Machine Learning
(6CS4-02)

Unit-5 Notes

Vision of the Institute

To become a renowned centre of outcome based learning and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission of the Institute

M1- Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.
M2- Identify, based on informed perception of Indian, regional and global needs, the areas of focus and provide platform to gain knowledge and solutions.
M3- Offer opportunities for interaction between academia and industry.
M4- Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

Vision of the Department

To become renowned Centre of excellence in computer science and engineering and make competent engineers & professionals with high ethical values prepared for lifelong learning.

Mission of the Department

M1-To impart outcome based education for emerging technologies in the field of computer science and engineering.
M2-To provide opportunities for interaction between academia and industry.
M3- To provide platform for lifelong learning by accepting the change in technologies
M4- To develop aptitude of fulfilling social responsibilities.

Program Outcomes (PO)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEO)

1. To provide students with the fundamentals of Engineering Sciences with more emphasis in Computer Science &Engineering by way of analyzing and exploiting engineering challenges.
2. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.
3. To inculcate professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, entrepreneurial thinking and an ability to relate engineering issues with social issues.
4. To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the self-motivated life-long learning needed for a successful professional career.
5. To prepare students to excel in Industry and Higher education by Educating Students along with High moral values and Knowledge

Program Specific Outcomes (PSO)

PSO1: Ability to interpret and analyze network specific and cyber security issues, automation in real word environment.

PSO2: Ability to Design and Develop Mobile and Web-based applications under realistic constraints.

Course Outcome:

CO1: Understand the concept of machine learning and apply supervised learning techniques.
CO2: Illustrate various unsupervised leaning algorithm for clustering, and market basket analysis.
CO3: Analyze statistical learning theory for dimension reduction and model evaluation in machine learning.
CO4: Apply the concept of semi supervised learning, reinforcement learning and recommendation system.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Understand the concept of machine learning and apply supervised learning techniques.	3	3	3	3	2	1	1	1	1	2	1	3
Illustrate various unsupervised leaning algorithm for clustering, and market basket analysis.	3	3	3	2	2	1	1	1	1	1	1	3
Analyze statistical learning theory for dimension reduction and model evaluation in machine learning.	3	3	3	3	2	2	2	2	1	2	2	3
Apply the concept of semi supervised learning, reinforcement learning and recommendation system.	3	3	3	3	2	1	1	1	1	2	1	3

SYLLABUS:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

III Year-VI Semester: B.Tech. Computer Science and Engineering

6CS4-02:Machine Learning

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Supervised learning algorithm:** Introduction, types of learning, application, Supervised learning: Linear Regression Model, Naive Bayes classifier Decision Tree, K nearest neighbor, Logistic Regression, Support Vector Machine, Random forest algorithm	09
3	**Unsupervised learning algorithm:** Grouping unlabelled items using k-means clustering, Hierarchical Clustering, Probabilistic clustering, Association rule mining, Apriori Algorithm, f-p growth algorithm, Gaussian mixture model.	08
4	**Introduction to Statistical Learning Theory**, Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods, Evaluating Machine Learning algorithms and Model Selection.	08
5	**Semi supervised learning, Reinforcement learning:** Markov decision process (MDP), Bellman equations, policy evaluation using Monte Carlo, Policy iteration and Value iteration, Q-Learning, State-Action-Reward-State-Action (SARSA), Model-based Reinforcement Learning.	08
6	**Recommended system,** Collaborative filtering, Content-based filtering Artificial neural network, Perceptron, Multilayer network, Backpropagation, Introduction to Deep learning.	08
	Total	42

LECTURE PLAN:

Unit No./ Total Lecture Reqd.	Topics	Lect. Reqd.	Lect. No.
Unit-I (10)	1. Introduction to subject and scope	1	1
	2. Introduction to learning, Types of learning and Applications	1	2
	3. Supervised Learning	1	3
	4. Linear Regression Model	1	4
	5. Naïve Bayes Classifier	1	5
	6. Decision Tree	1	6
	7. K-nearest Neighbor	1	7
	8. Logistic Regression	1	8
	9. Support Vector Machine	1	9
	10. Random Forest Algorithm	1	10
BC-1	**Gradient Descent**	1	11
Unit-II (8)	1. Introduction to clustering, K-mean clustering	2	12
	2. Hierarchical Clustering	1	14
	3. Probabilistic Clustering	1	15
	4. Association Rule Mining	1	16
	5. Apriori Algorithm	1	17
	6. f-p Growth Algorithm	1	18
	7. Gaussian Mixture Model	1	19
Unit-III (8)	1. Feature Extraction- PCA and SVD	3	22
	2. Feature Selection- Feature Ranking and Subset Selection	2	24
	3. Filter, Wrapper and Embedded Methods	1	25
	4. Evaluating Machine Learning Algorithms	1	26
	5. Evaluating Model Selection	1	27
Unit- IV (8)	1. Semi supervised learning: Markov Decision Process (MDP)	2	29
	2. Bellman Equations	1	30
	3. Policy Evaluation using Monte Carlo	1	31
	4. Policy iteration and Value iteration	1	32
	5. Q-Learning	1	33
	6. State-Action-Reward-State-Action (SARSA)	1	34
	7. Model-based Reinforcement Learning	1	35

Unit- V (8)	1. Recommendation system: Collborative Filtering	1	36
	2. Content based filtering	1	37
	3. Artificial neural network	1	38
	4. Perceptron	1	39
	5. Multilayer network	1	40
	6. Backpropagation	1	41
	7. Introduction to Deep learning.	2	42
BC-2	**Genetic Algorithms**	1	44

Text Book:
Machine learning- Tom M Mitchell

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE
Department of Computer Science & Engineering
Machine Learning (6CS4-02)
Hangout Session Classes

COURSE OUTCOMES

CO4: Apply the concept of semi supervised learning, reinforcement learning and recommendation system.

Topics Covered:

Recommended System

VISION & MISSION OF DEPARTMENT

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MISSION:

- M1: To impart outcome based education for emerging technologies in the field of computer science and engineering.
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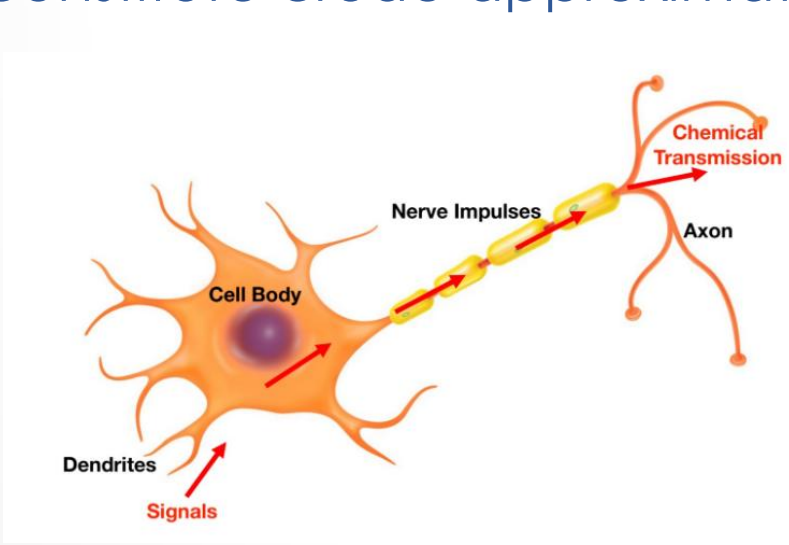
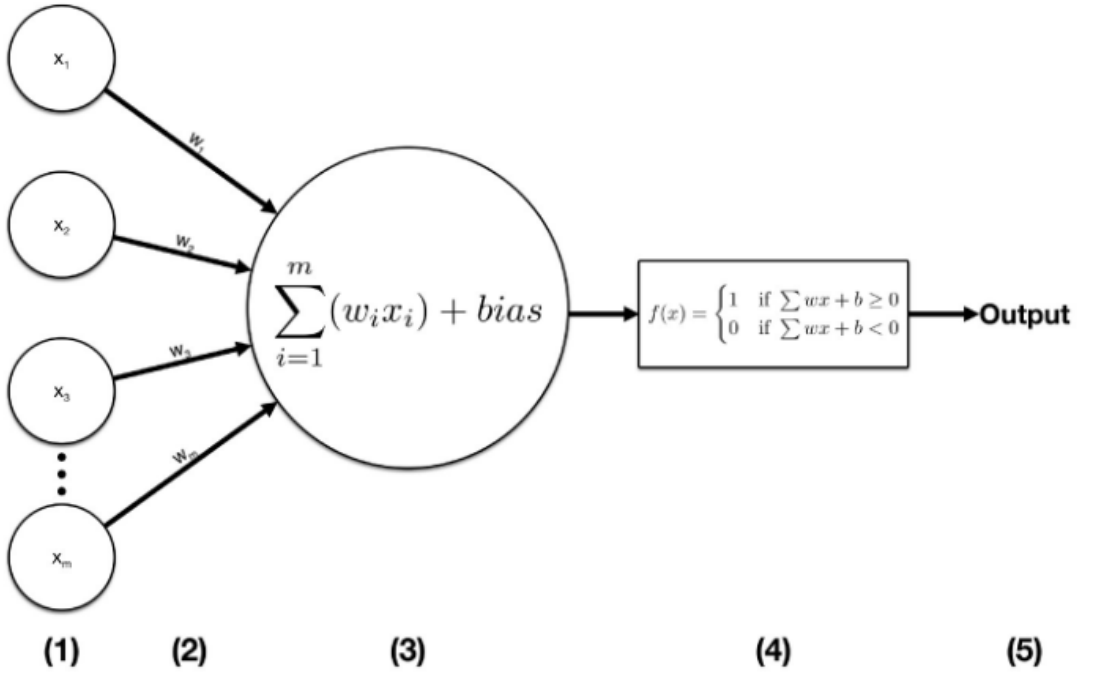
Course Outcomes

- Understand the concept of machine learning and apply supervised learning techniques.
- Illustrate various unsupervised leaning algorithm for clustering, and market basket analysis.
- Analyze statistical learning theory for dimension reduction and model evaluation in machine learning.
- Apply the concept of semi supervised learning, reinforcement learning and recommendation system.

Introduction to Neural Network

- **Neural Networks** are networks of neurons, for example, as found in real (i.e. biological) brains.
- **Artificial neurons** are crude approximations of the neurons found in real brains. They may be physical devices, or purely mathematical constructs.
- **Artificial Neural Networks** (ANNs) are networks of Artificial Neurons and hence constitute crude approximations to parts of real brains.



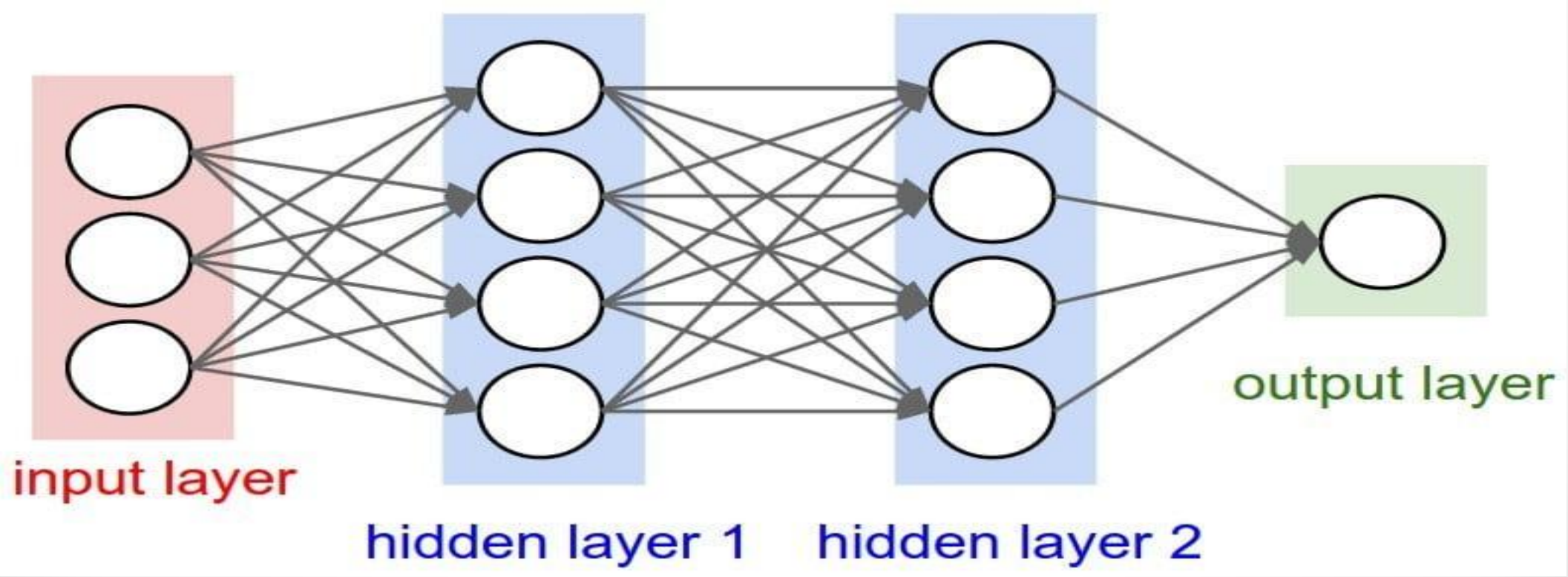


Basic Structure of ANNs

- The idea of ANNs is based on the belief that working of human brain by making the right connections, can be imitated using silicon and wires as living **neurons** and **dendrites**.
- The human brain is composed of 86 billion nerve cells called **neurons.** They are connected to other thousand cells by **Axons.**
- A neuron can then send the message to other neuron to handle the issue or does not send it forward.
- ANNs are composed of multiple **nodes**, which imitate biological **neurons** of human brain.
- The neurons are connected by links and they interact with each other. The nodes can take input data and perform simple operations on the data. The result of these operations is passed to other neurons. The output at each node is called its **activation** or **node value.**
- Each link is associated with **weight.** ANNs are capable of learning, which takes place by altering weight values.

Basic Structure of ANN

"Artificial Neural Networks or ANN is an information processing paradigm that is inspired by the way the biological nervous system such as brain process information. It is composed of large number of highly interconnected processing elements(neurons) working in unison to solve a specific problem."

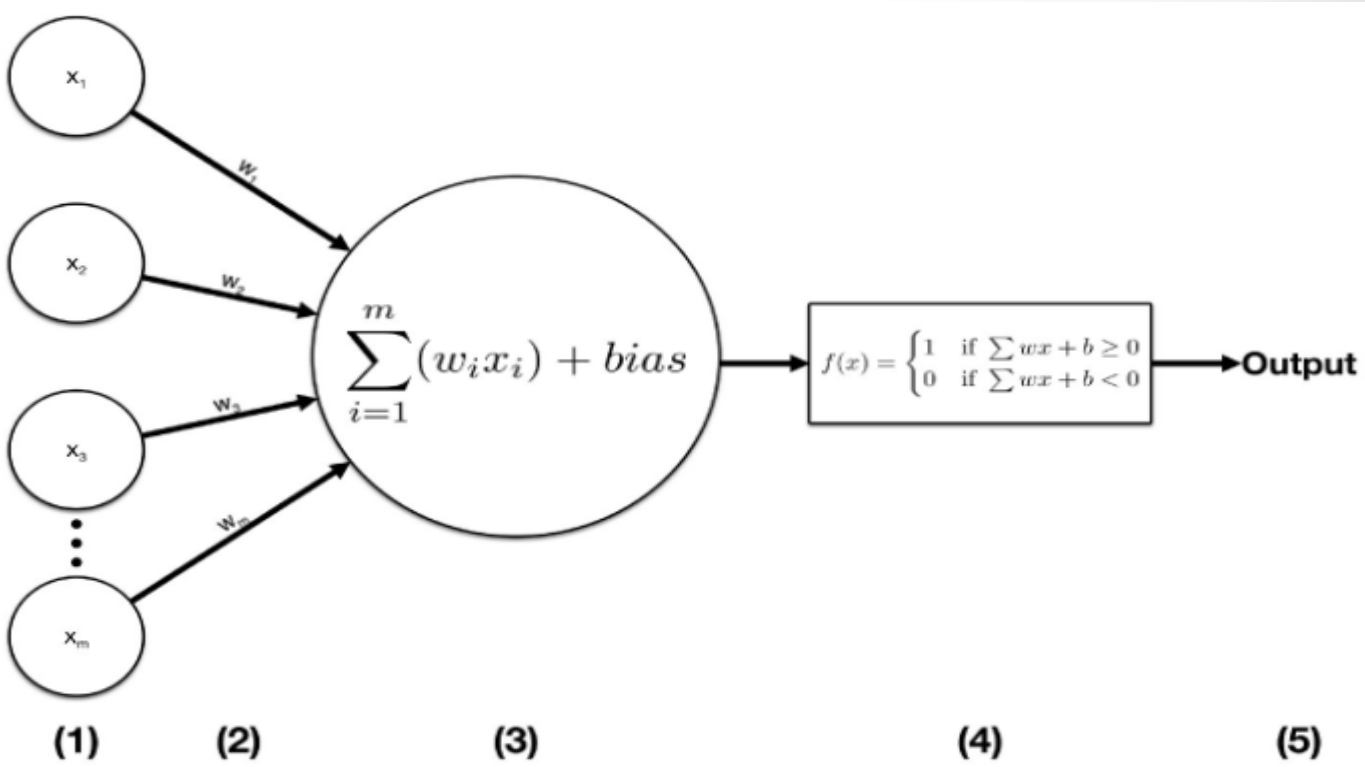


Working of ANNs

- Each arrow represents a connection between two neurons and indicates the pathway for the flow of information. Each connection has a weight, an integer number that controls the signal between the two neurons.
- If the network generates a “good or desired” output, there is no need to adjust the weights. However, if the network generates a “poor or undesired” output or an error, then the system alters the weights in order to improve subsequent results.

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.
- Inputs are summed and passed through a nonlinear function to produce output.
- Every neuron holds an internal state called activation signal.
- Every neuron is connected to another neuron via connection link



Perceptron Function

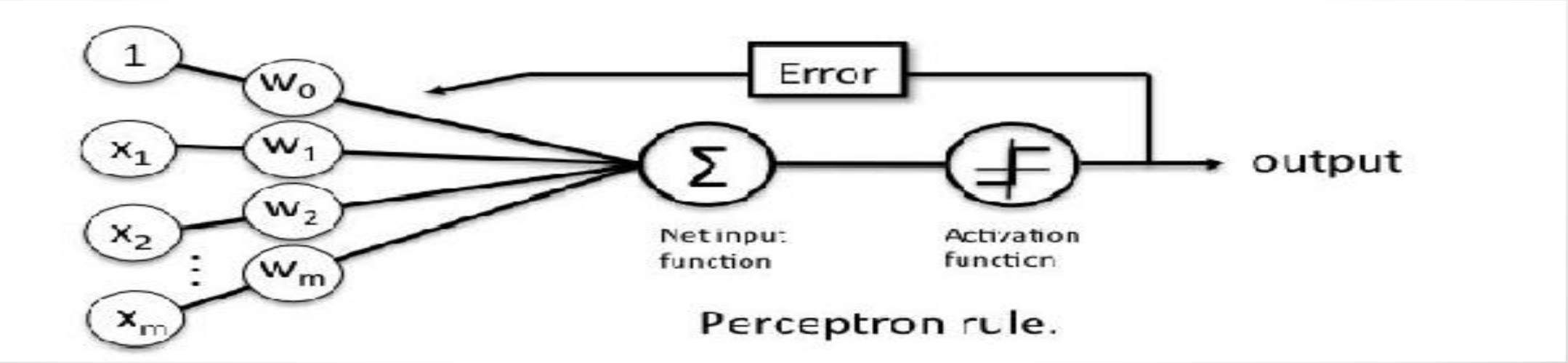
Perceptron is a function that maps its input “x,” which is multiplied with the learned weight coefficient; an output value ”f(x)”is generated. In the equation given above:

$$f(x) = \begin{cases} 1 & \text{if } w \cdot x + b > 0 \\ 0 & \text{otherwise} \end{cases}$$

w = vector of real-valued weights
b = bias (an element that adjusts the boundary away from origin without any dependence on the input value)
x = vector of input x values

Perceptron Learning Rule

- Perceptron Learning Rule states that the algorithm would automatically learn the optimal weight coefficients. The input features are then multiplied with these weights to determine if a neuron fires or not.
- The Perceptron receives multiple input signals, and if the sum of the input signals exceeds a certain threshold, it either outputs a signal or does not return an output.



Types of Artificial Neural Networks

- There are two Artificial Neural Network topologies – **Feed-Forward** and **Feedback.**

Feed-Forward ANN

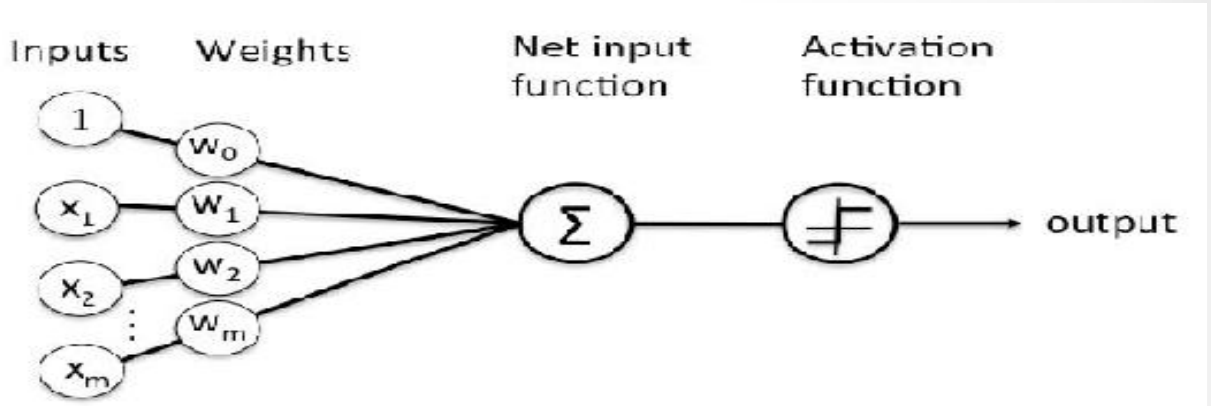
- In this ANN, the information flow is unidirectional. A unit sends information to other unit from which it does not receive any information. There are no feedback loops.
- They are used in pattern generation/recognition /classification. They have fixed inputs and outputs.
- Two different classes :
    - Single Layer Feed Forward
    - Multi Layer Feed Forward

Feedback ANN

- Feedback loops are allowed. They are used in content addressable memories.

Single Layer Feed-Forward

- The simplest kind of neural network is a **single layer perceptron network**, which consists of a single layer of output nodes; the inputs are fed directly to the output nodes via a series of weights.



- Sum of the products of the **weights and the inputs** is calculated in each node. If the value is above some threshold the neuron takes the activated value and otherwise it takes deactivated values.

So instead of $\sum_{i=1}^{m} w_i x_i + bias$ with the activation function written as

$$output = f(x) = \begin{cases} 1 & \text{if } \sum w_i x_i + b \geq 0 \\ 0 & \text{if } \sum w_i x_i + b < 0 \end{cases}$$

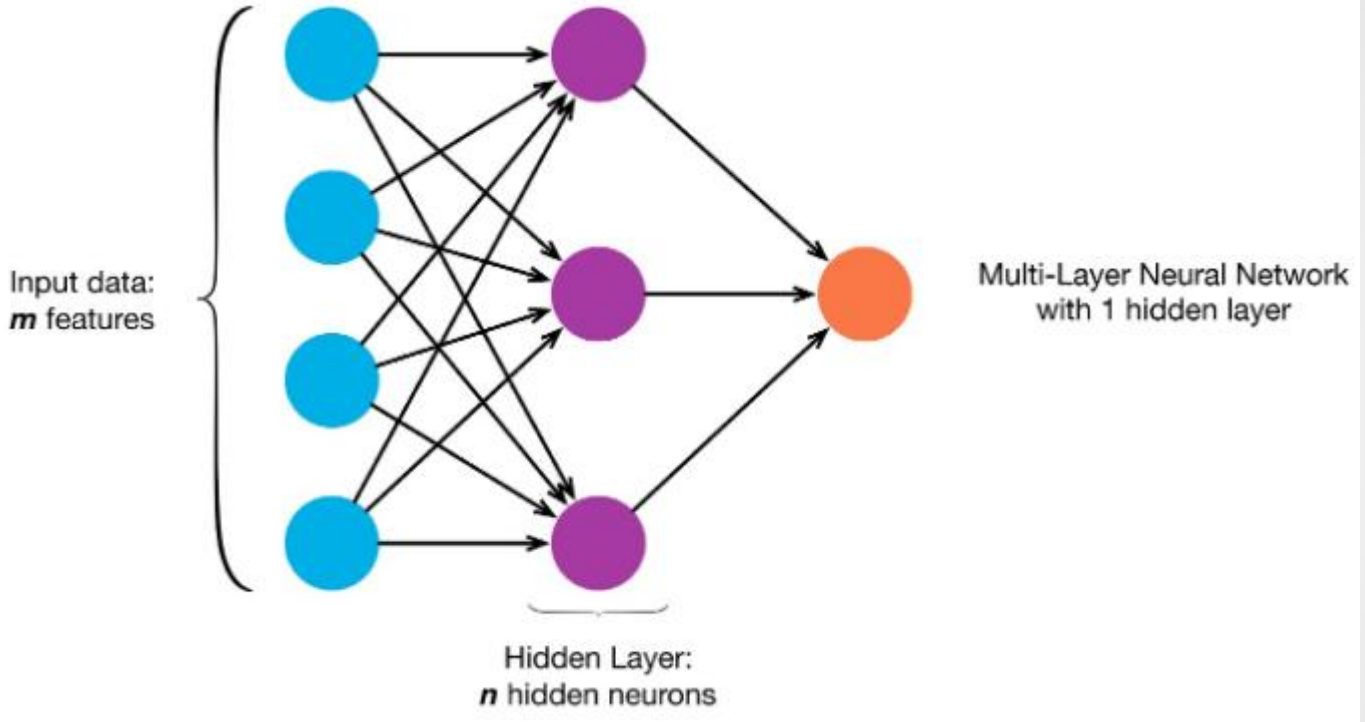
We could also write $\sum_{i=1}^{m} w_i x_i = -bias = threshold$ with the activation function written as

$$output = f(x) = \begin{cases} 1 & \text{if } \sum w_i x_i \geq threshold \\ 0 & \text{if } \sum w_i x_i < threshold \end{cases}$$

Illustration of using Threshold Value instead of Bias

Multi Layer Feed-Forward

- This class of networks consists of multiple layers of computational units, usually interconnected in a feed forward way.
- Each neuron in one layer has directed connections to the neurons of the next layer.
- The units of these networks apply a **sigmoid function** as an **activation function**.



$$z = \sum_{i=1}^{m} w_i x_i + bias$$

$$\text{Sigmoid Function is: } \sigma(z) = \frac{1}{1+e^{-z}}$$

Sigmoid Function

Machine Learning in ANNs

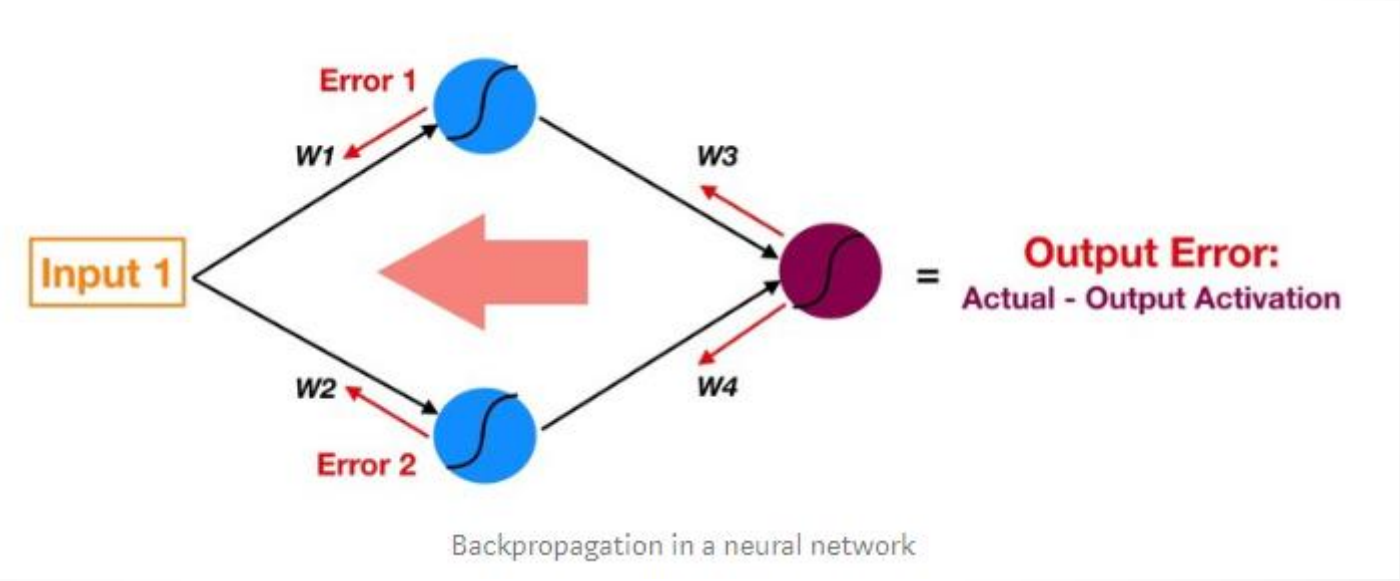
- ANNs are capable of learning and they need to be trained. There are several learning strategies –
- **Supervised Learning** – It involves a teacher that is scholar than the ANN itself. For example, the teacher feeds some example data about which the teacher already knows the answers. For example, pattern recognizing.
- **Unsupervised Learning** – It is required when there is no example data set with known answers. For example, searching for a hidden pattern. In this case, clustering i.e. dividing a set of elements into groups according to some unknown pattern is carried out based on the existing data sets present.
- **Reinforcement Learning** – This strategy built on observation. The ANN makes a decision by observing its environment. If the observation is negative, the network adjusts its weights to be able to make a different required decision the next time.

Inroduction to Backpropagation

- Backpropagation is a multi layered feed forward, supervised learning network based on gradient descent learning rule(a first order repeated optimization algorithm).
- It calculates gradient of a loss function with respect to all the weights in the network, so that the gradient is fed to the optimization method which in turn uses it to update the weights, in an attempt to minimize the loss function.
- Propagates backward to adjust for errors from outputs to hidden layers to inputs

Backpropagation Algorithm

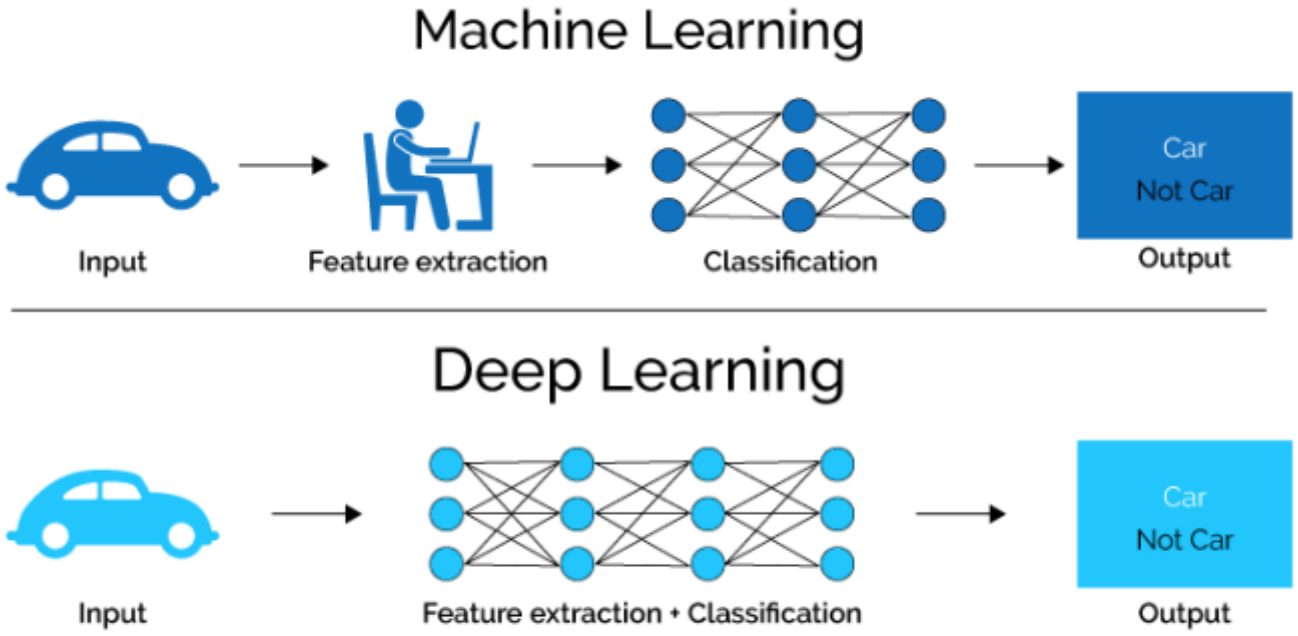
- Computes error term for the output units using the observed error.
- From output layer, repeat
  - Propagating the error term back to the previous layer and
  - Updating the weights between the two layers until the earliest hidden layer is reached.



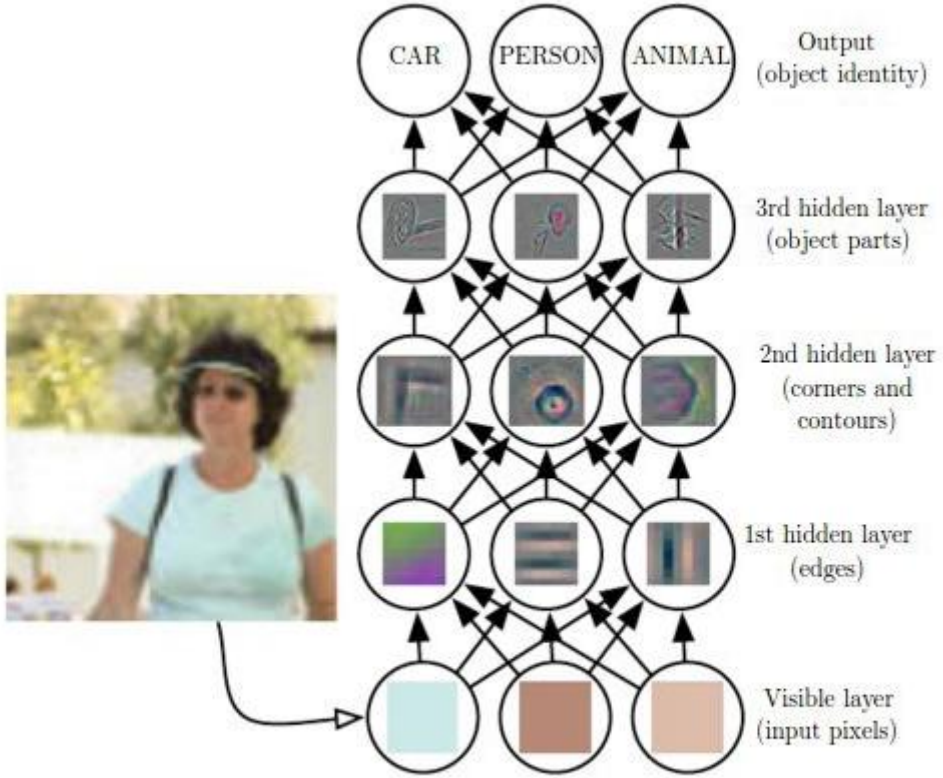
Backpropagation in a neural network

Introduction to Deep Learning

A branch of machine learning based on a set of algorithms that attempt to model high level abstractions in data by using multiple processing layers.



Difference between Machine Learning and Deep Learning



Deep Learning Model

Thank You

Queries!!