Introduction to Artificial Intelligence (AI)

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Definition AI

- Artificial Intelligence is an attempt to make a computer, a robot, or other piece of technology ‘think’ and process data in the same way as we humans do.
- Artificial Intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans.
- AI is a branch of science which deals with helping machines finds solutions to complex problems in a more human-like fashion.
- Often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving”.
- Artificial Intelligence, the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.
- AI therefore has to study how the human brain ‘thinks’, learns, and makes decisions when it tries to solve problems or execute a task.
- The aim of AI is to improve technology by adding functionality related to the human acts of reasoning, learning, and problem-solving.
- Example : Home Automation Systems, Cortana is example of a voice controlled intelligent system

Need of AI

- The need for AI is fueled by the fact that it is a technology that can enhance machines by equipping them with intelligence.
- The technology is used to have machines help humans by teaching themselves to adjust, adapt, refer to more data and process that quickly in order to provide a for a better or alternative answer where possible.
- AI is to create technology that allows machines to function in an intelligent manner with or without human supervision

History of AI

- 1941: First electronic Computer
- 1951 : Term Artificial Intelligence introduced
- 1960s: Checkers-playing program that was able to play games with opponents
- 1980s: Quality Control Systems
- 2000 : First sophisticated walking robot
- 1956 - John McCarthy coined the term ‘artificial intelligence’ and had the first AI conference.
- 1969 - Shakey was the first general-purpose mobile robot built. It is now able to do things with a purpose vs. just a list of instructions.
- 1997 - Supercomputer ‘Deep Blue’ was designed, and it defeated the world champion chess player in a match. It was a massive milestone by IBM to create this large computer.
- 2002 - The first commercially successful robotic vacuum cleaner was created.
- 2005 - 2019 - Today, we have speech recognition, robotic process automation (RPA), a dancing robot, smart homes, and other innovations make their debut.
- 2020 - Baidu releases the LinearFold AI algorithm to medical and scientific and medical teams developing a vaccine during the early stages of the SARS-CoV-2 (COVID-19) pandemic. The algorithm can predict the RNA sequence of the virus in only 27 seconds, which is 120 times faster than other methods.

AI Understanding

- Help machines find solutions to complex problems in a similar way that humans do and apply similar logic in the form of heuristic (self-learning) algorithms to calculate and display the required output.
- Intelligence can be loosely defined as the capability to obtain knowledge and skills and to apply those to various situations without supervision.
- **Intelligence is made up of following also known as AI Programming Cognitive Skills**
  - Learning
  - Reasoning
  - Problem Solving
  - Perception
  - Linguistic Intelligence

AI Programming Cognitive Skills or Components of AI

Learning

- Learning for AI includes the trial-and-error method.
- It includes memorizing individual items like different solutions to problems,

Reasoning

- It is to allow the platform to draw inferences that fit with the provided situation

Problem-solving

- AI's problem-solving ability comprises data, where the solution needs to find the features.

Perception

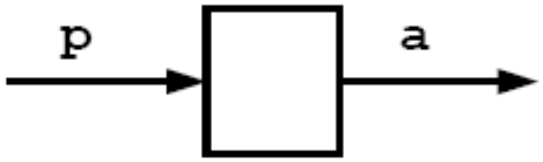
- the element scans any given environment by using different sense-organs, either artificial or real.

Language-understanding

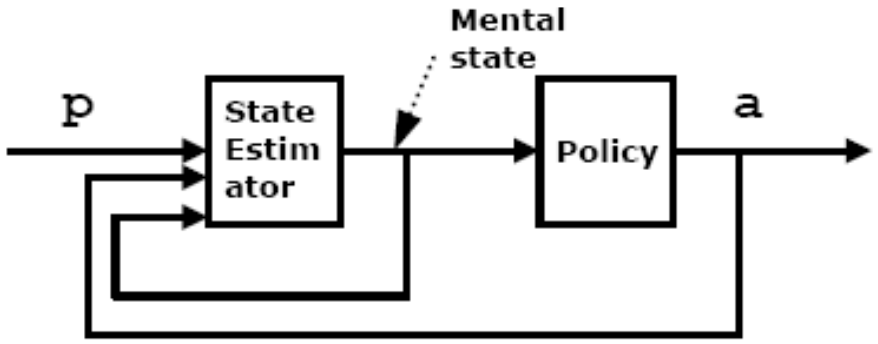
- distinctive types of language over different forms of natural meaning

AI Elements : An Agent

- AI system is composed of two main elements : Agent and Its surrounding Environment
- An agent can be either a human or a machine.
- An agent can be anything that can perceive its environment through sensors and act upon that environment through effectors.
- The intelligence of agents is calculated by their ability to create goals and achieve them.
- Anything' that can gather information about its environment and take action based on that information.



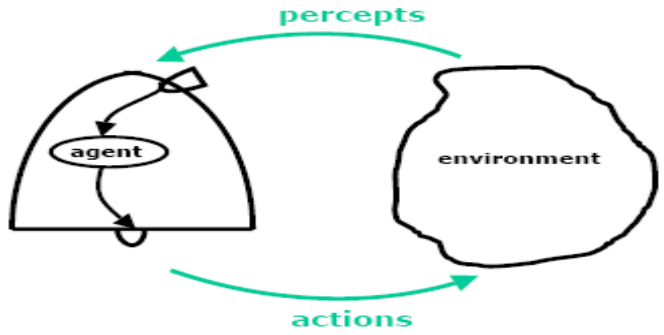
No Memory Agent



Agent with Memory

AI Elements : Environment

- An environment in artificial intelligence is the surrounding of the agent.
- The agent takes input from the environment through sensors and delivers the output to the environment through actuators.
- **There are several types of environments:**
  - Fully Observable vs Partially Observable(eg. chess and driving)
  - Deterministic vs Stochastic (random in nature)
  - Competitive (when agent competes against another agent to optimize the output) vs Collaborative (when multiple agents cooperate to produce the desired output)
  - Single-agent vs Multi-agent
  - Dynamic vs Static
  - Discrete vs Continuous



Types of AI

1. Reactive machines/ Purely Reactive
2. Limited memory
3. Theory of mind
4. Self-awareness

Types of AI : Four main types of AI

Reactive machines/ Purely Reactive

- Reactive machines are AI systems that have no memory and are task specific, meaning that an input always delivers the same output.
- These machines do not have any memory or data to work with, specializing in just one field of work. For example, in a chess game, the machine observes the moves and makes the best possible decision to win.
- Eg. Taking customer data, such as purchase or search history, and use it to deliver recommendations to the same customers.
- Eg. Netflix recommendations, beat at chess by IBM's supercomputer

Limited memory

- This algorithm imitates the way our brains' neurons work together, meaning that it gets smarter as it receives more data to train on.
- These machines collect previous data and continue adding it to their memory. They have enough memory or experience to make proper decisions, but memory is minimal. For example, this machine can suggest a restaurant based on the location data that has been gathered.
- They can look into the past and monitor specific objects or situations over time
- Eg. Self driving car

Types of AI : Four main types of AI Cont…

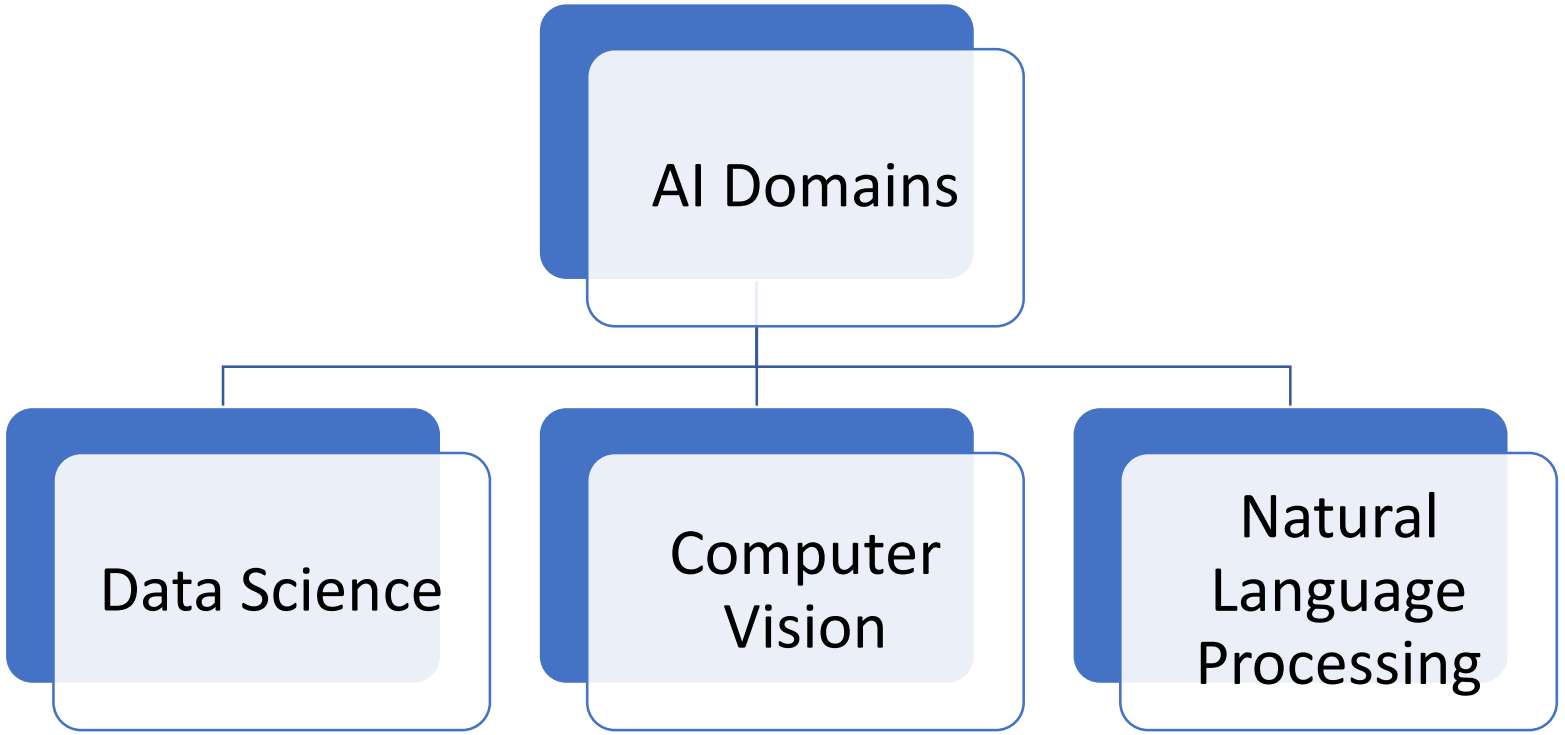
Theory of mind

- Theory of mind and self-awareness are AI types that will be built in the future. As such, there aren't any real world examples yet.
- This kind of AI can understand thoughts and emotions, as well as interact socially. However, a machine based on this type is yet to be built.
- If it is developed, theory of mind AI could have the potential to understand the world and how other entities have thoughts and emotions.
- In the future, theory of mind AI machines could be able to understand intentions and predict behavior, as if to simulate human relationships.

Self-awareness

- The finale for the evolution of AI would be to design systems that have a sense of self, a conscious understanding of their existence. This type of AI does not exist yet.
- Self-aware machines are the future generation of these new technologies. They will be intelligent, sentient, and conscious.
- because there is still so much to uncover about the human brain's intelligence and how memory, learning, and decision-making work.

Main Domains of AI Technology



What is Data Science ?

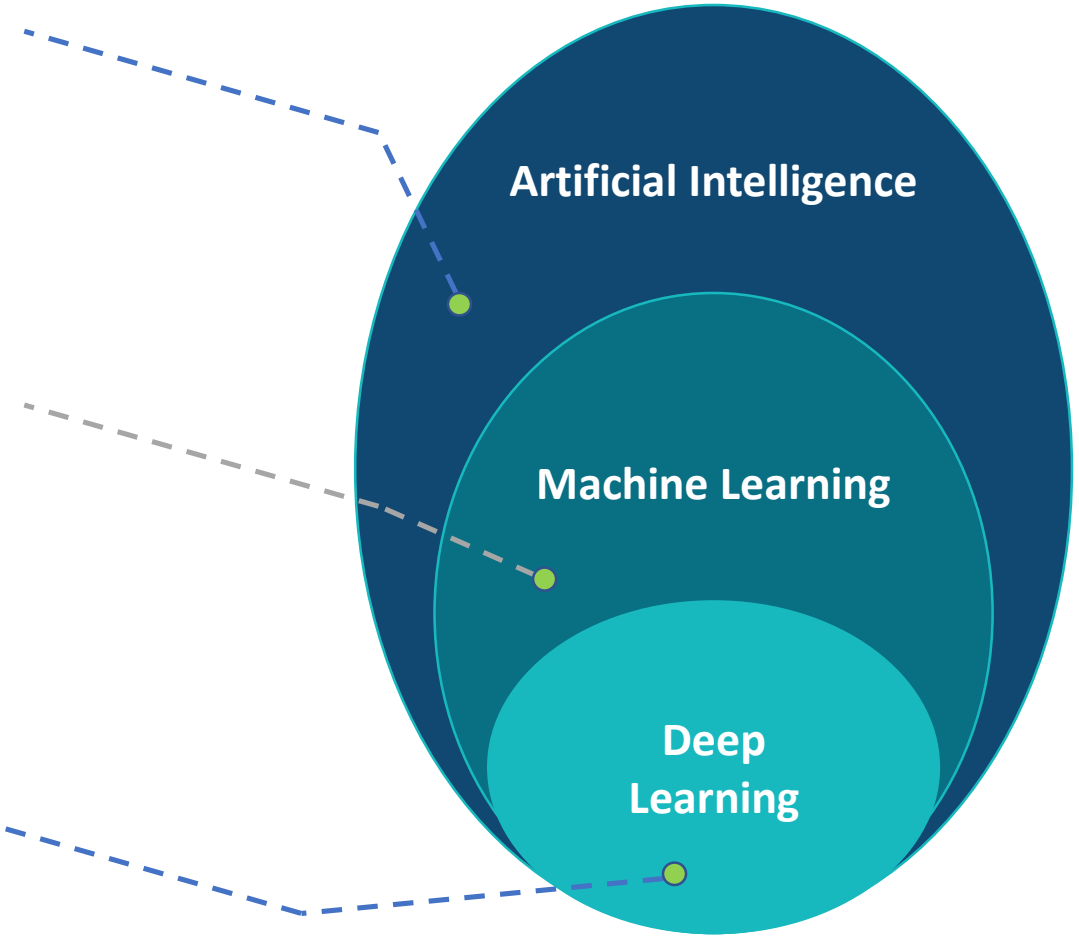
- Data science is an inter-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from many structural and unstructured data.
- Data science is related to data mining, machine learning and big data
- Data science is a "concept to unify statistics, data analysis and their related methods" in order to "understand and analyze actual phenomena" with data

AI, ML, DL

Artificial Intelligence:
- A technique which enables machine to mimic human behavior

Machine Learning:
- Subset of AI which uses statistical methods to enable machines to improve the experience

Deep Learning:
- Subset of ML which makes the computation of multi-layer neural network feasible



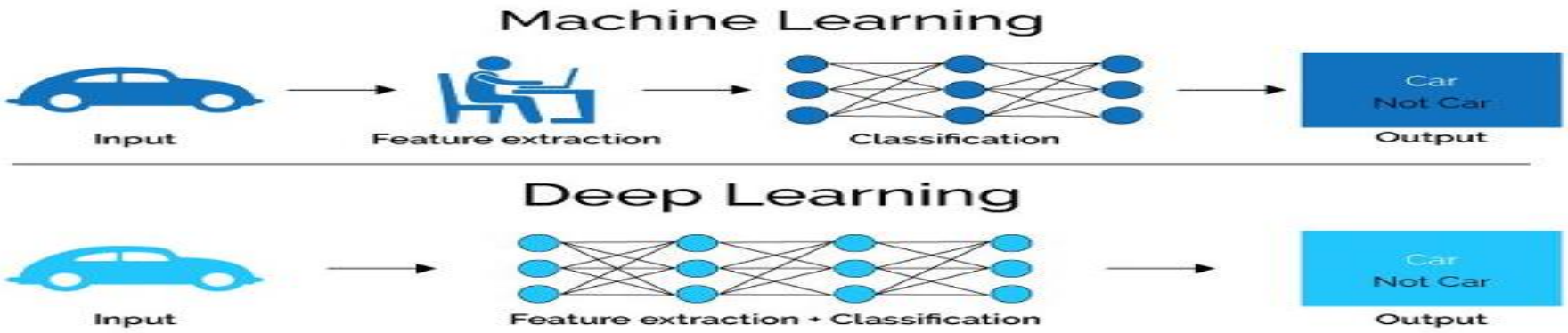
Ways to implement AI

Machine Learning

- It is machine learning that gives AI the ability to learn.
- This is done by using algorithms to discover patterns and generate insights from the data they are exposed to

Deep Learning

- Deep learning, which is a subcategory of machine learning, provides AI with the ability to mimic a human brain's neural network.
- It can make sense of patterns, noise, and sources of confusion in the data.



What is machine learning ?

- A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E
  - Tom Mitchell, 1997

- Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed
  - Arthur Samuel, 1959

- Machine Learning is the science (and art) of programming computers so they can learn from data

Examples of ML Applications

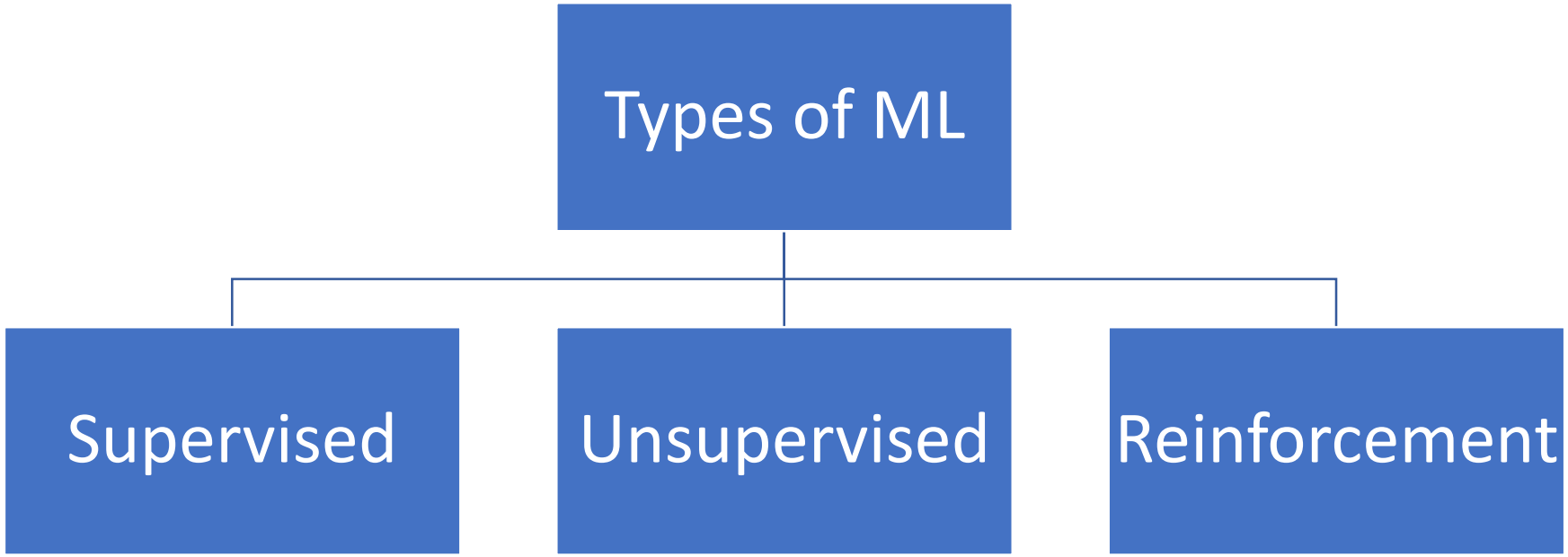
- Analyzing images of products on a production line to automatically classify them
  - This is image classification, typically performed using convolutional neural networks
- Detecting tumors in brain scans
  - This is semantic segmentation, where each pixel in the image is classified (typically use CNNs)
- Automatically classifying news articles
  - This is natural language processing (NLP), and more specifically text classification
- Automatically flagging offensive comments on discussion forums
  - This is also text classification, using the same NLP tools
- Forecasting your company's revenue next year, based on many performance metrics
  - This is a regression task (i.e., predicting values) that may be tackled using any regression model
- Making your app react to voice commands
  - This is speech recognition, which requires processing audio samples: since they are long and complex sequences, they are typically processed using RNNs, CNNs, or Transformers

Examples of ML Applications

- Detecting credit card fraud
  - This is anomaly detection example
- Segmenting clients based on their purchases so that you can design a different marketing strategy for each segment
  - This is clustering example
- Representing a complex, high-dimensional dataset in a clear and insightful diagram
  - This is data visualization, often involving dimensionality reduction techniques
- Recommending a product that a client may be interested in, based on past purchases
  - This is a recommender system
- Building an intelligent bot for a game
  - This is often tackled using Reinforcement Learning

Types of machine learning

- There are so many different types of Machine Learning systems that it is useful to classify them in broad categories, based on the following criteria
  - Whether or not they are trained with human supervision
    - supervised, unsupervised, and Reinforcement Learning



Supervised
Unsupervised
Reinforcement Learning

Supervised Learning

- The majority of practical machine learning uses supervised learning
- Supervised learning is where you have **input variables (x)** and an **output variable (Y)** and you use an algorithm to learn the mapping function from the input to the output

$$Y = f(X) \quad \Rightarrow \quad \text{model / formula} \quad ,$$

- The goal is to approximate the mapping function so well that when you have new input data (x) that you can predict the output variables (Y) for that data
- It is called supervised learning because the process of an algorithm learning from the training dataset can be thought of as a teacher supervising the learning process
- We know the correct answers, the algorithm iteratively makes predictions on the training data and is corrected by the teacher
- Learning stops when the algorithm achieves an acceptable level of performance (measured in terms of **accuracy**)

Supervised Learning – Problems

- **Regression**
  - Related to predicting future values
  - E.g.
    - Population growth prediction
    - Expecting life expectancy
    - Market forecasting/prediction
    - Advertising Popularity prediction
    - Stock prediction
  - Algorithms
    - Linear and multi-linear regression
    - Logistic regression
    - Naïve Bayes
    - Support Vector Machine

Supervised Learning – Problems

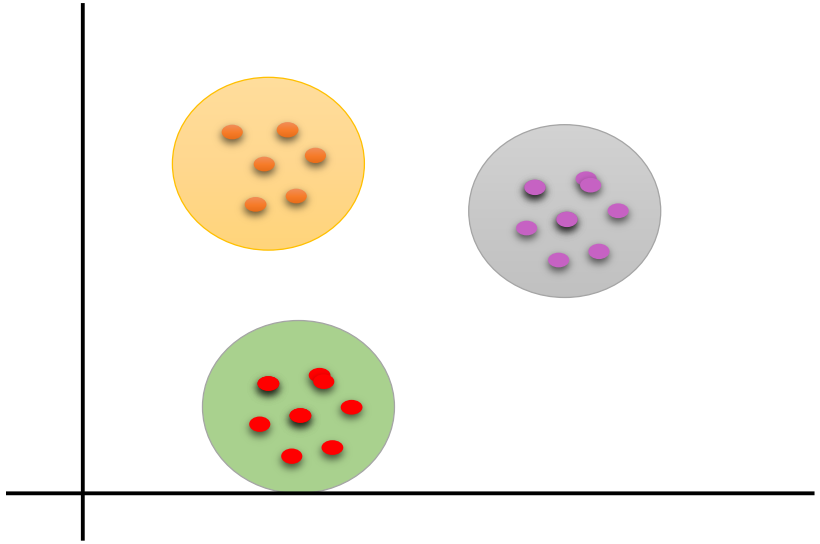
- **Classification**
  - Related to classify the records
  - Based on class / labels (eg. Email : Spam / Ham , Gender : Male / Female , Loan : Yes / No)
  - E.g.
    - Find whether an email received is a spam or ham
    - Identify customer segments
    - Find if a bank loan is granted
    - Identify if a kid will pass or fail in an examination
  - Algorithms
    - Logistic Regression
    - Decision Tree
    - Random Forest
    - Support Vector Machine
    - K-nearest neighbor

Unsupervised Learning

- Unsupervised learning is where you only have input data (X) and no corresponding output variables
- The goal for unsupervised learning is to model the underlying structure or distribution in the data in order to learn more about the data
- These are called unsupervised learning because unlike supervised learning above there is no correct answers and there is no teacher
- Algorithms are left to their own devises to discover and present the interesting **structure** in the data
- Structure in the form of GROUPS / CLUSTERS / ASSOCIATION
- Mostly used for EDA (Exploratory Data Analysis)

Unsupervised Learning - Problems

- **Clustering**
  - discover the inherent groupings in the data, such as grouping customers by purchasing behaviour
  - E.g.
    - Batsman vs bolwer
    - Customer spending more money vs less money
  - Algorithms
    - K-means clustering
    - Hierarchical clustering



Unsupervised Learning - Problems

- **Association**
  - An association rule learning problem is where you want to discover rules that describe large portions of your data, such as people that buy X also tend to buy Y
  - E.g.
    - Market basket analysis
  - Algorithms
    - Apriori
    - Eclat

Reinforcement Learning

- It is about taking suitable action to maximize reward in a particular situation
- It is employed by various software and machines to find the best possible behaviour or path it should take in a specific situation
- Reinforcement learning differs from the supervised learning in a way that in supervised learning the training data has the answer key with it so the model is trained with the correct answer itself whereas in reinforcement learning, there is no answer but the reinforcement agent decides what to do to perform the given task
- In the absence of training dataset, it is bound to learn from its experience.
- Examples
  - Resources management in computer clusters
  - Traffic Light Control
  - Robotics
  - Web system configuration
  - Chemistry
- Algorithms
  - Q-Learning
  - Deep Q-Learning

Deep Learning

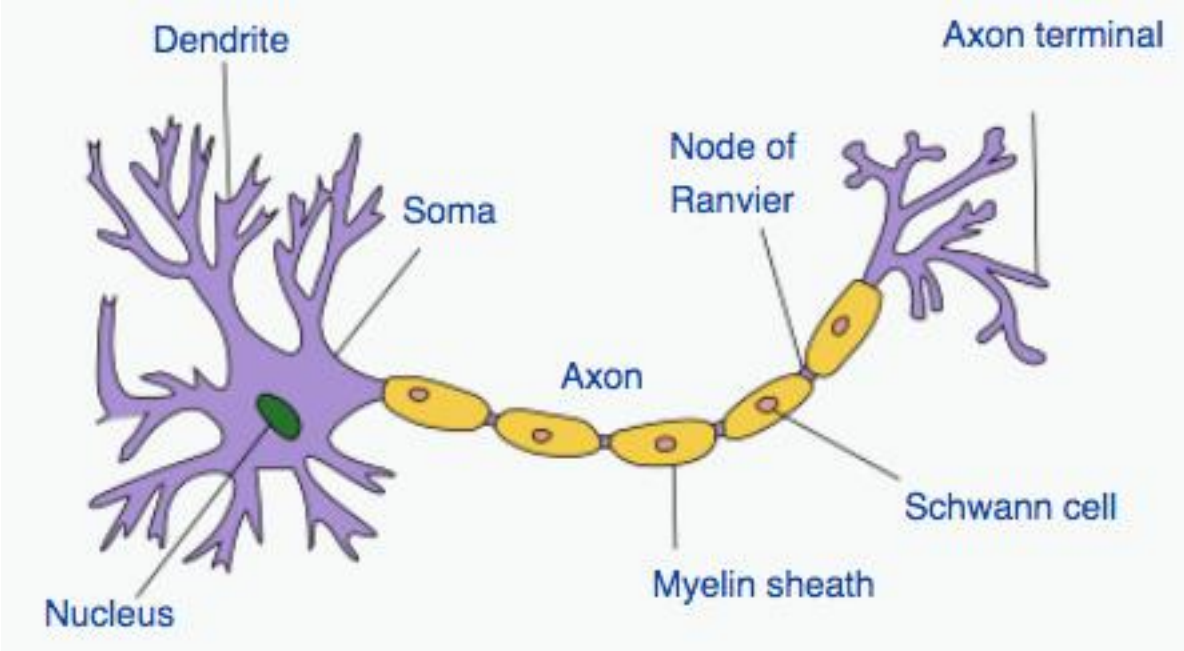
- Deep learning is a method in artificial intelligence (AI) that teaches computers to process data in a way that is inspired by the human brain.
- Deep learning models can recognize complex patterns in pictures, text, sounds, and other data to produce accurate insights and predictions.
- Artificial intelligence (AI) attempts to train computers to think and learn as humans do.
- Deep learning technology drives many AI applications used in everyday products, such as the following:
  - Digital assistants
  - Voice-activated television remotes
  - Fraud detection
  - Automatic facial recognition

How does Deep Learning Works ?

- Deep learning algorithms are neural networks that are modeled after the human brain.
- For example, a human brain contains millions of interconnected neurons that work together to learn and process information.
- Similarly, deep learning neural networks, or artificial neural networks, are made of many layers of artificial neurons that work together inside the computer.

Neuron

- A neuron or nerve cell, is an electrically excitable cell that communicates with other cells via specialized connections called synapses
- A typical neuron consists of a cell body (soma), dendrites, and a single axon
- The soma is the body of the neuron
- The dendrites of a neuron are cellular extensions with many branches
- The axon primarily carries nerve signals away from the soma, and carries some types of information back to it

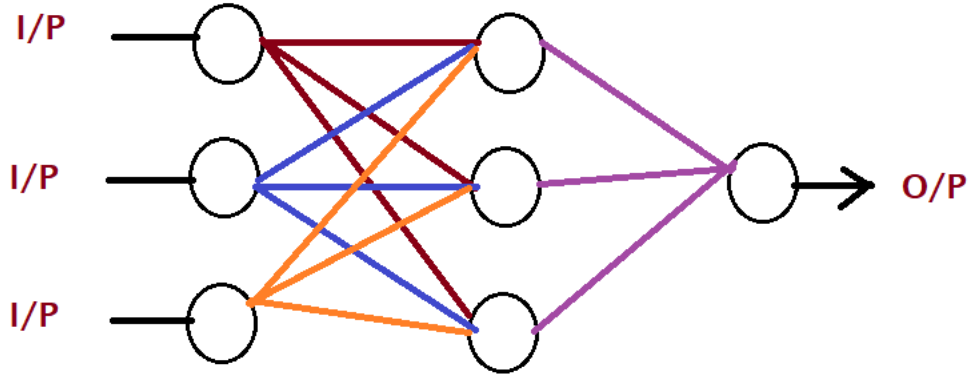


Types of Neural Network

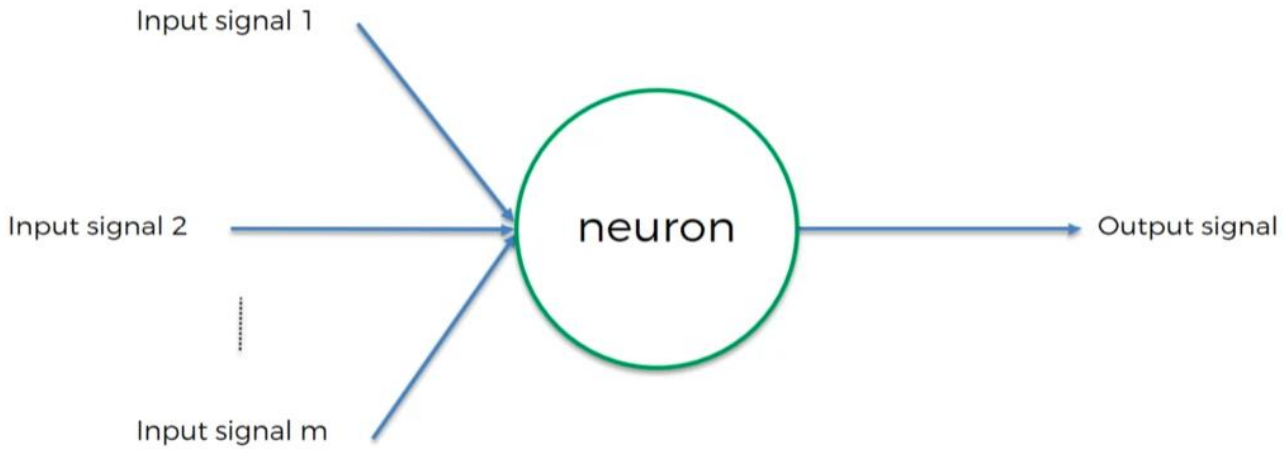
- Artificial Neural Networks (ANN)
- Convolution Neural Networks (CNN)
- Recurrent Neural Networks (RNN)

Artificial Neural Network

- Artificial neural networks (ANN) or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains
- The basic building block is a neuron

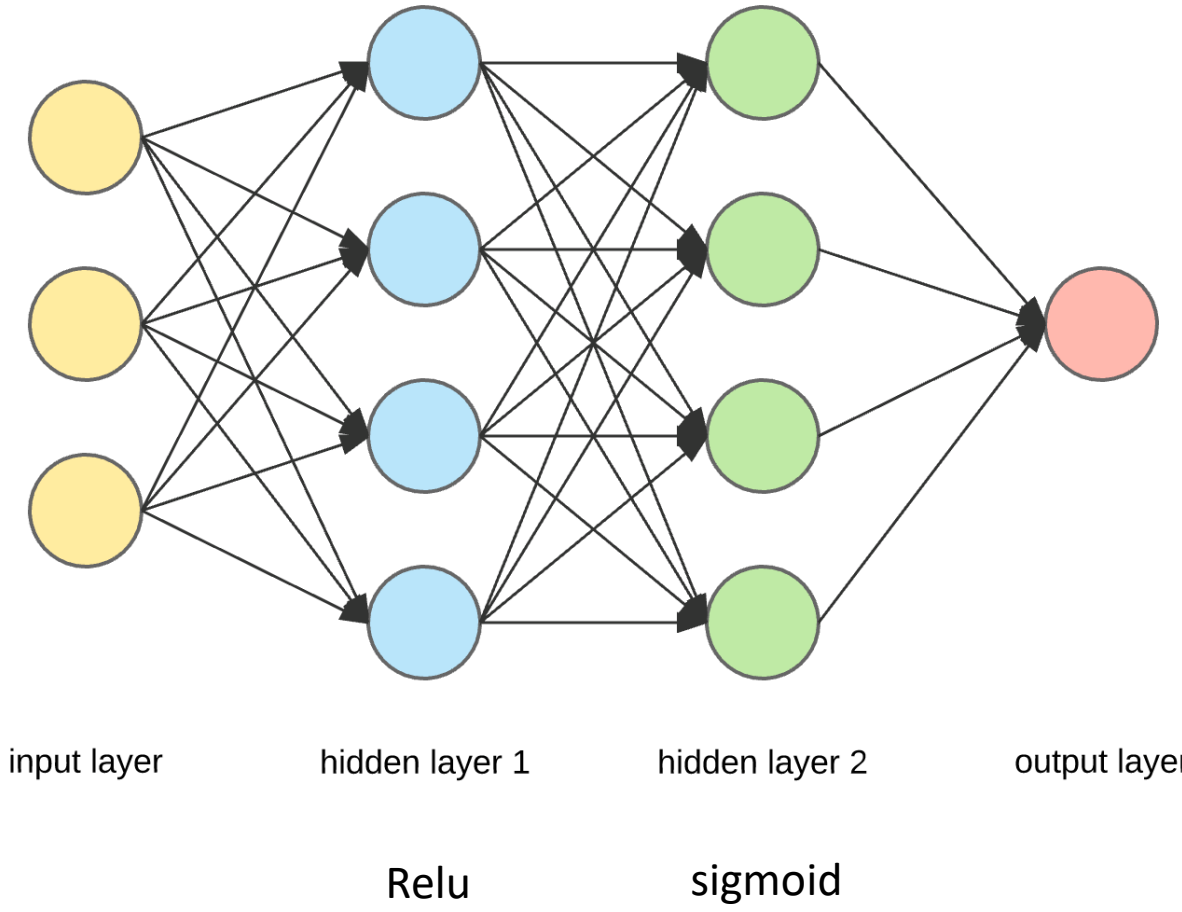


ANN



Artificial Neural Network

- Artificial Neural Networks (ANN) are **multi-layer** fully-connected neural nets
- They consist of an **input layer**, multiple hidden layers, and an **output layer**
- Every node in one layer is connected to every other node in the next layer
- We can make the network deeper by increasing the number of hidden layers.



Characteristics of Artificial Neural Network

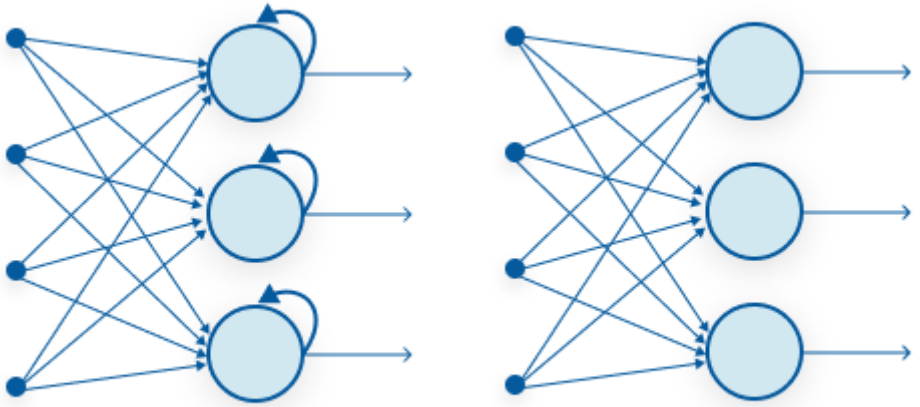
- It is neurally implemented mathematical model
- It contains huge number of interconnected processing elements called **neurons** to do all operations
- Information stored in the neurons are basically the weighted linkage of neurons
- The input signals arrive at the processing elements through connections and connecting weights.
- It has the ability to learn , recall and generalize from the given data by suitable assignment and adjustment of weights.
- The collective behavior of the neurons describes its computational power, and no single neuron carries specific information

Application of Neural Network

- Neural network is suitable for the research on *Animal behavior, predator/prey relationships etc.*
- It would be easier to do *proper valuation* of property, buildings, automobiles, machinery etc. with the help of neural network.
- Neural Network can be used in betting on horse races, sporting events and most importantly in stock market .
- It can be used to predict the correct judgement for any crime by using a large data of crime details as input and the resulting sentences as output.
- By analyzing data and determining which of the data has any fault (files diverging from peers) called as *Data mining, cleaning and validation* can be achieved through neural network.
- Neural Network can be used to predict targets with the help of echo patterns we get from sonar, radar, seismic and magnetic instruments .
- It can be used efficiently in *Employee hiring* so that any company can hire right employee depending upon the skills the employee has and what should be it's productivity in future .
- It has a large application in *Medical Research* .
- It can be used to for *Fraud Detection* regarding credit cards , insurance or taxes by analyzing the past records

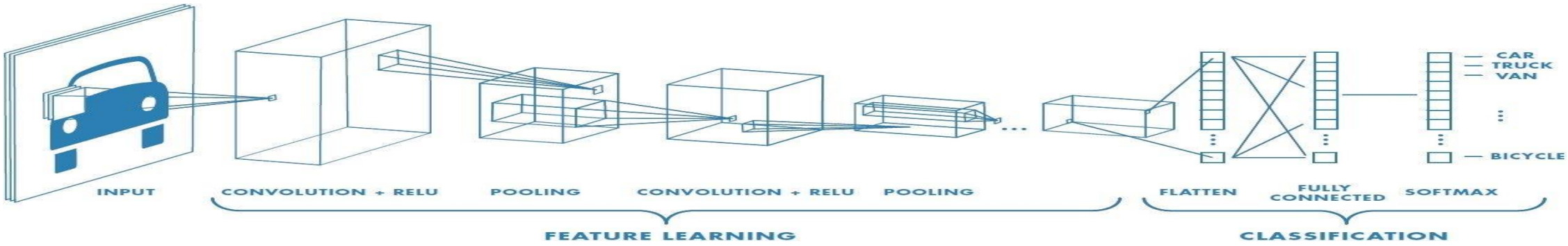
RNN

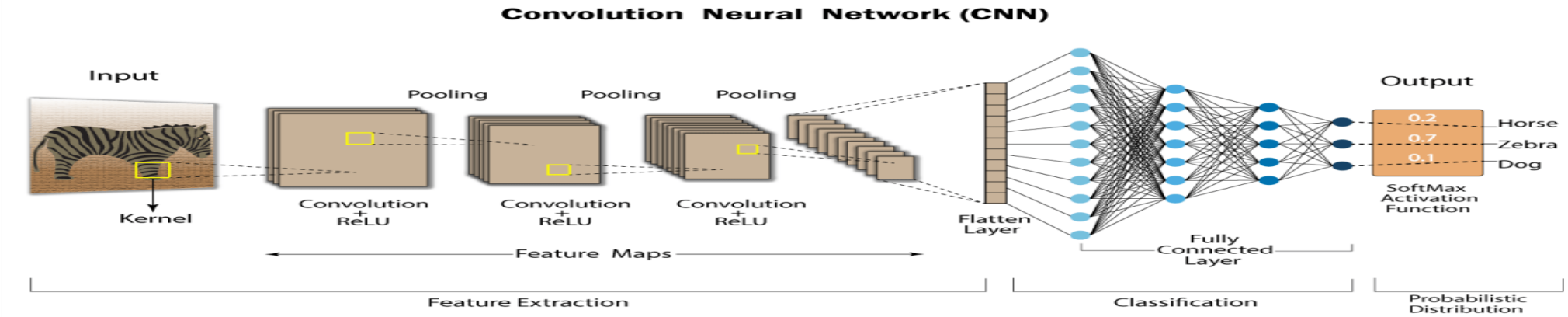
- A looping constraint on the hidden layer of ANN turns to RNN.
- We can use recurrent neural networks to solve the problems related to:
  - Time Series data
  - Text data
  - Audio data



Convolution Neural Network (CNN)

- These CNN models are being used across different applications and domains, and they're especially used in image and video processing projects.



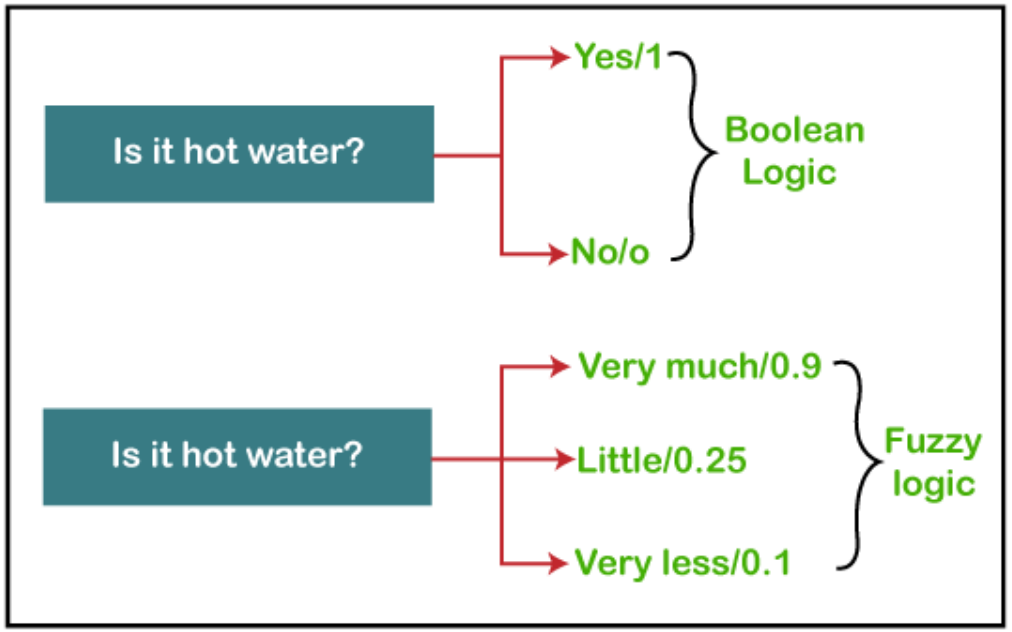


Fuzzy Logic

- The **'Fuzzy'** word means the things that are not clear or are vague.
- Sometimes, we cannot decide in real life that the given problem or statement is either true or false.
- At that time, this concept provides many values between the true and false and gives the flexibility to find the best solution to that problem.
- In artificial intelligence systems, fuzzy logic is used to imitate human reasoning and cognition.
- fuzzy logic is well-suited for the following:
  - Engineering for decisions without clear certainties and uncertainties, or with imprecise data -- such as with natural language processing technologies; and
  - Regulating and controlling machine outputs, according to multiple inputs/input variables -- such as with temperature control systems.

Example of Fuzzy Logic

- Fuzzy logic contains the multiple logical values and these values are the truth values of a variable or problem between 0 and 1.
- This concept provides the possibilities which are not given by computers, but similar to the range of possibilities generated by humans.
- the fuzzy system, there are multiple possibilities present between the 0 and 1, which are partially false and partially true



Genetic Algorithm

- ***A genetic algorithm is an adaptive heuristic search algorithm inspired by "Darwin's theory of evolution in Nature***."
- It is used to solve optimization problems in machine learning.
- It is one of the important algorithms as it helps solve complex problems that would take a long time to solve.
- Genetic Algorithms are being widely used in different real-world applications, for example, **Designing electronic circuits, code-breaking, image processing, and artificial creativity.**

Computer Vision

- Computer vision is the computer's ability to extract information and insights from images and videos.
- Computers can use deep learning techniques to comprehend images in the same way that humans do.
- Computer vision has several applications, such as the following:
  - Content moderation to automatically remove unsafe or inappropriate content from image and video archives
  - Facial recognition
  - Image classification

What is NLP?

- Natural Language Processing (NLP) refers to AI method of communicating with an intelligent systems using a natural language such as English
- It is the sub-field of AI that is focused on enabling computers to understand and process human language
- The ultimate objective of NLP is to read, decipher, understand, and make sense of the human languages in a manner that is valuable
- Most NLP techniques rely on machine learning to derive meaning from human languages

Uses cases of NLP

- NLP enables the recognition and **prediction of diseases** based on electronic health records and patient's own speech
- Organizations can determine what customers are saying about a service or product by identifying and extracting information in sources like social media (**sentiment analysis**)
- Companies like Yahoo and Google filter and classify your emails with NLP by analyzing text in emails that flow through their servers and **stopping spam** before they even enter your inbox
- To help **identifying fake news**, a system can be developed to determine if a source is accurate or politically biased, detecting if a news source can be trusted or not
- Amazon's Alexa and Apple's Siri are examples of intelligent **voice driven interfaces** that use NLP to respond to vocal prompts
- NLP is also being used in both the search and selection phases of **talent recruitment**
- NLP is particularly booming in the **healthcare industry**

Terminology used in NLP

- **Phonology**
  - It is study of organizing sound systematically.
- **Morphology**
  - It is a study of construction of words from primitive meaningful units.
- **Morpheme**
  - It is primitive unit of meaning in a language.
- **Syntax**
  - It refers to arranging words to make a sentence. It also involves determining the structural role of words in the sentence and in phrases.
- **Semantics**
  - It is concerned with the meaning of words and how to combine words into meaningful phrases and sentences.
- **Pragmatics**
  - It deals with using and understanding sentences in different situations and how the interpretation of the sentence is affected.
- **Discourse**
  - It deals with how the immediately preceding sentence can affect the interpretation of the next sentence.
- **World Knowledge**
  - It includes the general knowledge about the world.

Steps in NLP

Lexical Analysis	It involves identifying and analyzing the structure of words. Lexicon of a language means the collection of words and phrases in a language. Lexical analysis is dividing the whole chunk of txt into paragraphs, sentences, and words
Syntactic Analysis	It involves analysis of words in the sentence for grammar and arranging words in a manner that shows the relationship among the words. The sentence such as “The school goes to boy” is rejected by English syntactic analyzer
Semantic Analysis	It draws the exact meaning or the dictionary meaning from the text. The text is checked for meaningfulness. It is done by mapping syntactic structures and objects in the task domain.
Disclosure Integration	The meaning of any sentence depends upon the meaning of the sentence just before it. In addition, it also brings about the meaning of immediately succeeding sentence.
Pragmatic Analysis	During this, what was said is re-interpreted on what it actually meant. It involves deriving those aspects of language which require real world knowledge

AI Uses and Applications

Natural Language Processing (NLP)

- AI is used in NLP to analyze and understand human language.
- speech recognition, machine translation, sentiment analysis
- Eg. Siri , alexa

Image and Video Analysis

- AI techniques, including computer vision, enable the analysis and interpretation of images and videos.
- Eg. facial recognition, object detection, medical imaging

Robotics and Automation

- Robots equipped with AI algorithms can perform complex tasks in manufacturing, healthcare, logistics, and exploration.
- They can adapt to changing environments, learn from experience, and collaborate with humans.

AI Uses and Applications Cont…

Recommendation Systems

- AI-powered recommendation systems are used in e-commerce, streaming platforms, and social media to personalize user experiences.

Financial Services

- AI is extensively used in the finance industry for fraud detection, algorithmic trading, credit scoring, and risk assessment. Machine learning models can analyze vast amounts of financial data to identify patterns and make predictions.

Healthcare

- AI applications in healthcare include disease diagnosis, medical imaging analysis, drug discovery, personalized medicine, and patient monitoring. AI can assist in identifying patterns in medical data and provide insights for better diagnosis and treatment.

AI Uses and Applications Cont..

Virtual Assistants and Chatbots

- AI-powered virtual assistants and chatbots interact with users, understand their queries, and provide relevant information or perform tasks. They are used in customer support, information retrieval, and personalized assistance.

Gaming

- AI algorithms are employed in gaming for creating realistic virtual characters, opponent behavior, and intelligent decision-making. AI is also used to optimize game graphics, physics simulations, and game testing.

Smart Homes and IoT

- AI enables the development of smart home systems that can automate tasks, control devices, and learn from user preferences. AI can enhance the functionality and efficiency of Internet of Things (IoT) devices and networks

Cybersecurity

- AI helps in detecting and preventing cyber threats by analyzing network traffic, identifying anomalies, and predicting potential attacks. It can enhance the security of systems and data through advanced threat detection and response mechanisms.

Advantages and Disadvantages of AI

- Pros
  - It reduces human error
  - It never sleeps, so it's available 24x7
  - It never gets bored, so it easily handles repetitive tasks
  - It's fast
- Cons
  - It's costly to implement
  - It can't duplicate human creativity
  - It will definitely replace some jobs, leading to unemployment
  - People can become overly reliant on it

Current Trends and Future Directions in AI

- When one considers the computational costs and the technical data infrastructure running behind artificial intelligence, actually executing on AI is a complex and costly
- Ai in transportation
- Ai in manufacturing
- Ai in healthcare
- AI IN education
- AI in media
- AI in customer service

Thank You

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