is a **specific representation** learned from data by applying some machine learning algorithm. A model is also called **hypothesis**.
- **Feature**
  A feature is an individual measurable property of our data. A set of numeric features can be conveniently described by a **feature vector**. Feature vectors are fed as input to the model. For example, in order to predict a fruit, there may be features like color, smell, taste, **etc.**
  Note: Choosing informative, discriminating and independent features is a crucial step for effective algorithms. We generally employ a **feature extractor** to extract the relevant features from the raw data.
- **Target (Label)**
  A target variable or label is the value to be predicted by our model. For the fruit example discussed in the features section, the label with each set of input would be the name of the fruit like apple, orange, banana, etc.
- **Training**
  The idea is to give a set of inputs(features) and it's expected

outputs(labels), so after training, we will have a model (hypothesis) that will then map new data to one of the categories trained on.

- **Prediction**
  Once our model is ready, it can be fed a set of inputs to which it will provide a predicted output(label).

"Field of study that gives computers the capability to learn without being explicitly programmed".



- **Traditional Programming :** We feed in DATA (Input) + PROGRAM (logic), run it on machine and get output.
- **Machine Learning :** We feed in DATA(Input) + Output, run it on machine during training and the machine creates its own program(logic), which can be evaluated while testing.

How ML works?

- Gathering past data in any form suitable for processing.The better the quality of data, the more suitable it will be for modeling

- Data Processing – Sometimes, the data collected is in the raw form and it needs to be pre-processed.
  Example: Some tuples may have missing values for certain attributes, an, in this case, it has to be filled with suitable values in order to perform machine learning or any form of data mining.
  Missing values for numerical attributes such as the price of the house may be replaced with the mean value of the attribute whereas missing values for categorical attributes may be replaced with the attribute with the highest mode. This invariably depends on the types of filters we use. If data is in the form of text or images then converting it to numerical form will be required, be it a list or array or matrix. Simply, Data is to be made relevant and consistent. It is to be converted into a format understandable by the machine
- Divide the input data into training,cross-validation and test sets. The ratio between the respective sets must be 6:2:2
- Building models with suitable algorithms and techniques on the training set.
- Testing our conceptualized model with data which was not fed to the model at the time of training and evaluating its performance using metrics such as F1 score, precision and recall.

DATA : It can be any unprocessed **fact, value, text, sound or picture** that is not being interpreted and analyzed. Data is the most important part of all **Data Analytics, Machine Learning, Artificial Intelligence**. Without data, we can’t train any model and all modern research and automation will go vain. Big Enterprises are spending lots of money just to gather as much certain data as possible.

- **Training Data:** The part of data we use to train our model. This is the data which your model actually sees(both input and output) and learn from.

- **Validation Data:** The part of data which is used to do a frequent evaluation of model, fit on training dataset along with improving involved hyperparameters (initially set parameters before the model begins learning). This data plays it’s part when the model is actually training.
- **Testing Data:** Once our model is completely trained, testing data provides the unbiased evaluation. When we feed in the inputs of Testing data, our model will predict some values(without seeing actual output). After prediction, we evaluate our model by comparing it with actual output present in the testing data. This is how we evaluate and see how much our model has learned from the experiences feed in as training data, set at the time of training.

Properties of Data –

1. **Volume :** Scale of Data. With growing world population and technology at exposure, huge data is being generated each and every millisecond.
2. **Variety :** Different forms of data – healthcare, images, videos, audio clippings.
3. **Velocity :** Rate of data streaming and generation.
4. **Value :** Meaningfulness of data in terms of information which researchers can infer from it.
5. **Veracity :** Certainty and correctness in data we are working on.

Machine Learning: The Expected

We’ll start with some places where you might expect Machine Learning to play a part.

1. **Speech Recognition (Natural Language Processing in more technical terms) :** You talk to Cortana on Windows Devices. But how does it understand what you say? Along comes the field of Natural Language

Processing, or N.L.P. It deals with the study of interactions between Machines and Humans, via Linguistics. Guess what is at the heart of NLP: Machine Learning Algorithms and Systems (Hidden Markov Models being one).

2. **Computer Vision :** Computer Vision is a subfield of AI which deals with a Machine's (probable) interpretation of the Real World. In other words, all Facial Recognition, Pattern Recognition, Character Recognition Techniques belong to Computer Vision. And Machine Learning once again, with it wide range of Algorithms, is at the heart of Computer Vision.
3. **Google's Self Driving Car** : Well. You can imagine what drives it actually. More Machine Learning goodness.

Machine Learning : The Unexpected

Let's visit some places normal folks would not really associate easily with Machine Learning:

1. **Amazon's Product Recommendations:** Ever wondered how Amazon always has a recommendation that just tempts you to lighten your wallet. Well, that's a Machine Learning Algorithm(s) called "Recommender Systems" working in the backdrop. It learns every user's personal preferences and makes recommendations according to that.
2. **Youtube/Netflix :** They work just as above!
3. **Data Mining / Big Data :** This might not be so much of a shock to many. But Data Mining and Big Data are just manifestations of studying and learning from data at a larger scale. And wherever there's the objective of extracting information from data, you'll find Machine Learning lurking nearby.

Stock Market/Housing Finance/Real Estate : All of these fields, incorporate a lot of Machine Learning systems in order to better assess the market, namely "Regression Techniques", for things as mediocre as predicting the price of a House, to predicting and analyzing stock market trends.

- **Web Search Engine:** One of the reasons why search engines like google, bing etc work so well is because the system has learnt how to rank pages through a complex learning algorithm.
- **Photo tagging Applications:** Be it facebook or any other photo tagging application, the ability to tag friends makes it even more happening. It is all possible because of a face recognition algorithm that runs behind the application.
- **Spam Detector:** Our mail agent like Gmail or Hotmail does a lot of hard work for us in classifying the mails and moving the spam mails to spam folder. This is again achieved by a spam classifier running in the back end of mail application.
- **Database Mining for growth of automation:** Typical applications include Web-click data for better UX(User eXperience), Medical records for better automation in healthcare, biological data and many more.
    - **Applications that cannot be programmed:** There are some tasks that cannot be programmed as the computers we use are not modelled that way. Examples include Autonomous Driving, Recognition tasks from unordered data (Face Recognition/ Handwriting Recognition), Natural language Processing, computer Vision etc.
    - **Understanding Human Learning:** This is the closest we have understood and mimicked the human brain. It is the start of a new revolution, The real AI. Now, After a brief insight lets come to a more formal definition of Machine Learning
    - **Arthur Samuel(1959):** "Machine Learning is a field of study that gives computers, the ability to learn without explicitly being programmed."Samuel wrote a Checker playing program which could learn over time. At first it

could be easily won. But over time, it learnt all the board position that would eventually lead him to victory or loss and thus became a better chess player than Samuel itself. This was one of the most early attempts of defining Machine Learning and is somewhat less formal.

- **Tom Michel(1999):** “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.” This is a more formal and mathematical definition. For the previous Chess program
    - E is number of games.
    - T is playing chess against computer.
    - P is win/loss by computer.

Python libraries that used in Machine Learning are:

- Numpy
- Scipy
- Scikit-learn
- Theano
- TensorFlow
- Keras
- PyTorch
- Pandas
- Matplotlib

Intelligence is composed of:

- Reasoning
- Learning
- Problem Solving
- Perception
- Linguistic Intelligence

Applications of AI include **Natural Language Processing, Gaming, Speech Recognition, Vision Systems, Healthcare, Automotive**

AI has developed a large number of tools to solve the most difficult problems in computer science, like:

- Search and optimization
- Logic
- Probabilistic methods for uncertain reasoning
- Classifiers and statistical learning methods
- Neural networks
- Control theory
- Languages

ARTIFICIAL INTELLIGENCE	MACHINE LEARNING
AI manages more comprehensive issues of automating a system. This computerization should be possible by utilizing any field such as image processing, cognitive science, neural systems, machine learning etc.	Machine Learning (ML) manages influencing user's machine to gain from the external environment. This external environment can be sensors, electronic segments, external storage gadgets and numerous other devices.
AI manages the making of machines, frameworks and different gadgets savvy by enabling them to think and do errands as all people generally do.	What ML does, depends on the user input or a query requested by the client, the framework checks whether it is available in the knowledge base or not. If it is available, it will restore the outcome to the user related with that query, however if it isn't stored initially, the machine will take in the user input and will enhance its knowledge base, to give a better value to the end user

Future Scope –

- Artificial Intelligence is here to stay and is going nowhere. It digs out the facts from algorithms for a meaningful execution of various decisions and goals predetermined by a firm.
- Artificial Intelligence and Machine Learning are likely to replace the current mode of technology that we see these days, for example, traditional programming packages like **ERP** and **CRM** are certainly losing their charm.
- Firms like Facebook, Google are investing a hefty amount in AI to get the desired outcome at a relatively lower computational time.
- Artificial Intelligence is something that is going to redefine the world of software and IT in the near future.

ARTIFICIAL INTELLIGENCE	***MACHINE LEARNING***
AI stands for Artificial intelligence, where intelligence is defined acquisition of knowledge intelligence is defined as a ability to acquire and apply knowledge.	ML stands for Machine Learning which is defined as the acquisition of knowledge or skill
The aim is to increase chance of success and not accuracy.	The aim is to increase accuracy, but it does not care about success

It work as a computer program that does smart work	It is a simple concept machine takes data and learn from data.
The goal is to simulate natural intelligence to solve complex problem	The goal is to learn from data on certain task to maximize the performance of machine on this task.
AI is decision making.	ML allows system to learn new things from data.
It leads to develop a system to mimic human to respond behave in a circumstances.	It involves in creating self learning algorithms.
AI will go for finding the optimal solution.	ML will go for only solution for that whether it is optimal or not.
AI leads to intelligence or wisdom.	ML leads to knowledge.

Types of Agents

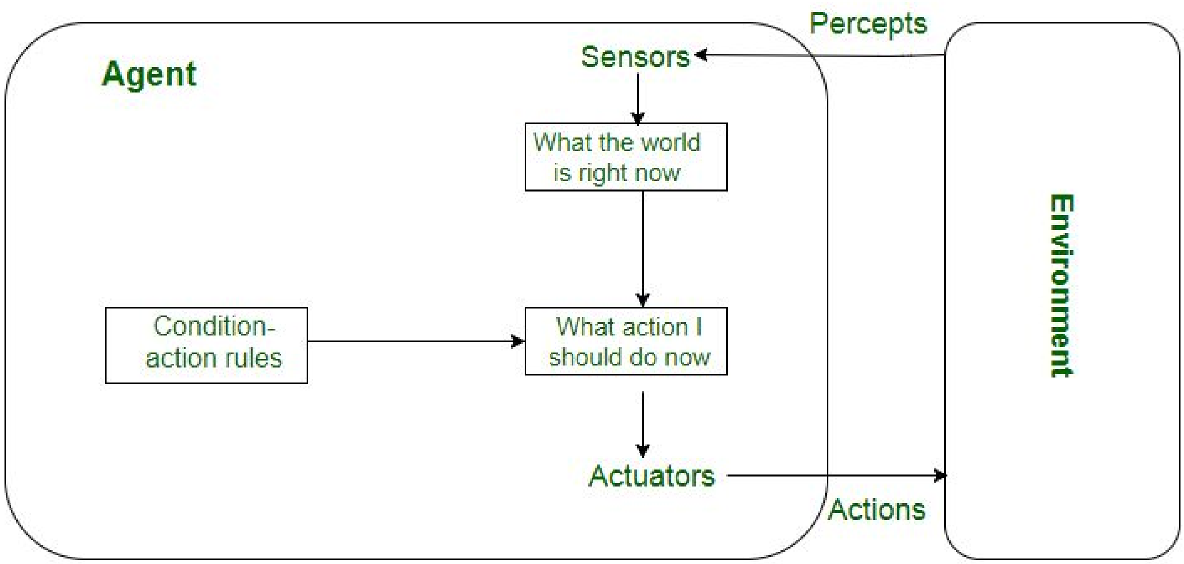
Agents can be grouped into four classes based on their degree of perceived intelligence and capability :

- Simple Reflex Agents
- Model-Based Reflex Agents
- Goal-Based Agents
- Utility-Based Agents
- Learning Agent

Simple reflex agents

Simple reflex agents ignore the rest of the percept history and act only on the basis of the **current percept**. Percept history is the history of all that an agent has perceived till date. The agent function is based on the **condition-action rule**. A condition-action rule is a rule that maps a state i.e, condition to an action. If the condition is true, then the action is taken, else not. This agent function only succeeds when the environment is fully observable. For simple reflex agents operating in partially observable environments, infinite loops are often unavoidable. It may be possible to escape from infinite loops if the agent can randomize its actions. Problems with Simple reflex agents are :

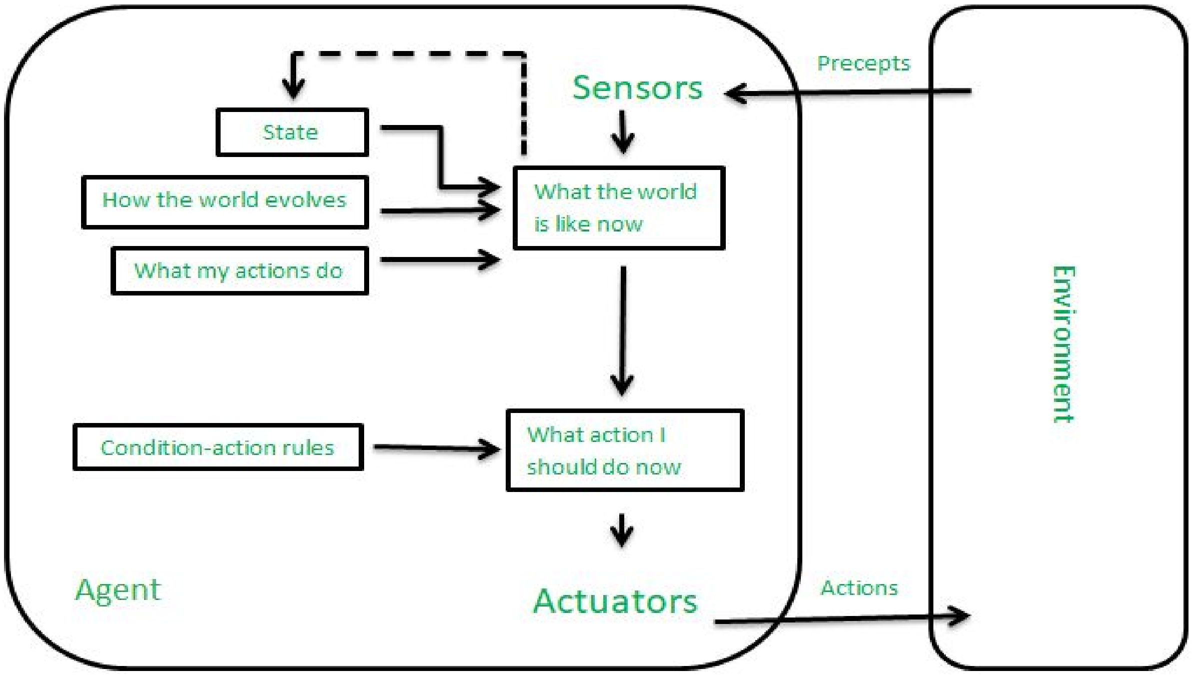
- Very limited intelligence.
- No knowledge of non-perceptual parts of state.
- Usually too big to generate and store.
- If there occurs any change in the environment, then the collection of rules need to be updated.



Model-based reflex agents

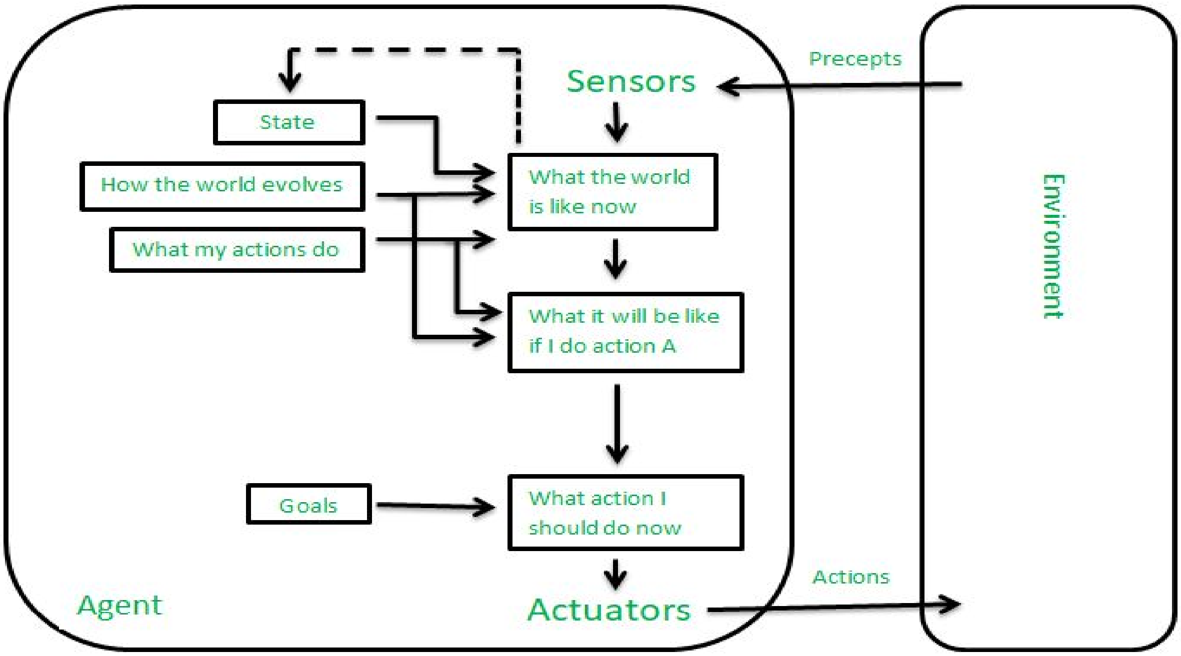
It works by finding a rule whose condition matches the current situation. A model-based agent can handle **partially observable environments** by use of model about the world. The agent has to keep track of **internal state** which is adjusted by each percept and that depends on the percept history. The current state is stored inside the agent which maintains some kind of structure describing the part of the world which cannot be seen. Updating the state requires information about :

- how the world evolves in-dependently from the agent, and
- how the agent actions affects the world.



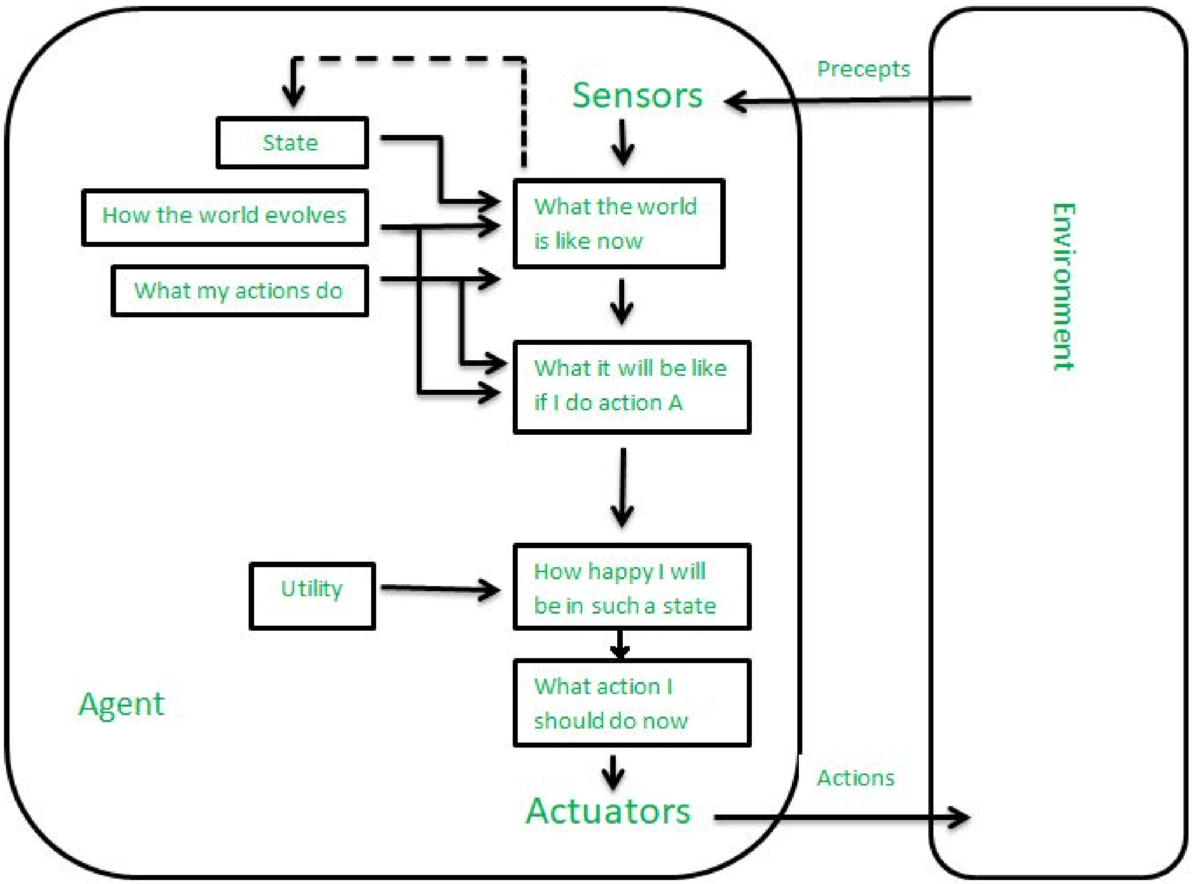
Goal-based agents

These kind of agents take decision based on how far they are currently from their **goal**(description of desirable situations). Their every action is intended to reduce its distance from the goal. This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state. The knowledge that supports its decisions is represented explicitly and can be modified, which makes these agents more flexible. They usually require search and planning. The goal-based agent's behavior can easily be changed.



Utility-based agents

The agents which are developed having their end uses as building blocks are called utility based agents. When there are multiple possible alternatives, then to decide which one is best, utility-based agents are used.They choose actions based on a **preference (utility)** for each state. Sometimes achieving the desired goal is not enough. We may look for a quicker, safer, cheaper trip to reach a destination. Agent happiness should be taken into consideration. Utility describes how **"happy"** the agent is. Because of the uncertainty in the world, a utility agent chooses the action that maximizes the expected utility. A utility function maps a state onto a real number which describes the associated degree of happiness.



Learning Agent

A learning agent in AI is the type of agent which can learn from its past experiences or it has learning capabilities.

It starts to act with basic knowledge and then able to act and adapt automatically through learning.

A learning agent has mainly four conceptual components, which are:

1. **Learning element :**It is responsible for making improvements by learning from the environment
2. **Critic:** Learning element takes feedback from critic which describes how well the agent is doing with respect to a fixed performance standard.
3. **Performance element:** It is responsile for selecting external action

4. **Problem Generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.