MIT-WPU
॥ विश्वशान्तिर्भुवं ध्रुवा ॥

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School of Computer Engineering & Technology.

Unit 5 – Advanced topics and Applications of AI

Syllabus

Advanced topics and Applications of AI

- Applications of AI, Introduction to Machine Learning, Artificial Neural Network, Deep learning, Natural Language Processing, Introduction to Robotics and Computer Vision, Applications of AI in Business.

- https://youtu.be/Pq6Rdf7Va4c (application of AI)
- https://youtu.be/nOnsbd7rdhc (application of AI)
- https://youtu.be/Ta_vWUsrjho (neuron)
- https://youtu.be/bfmFfD2RIcg (ANN)
- https://youtu.be/6M5VXKLf4D4 (deep learning)
- https://youtu.be/WSbgixdC9g8 (AI vs deep learning vs Machine learning)
- https://youtu.be/w-8MTXT_N6A (AI vs deep learning vs Machine learning)
- https://youtu.be/rln_kZbYaWc (fuzzy logic)
- https://youtu.be/d4gGtcobq8M (NLP)
- https://youtu.be/ukzFI9rgwfU (Machine Learning)
- https://youtu.be/OOfXhz4In_w (Robotics)
- https://youtu.be/OcycT1Jwsns (computer vision)
- https://youtu.be/YOEFogy9VSQ (AI in business)

Applications of AI

- ✓ There are several fields where AI is helping human beings to solve real life problems effectively and accurately.
- ✓ There are various domains in which AI applications are playing significant role. Today, many thousands of AI applications are deeply embedded in the infrastructure of every industry.
- ✓ Following are domains and few examples

Applications of AI (Cntd.)

✓ ***Marketing –*** to attract the customer based on their likeliness, experience, requirements etc. build bots or autonomous systems that provides highly accurate predictions, suggestions based on customer's reactions. **For example,**

- **Netflix –** finding the right movies, to suggest shows and films that you might like based on your previous actions and choices of films**.**
- **Amazon –** finding the right products, to suggest products that you might like based on your previous actions and choices of products**.**

✓ ***Banking –*** to fulfill various customer related services completing their requirements. A lot of banks have already adopted AI-based systems to provide customer support, detect anomalies and credit card frauds. **For example,**

- **HDFC Bank –** developed an AI-based chatbot called EVA (Electronic Virtual Assistant)**.**
- **MasterCard and RBS WorldPay –** have relied on AI and Deep Learning to detect fraudulent transaction patterns and prevent card fraud for years now.

Applications of AI (Cntd.)

$ ✓ ***Finance –*** to determine future patterns in the market. Trading mainly depends on the ability to predict the future accurately. Machines are great at this because they can crunch a huge amount of data in a short span. Machines can also learn to observe patterns in past data and predict how these patterns might repeat in the future. In the age of ultra-high-frequency trading, financial organizations are turning to AI to improve their stock trading performance and boost profit. **For example,**

- **Nomura Securities –** Japan's leading brokerage house. The company has been reluctantly pursuing one goal, i.e. to analyze the insights of experienced stock traders with the help of computers.

Applications of AI (Cntd.)

✓ ***Agriculture –*** Issues such as climate change, population growth, and food security concerns have pushed the industry into seeking more innovative approaches to improve crop yield as the world will need to produce 50 percent more food by 2050. AI can help farmers get more from the land while using resources more sustainably. **For example,**

- Organizations are using automation and robotics to help farmers find more efficient ways to protect their crops from weeds. **Blue River Technology has developed a robot called See & Spray which uses computer vision technologies like object detection to monitor and precisely spray weedicide on cotton plants.** Precision spraying can help prevent herbicide resistance.
- Apart from this, **Berlin-based agricultural tech start-up called PEAT, has developed an application called Plantix that identifies potential defects and nutrient deficiencies in the soil through images.** The image recognition app identifies possible defects through images captured by the user's smartphone camera. Users are then provided with soil restoration techniques, tips, and other possible solutions. The company claims that its software can achieve pattern detection with an estimated accuracy of up to 95%.

Applications of AI (Cntd.)

✓ ***Healthcare –*** When it comes to saving our lives, a lot of organizations and medical care centers are relying on AI. There are many examples of how AI in healthcare has helped patients all over the world. **For example,**

- An organization called **Cambio Health Care** developed a clinical decision support system for stroke prevention that can give the physician a warning when there's a patient at risk of having a heart stroke.
- Another such example is **Coala life** which is a company that has a digitalized device that can find cardiac diseases.
- Similarly, **Aifloo** is developing a system for keeping track of how people are doing in nursing homes, home care, etc.

The best thing about AI in healthcare is that you don't even need to develop a new medication. Just by using an existing medication in the right way, you can also save lives.

Applications of AI (Cntd.)

✓ ***Gaming –*** Over the past few years, Artificial Intelligence has become an integral part of the gaming industry. In fact, one of the biggest accomplishments of AI is in the gaming industry.
For example,

- DeepMind's AI-based **AlphaGo software,** which is known for defeating Lee Sedol, the world champion in the game of GO, is considered to be one of the most significant accomplishment in the field of AI.
- **IBM's DEEP BLUE** became the first computer program to defeat the world champion in a chess match when it defeated Garry Kasparov by a score of 3.5 to 2.5 in an exhibition match.
- **IBM Watson** is a question-answering computer system capable of answering questions posed in natural language. Watson computer system competed on Jeopardy! against champions Brad Rutter and Ken Jennings, winning the first place prize of $1 million.

Applications of AI (Cntd.)

✓ ***Gaming –*** (Cntd.)

- Other examples of Artificial Intelligence in gaming include the **First Encounter Assault Recon, popularly known as F.E.A.R,** which is a first-person shooter video game. But what makes this game so special? The actions taken by the opponent AI are unpredictable because the game is designed in such a way that the opponents are trained throughout the game and never repeat the same mistakes. They get better as the game gets harder.
- Few more example include **S.T.A.L.K.E.R. Series, Far Cry 2, StarCraft 2** and
- **Halo: Combat evolved game** – A first-person shooter game assumes the role of the Master Chief, battling various aliens on foot or in vehicles. Enemies use cover very wisely, and employ suppressing fire and grenades. The squad situation affects the individuals, so certain enemies flee when their leader dies. A lot of attention is paid to the little details, with enemies notably throwing back grenades or team-members responding to you bothering them. **The underlying "behavior tree" technology has become very popular in the games industry (especially since Halo 2).**

Applications of AI (Cntd.)

✓ ***Space Exploration –*** Space expeditions and discoveries always require analyzing vast amounts of data. Artificial Intelligence and Machine learning is the best way to handle and process data on this scale. **For Example,**

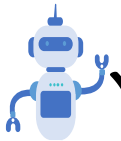
- After rigorous research, astronomers used Artificial Intelligence to sift through years of data obtained by the Kepler telescope in order **to identify a distant eight-planet solar system**.
- Artificial Intelligence is also being used for **NASA's** next rover mission to Mars, the Mars 2020 Rover. The **AEGIS**, which is an AI-based Mars rover is already on the red planet. The rover is responsible for autonomous targeting of cameras in order to perform investigations on Mars.
- A hundred million miles from Earth, **NASA's Remote Agent program** became the first on-board autonomous planning program to control the scheduling of operations for a spacecraft. Successor program **MAPGEN** plans the daily operations for NASA's Mars Exploration Rovers, and **MEXAR2** did mission planning both logistics and science planning for the European Space Agency's Mars Express mission in 2008.

Applications of AI (Cntd.)

✓ ***Autonomous Vehicles –*** For the longest time, self-driving cars have been a buzzword in the AI industry. The development of autonomous vehicles will definitely revolutionaries the transport system. AI have contributed to the growth of the automotive industry through the creation and evolution of self-driving vehicles. As of 2016, there are over 30 companies utilizing **AI into the creation of self-driving cars**. A few companies involved with AI include **Tesla, Google, and Apple**.

- Companies like **Waymo** conducted several test drives in Phoenix before deploying their first AI-based public ride-hailing service. The AI system collects data from the vehicles radar, cameras, GPS, and cloud services to produce control signals that operate the vehicle. Advanced Deep Learning algorithms can accurately predict what objects in the vehicle's vicinity are likely to do. This makes Waymo cars more effective and safer.
- Another famous example of an autonomous vehicle is **Tesla's self-driving car**. Artificial Intelligence implements computer vision, image detection and deep learning to build cars that can automatically detect objects and drive around without human intervention.

Applications of AI (Cntd.)



✓ ***Chatbots –*** These days **Virtual assistants** have become a very common technology. Almost every household has a virtual assistant that controls the appliances at home. **A few examples include Siri, Cortana,** which are gaining popularity because of the user experience they provide.

- **Amazon's Echo** is an example of how Artificial Intelligence can be used to translate human language into desirable actions. This device uses speech recognition and NLP to perform a wide range of tasks on your command. It can do more than just play your favorite songs. It can be used to control the devices at your house, book cabs, make phone calls, order your favorite food, check the weather conditions and so on.
- Another example is the newly released Google's virtual assistant called **Google Duplex,** that has astonished millions of people. Not only can it respond to calls and book appointments for you, but it also adds a human touch. The device uses Natural language processing and machine learning algorithms to process human language and perform tasks such as manage your schedule, control your smart home, make a reservation and so on.

Applications of AI (Cntd.)

✓ ***Social media –*** Ever since social media has become our identity, we've been generating an immeasurable amount of data through chats, tweets, posts and so on. And wherever there is an abundance of data, AI and Machine Learning are always involved.

- In social media platforms like **Facebook,** AI is used for face verification wherein machine learning and deep learning concepts are used to detect facial features and tag your friends. Deep Learning is used to extract every minute detail from an image by using a bunch of deep neural networks. On the other hand, Machine learning algorithms are used to design your feed based on your interests.
- Another such example is **Twitter's AI,** which is being used to identify hate speech and terroristic language in tweets. It makes use of Machine Learning, Deep Learning, and Natural language processing to filter out offensive content. The company discovered and banned 300,000 terrorist-linked accounts, 95% of which were found by non-human, artificially intelligent machines.

Applications of AI (Cntd.)

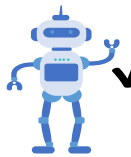
- ✓ ***Artificial Creativity –*** Have you ever wondered what would happen if an artificially intelligent machine tried to create music and art?
  - ➢ An AI-based system called **MuseNet** can now compose classical music that echoes the classical legends, Bach and Mozart. MuseNet is a deep neural network that is capable of generating 4-minute musical compositions with 10 different instruments and can combine styles from country to Mozart to the Beatles. MuseNet was not explicitly programmed with an understanding of music, but instead discovered patterns of harmony, rhythm, and style by learning on its own.
  - ➢ Another creative product of Artificial Intelligence is a content automation tool called **WordSmith**. WordSmith is a natural language generation platform that can transform your data into insightful narratives. Tech giants such as Yahoo, Microsoft, Tableau, are using WordSmith to generate around 1.5 billion pieces of content every year.

Applications of AI (Cntd.)

✓ ***Spam fighting –*** Each day, learning algorithms classify over a billion messages as spam, saving the recipient from having to waste time deleting what, for many users, could comprise 80% or 90% of all messages, if not classified away by algorithms. Because the spammers are continually updating their tactics, it is difficult for a static programmed approach to keep up, and learning algorithms work best.

✓ ***Logistics planning –*** During the Persian Gulf crisis of 1991, U.S. forces deployed a **Dynamic Analysis and Replanning Tool (DART),** to do automated logistics planning and scheduling for transportation. This involved up to 50,000 vehicles, cargo, and people at a time, and had to account for starting points, destinations. routes, and conflict resolution among all parameters. The AI planning techniques generated in hours a plan that would have taken weeks with older methods. The Defense Advanced Research Project Agency (DARPA) stated that this single application more than paid back DARPA's 30-year investment in Al.

Applications of AI (Cntd.)



✓ ***Robotics –*** The iRobot Corporation has sold over two million **Roomba** robotic vacuum cleaners for home use. The company also deploys the more rugged **PackBot** to Iraq and Afghanistan, where it is used to handle hazardous materials, clear explosives, and identify the location of snipers. Hanson Robotics is building **humanoid robots** with artificial intelligence for both the commercial and consumer markets. The Hanson-created Sophia is an incredibly advanced social-learning robot. Through AI, **Sophia** can efficiently communicate with natural language and use facial expressions to convey human-like emotions.

Introduction to Machine Learning

- ✓ The term Machine Learning was coined by Arthur Samuel in 1959, an American pioneer in the field of computer gaming and artificial intelligence and stated that “it gives computers the ability to learn without being explicitly programmed”.
- ✓ And in 1997, Tom Mitchell gave a “well-posed” mathematical and relational definition that “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.

Introduction to Machine Learning (Cntd.)

✓ ***Classification of Machine Learning:***

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

✓ ***Classification of Machine Learning on the basis of required Output:***

- Another categorization of machine learning tasks arises when one considers the desired output of a machine-learned system:
  - *Classification :* When 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 :* Which is also a supervised problem, A case when the outputs are continuous rather than discrete.
  - *Clustering :* When 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.

Introduction to Machine Learning (Cntd.)

✓ Key Differences between AI and ML:

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.

Introduction to Robotics

- ✓ Robotics is a branch of engineering and science that includes electronics engineering, mechanical engineering and computer science and so on.
- ✓ This branch deals with the design, construction, use to control robots, sensory feedback and information processing.

Introduction to Robotics (Cntd.)

✓ ***Characteristics of Robot:***

- **Appearance:** Robots have a physical body. They are held by the structure of their body and are moved by their mechanical parts. Without appearance, robots will be just a software program.
- **Brain:** Another name of brain in robots is On-board control unit. Using this robot receive information and sends commands as output. With this control unit robot knows what to do else it'll be just a remote-controlled machine.
- **Sensors:** The use of these sensors in robots is to gather info from the outside world and send it to Brain. Basically, these sensors have circuits in them that produces the voltage in them.
- **Actuators:** The robots move and the parts with the help of these robots move is called Actuators. Some examples of actuators are motors, pumps, and compressor etc. The brain tells these actuators when and how to respond or move.
- **Program:** Robots only works or responds to the instructions which are provided to them in the form of a program. These programs only tell the brain when to perform which operation like when to move, produce sounds etc. These programs only tell the robot how to use sensors data to make decisions.
- **Behavior:** Robots behavior is decided by the program which has been built for it. Once the robot starts making the movement, one can easily tell which kind of program is being installed inside the robot.

Introduction to Robotics (Cntd.)

✓ ***Advantages of using Robots:***

- They can get information that a human can't get.
- They can perform tasks without any mistakes and very efficiently and fast.
- Maximum robots are automatic, so they can perform different tasks without needing human interaction.
- Robots are used in different factories to produce items like plane, car parts etc.
- They can be used for mining purposes and can be sent to earth's nadris.

✓ ***Disadvantages of using Robots:***

- They need the power supply to keep going. People working in factories may lose their jobs as robots can replace them.
- They need high maintenance to keep them working all day long. And the cost of maintaining the robots can be expensive.
- They can store huge amount of data but they are not as efficient as our human brains.
- As we know that robots work on the program that has been installed in them. So other than the program installed, robots can't do anything different.
- The most important disadvantage is that if the program of robots comes in wrong hands they can cause the huge amount of destruction.

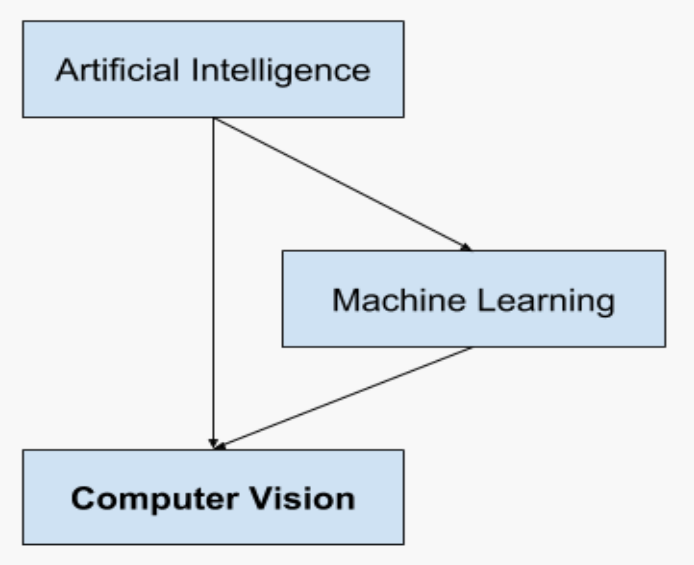
Introduction to Robotics (Cntd.)

✓ ***Applications using Robots:***

- Robots are increasingly been used more than humans in manufacturing while in auto-industry there are more than half of the labors are “Robots”.
- Many of the robots are used as Military Robots.
- Robots have been used in cleaning up of areas like toxic waste or industrial wastes etc.
- Agricultural robots.
- Household robots.
- Domestic robots.
- Nano robots.
- Swarm robots.

Introduction to Computer Vision

- ✓ Computer Vision, often abbreviated as CV, is defined as a field of study that seeks to develop techniques to help computers “see” and understand the content of digital images such as photographs and videos.
- ✓ At an abstract level, the goal of computer vision problems is to use the observed image data to infer something about the world.
- ✓ It is a multidisciplinary field that could broadly be called a subfield of artificial intelligence and machine learning, which may involve the use of specialized methods and make use of general learning algorithms.



Introduction to Computer Vision (Cntd.)

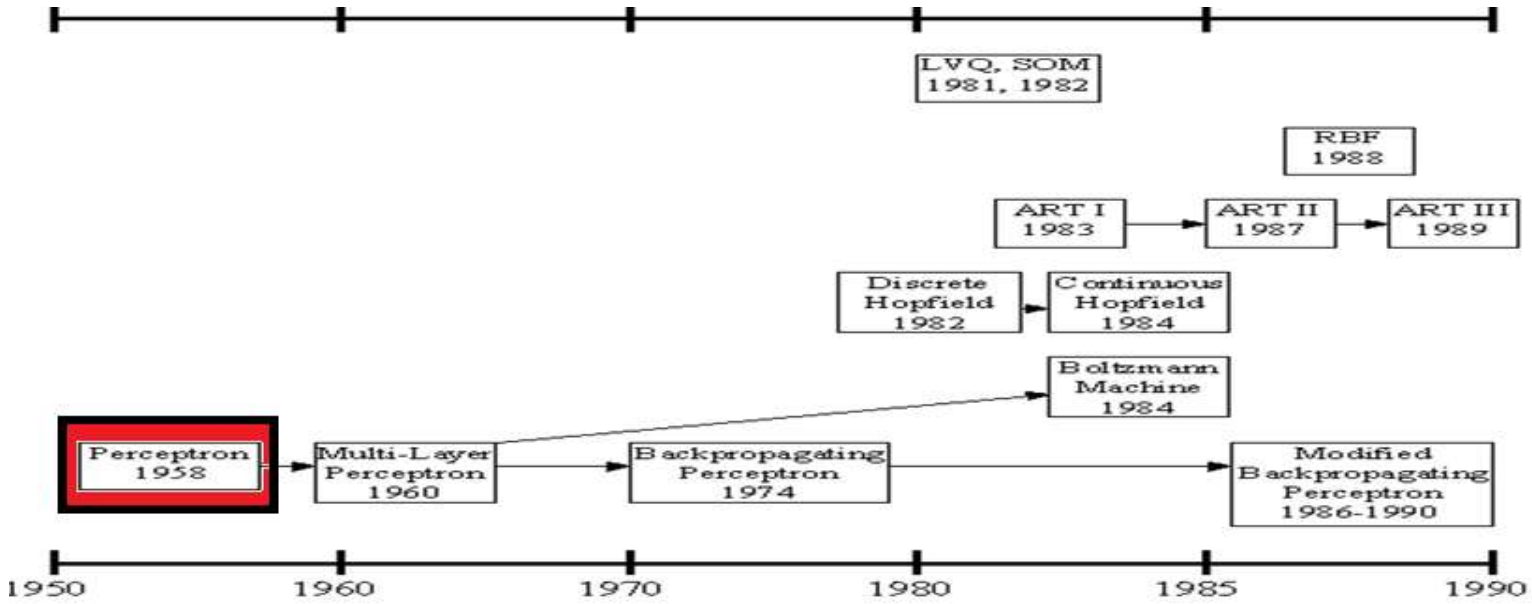
✓ ***Application:***

- **Laptop:** Biometrics auto-login (face recognition, 3D), OCR
- **Smartphones:** QR codes, computational photography (Android Lens Blur, iPhone Portrait Mode), panorama construction (Google Photo Spheres), face detection, expression detection (smile), Snapchat filters (face tracking), Google Tango (3D reconstruction), Night Sight (Pixel)
- **Web:** Image search, Google photos (face recognition, object recognition, scene recognition, geolocalization from vision), Facebook (image captioning), Google maps aerial imaging (image stitching), YouTube (content categorization)
- **VR/AR:** Outside-in tracking (HTC VIVE), inside out tracking (simultaneous localization and mapping, HoloLens), object occlusion (dense depth estimation)
- **Motion:** Kinect, full body tracking of skeleton, gesture recognition, virtual try-on
- **Medical imaging:** CAT / MRI reconstruction, assisted diagnosis, automatic pathology, connectomics, endoscopic surgery
- **Industry:** Vision-based robotics (marker-based), machine-assisted router (jig), automated post, ANPR (number plates), surveillance, drones, shopping
- **Transportation:** Assisted driving (everything), face tracking/iris dilation for drunkeness, drowsiness, automated distribution (all modes)
- **Media:** Visual effects for film, TV (reconstruction), virtual sports replay (reconstruction), semantics-based auto edits (reconstruction, recognition)

Artificial Neural Network [ANN]

✓ ***History of ANN:***

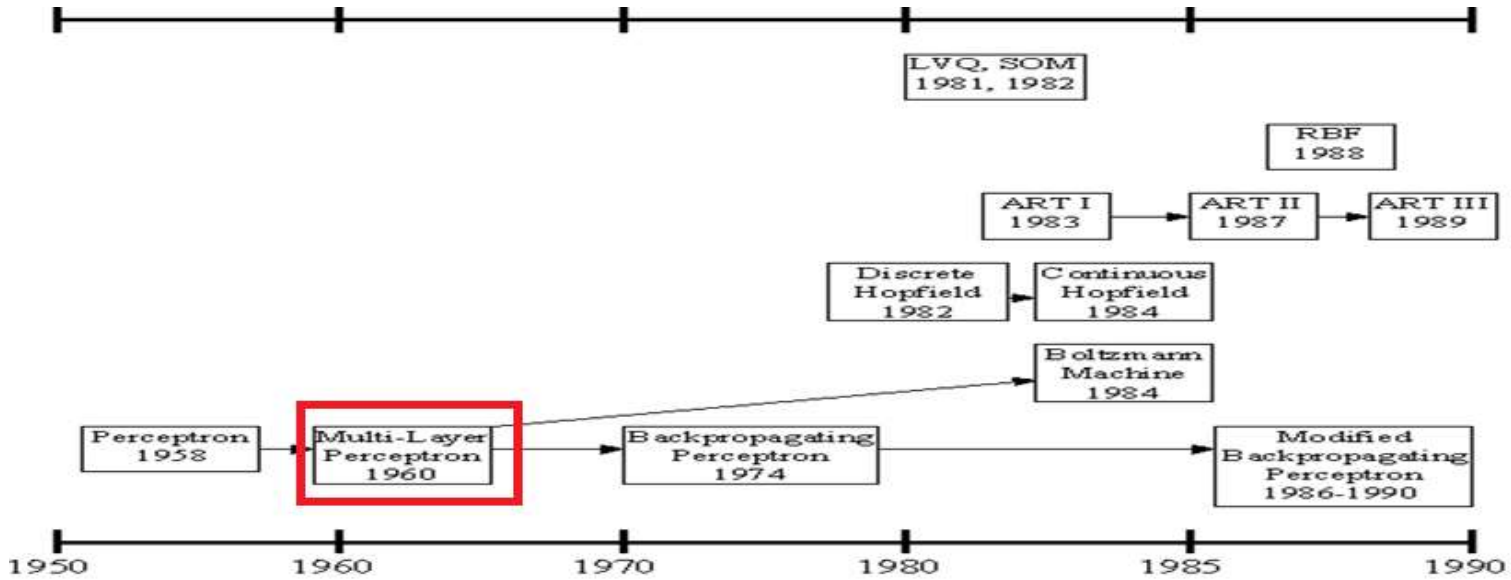
- History of the ANNs stems from the **1940s**, the decade of the first electronic computer.
- However, the first important step took place in **1957** when **Rosenblatt** introduced the first concrete neural model, the **perceptron**. Rosenblatt also took part in constructing the first successful neurocomputer, the Mark I Perceptron. After this, the development of ANNs has proceeded as described in *Figure*.



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

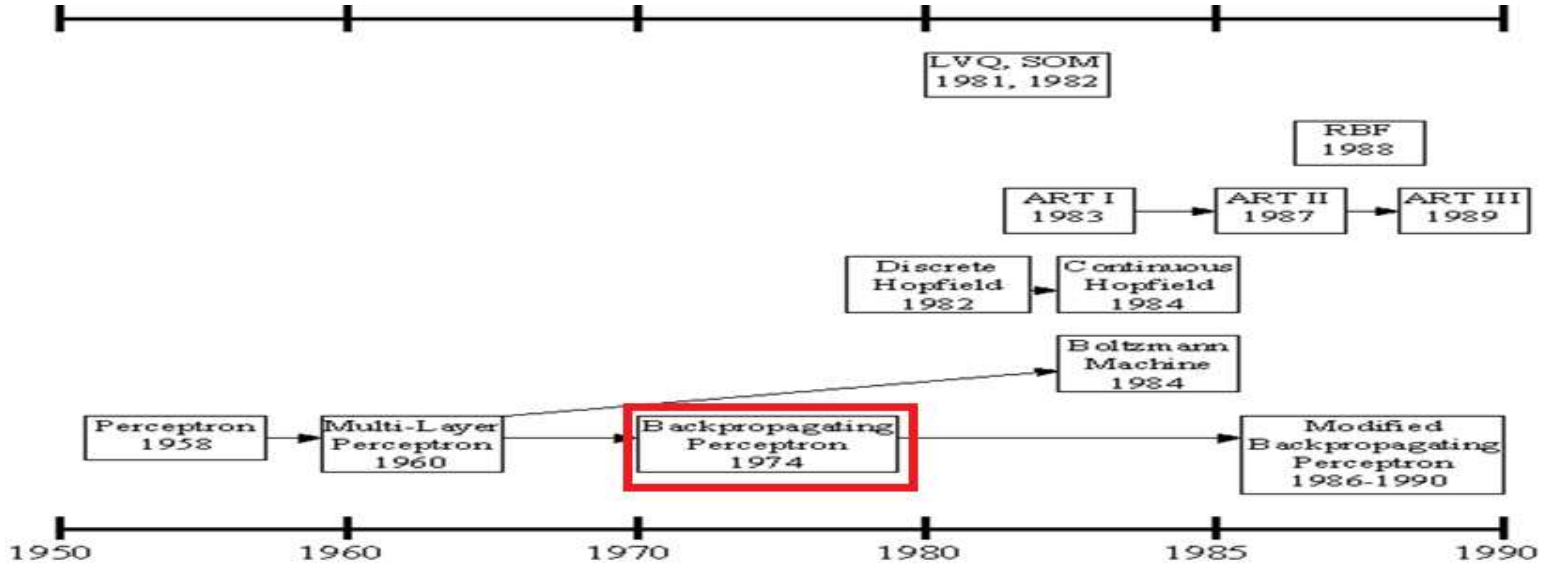
- Rosenblatt's original perceptron model contained only one layer. From this, a multi-layered model was derived in 1960. At first, the use of the **multi-layer perceptron (MLP)** was complicated by the lack of a appropriate learning algorithm.
- In 1974, Werbos came to introduce a so-called back propagation algorithm for the three-layered perceptron network.



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

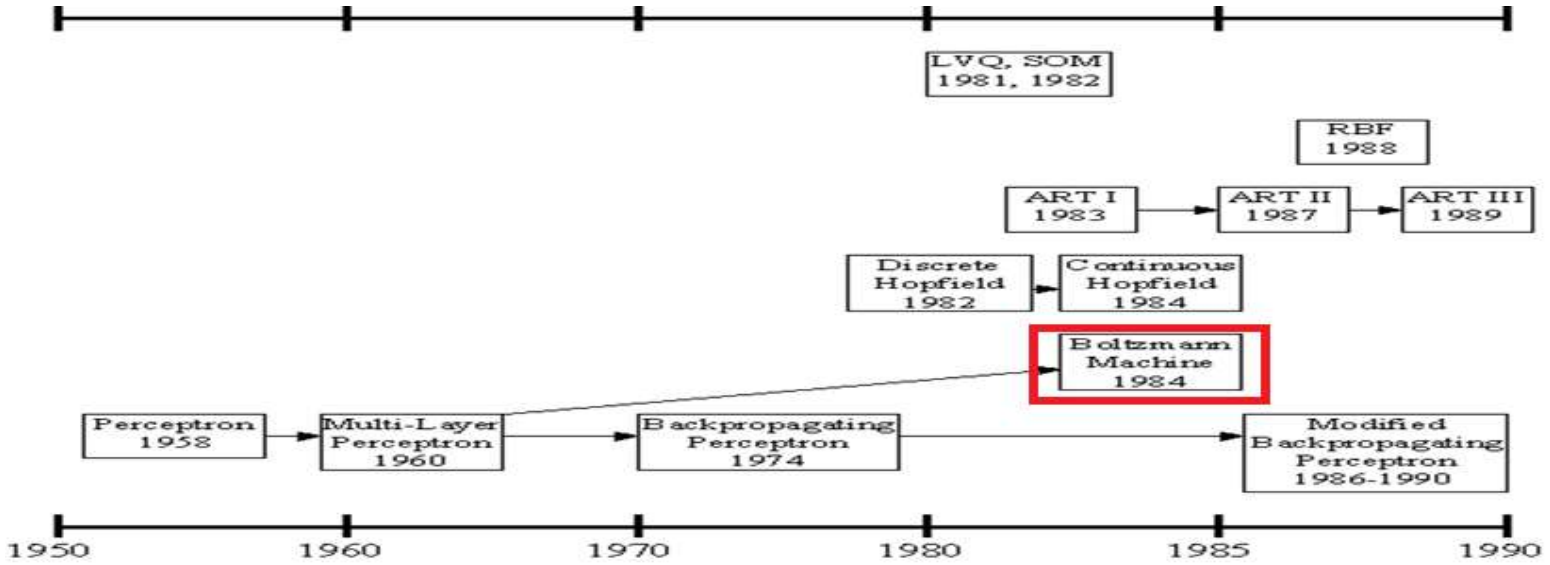
- in 1986, The application area of the MLP networks remained rather limited until the breakthrough when a general back propagation algorithm for a multi-layered perceptron was introduced by Rummelhart and Mclelland.
- in 1982, **Hopfield** brought out his idea of a neural network. Unlike the neurons in MLP, the Hopfield network consists of **only one layer whose neurons are fully connected with each other.**



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

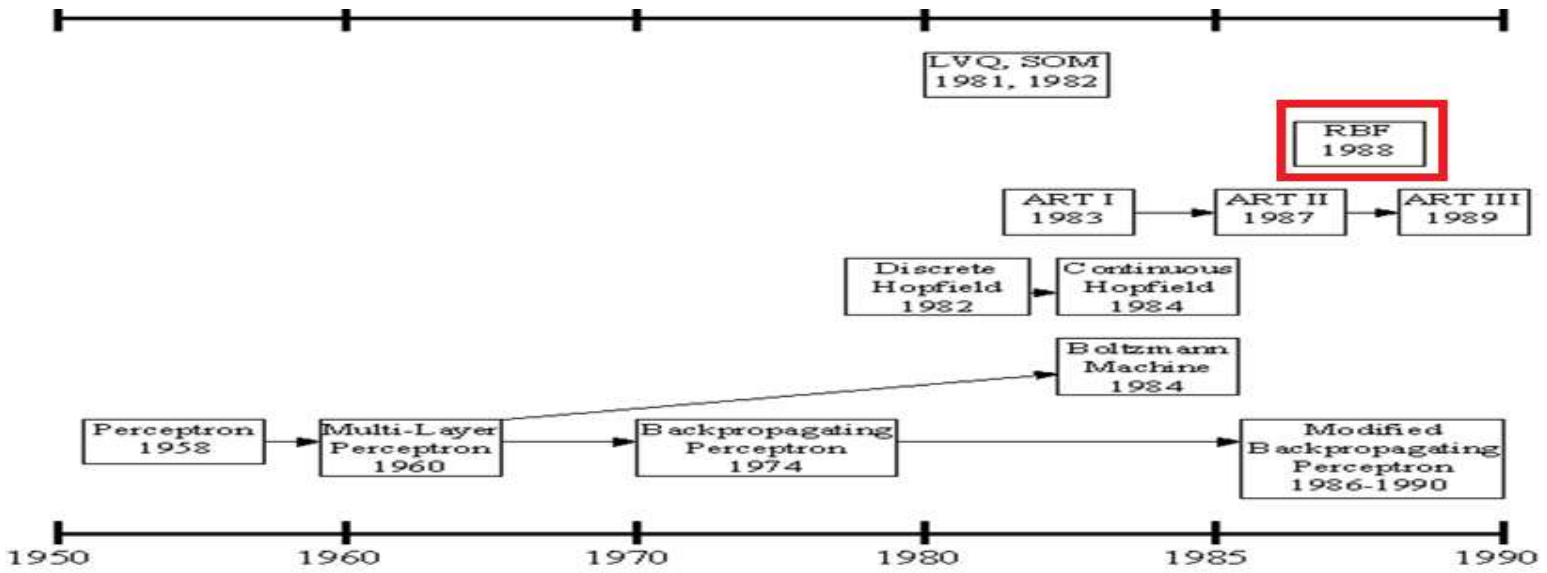
- Since then, new versions of the Hopfield network have been developed. The **Boltzmann machine** has been **influenced by both the Hopfield network and the MLP.**



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

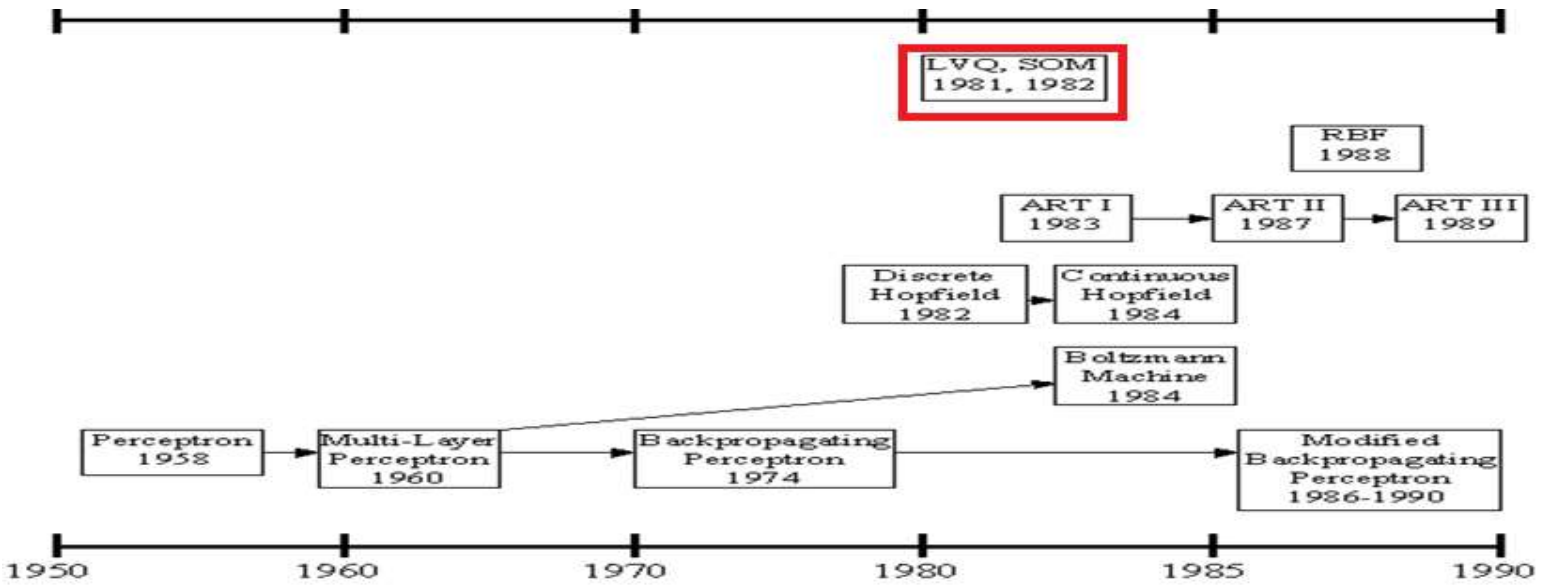
- in 1988, **Radial Basis Function (RBF)** networks were first introduced by Broomhead & Lowe. Although the basic idea of RBF was developed 30 years ago under the name method of potential function, the work by Broomhead & Lowe opened a new frontier in the neural network community.



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

- in 1982, A totally unique kind of network model is the **Self-Organizing Map (SOM)** introduced by Kohonen. SOM is a certain kind of topological map which organizes itself based on the input patterns that it is trained with. The SOM originated from the **LVQ (Learning Vector Quantization)** network the underlying idea of which was also Kohonen's in 1972.



Artificial Neural Network [ANN] (Cntd.)

✓ ***History of ANN (Cntd.):***

- Since then, research on artificial neural networks has remained active, leading to many new network types, as well as hybrid algorithms and hardware for neural information processing.

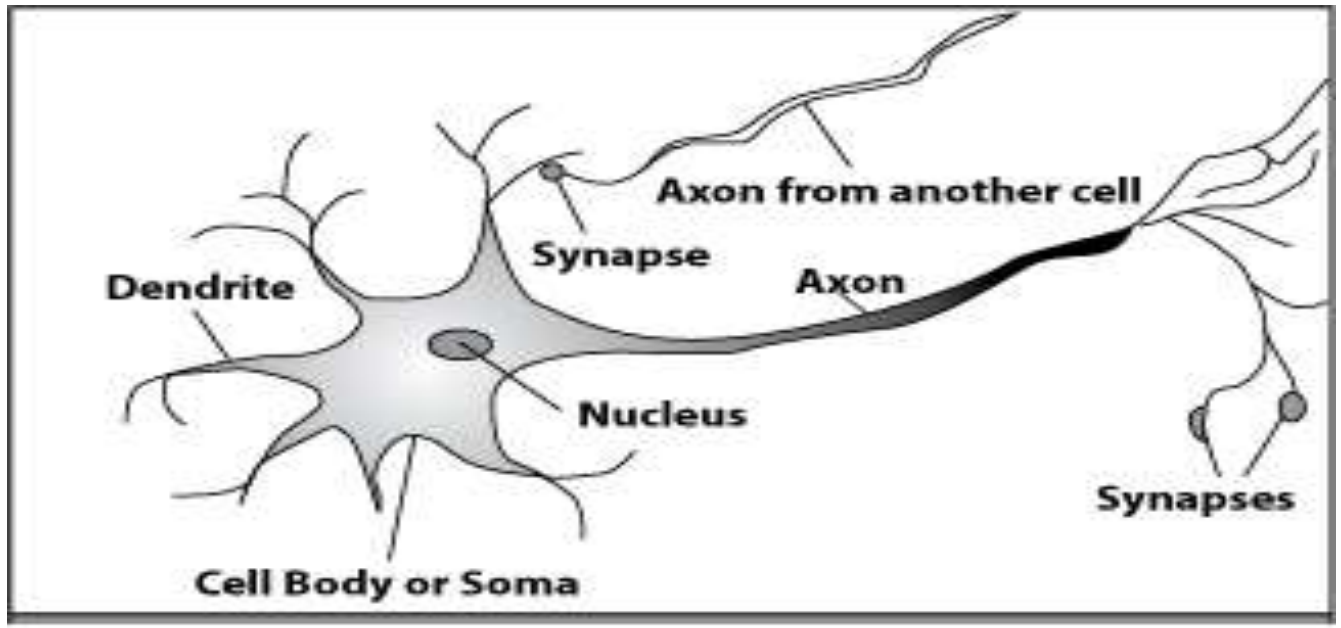
Artificial Neural Network [ANN] (Cntd.)

✓ An **artificial neural network** consists of a **pool of simple processing units** which **communicate by** sending **signals to each other** over a large number of **weighted connections.**

Artificial Neural Network [ANN] (Cntd.)

✓ ***How Brain works?***

- We have discussed briefly on the basic findings of neuroscience—in particular, the hypothesis that mental activity consists primarily of electrochemical activity in networks of brain cells called **neurons**. Following showed a schematic diagram of a typical neuron.



Dendrites: Input
Cell body: Processor
Synaptic: Link
Axon: Output

Artificial Neural Network [ANN] (Cntd.)

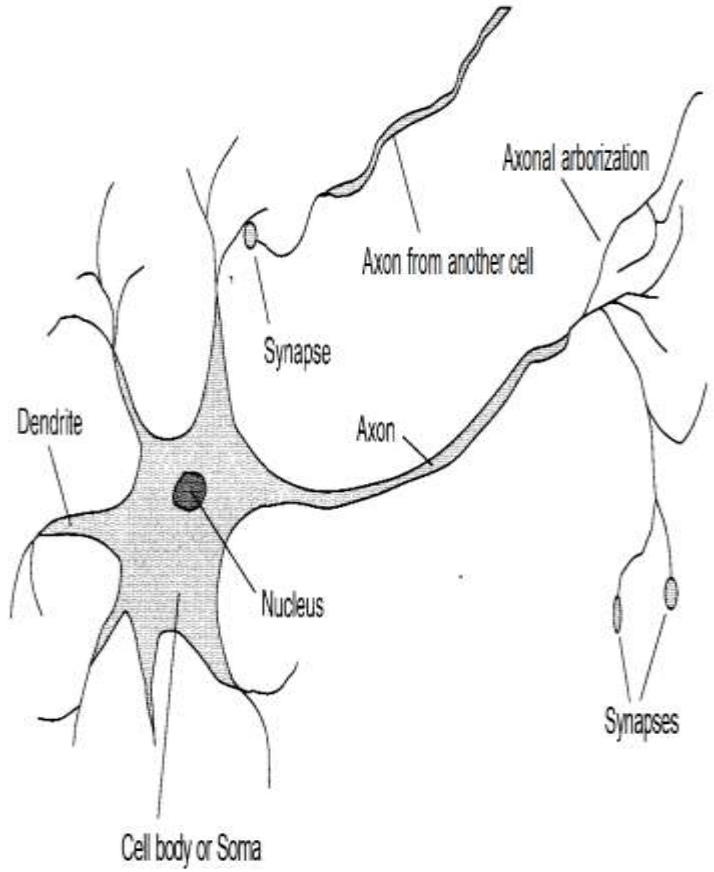
✓ ***How Brain works? (Cntd.)***

- The Brain is A massively parallel information processing system.
- Our brains are a huge network of processing elements. A typical brain contains a network of 10 billion neurons.

Artificial Neural Network [ANN] (Cntd.)

✓ ***How Brain works? (Cntd.)***

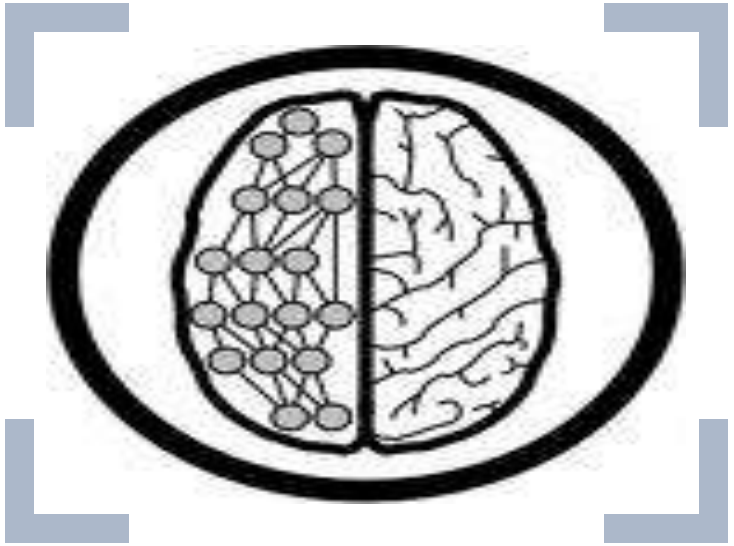
- A neuron is connected to other neurons through about 10,000 synapses.
- A neuron receives input from other neurons. Inputs are combined.
- Once input exceeds a critical level, the neuron discharges a spike - an electrical pulse that travels from the body, down the axon, to the next neuron(s)
- The axon endings almost touch the dendrites or cell body of the next neuron.
- Transmission of an electrical signal from one neuron to the next is effected by neurotransmitters.
- Neurotransmitters are chemicals which are released from the first neuron and which bind to the Second.
- This link is called a synapse. The strength of the signal that reaches the next neuron depends on factors such as the amount of neurotransmitter available.



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works?***

- An artificial neural network (ANN) is either a **hardware implementation** or a **computer program** which strives to simulate the information processing capabilities of its biological exemplar. ANNs are typically composed of a great number of interconnected artificial neurons. The artificial neurons are simplified models of their biological counterparts.
- ANN is a technique for solving problems by constructing software that works like our brains.

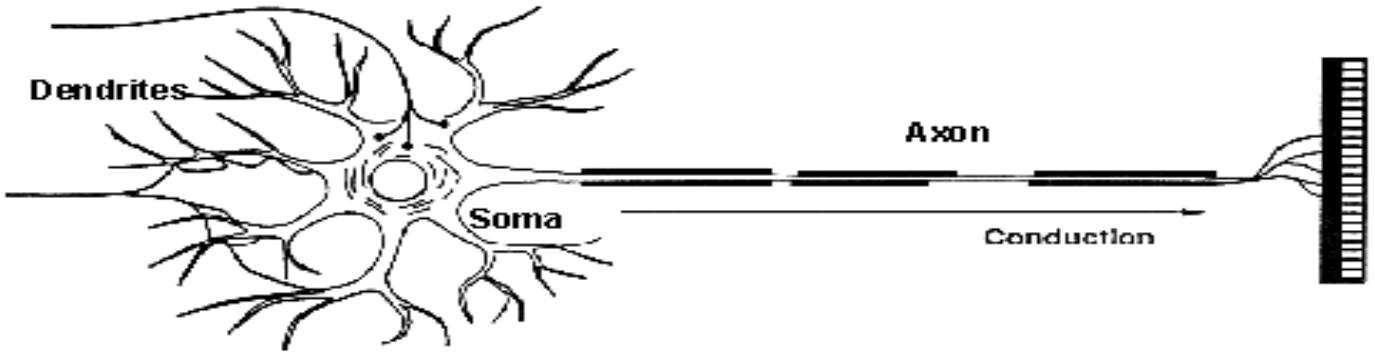


Artificial Neural Network [ANN] (Cntd.)

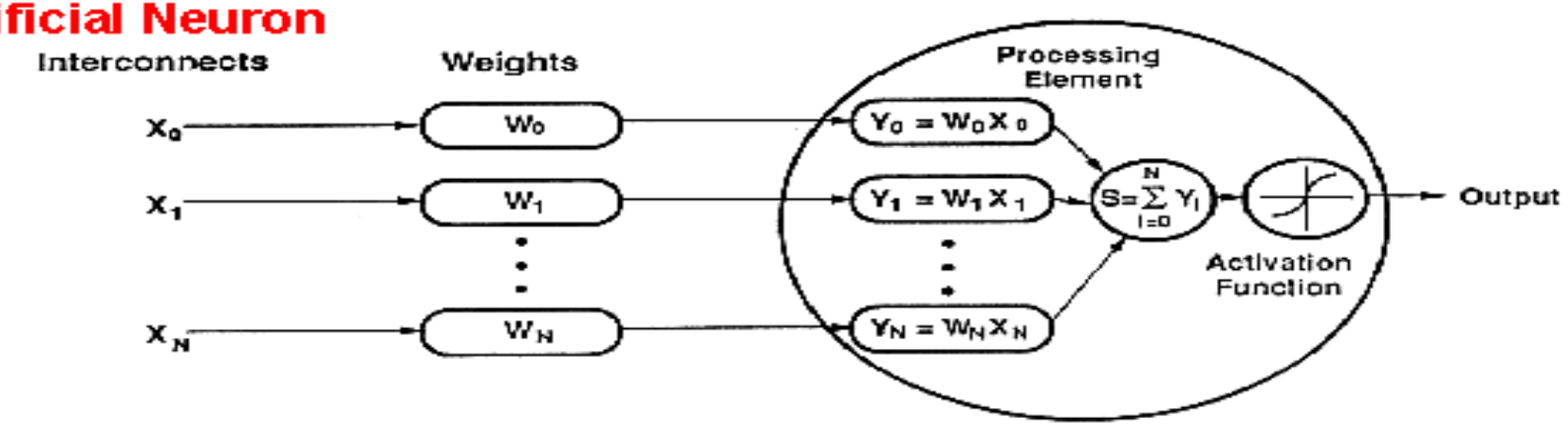
✓ ***How do ANN works? (Cntd.)***

- An artificial neuron is an imitation of a human neuron

Biological Neuron



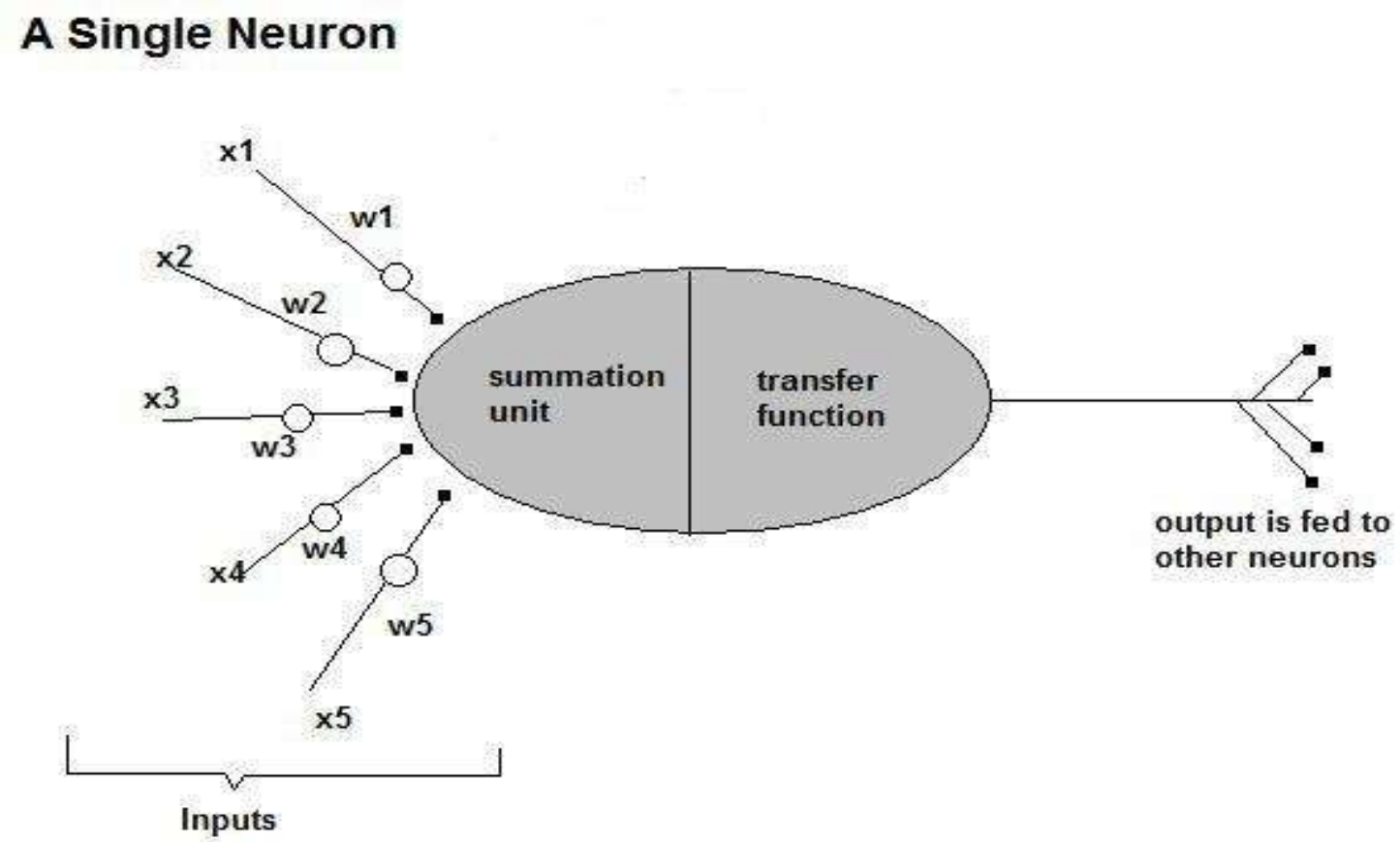
Artificial Neuron



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

- Now, let us have a look at the model of an artificial neuron.



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

- Neural networks have lots of pieces, and to refer to them we will need to introduce a variety of mathematical notations. Following Table lists all notations used

Artificial Neural Network [ANN] (Cntd.)

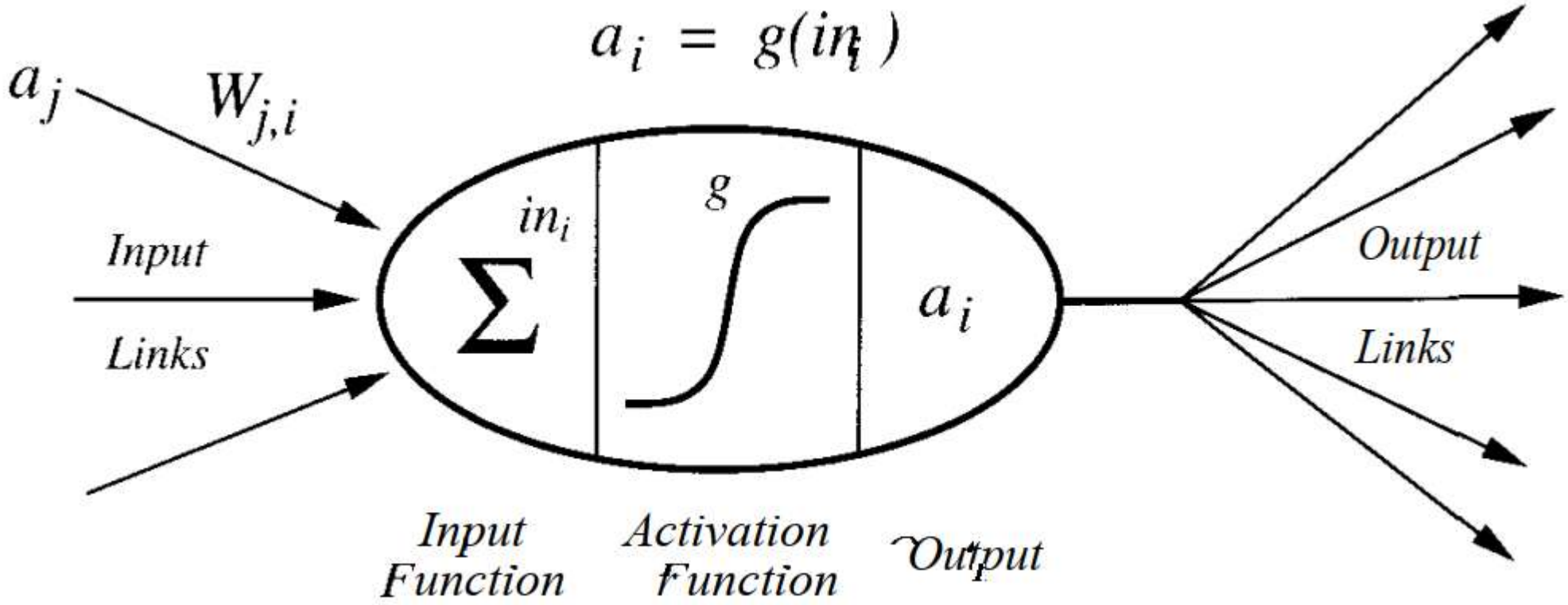
Notation	Meaning
a_i $\mathbf{a}_i$	Activation value of unit i (also the output of the unit) Vector of activation values for the inputs to unit i
g g'	Activation function Derivative of the activation function
Err_i Err^e	Error (difference between output and target) for unit i Error for example e
I_i $\mathbf{I}$ $\mathbf{I}^e$	Activation of a unit i in the input layer Vector of activations of all input units Vector of inputs for example e
in_i	Weighted sum of inputs to unit i
N	Total number of units in the network
O O_i $\mathbf{O}$	Activation of the single output unit of a perceptron Activation of a unit i in the output layer Vector of activations of all units in the output layer
t	Threshold for a step function
T $\mathbf{T}$ $\mathbf{T}^e$	Target (desired) output for a perceptron Target vector when there are several output units Target vector for example e
$W_{j,i}$ W_i $\mathbf{W}_i$ $\mathbf{W}$	Weight on the link from unity to unit i Weight from unit r to the output in a perceptron Vector of weights leading into unit i Vector of all weights in the network

Figure 19.3 Neural network notation. Subscripts denote units; superscripts denote examples.

Artificial Neural Network [ANN] (Cntd.)

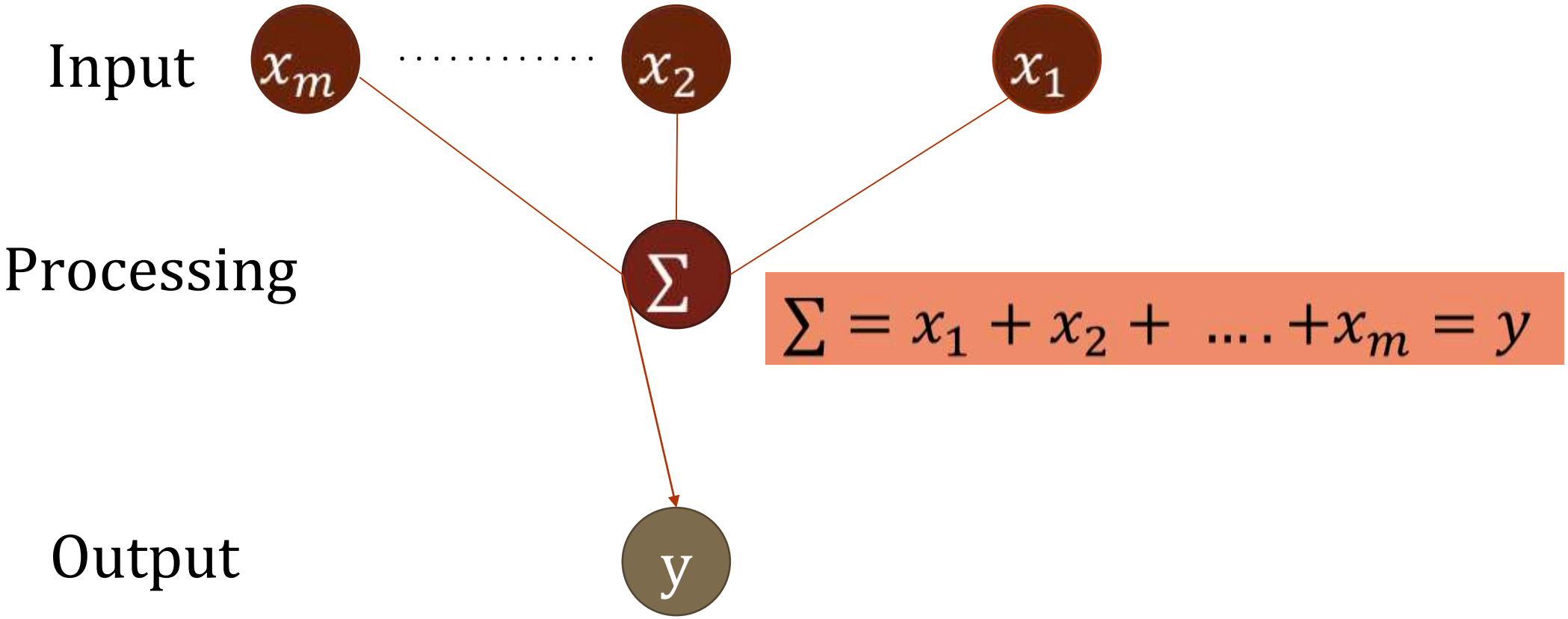
✓ ***How do ANN works? (Cntd.)***

- The basic unit of computation in a neural network is the **neuron**, often called a **node or unit**. Following figure shows a Unit in Neural network.



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

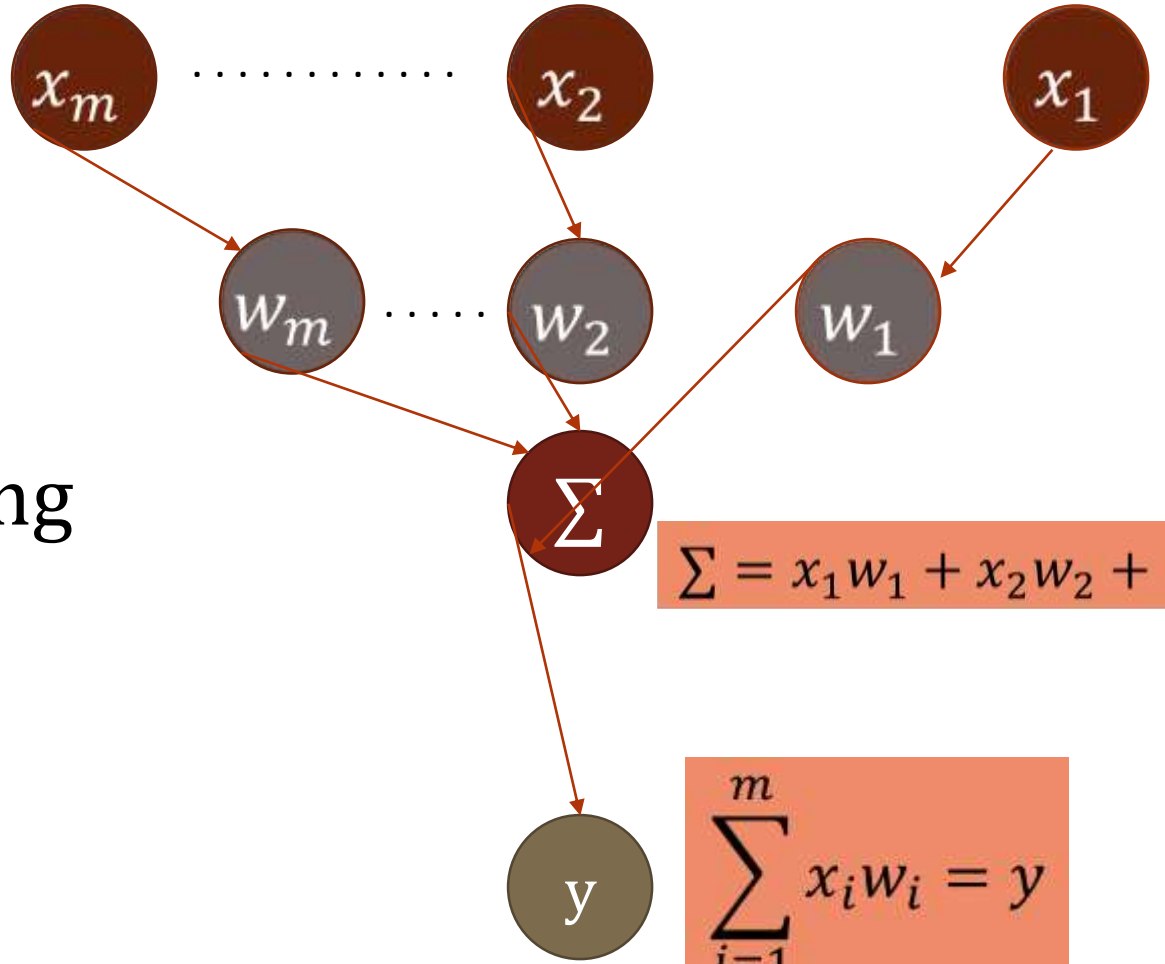
Input

Weights

Not all inputs are equal

Processing

Output



$$\sum = x_1 w_1 + x_2 w_2 + \ldots . + x_m w_m = y$$

$$\sum_{i=1}^{m} x_i w_i = y$$

Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

Input

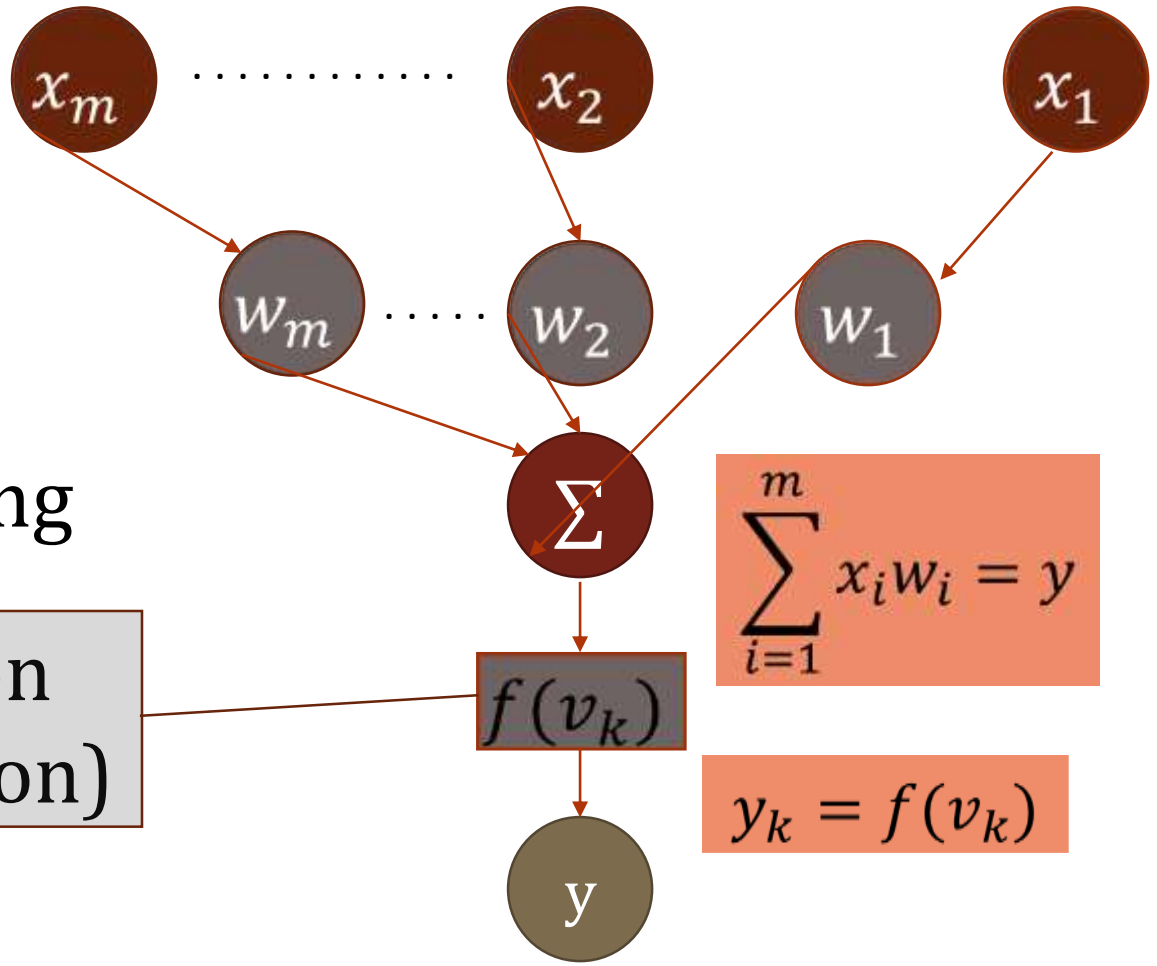
Weights

Processing

The signal is not passed down to the next neuron verbatim

Transfer Function (Activation Function)

Output



Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

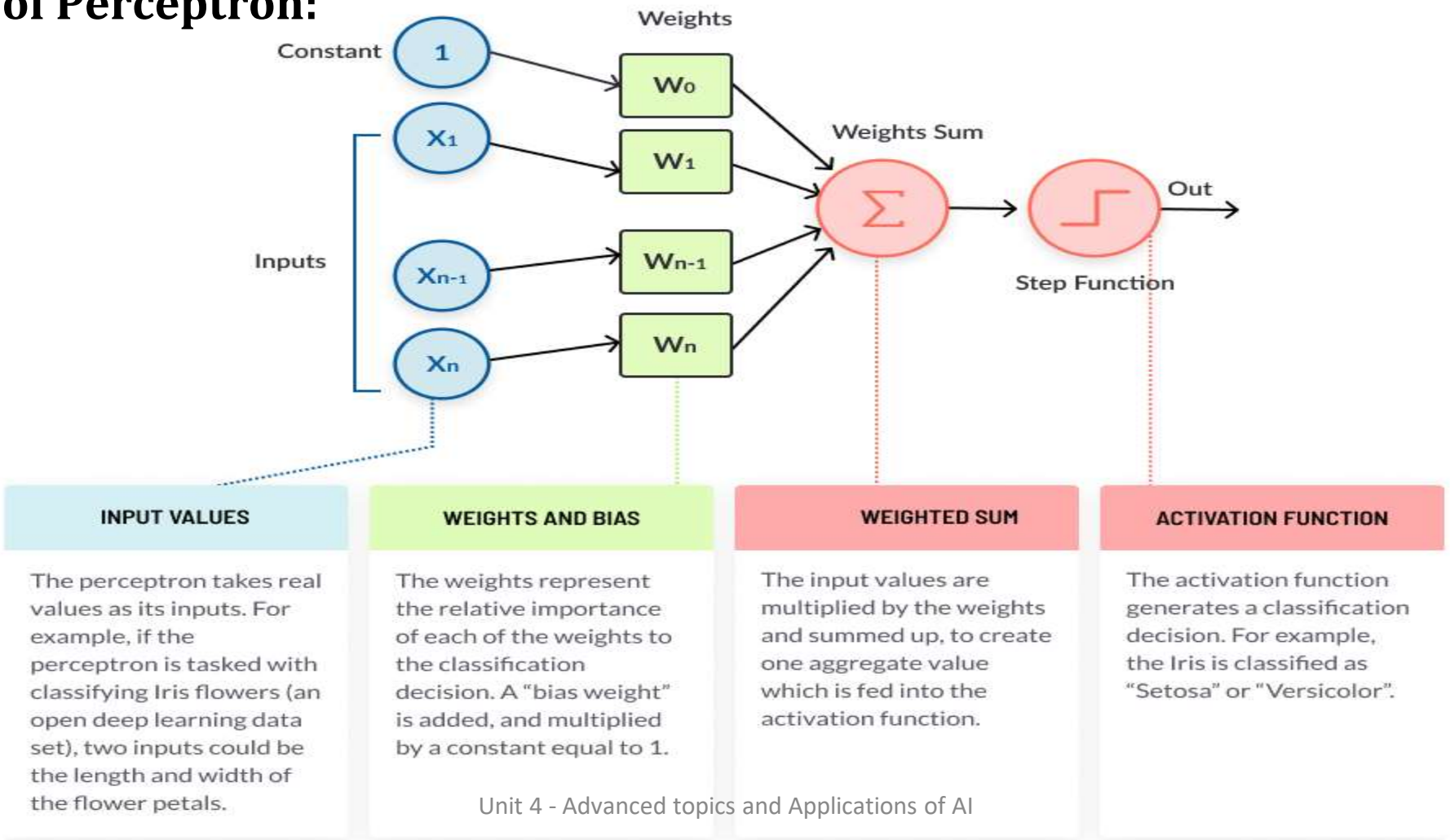
Perceptron:

- A perceptron is a neural network unit (an artificial neuron) that does certain computations to detect features or business intelligence in the input data.
- Perceptron is usually used to classify the data into two parts. Therefore, it is also known as a **Linear Binary Classifier**. Also, it is used in supervised learning. It helps to classify the given input data.
- Perceptron is a single layer neural network and a multi-layer perceptron is called Neural Networks.
- There are two types of Perceptrons: Single layer and Multilayer.
  - **Single layer Perceptrons** can learn only linearly separable patterns.
  - **Multilayer Perceptrons** or **feed forward neural networks** with two or more layers have the greater processing power.

Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

Structure of Perceptron:

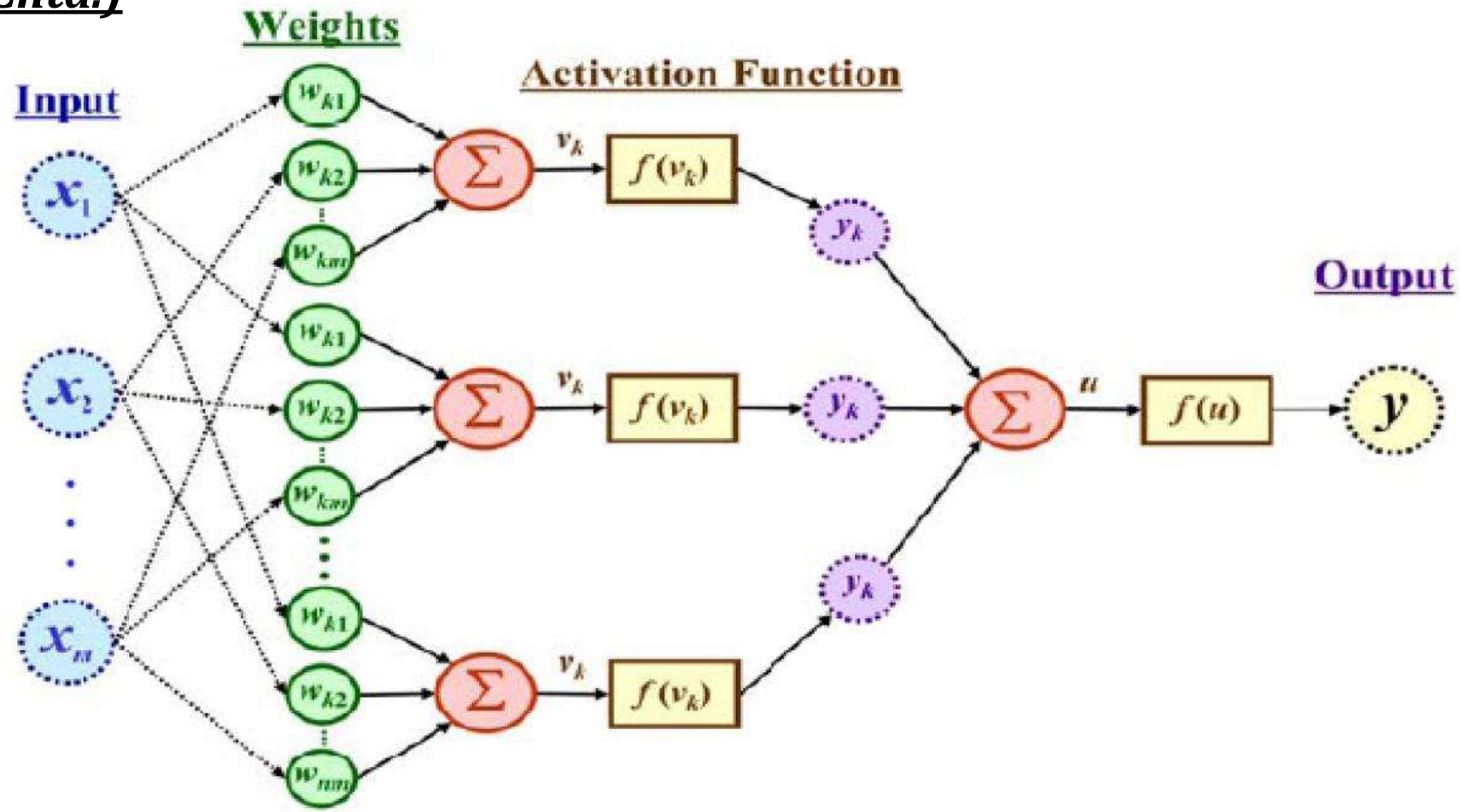


Artificial Neural Network [ANN] (Cntd.)

✓ ***How do ANN works? (Cntd.)***

Multilayer Perceptron:

The output is a function of the input, that is affected by the weights, and the transfer functions



Artificial Neural Network [ANN] (Cntd.)

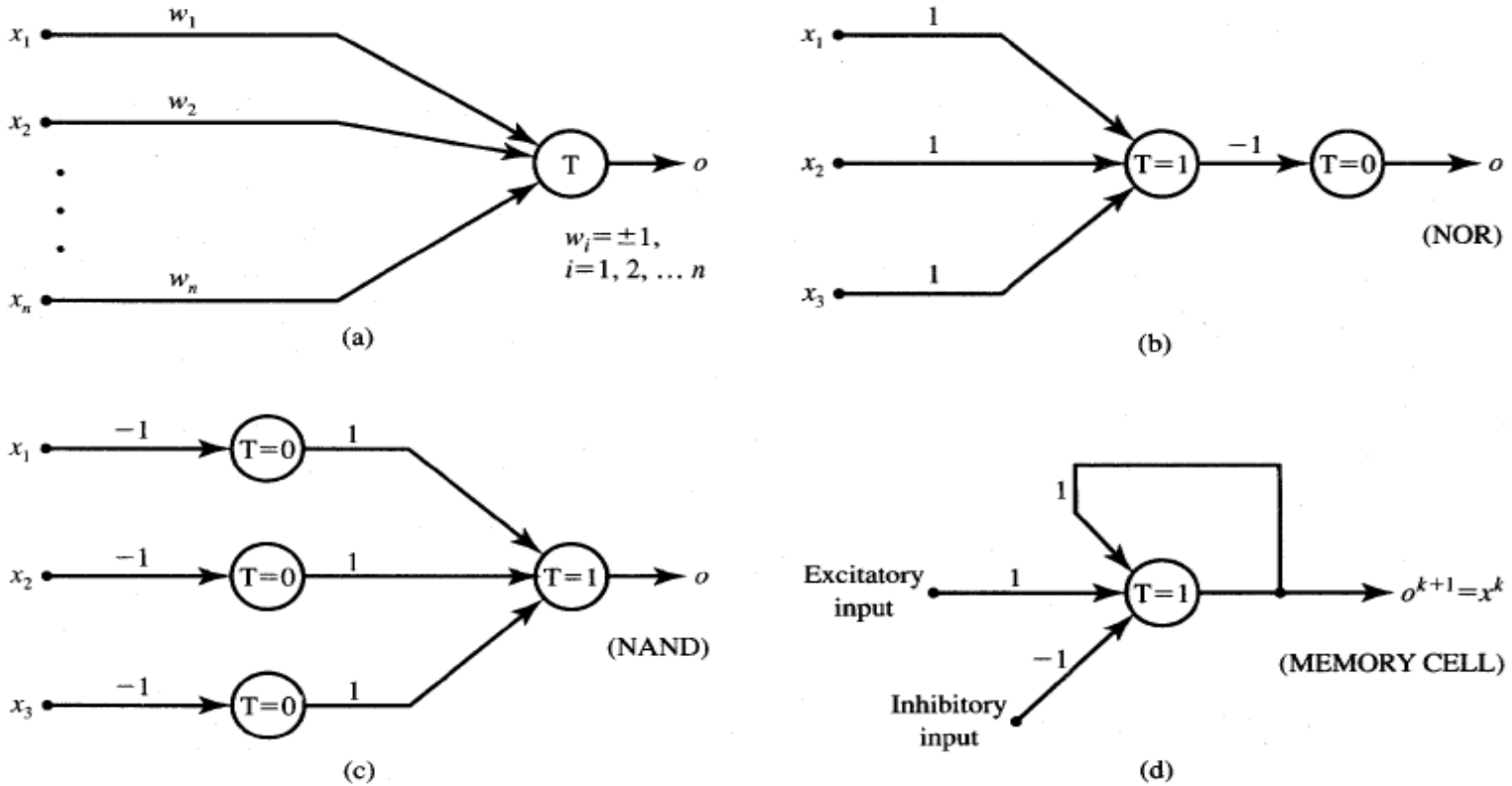
✓ Comparison between brain verses computer

	Brain	ANN
Speed	Few ms.	Few nano sec. massive ||el processing
Size and complexity	10^{11} neurons & 10^{15} interconnections	Depends on designer
Storage capacity	Stores information in its interconnection or in synapse. No Loss of memory	Contiguous memory locations loss of memory may happen sometimes.
Tolerance	Has fault tolerance	No fault tolerance If gets disrupted when interconnections are disconnected
Control mechanism	Complicated involves chemicals in biological neuron	Simpler in ANN

Artificial Neural Network [ANN] (Cntd.)

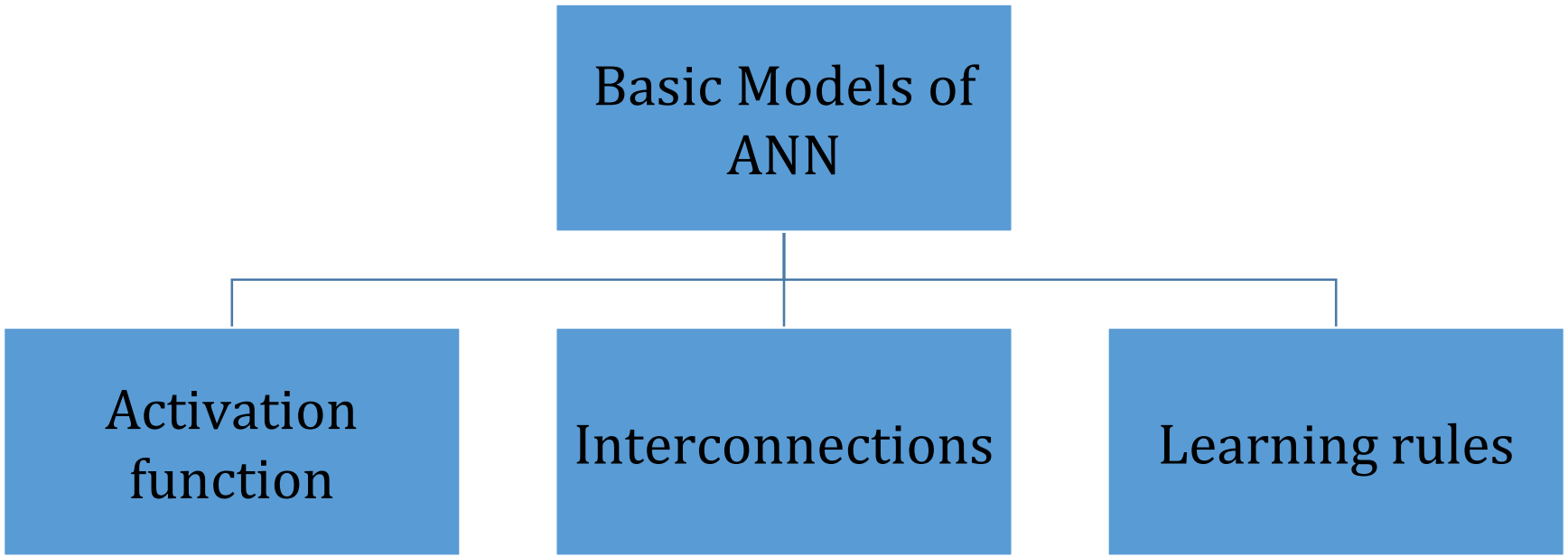
✓ McCulloch-Pitts Neuron Model

$$o^{k+1} = \begin{cases} 1 & \text{if } \sum_{i=1}^{n} w_i x_i^k \geq T \\ 0 & \text{if } \sum_{i=1}^{n} w_i x_i^k < T \end{cases}$$



Artificial Neural Network [ANN] (Cntd.)

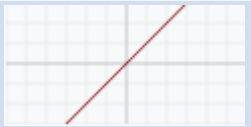
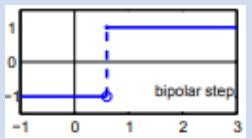
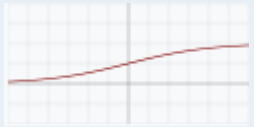
✓ Basic models of ANN



Artificial Neural Network [ANN] (Cntd.)

✓ ***Activation Function:***

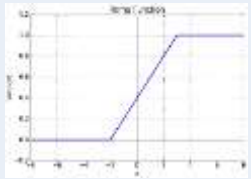
- The purpose of the activation function is to introduce non-linearity into the output of a neuron.

Name	Equation	Plot	Range
Linear or Identity Function			
Binary Step function			
Bipolar Step function			
Logistic (a.k.a. Sigmoid or Soft step)			
TanH (a.k.a. Tangent Hyperbolic function)			

Artificial Neural Network [ANN] (Cntd.)

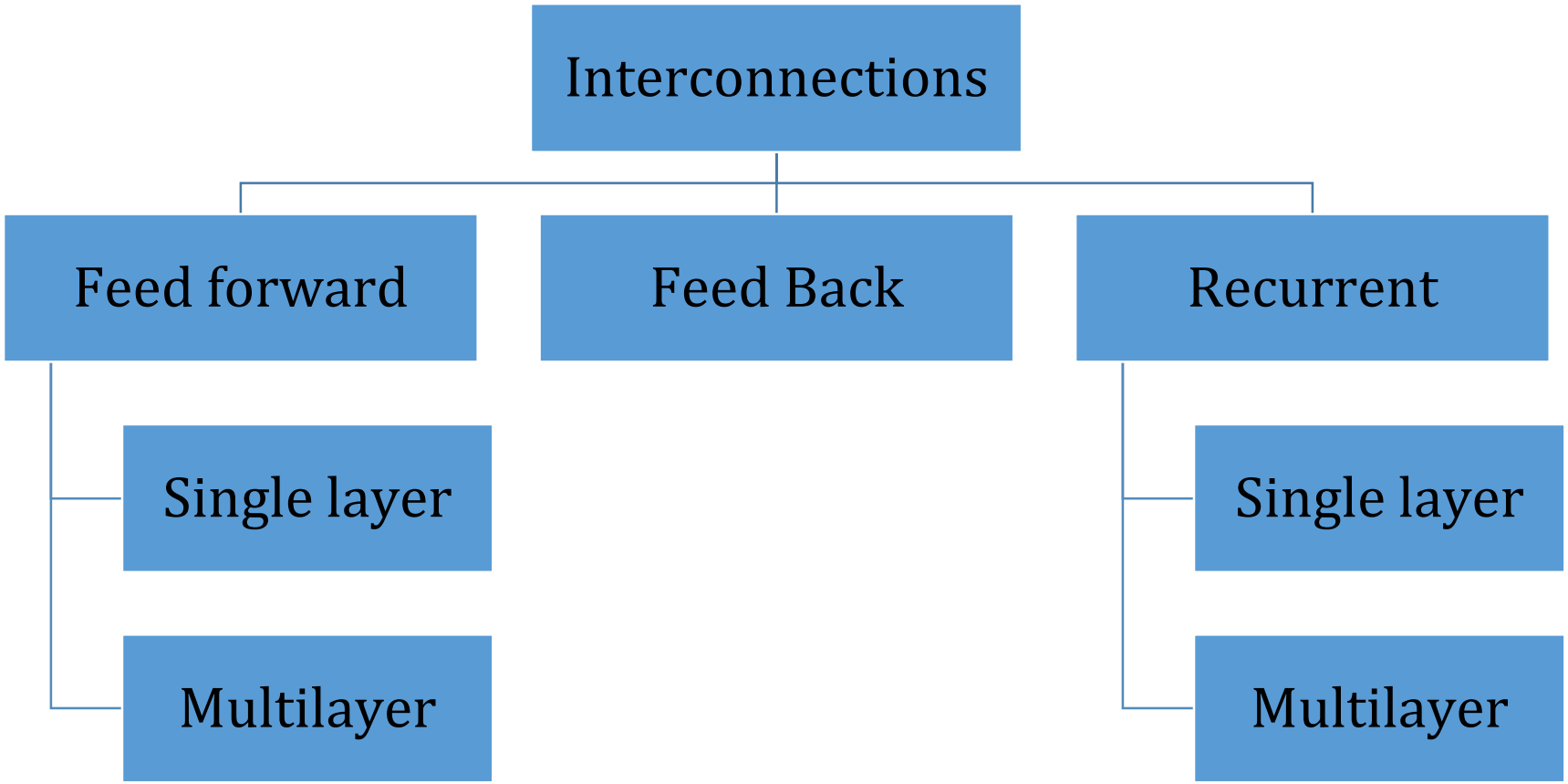
✓ ***Activation Function: (cntd.)***

- The purpose of the activation function is to introduce non-linearity into the output of a neuron.

Name	Equation	Plot	Range
Rectified linear unit (ReLU)			
Ramp Function			

Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection:***

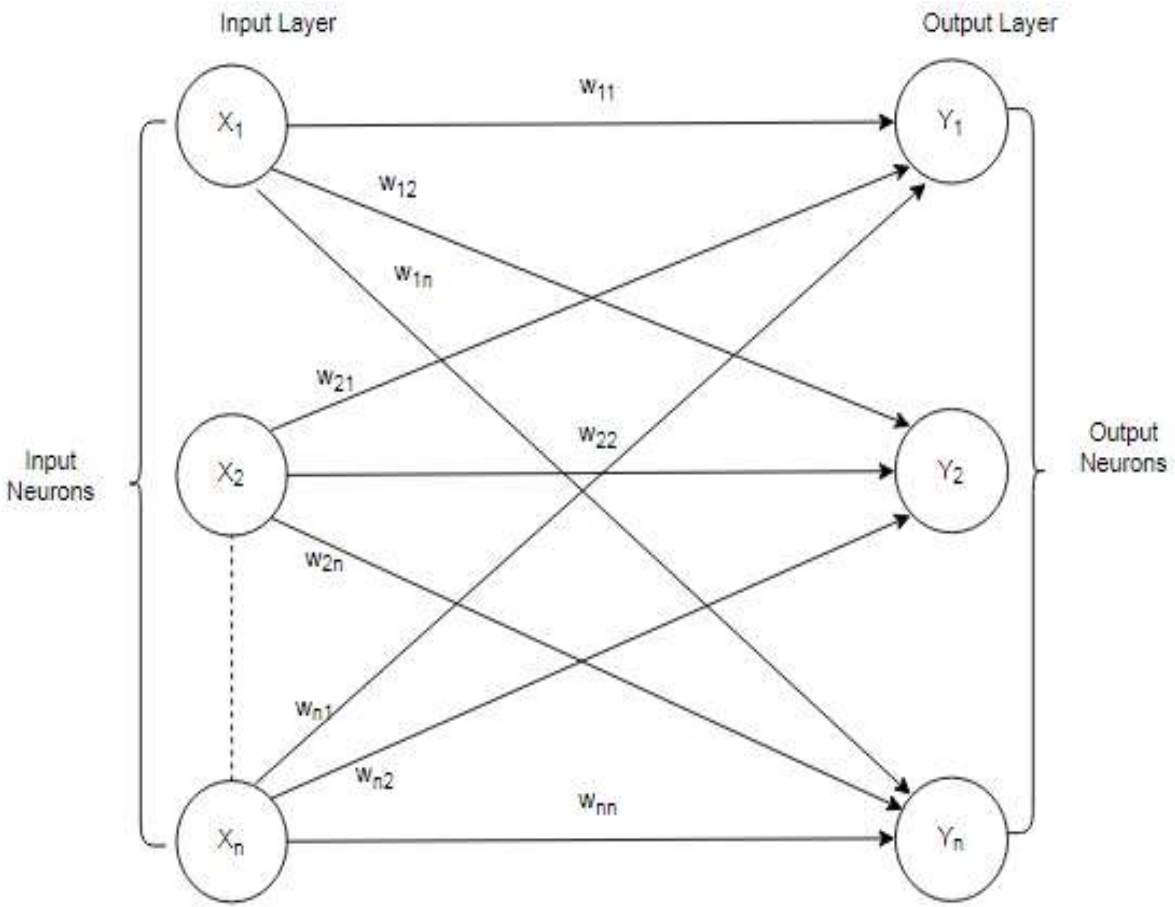


Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Single Layer Feed Forward Network***

- A layer is formed by taking a processing element and combining it with other processing elements. When a layer of the processing nodes is formed, the inputs can be connected to these nodes with various weights, resulting in a series of outputs, one per node. Thus, a single layer feed forward network is formed.

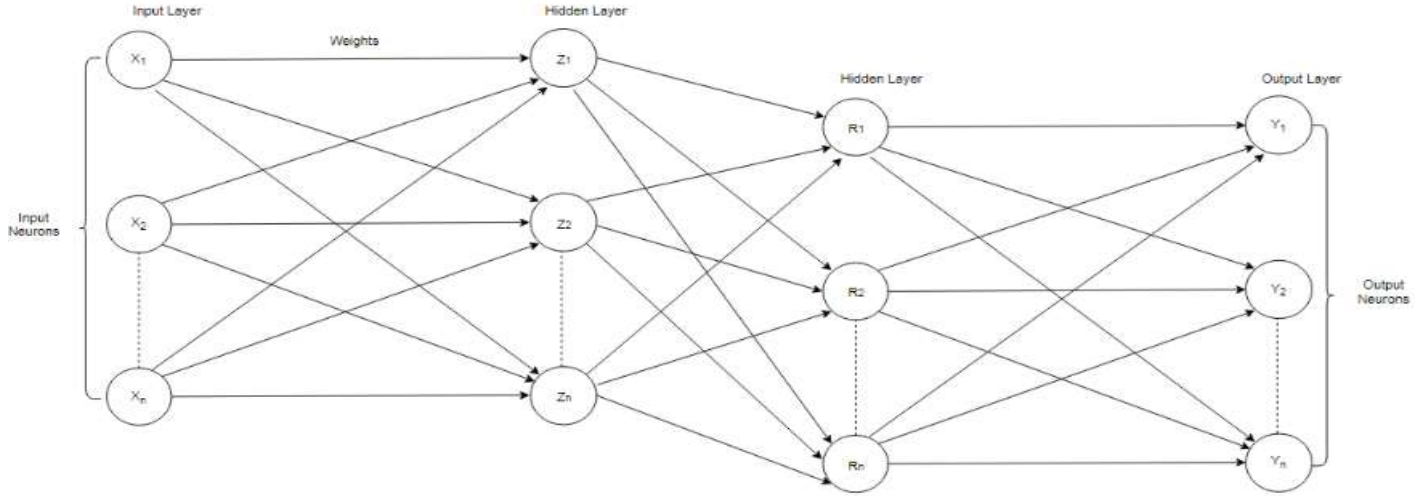


Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Multilayer feed forward network***

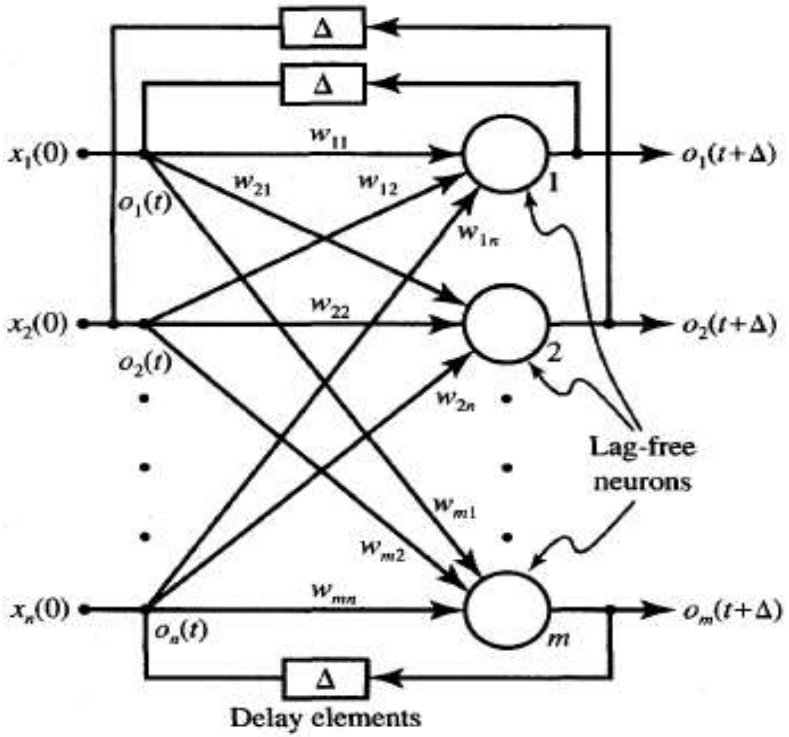
- A multilayer feed forward network is formed by the interconnection of several layers. The input layer is that which receives the input and this layer has no function except buffering the input signal. The output layer generates the output of the network. Any layer that is formed between the input layer and the output layer is called the hidden layer.
- Can be used to solve complicated problems.

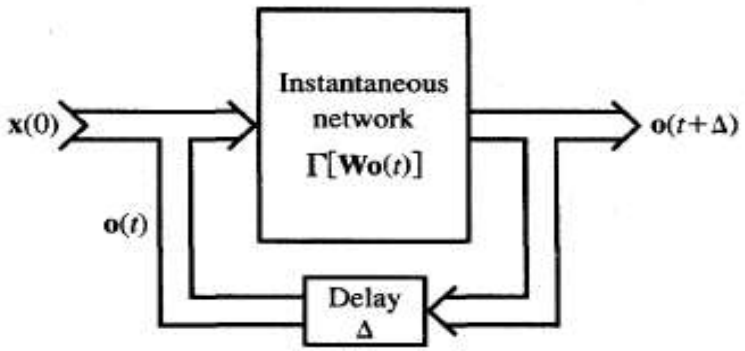


Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

- ***Feedback network***
  - When outputs are directed back as inputs to same or preceding layer nodes it results in the formation of feedback networks.



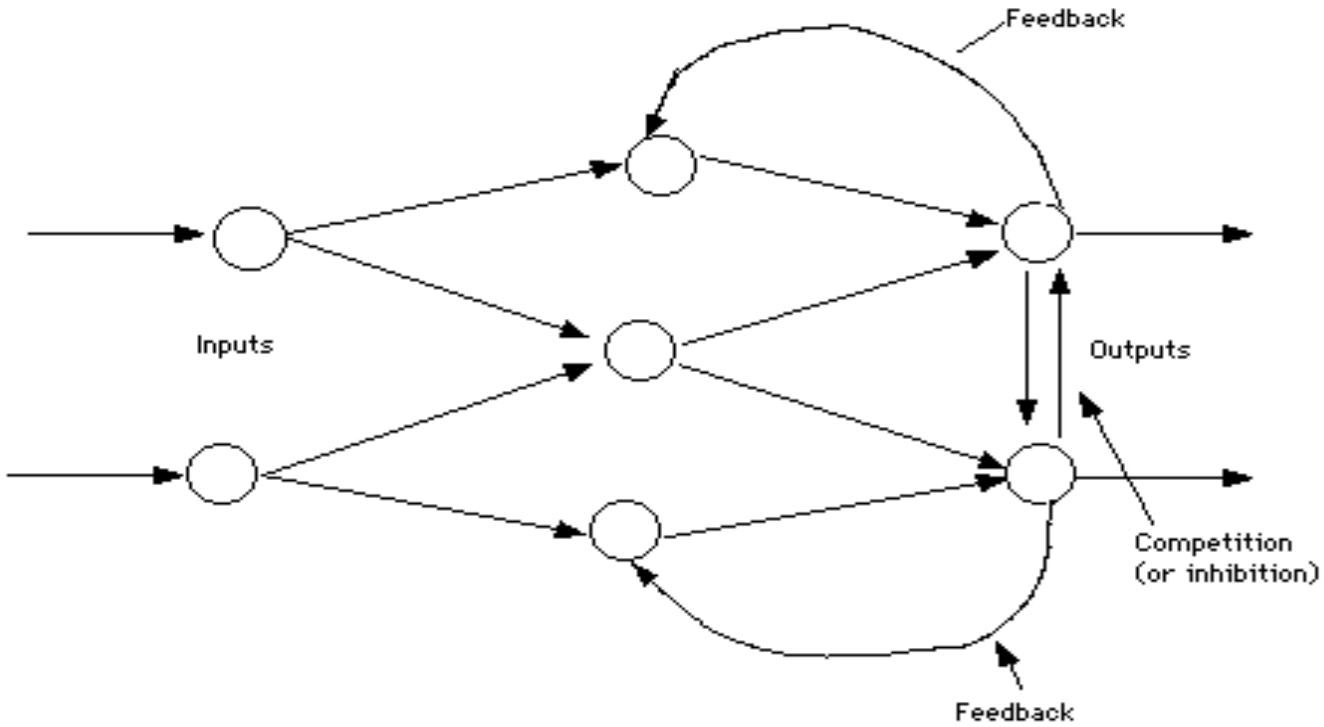


Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Lateral feedback***

- If the feedback of the output of the processing elements is directed back as input to the processing elements in the same layer then it is called **lateral feedback**.



Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Recurrent network***

- Feedback networks with closed loop are called Recurrent Networks.
- Recurrent neural network is a class of artificial neural network where connections between nodes form a directed graph along a sequence. This allows it to exhibit dynamic temporal behavior for a time sequence. Unlike feed forward neural networks, RNNs can use their internal state (memory) to process sequences of inputs.

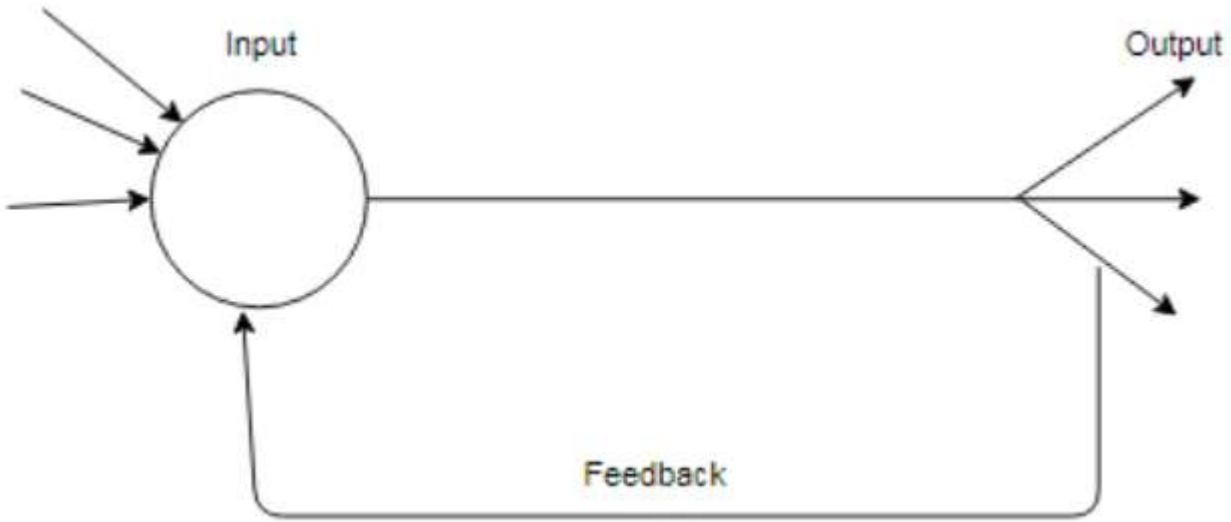
1. Single node with own feedback
2. Competitive networks
3. Single-layer recurrent networks
4. Multilayer recurrent networks
5. Jordan Network

Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Recurrent network (Cntd.)***

- **Single node with own feedback**



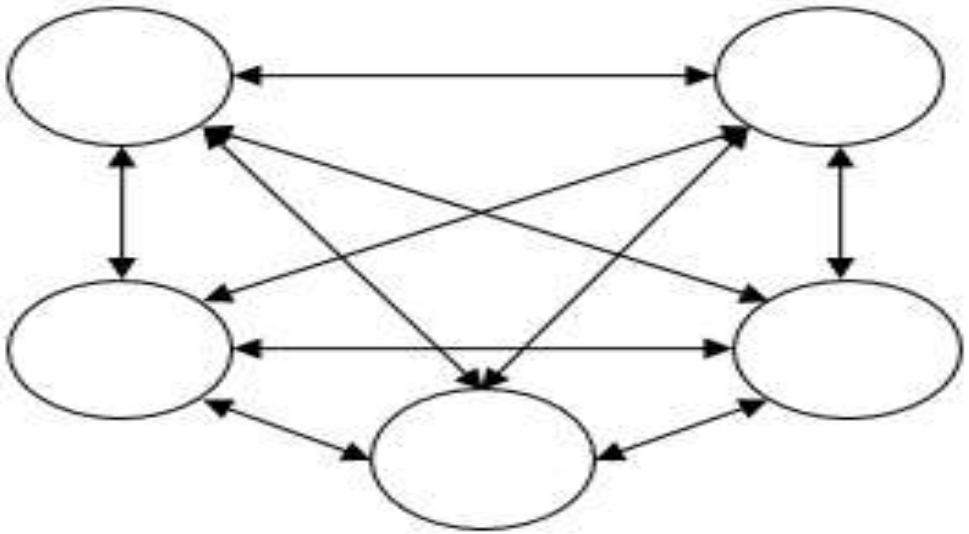
Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

- ➢ ***Recurrent network (Cntd.)***

- **Fully recurrent network (Competitive networks)**

It is the simplest neural network architecture because all nodes are connected to all other nodes and each node works as both input and output.



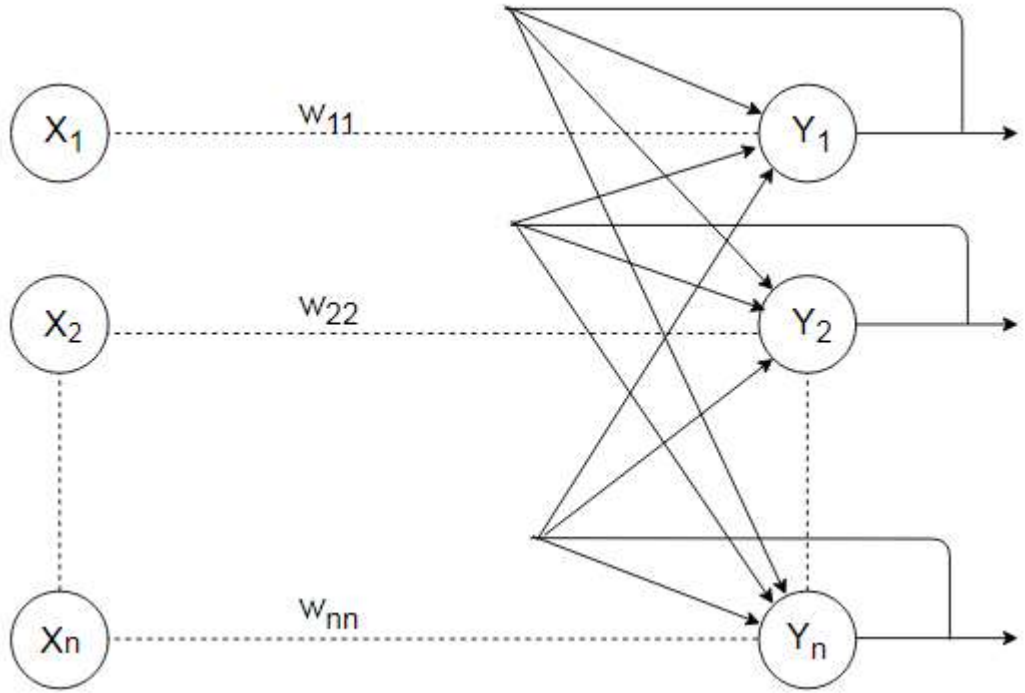
Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Recurrent network (Cntd.)***

- **Single-layer recurrent network**

This network is single layer network with feedback connection in which processing element's output can be directed back to itself or to other processing element or both.



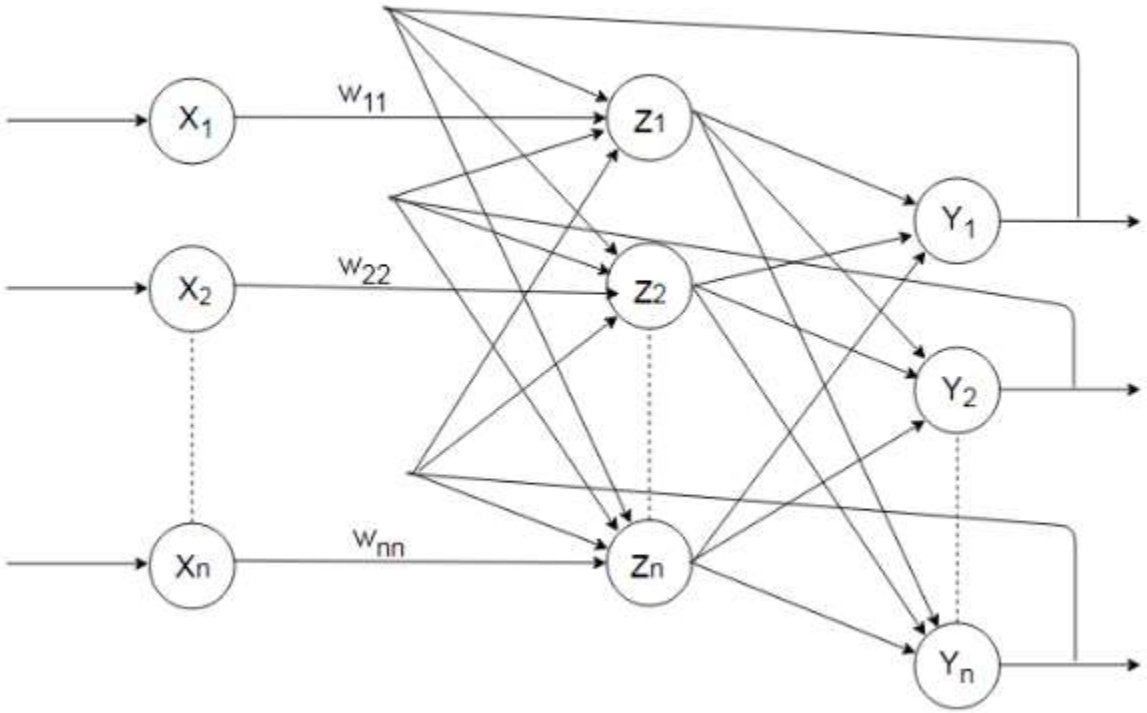
Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

➢ ***Recurrent network (Cntd.)***

- **Multi-layer recurrent network**

In this type of network, processing element output can be directed to the processing element in the same layer and in the preceding layer forming a multilayer recurrent network. They perform the same task for every element of a sequence, with the output being depended on the previous computations. Inputs are not needed at each time step. The main feature of an Recurrent Neural Network is its hidden state, which captures some information about a sequence.



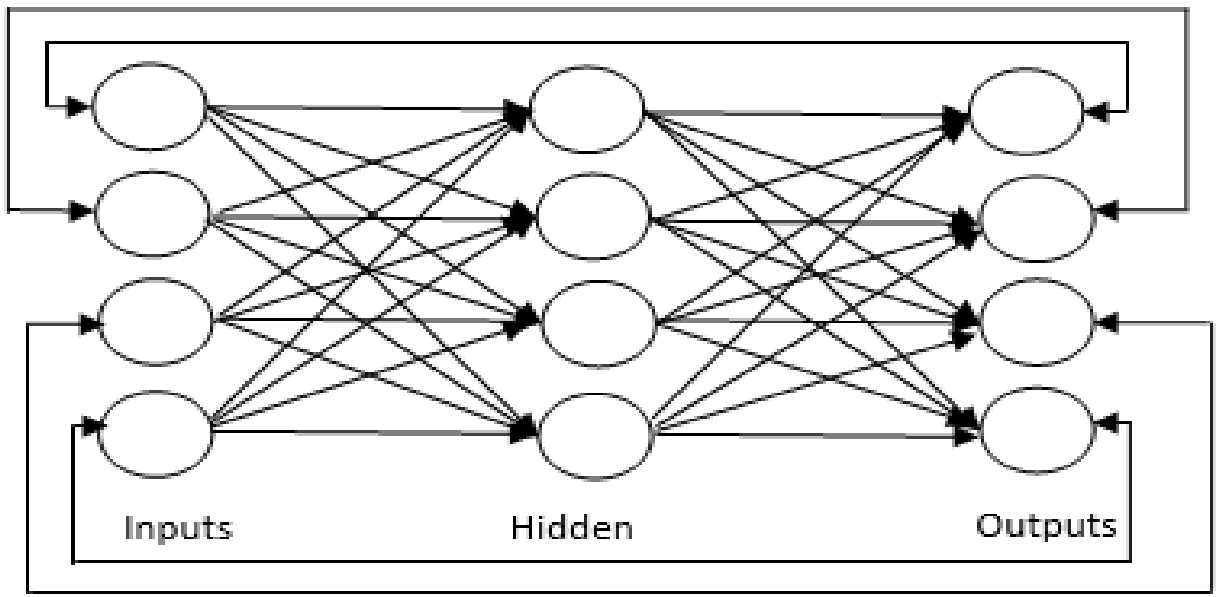
Artificial Neural Network [ANN] (Cntd.)

✓ ***Interconnection: (Cntd.)***

- ➢ ***Recurrent network (Cntd.)***

- **Jordan network**

It is a closed loop network in which the output will go to the input again as feedback as shown in the following diagram.



Artificial Neural Network [ANN] (Cntd.)

✓ ***Learning:***

- It's a process by which a NN adapts itself to a stimulus by making proper parameter adjustments, resulting in the production of desired response
- Two kinds of learning
  1. Parameter learning:- connection weights are updated
  2. Structure Learning:- change in network structure

Artificial Neural Network [ANN] (Cntd.)

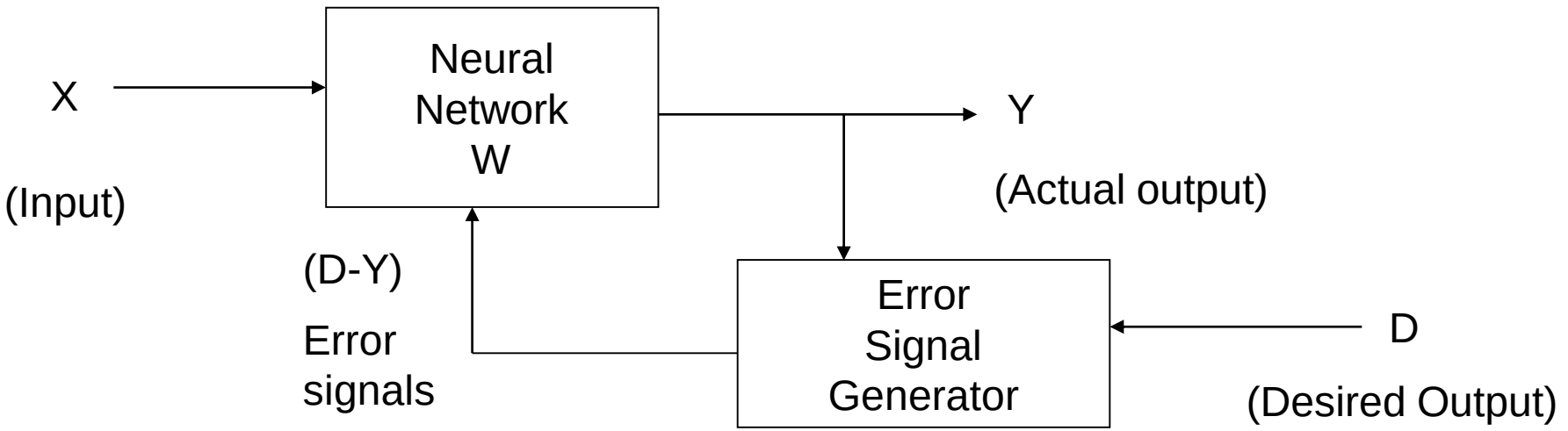
✓ ***Classification of learning***

1. Supervised learning
2. Unsupervised learning
3. Reinforcement learning

Artificial Neural Network [ANN] (Cntd.)

✓ ***Classification of learning (Cntd.)***

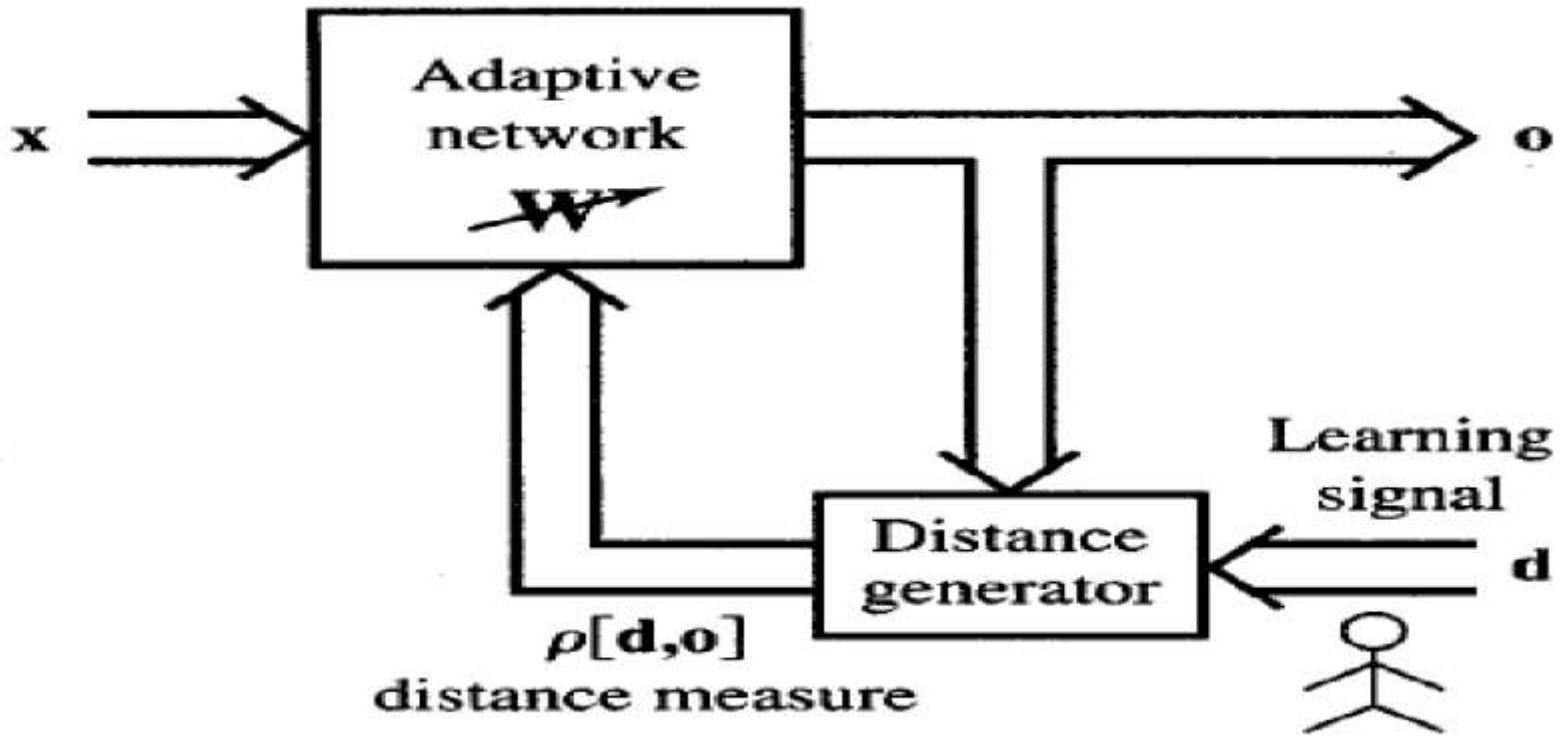
1. Supervised learning
   - Child learns from a teacher
   - Each input vector requires a corresponding target vector.
   - Training pair=[input vector, target vector]



Artificial Neural Network [ANN] (Cntd.)

✓ ***Classification of learning (Cntd.)***

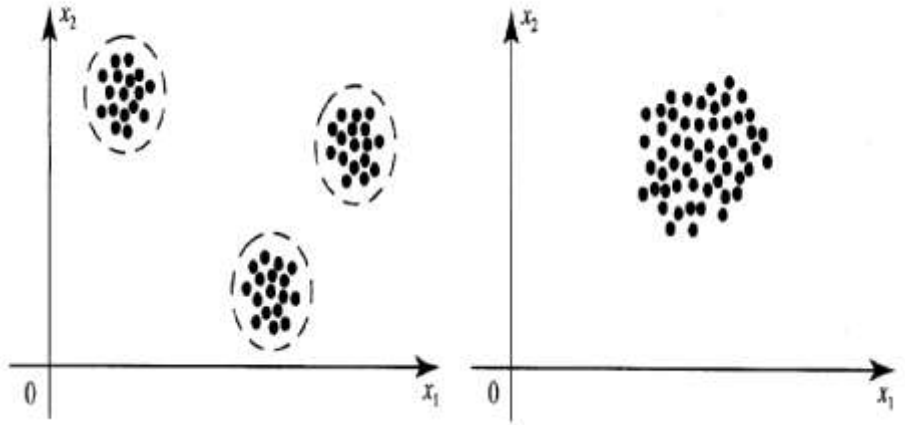
1. Supervised learning (Cntd.)
   - Supervised learning does minimization of error

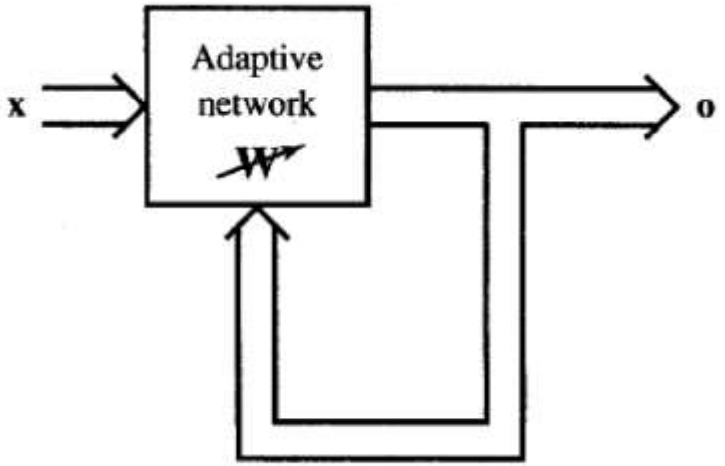


Artificial Neural Network [ANN] (Cntd.)

✓ ***Classification of learning (Cntd)***

2. Unsupervised learning
   - How a fish or tadpole learns
   - All similar input patterns are grouped together as clusters.
   - If a matching input pattern is not found a new cluster is formed





Artificial Neural Network [ANN] (Cntd.)

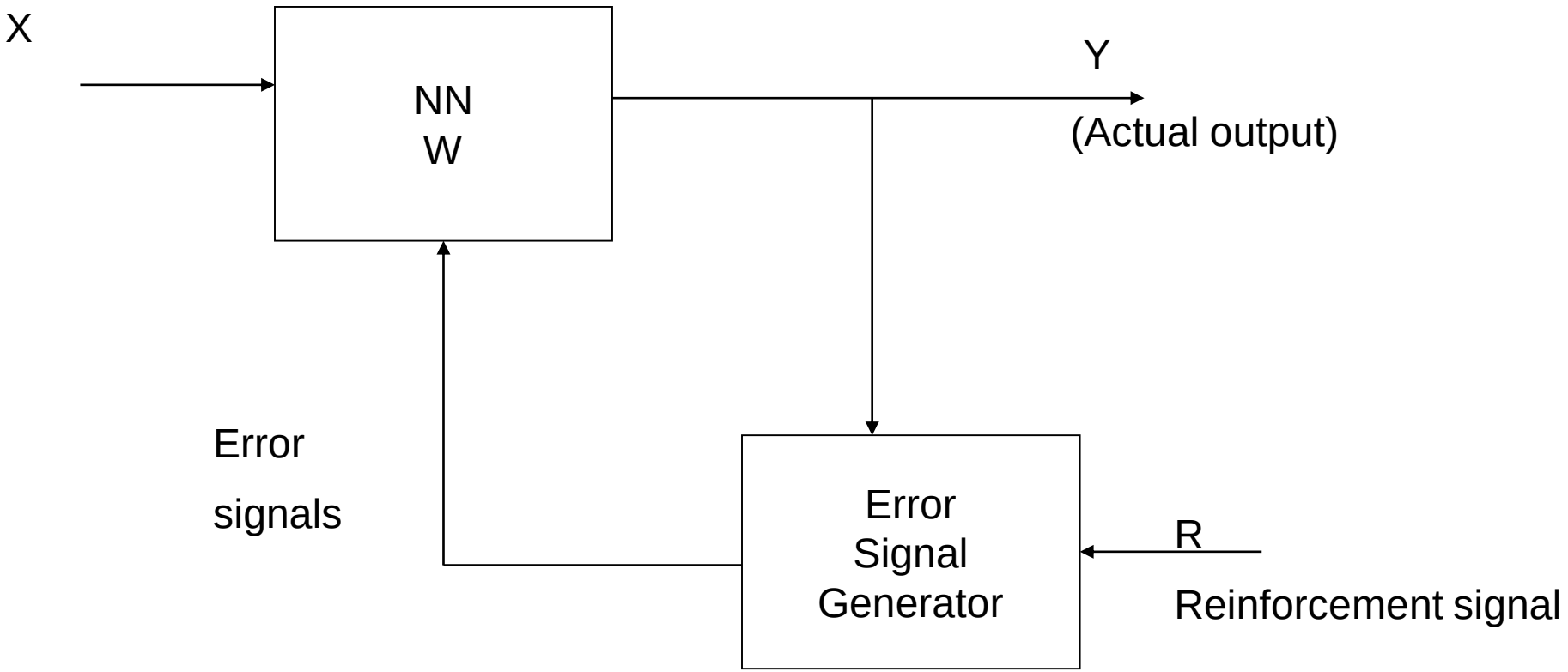
✓ ***Classification of learning (Cntd)***

2. Unsupervised learning (Cntd.)
   - In unsupervised learning there is no feedback
   - Network must discover patterns, regularities, features for the input data over the output
   - While doing so the network might change in parameters
   - This process is called **self-organizing**

Artificial Neural Network [ANN] (Cntd.)

✓ ***Classification of learning***

3. Reinforcement learning



Artificial Neural Network [ANN] (Cntd.)

✓ ***Classification of learning***

3. Reinforcement learning (Cntd.)
   - When Reinforcement learning is used?
     - If less information is available about the target output values (critic information)
     - Learning based on this critic information is called reinforcement learning and the feedback sent is called reinforcement signal
     - Feedback in this case is only evaluative and not instructive

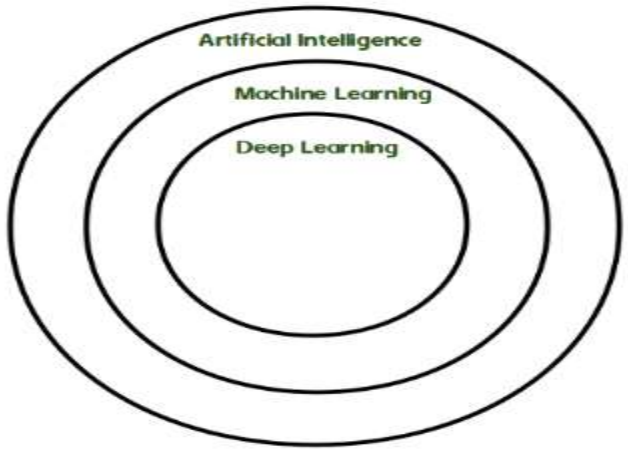
Artificial Neural Network [ANN] (Cntd.)

✓ ***Example learning algorithms***

- Supervised:
  - Adaline, Madaline
  - Perceptron
  - Back Propagation
  - multilayer perceptrons
  - Radial Basis Function Networks
- Unsupervised
  - Competitive Learning
  - Kohenen self organizing map
  - Learning vector quantization
  - Hebbian learning

Deep Learning

- ✓ Deep learning is a branch of machine learning which is completely based on artificial neural networks, as neural network is going to mimic the human brain so deep learning is also a kind of mimic of human brain. In deep learning, we don't need to explicitly program everything.
- ✓ **Definition:** Deep learning is a particular kind of machine learning that achieves great power and flexibility by learning to represent the world as a nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones.



Deep Learning (Cntd.)

✓ ***Architectures :***

- *Deep Neural Network –* It is a neural network with a certain level of complexity (having multiple hidden layers in between input and output layers). They are capable of modeling and processing non-linear relationships.
- *Deep Belief Network(DBN) –* It is a class of Deep Neural Network. It is multi-layer belief networks. Steps for performing DBN :
  1. Learn a layer of features from visible units using Contrastive Divergence algorithm.
  2. Treat activations of previously trained features as visible units and then learn features of features.
  3. Finally, the whole DBN is trained when the learning for the final hidden layer is achieved.
- *Recurrent (perform same task for every element of a sequence) Neural Network –* Allows for parallel and sequential computation. Similar to the human brain (large feedback network of connected neurons). They are able to remember important things about the input they received and hence enables them to be more precise.

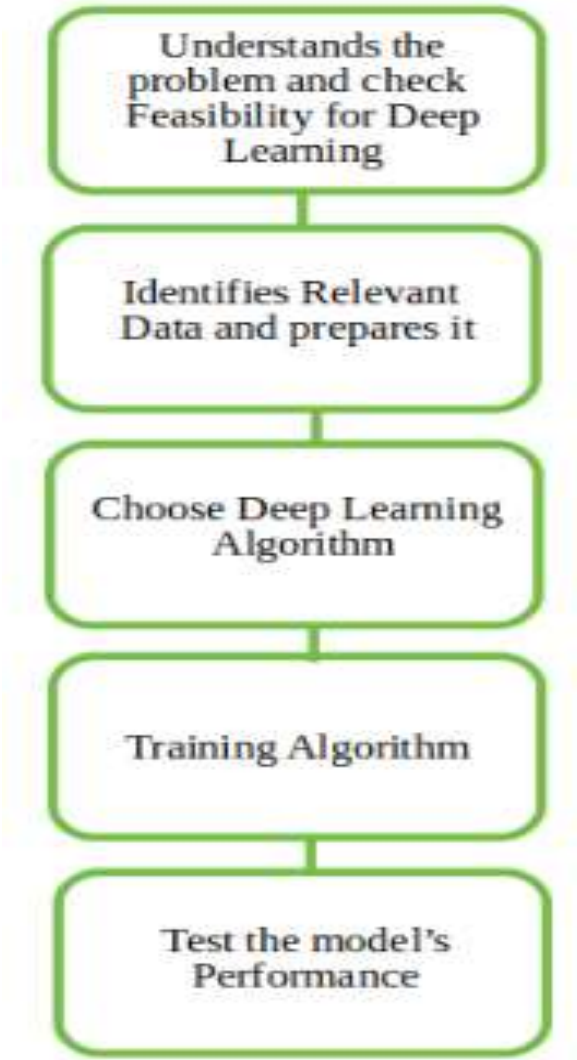
Deep Learning (Cntd.)

✓ ***Difference Between ML and DL:***

MACHINE LEARNING	DEEP LEARNING
Works on small amount of Dataset for accuracy.	Works on Large amount of Dataset.
Dependent on Low-end Machine.	Heavily dependent on High-end Machine.
Divides the tasks into sub-tasks, solves them individually and finally combine the results.	Solves problem end to end.
Takes less time to train.	Takes longer time to train.
Testing time may increase.	Less time to test the data.

Deep Learning (Cntd.)

✓ ***Working:***



Deep Learning (Cntd.)

✓ ***Advantages :***

- Best in-class performance on problems.
- Reduces need for feature engineering.
- Eliminates unnecessary costs.
- Identifies defects easily that are difficult to detect.

✓ ***Disadvantages :***

- Large amount of data required.
- Computationally expensive to train.
- No strong theoretical foundation.

Deep Learning (Cntd.)

✓ ***Applications :***

- Automatic Text Generation
- Healthcare
- Automatic Machine Translation
- Image Recognition
- Predicting Earthquakes

And many more…

Natural Language Processing

✓ ***Brief History of NLP***

- 1940s –1950s: Foundations
  - Development of formal language theory (Chomsky, Backus, Naur, Kleene)
  - Probabilities and information theory (Shannon)
- 1957 – 1970s:
  - Use of formal grammars as basis for natural language processing (Chomsky, Kaplan)
  - Use of logic and logic based programming (Minsky, Winograd, Colmerauer, Kay)
- 1970s – 1983:
  - Probabilistic methods for early speech recognition (Jelinek, Mercer)
  - Discourse modeling (Grosz, Sidner, Hobbs)
- 1983 – 1993:
  - Finite state models (morphology) (Kaplan, Kay)
- 1993 – present:
  - Strong integration of different techniques, different areas.

Natural Language Processing (Cntd.)

✓ ***Knowledge Representation for NLP:***

- Which knowledge representation will be used depends on the application -- Machine Translation, Database Query System.
- Requires the choice of representational framework, as well as the specific meaning vocabulary (what are concepts and relationship between these concepts -- ontology)
- Must be computationally effective.
- Common representational formalisms:
  - first order predicate logic
  - conceptual dependency graphs
  - semantic networks
  - Frame-based representations

Natural Language Processing (Cntd.)

- ✓ The process of computer analysis of input provided in a human language (natural language), and conversion of this input into a useful form of representation.
- ✓ The field of NLP is primarily concerned with getting computers to perform useful and interesting tasks with human languages.
- ✓ The field of NLP is secondarily concerned with helping us come to a better understanding of human language.

Natural Language Processing (Cntd.)

✓ ***Forms of Natural Language:***

- The input/output of a NLP system can be:
  - written text
  - speech
- We will mostly concerned with written text (not speech).
- To process written text, we need:
  - lexical, syntactic, semantic knowledge about the language
  - discourse information, real world knowledge
- To process spoken language, we need everything required to process written text, plus the challenges of speech recognition and speech synthesis.

Natural Language Processing (Cntd.)

✓ ***Components of NLP:***

- Natural Language Understanding
  - Mapping the given input in the natural language into a useful representation.
  - Different level of analysis required:
    - morphological analysis,
    - syntactic analysis,
    - semantic analysis,
    - discourse analysis, …
- Natural Language Generation
  - Producing output in the natural language from some internal representation.
  - Different level of synthesis required:
    - deep planning (what to say),
    - syntactic generation
- NL Understanding is much harder than NL Generation. But, still both of them are hard.

Natural Language Processing (Cntd.)

✓ ***Natural Language Understanding:***

- Taking some spoken/typed sentence and working out what it means

✓ ***Natural Language Generation:***

- Taking some formal representation of what you want to say and working out a way to express it in a natural (human) language (e.g., English)

Natural Language Processing (Cntd.)

✓ ***Natural Language Understanding:***

Raw speech signal

↓ • **Speech recognition**

Sequence of words spoken

↓ • **Syntactic analysis** using knowledge of the grammar

Structure of the sentence

↓ • **Semantic analysis** using info. about meaning of words

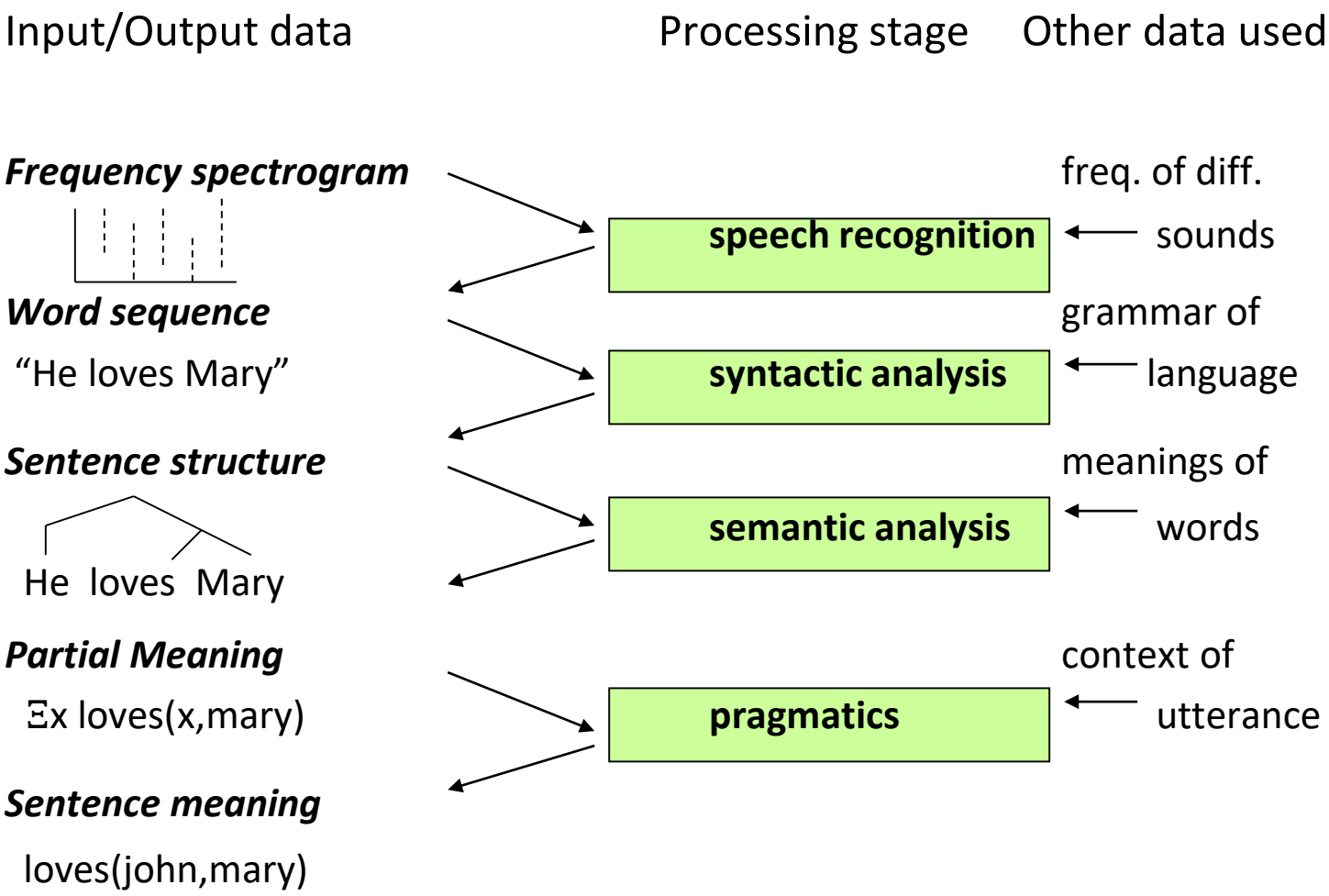
Partial representation of meaning of sentence

↓ • **Pragmatic analysis** using info. about context

Final representation of meaning of sentence

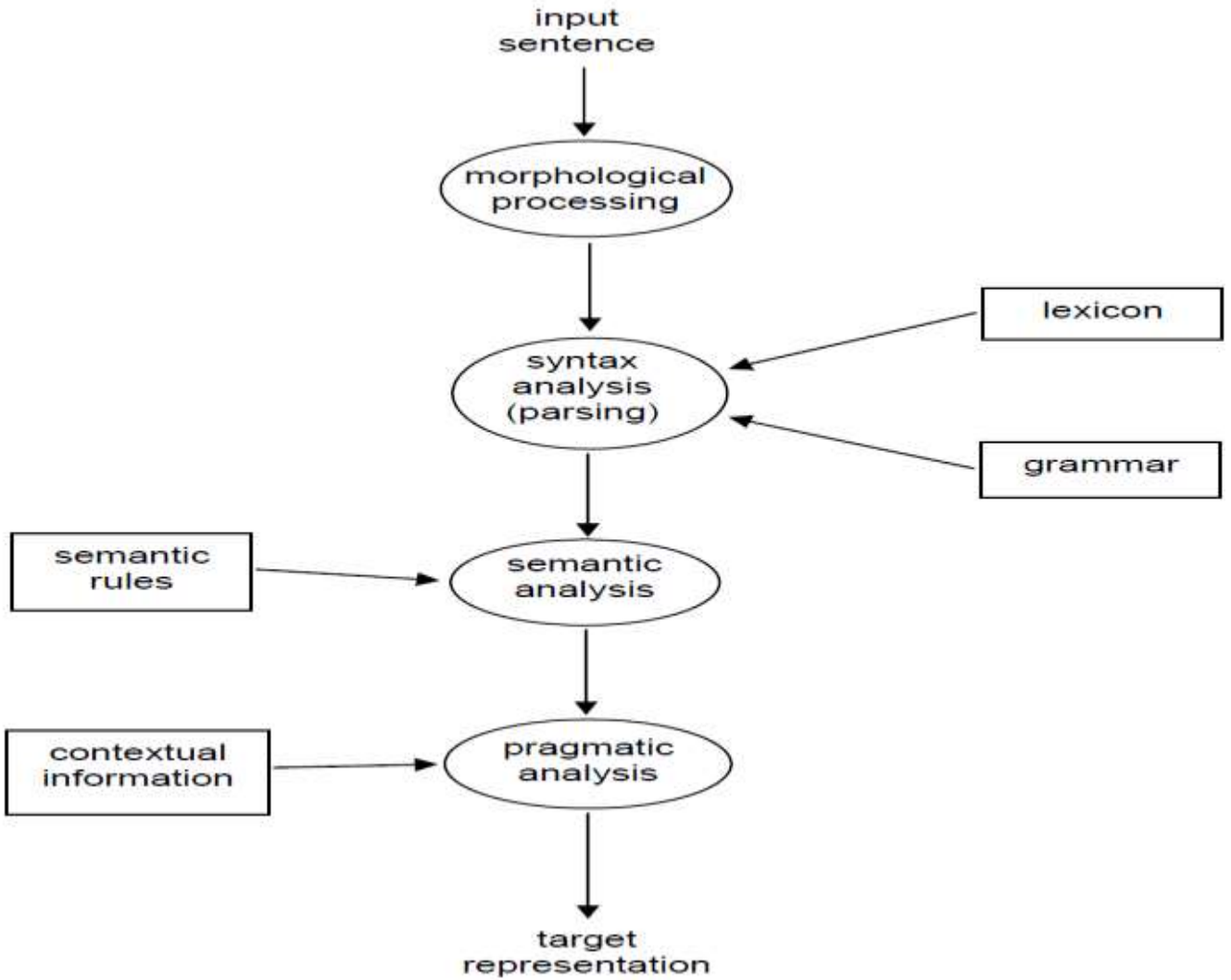
Natural Language Processing (Cntd.)

✓ ***Natural Language Understanding: (Cntd.)***



Natural Language Processing (Cntd.)

✓ ***Steps in NLP:***



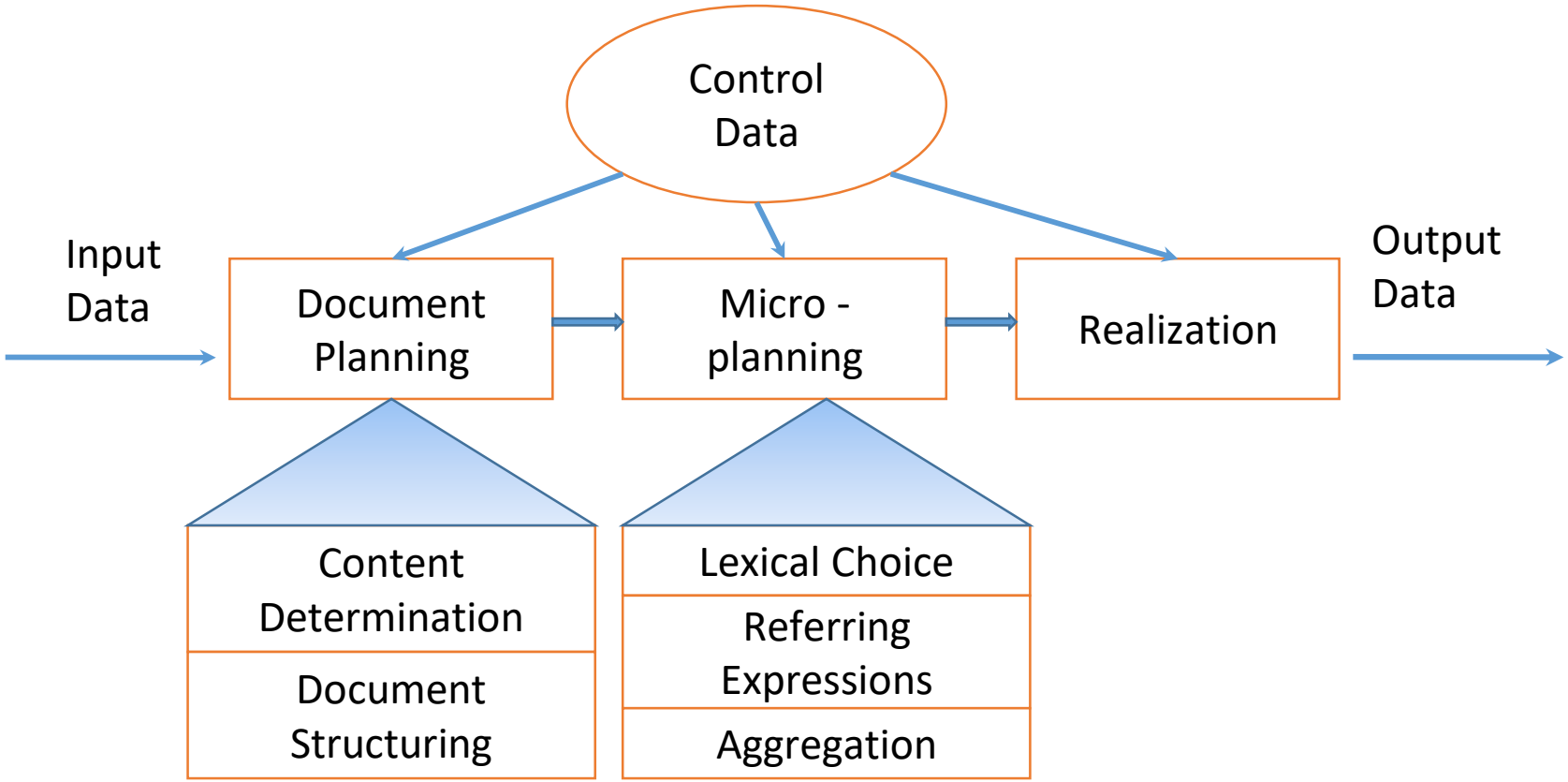
Natural Language Processing (Cntd.)

✓ ***Natural Language Generation:***

- NLG is the process of constructing natural language outputs from non-linguistic inputs.
- NLG can be viewed as the reverse process of NL understanding.
- A NLG system may have two main parts:
  - Discourse Planner -- what will be generated. which sentences.
  - Surface Realizer -- realizes a sentence from its internal representation.
- Lexical Selection -- selecting the correct words describing the concepts.
- Traditional approach to NLG involves following steps:
  - Document Planning
  - Micro planning
  - Surface realization
  - Final Presentation

Natural Language Processing (Cntd.)

✓ ***NLG System Architecture:***



Natural Language Processing (Cntd.)

✓ ***Applications of NLG:***

- Present information in more convenient way
  - Airline schedule database
  - Accounting spreadsheet
- Automating document production
  - Doctor writing discharge summaries
  - Programmer writing code documentation, logic description etc.
- In many contexts, human intervention is required to create texts
- NLG system is used to produce an initial draft of a document which can be further edited by human author. E.g.
  - Weather Reporter, which helps meteorologists compose weather forecasts
  - DRAFTER, which helps technical authors write software manuals
  - AlethGen, which helps customer-service representatives write response letters to customers

Introduction to Machine Learning

- ✓ The term Machine Learning was coined by Arthur Samuel in 1959, an American pioneer in the field of computer gaming and artificial intelligence and stated that “it gives computers the ability to learn without being explicitly programmed”.
- ✓ And in 1997, Tom Mitchell gave a “well-posed” mathematical and relational definition that “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.

Introduction to Machine Learning (Cntd.)

✓ ***Classification of Machine Learning:***

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

✓ ***Classification of Machine Learning on the basis of required Output:***

- Another categorization of machine learning tasks arises when one considers the desired output of a machine-learned system:
  - *Classification :* When 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 :* Which is also a supervised problem, A case when the outputs are continuous rather than discrete.
  - *Clustering :* When 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.

Introduction to Machine Learning (Cntd.)

✓ Key Differences between AI and ML:

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.

Introduction to Robotics

- ✓ Robotics is a branch of engineering and science that includes electronics engineering, mechanical engineering and computer science and so on.
- ✓ This branch deals with the design, construction, use to control robots, sensory feedback and information processing.

Introduction to Robotics (Cntd.)

✓ ***Characteristics of Robot:***

- **Appearance:** Robots have a physical body. They are held by the structure of their body and are moved by their mechanical parts. Without appearance, robots will be just a software program.
- **Brain:** Another name of brain in robots is On-board control unit. Using this robot receive information and sends commands as output. With this control unit robot knows what to do else it'll be just a remote-controlled machine.
- **Sensors:** The use of these sensors in robots is to gather info from the outside world and send it to Brain. Basically, these sensors have circuits in them that produces the voltage in them.
- **Actuators:** The robots move and the parts with the help of these robots move is called Actuators. Some examples of actuators are motors, pumps, and compressor etc. The brain tells these actuators when and how to respond or move.
- **Program:** Robots only works or responds to the instructions which are provided to them in the form of a program. These programs only tell the brain when to perform which operation like when to move, produce sounds etc. These programs only tell the robot how to use sensors data to make decisions.
- **Behavior:** Robots behavior is decided by the program which has been built for it. Once the robot starts making the movement, one can easily tell which kind of program is being installed inside the robot.

Introduction to Robotics (Cntd.)

✓ ***Advantages of using Robots:***

- They can get information that a human can't get.
- They can perform tasks without any mistakes and very efficiently and fast.
- Maximum robots are automatic, so they can perform different tasks without needing human interaction.
- Robots are used in different factories to produce items like plane, car parts etc.
- They can be used for mining purposes and can be sent to earth's nadris.

✓ ***Disadvantages of using Robots:***

- They need the power supply to keep going. People working in factories may lose their jobs as robots can replace them.
- They need high maintenance to keep them working all day long. And the cost of maintaining the robots can be expensive.
- They can store huge amount of data but they are not as efficient as our human brains.
- As we know that robots work on the program that has been installed in them. So other than the program installed, robots can't do anything different.
- The most important disadvantage is that if the program of robots comes in wrong hands they can cause the huge amount of destruction.

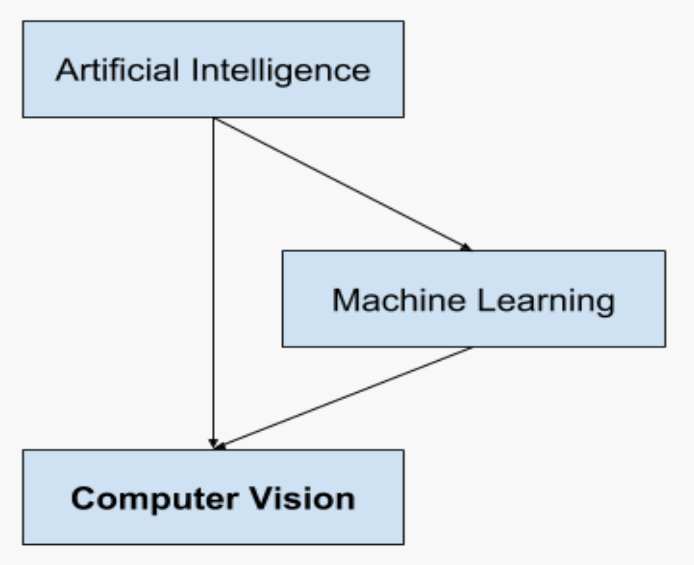
Introduction to Robotics (Cntd.)

✓ ***Applications using Robots:***

- Robots are increasingly been used more than humans in manufacturing while in auto-industry there are more than half of the labors are “Robots”.
- Many of the robots are used as Military Robots.
- Robots have been used in cleaning up of areas like toxic waste or industrial wastes etc.
- Agricultural robots.
- Household robots.
- Domestic robots.
- Nano robots.
- Swarm robots.

Introduction to Computer Vision

- ✓ Computer Vision, often abbreviated as CV, is defined as a field of study that seeks to develop techniques to help computers “see” and understand the content of digital images such as photographs and videos.
- ✓ At an abstract level, the goal of computer vision problems is to use the observed image data to infer something about the world.
- ✓ It is a multidisciplinary field that could broadly be called a subfield of artificial intelligence and machine learning, which may involve the use of specialized methods and make use of general learning algorithms.



Introduction to Computer Vision (Cntd.)

✓ ***Application:***

- **Laptop:** Biometrics auto-login (face recognition, 3D), OCR
- **Smartphones:** QR codes, computational photography (Android Lens Blur, iPhone Portrait Mode), panorama construction (Google Photo Spheres), face detection, expression detection (smile), Snapchat filters (face tracking), Google Tango (3D reconstruction), Night Sight (Pixel)
- **Web:** Image search, Google photos (face recognition, object recognition, scene recognition, geolocalization from vision), Facebook (image captioning), Google maps aerial imaging (image stitching), YouTube (content categorization)
- **VR/AR:** Outside-in tracking (HTC VIVE), inside out tracking (simultaneous localization and mapping, HoloLens), object occlusion (dense depth estimation)
- **Motion:** Kinect, full body tracking of skeleton, gesture recognition, virtual try-on
- **Medical imaging:** CAT / MRI reconstruction, assisted diagnosis, automatic pathology, connectomics, endoscopic surgery
- **Industry:** Vision-based robotics (marker-based), machine-assisted router (jig), automated post, ANPR (number plates), surveillance, drones, shopping
- **Transportation:** Assisted driving (everything), face tracking/iris dilation for drunkeness, drowsiness, automated distribution (all modes)
- **Media:** Visual effects for film, TV (reconstruction), virtual sports replay (reconstruction), semantics-based auto edits (reconstruction, recognition)

Question Bank

- ✓ List and explain applications of Artificial Intelligence.
- ✓ List and explain applications of Robotics.
- ✓ List and explain applications of Computer Vision.
- ✓ Compare between Human Brain and Artificial Neural Network.
- ✓ Write detailed note on how ANN works.
- ✓ Discuss in detail Activation Functions used in ANN.
- ✓ Discuss with neat diagrams various interconnections used in ANN.
- ✓ Write a short note on Classification of Learning in ANN.
- ✓ Compare between ML and DL.
- ✓ Compare between AI, ML and DL.
- ✓ Explain advantages and disadvantages of deep learning along with various applications of DL.
- ✓ Explain advantages and disadvantages of Fuzzy Logic along with various applications of Fuzzy Logic.
- ✓ Discuss in detail components of NLP.
- ✓ Explain advantages and disadvantages of NLP along with various applications of NLP.
- ✓ Compare AI with ML.
- ✓ Discuss Applications of Computer Vision.

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