Introduction to Digital Transformation (ZZ-1103)
Technology Usage – Part 1

ANN, Block Chain, AR, VR, MR & IoT

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- ANN is a massively parallel distributed network that has a natural property for storing experimental knowledge and making it available for use.

- It resembles human brain in two respects:
  - Knowledge is acquired by the network through a learning process
  - Interneuron connection strengths known as synaptic weights are used to store the knowledge.

Neural Network Applications

- Optical Character Recognition
- Human Face Recognition
- Number Plate Recognition
- Speaker Identification using Voice Data
- Credit Card Fraud Detection
- Human Health Monitoring
- Stock Market Forecasting
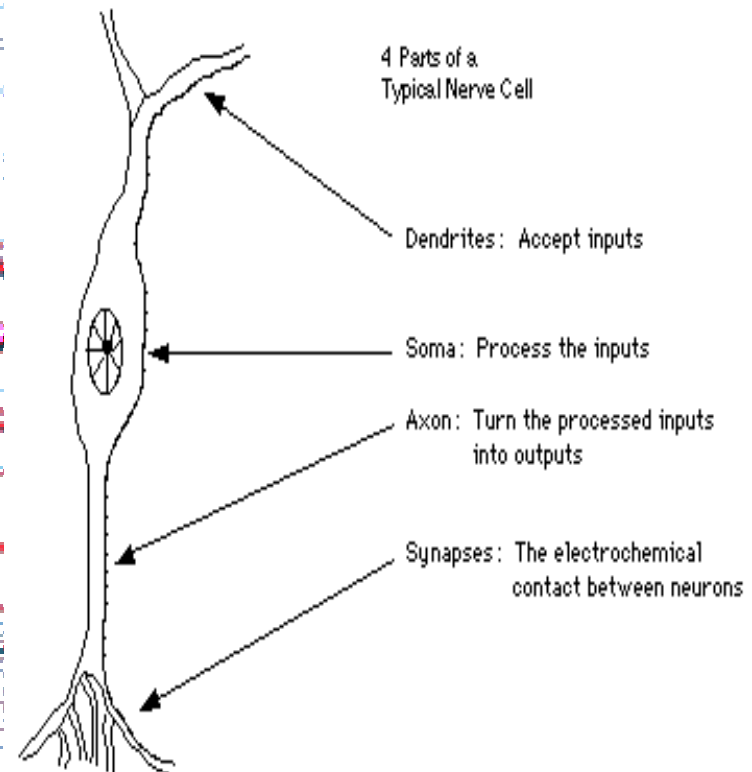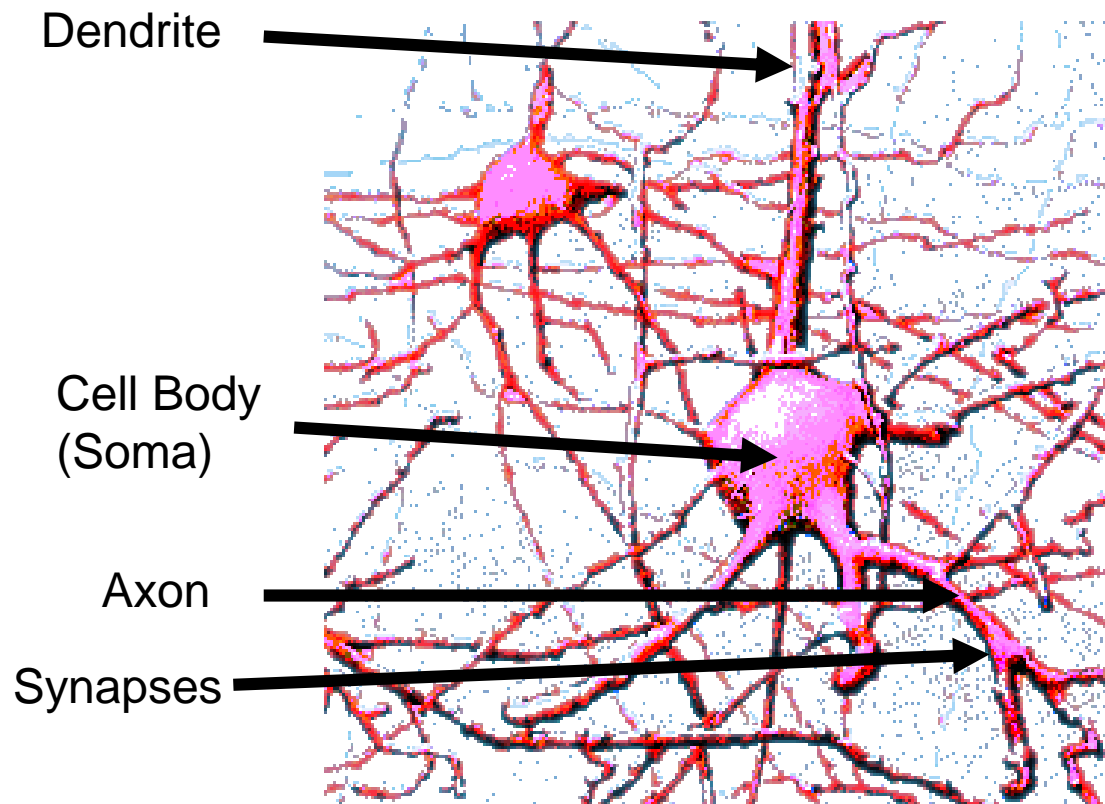- Aircraft Auto Pilot Systems etc.

- The brain is probably the most complex structure in the known universe.

- While it is the product of many millions of years of evolution, some of the structures unique to the human species have only appeared relatively recently.

- For example, only 100,000 years ago, the ancestors of modern man had a brain weighing only about one pound - roughly a third of the weight of the current version.

- Most of this increased weight is associated with the most striking feature of the human brain - the **cortex** - the two roughly symmetrical, corrugated and folded hemispheres which sit astride the central core.

- Almost all the tasks that seem hard or difficult for human beings but that the present generation of computers can easily perform are associated with processing in parts of the relatively new cortex.

- Conversely, tasks that humans normally find easy but that are difficult for computers typically have a much longer evolutionary history.
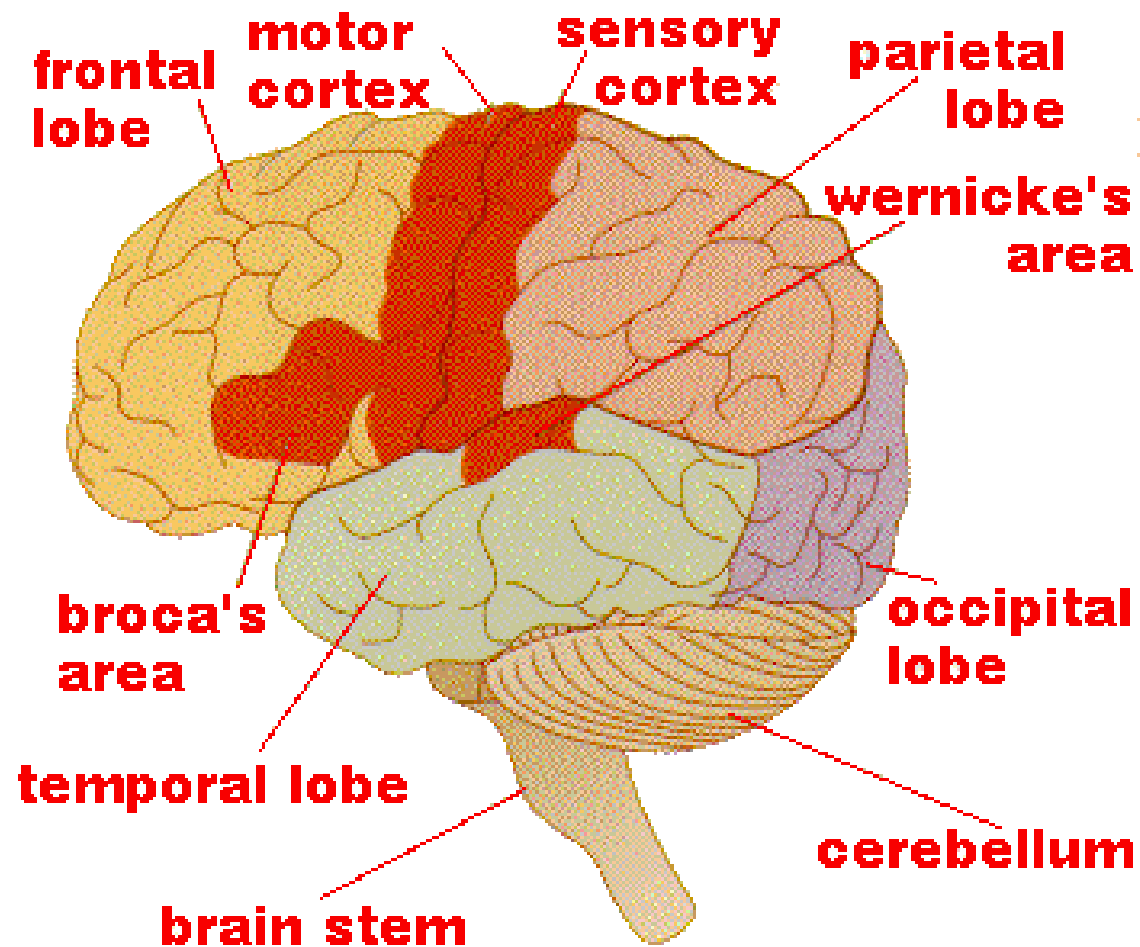
- Although playing chess, doing higher mathematics and trouble-shooting electronic circuits may seem intellectually challenging for humans, current computers can cope very straightforwardly.

- However, a modern computer (even after much careful programming) is typically very poor at such simple tasks as sensing its environment or coordinating movements.

- A simple operation like recognizing someone's face, which we find rather straightforward, is a formidable problem for a computer.

- Nerve cells, called **neurons**, are the fundamental elements of the central nervous system.

- The **central nervous system** is made up of about 100 billion neurons (10 to the power 11).

- A given neuron may both receive and send out signals to neighboring neurons in the form of electrical pulses.

- A neuron is built up of three parts: the *cell body (soma)*, *the dendrites* and the *axon* as shown in the figure.

Dendrite

Cell Body
(Soma)

Axon

Synapses

4 Parts of a
Typical Nerve Cell

Dendrites: Accept inputs

Soma: Process the inputs

Axon: Turn the processed inputs
into outputs

Synapses: The electrochemical
contact between neurons

- The body of the cell contains the **nucleus** of the cell and carries the *biochemical* transformations necessary to synthesize enzymes and other molecules necessary to the life of the neuron.

- It is roughly spherical or pyramidal in shape - the precise shape depending on position and function in the brain.

- It is typically several microns in diameter (a micron is a millionth of a meter).

- **Dendrites** are the hair-like structure surrounding the cell body. Dendrites are some tens of microns in length.

- The dendrites are like electrical cables which serve to conduct incoming signals to the cell.

- The **axon** or nerve fiber is the outgoing connection for signals emitted by the neuron.

- It differs from the dendrites in its shape and by the properties of its external membrane. It is usually much longer than the dendrites, varying from a millimeter (one thousandth of a meter) to one meter.

- At its end it branches into smaller structures which communicate with other neurons.

- The branching of the dendrites, in contrast, takes place much closer to the cell body.

- Typically a given neuron is connected to about ten thousand other neurons.

- The specific point of contact between the axon of one cell and a dendrite of another is called a **synapse**.

- Let us first recap the most important features of the neural networks found in the brain.
- Firstly the brain contains many billions of very special kinds of cell - these are the nerve cells or neurons.
- These cells are organized into a very complicated intercommunicating network.
- Typically each neuron is physically connected to tens of thousands of others.
- Using these connections neurons can pass electrical signals between each other.

- These connections are not merely *on* or *off* - the connections have varying *strength* which allows the influence of a given neuron on one of its neighbors to be either very strong, very weak (perhaps even no influence) or anything in between.

- Furthermore, many aspects of brain function, particularly the learning process, are closely associated with the adjustment of these connection strengths.

- Brain activity is then represented by particular patterns of firing activity amongst this network of neurons.

- It is this simultaneous cooperative behavior of very many simple processing units which is at the root of the enormous sophistication and computational power of the brain.
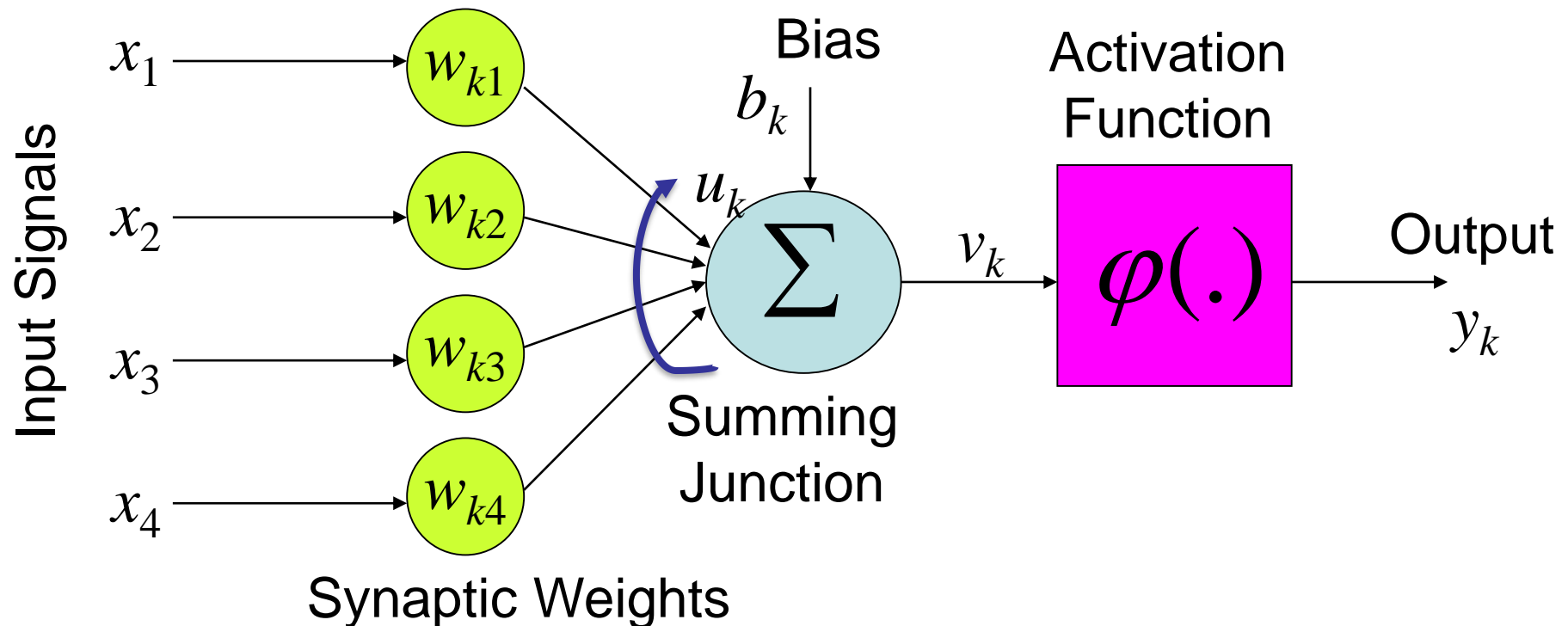
- **Artificial Neural Networks (ANN)** are computers whose architecture is modeled after the brain.

- They typically consist of many hundreds of simple processing units which are wired together in a complex communication network.

- Each unit or **node** is a simplified model of a real neuron which **fires** (sends off a new signal) if it receives a sufficiently strong input signal from the other nodes to which it is connected.

- The strength of these connections may be varied in order for the network to perform different tasks corresponding to different patterns of node firing activity.

- This structure is very different from traditional computers and hence make way to Intelligent Machines.

- **To what extent can we *ever* expect to be able to create a machine which is `truly' intelligent?**

- The model consists of a set of synapses each of which is characterized by a weight or strength of its own.

- An adder, an activation function and a bias.

Input Signals

x_1

x_2

x_3

x_4

w_{k1}

w_{k2}

w_{k3}

w_{k4}

Synaptic Weights

u_k

$\sum$

Summing Junction

Bias

b_k

v_k

Activation Function

$\varphi(.)$

Output

y_k

- In mathematical terms, a neuron k can be described by:

$$u_k = \sum_{j=1}^{m} w_{kj} x_j \quad u_k = \sum_{j=1}^{m} w_{kj} x_j$$

- and

$$y_k = \varphi\left(u_k + b_k\right)$$

- where u_k is the linear combiner output due to input signals.
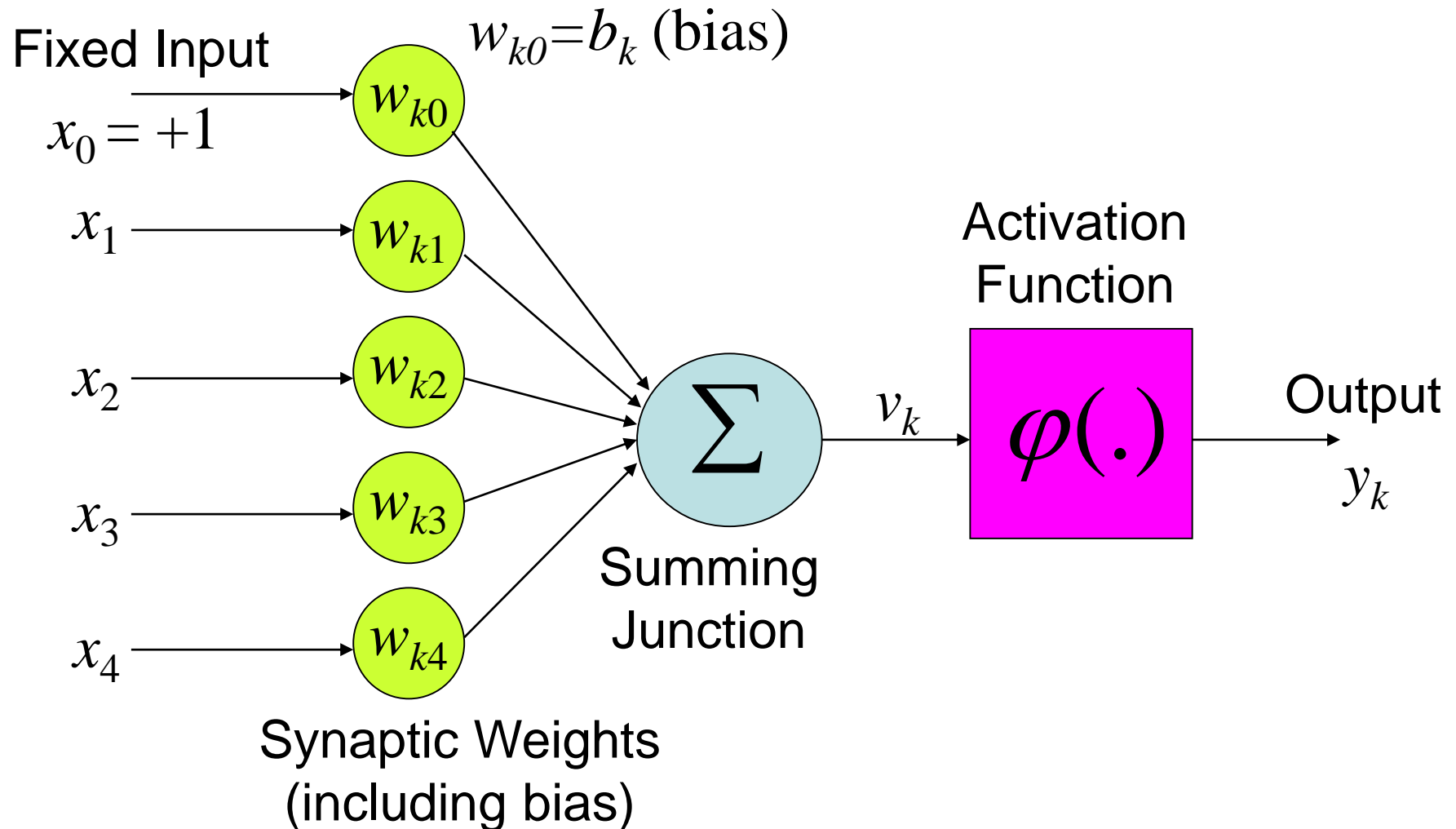
- Also $v_k = u_k + b_k.$

- The bias is an external parameter of artificial neuron and can be included into the equations as follows:
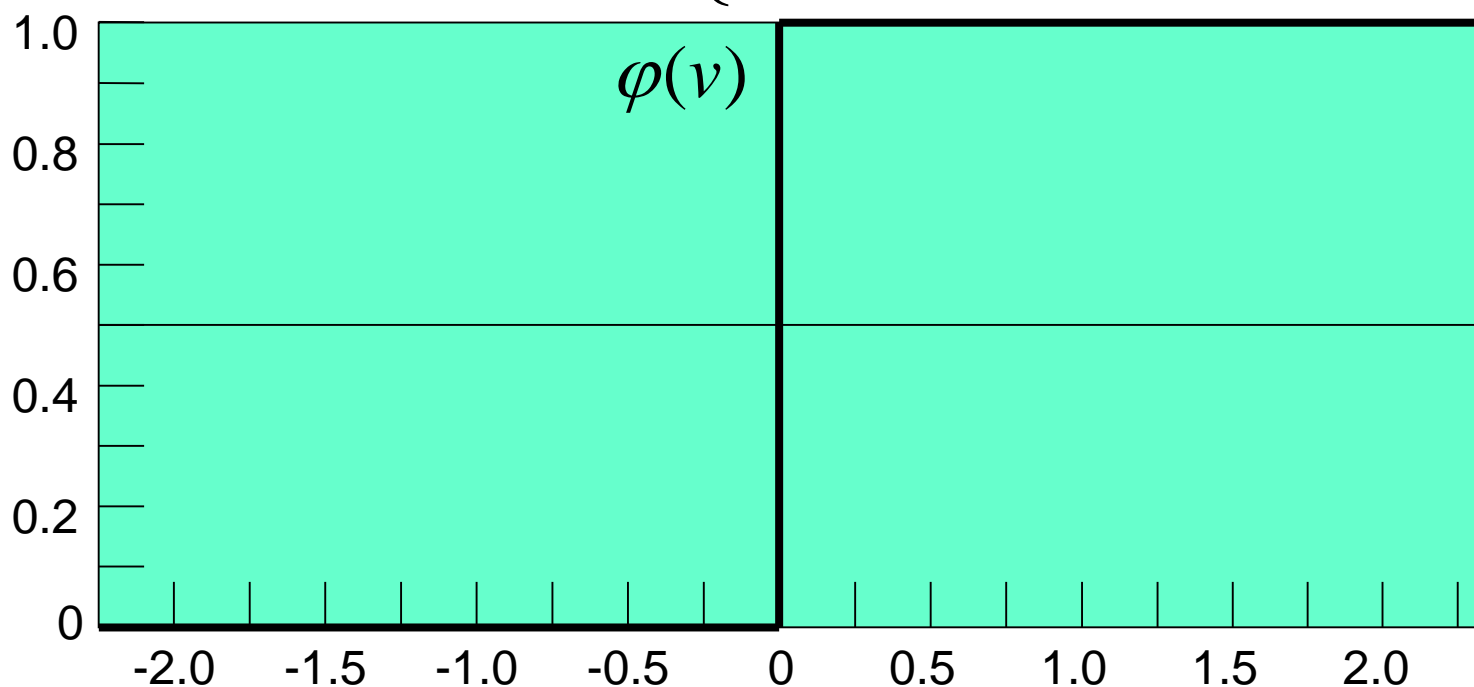
-
$$v_k = \sum_{j=0}^{m} w_{kj} x_j$$

- and
$$y_k = \varphi(v_k)$$

- Note the change of limits of j from 1 to 0.
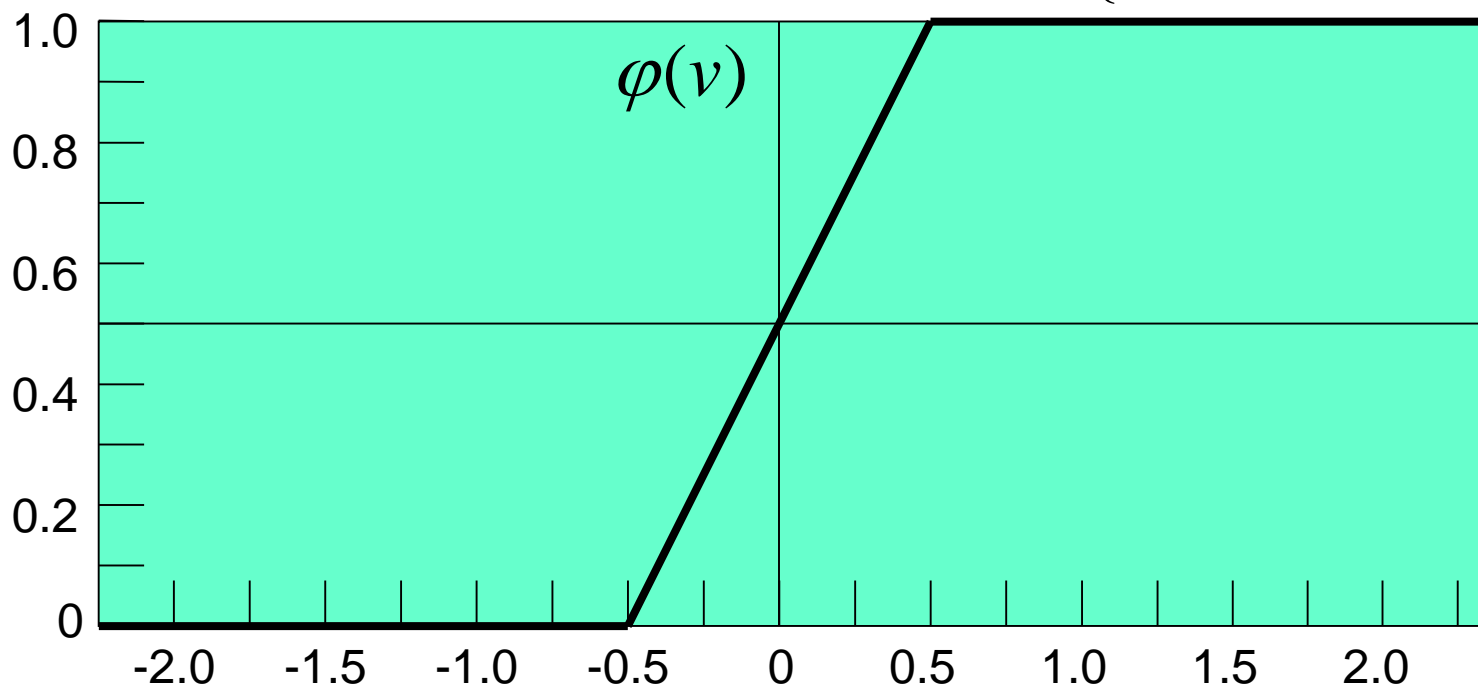
Fixed Input

$w_{k0}=b_k$ (bias)

$x_0 = +1$

w_{k0}

x_1 w_{k1}

x_2 w_{k2}

x_3 w_{k3}

x_4 w_{k4}

$\sum$

v_k

Activation Function

$\varphi(.)$

Output

y_k

Summing Junction

Synaptic Weights (including bias)

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- Threshold Function or Heaviside Function:

$$\varphi(v) = \begin{cases} 1 & \text{if } v \geq 0 \\ 0 & \text{if } v < 0 \end{cases}$$

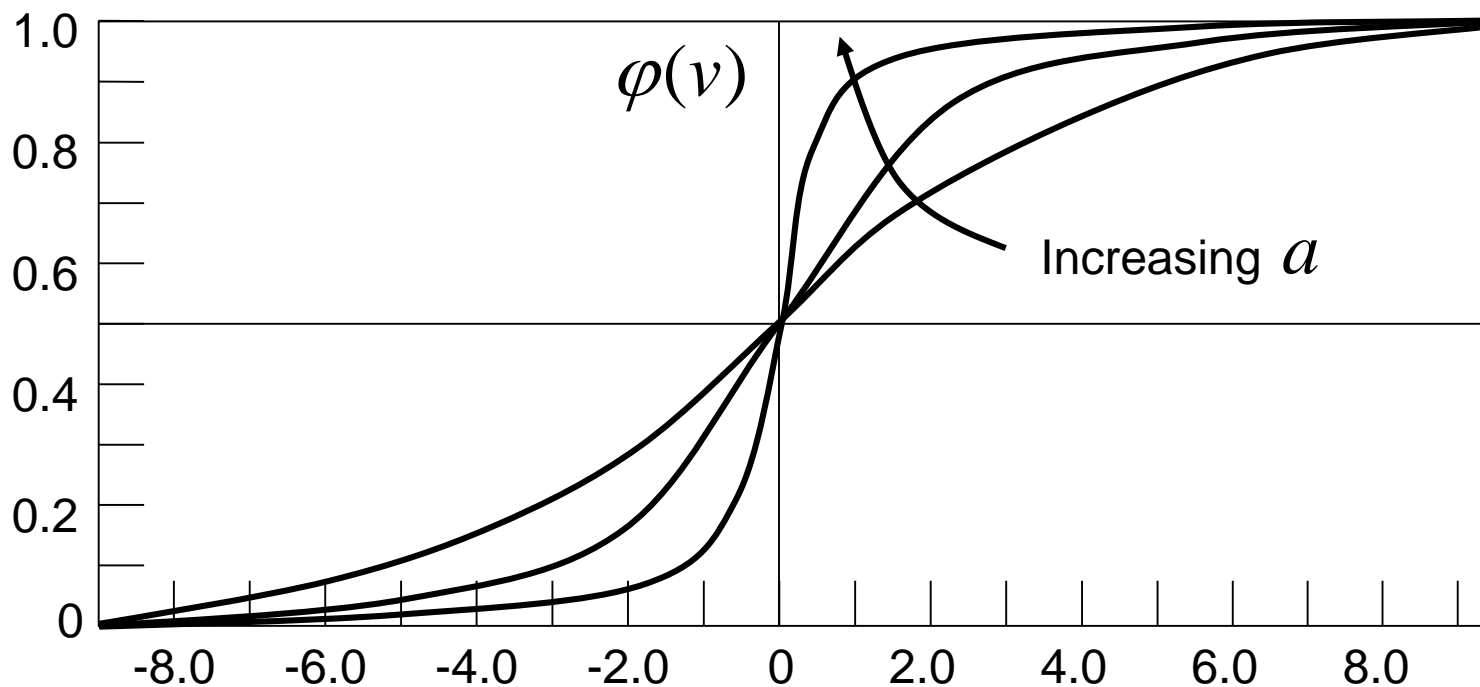$$\varphi(v) = \begin{cases} 1, & v \ge +\dfrac{1}{2} \\ v, & +\dfrac{1}{2} > v > -\dfrac{1}{2} \\ 0, & v \le -\dfrac{1}{2} \end{cases}$$

- Piecewise-Linear Function:

- Sigmoid Function: $\varphi(v) = \dfrac{1}{1 + \exp(-av)}$

  where a is the slope parameter of the sigmoid function.

- The neuronal model we have just discussed is also known as a perceptron.

- The perceptron is the simplest form of a neural network used for the classification of patterns said to be linearly separable.

- Basically, it consists of a single neuron with adjustable synaptic weights and bias.

- Now we will look at a method of achieving **learning** in our model we have formulated.

- ## Variables and Parameters

$$x(n) = [+1, \ x_1(n), \ x_2(n), ..., \ x_m(n)]^T$$

$\mathbf{x}(n) = (m+1) \times 1$ input vector

$$w(n) = [b(n), \ w_1(n), \ w_2(n), ..., \ w_m(n)]^T$$

$$= \left[+1, x_1(n), x_2(n), \ldots, x_m(n)\right]^T$$

$\mathbf{w}(n) = (m+1) \times 1$ weight vector

$$= \left[b(n), w_1(n), w_2(n), \ldots, w_m(n)\right]^T$$

$b(n) = \text{bias}$

$y(n) = \text{actual response}$

$d(n) = \text{desired response}$

$\eta = \text{learning-rate parameter, a postive constant less than unity}$

1. ***Initialization***. Set $\mathbf{w}(0) = \mathbf{0}$. Then perform the following computations for time step $n = 1, 2, \ldots$

2. ***Activation***. At time step n, activate the perceptron by applying input vector $\mathbf{x}(n)$ and desired response $d(n)$.

3. ***Computation of Actual Response***. Compute the actual response of the perceptron:

$$y(n) = \mathrm{sgn}[\mathbf{w}^T(n)\mathbf{x}(n)]$$

where $\mathrm{sgn}(\mathbf{.})$ is the signum function.

4. ***Adaptation of Weight Vector***. Update the weight vector of the perceptron:

$$\mathbf{w}(n+1) = \mathbf{w}(n) + \eta \big[d(n) - y(n) \big] \mathbf{x}(n)$$

where

$$d(n) = \begin{cases} +1 & \text{if } \mathbf{x}(n) \text{ belongs to class } C_1 \\ -1 & \text{if } \mathbf{x}(n) \text{ belongs to class } C_2 \end{cases}$$

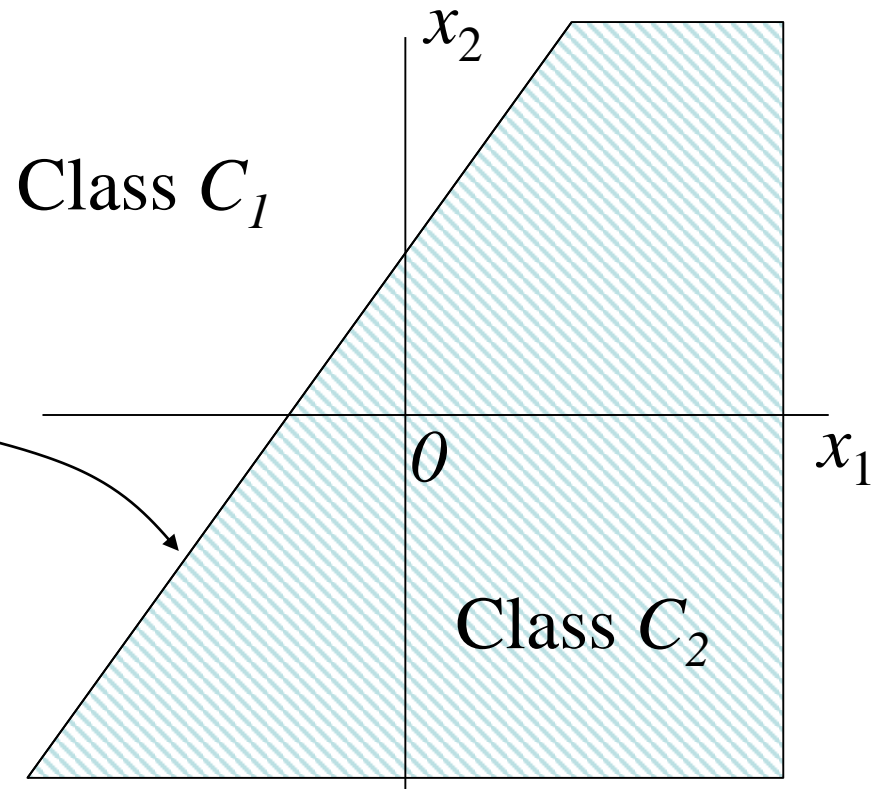5. ***Continuation***. Increment time step n by one and go back to step 2.

- The hyperplane

$$\sum_{i=1}^{m} w_i x_i + b = 0$$

or

$$w_1 x_1 + w_2 x_2 + b = 0$$

is the decision boundary for a two class classification problem.

Class C_1

Class C_2

x_2

x_1

0

- The following table shows sample data obtained from two different fruits.

	Weight (grams)	Length (cm)
Fruit 1	121	16.8
	114	15.2
Fruit 2	210	9.4
	195	8.1

- Train a single layer perceptron model using the above parameters to classify the two fruits.

- Using the model parameters you have obtained classify the fruit with weight 140gm and length 17.9cm.

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- Simon Haykin, "*Neural Networks: A Comprehensive Foundation*", Prentice Hall International, 2nd Edition, 1999.
- Robert Callan, " *The Essence of Neural Networks*", Prentice Hall International, 1999.
- R Beale and T Jackson, "*Neural Computing: An Introduction*", Adam Hilgar, Bristol, Philadelphia and New York, 1990.

(1)

$$w_1(0) = -30, \; w_2(0) = 300,$$
$$b(0) = 50, \; \eta = 0.01$$
$\Big\}$ *given*

$$\mathbf{x}(n) = \mathbf{x}(0) = \begin{bmatrix} +1, 121, 16.8 \end{bmatrix}^T \quad \text{and} \quad d(0) = +1$$

$$\mathbf{w}(n) = \mathbf{w}(0) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$y(n) = y(0) = \operatorname{sgn}\left(\mathbf{w}^T(0)\mathbf{x}(0) \right)$$

$$= \operatorname{sgn}\left(50 \times 1 - 30 \times 121 + 300 \times 16.8 \right)$$

$$= \operatorname{sgn}(1460) = +1 = d(0)$$

	x_1	x_2	
Fruit 1	121	16.8	C_1 (+1)
	114	15.2	
Fruit 2	210	9.4	C_2 (-1)
	195	8.1	

Hence no need to recalculate the weights.

$$\therefore \mathbf{w}(n+1) = \mathbf{w}(1) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$\mathbf{x}(1) = \begin{bmatrix} +1, 114, 15.2 \end{bmatrix}^T \quad \text{and} \quad d(1) = +1$$

$$\mathbf{w}(1) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$y(1) = \text{sgn}\left(\mathbf{w}^T(1)\mathbf{x}(1)\right) = \text{sgn}\left(50 \times 1 - 30 \times 114 + 300 \times 15.2\right)$$

$$= \text{sgn}(1190) = +1 = d(1)$$

Hence no need to recalculate the weights.

$$\therefore \mathbf{w}(n+1) = \mathbf{w}(2) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$\mathbf{x}(2) = \begin{bmatrix} +1, 210, 9.4 \end{bmatrix}^T \quad \text{and} \quad d(2) = -1$$

$$\mathbf{y}(2) = \text{sgn}\left(\mathbf{w}^T(2)\mathbf{x}(2)\right) = \text{sgn}\left(50 \times 1 - 30 \times 210 + 300 \times 9.4\right)$$

$$= \text{sgn}(-3430) = -1 = d(2)$$

Hence no need to recalculate the weights.

$$\therefore \mathbf{w}(n+1) = \mathbf{w}(3) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

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$$\mathbf{x}(3) = \begin{bmatrix} +1, 195, 8.1 \end{bmatrix}^T \quad \text{and} \quad d(3) = -1$$

$$\mathbf{w}(3) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$y(3) = \text{sgn}\left(\mathbf{w}^T(3)\mathbf{x}(3)\right) = \text{sgn}\left(50 \times 1 - 30 \times 195 + 300 \times 8.1\right)$$

$$= \text{sgn}(-3370) = -1 = d(3)$$

Hence no need to recalculate the weights.

$$\therefore \mathbf{w}(n+1) = \mathbf{w}(3) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$
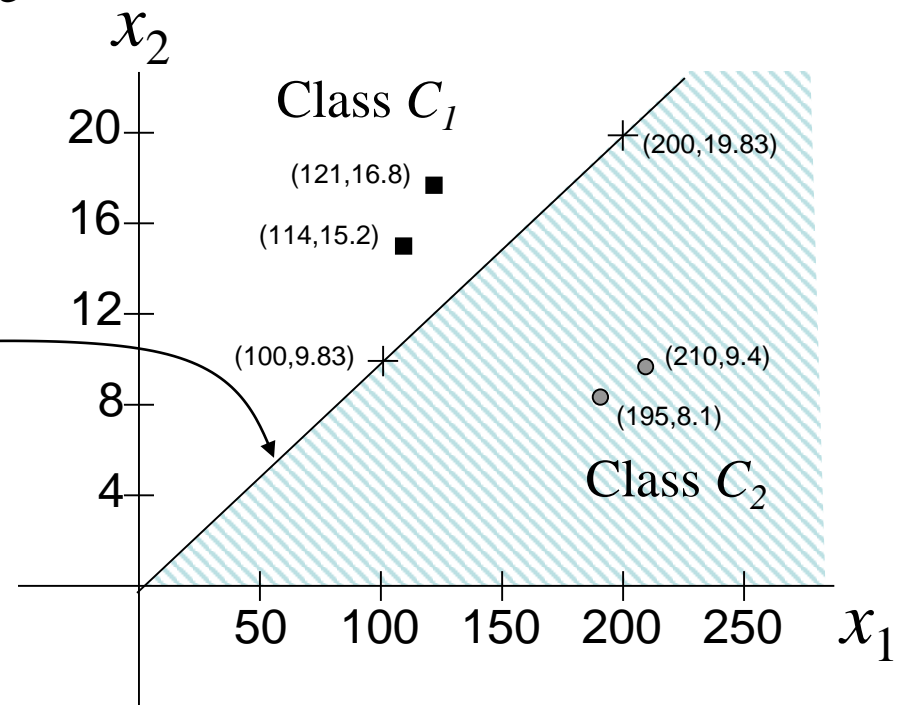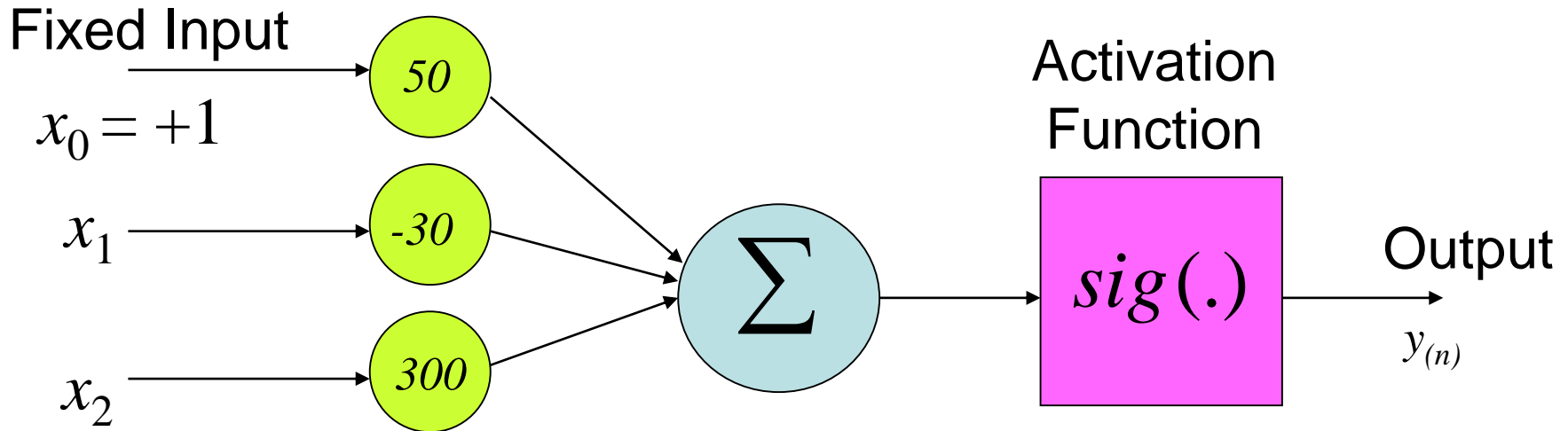
Therefore the Decision Boundary is:

$$w_1 x_1 + w_2 x_2 + b = 0$$

$$-30x_1 + 300x_2 + 50 = 0$$

$$x_1 = 100, \ x_2 = \frac{30 \times 100 - 50}{300} = 9.83$$

$$x_1 = 200, \ x_2 = \frac{30 \times 200 - 50}{300} = 19.83$$

x_2

Class C_1

20

(121,16.8) ■

16

(114,15.2) ■

(200,19.83)

12

(100,9.83)

(210,9.4)

8

(195,8.1)

Class C_2

4

50   100   150   200   250 x_1

Fixed Input

$x_0 = +1$

50

x_1

-30

x_2

300

Σ

Activation
Function

$sig(.)$

Output

$y_{(n)}$

Now use the above model to classify the unknown fruit.

$$\mathbf{x}(\text{unknown}) = \begin{bmatrix} +1, 140, 17.9 \end{bmatrix}^T$$

$$\mathbf{w}(3) = \begin{bmatrix} 50, -30, 300 \end{bmatrix}^T$$

$$y(\text{unknown}) = \text{sgn}\left(\mathbf{w}^T(3)\mathbf{x}(\text{unknown})\right) = \text{sgn}\left(50 \times 1 - 30 \times 140 + 300 \times 17.9\right)$$
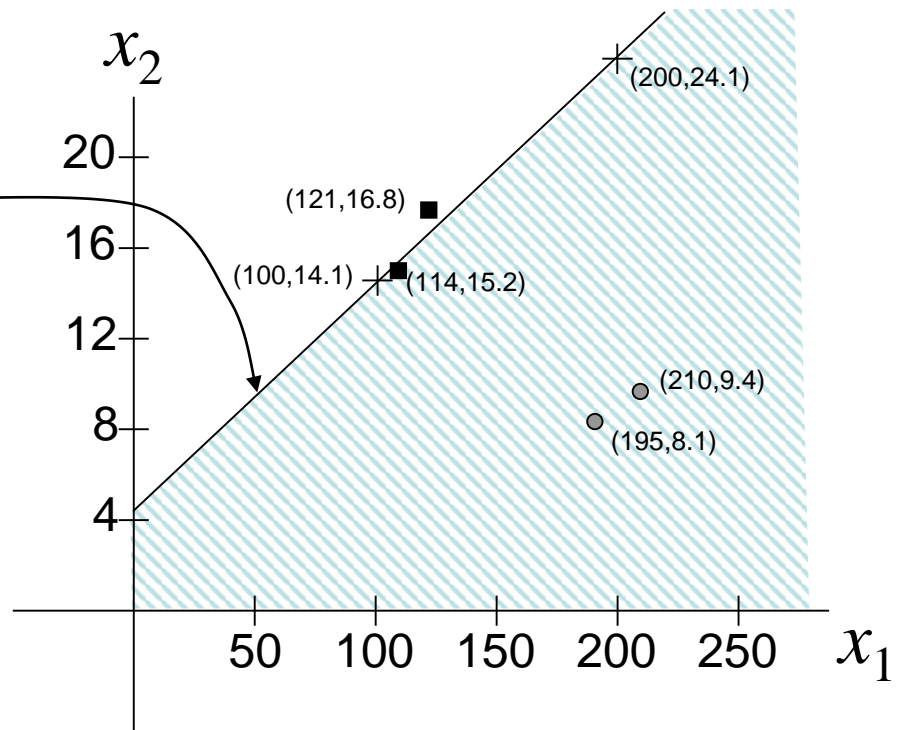
$$= \text{sgn}(1220) = +1$$

$\therefore$ this unkown fruit belonge to the class C_1.

(2) $\quad w_1(0) = -30, \; w_2(0) = 300,$
$\quad\quad\quad b(0) = -1230, \; \eta = 0.01$ $\Bigg\}$ *given*

$$-30x_1 + 300x_2 - 1230 = 0$$

$$x_1 = 100, \; x_2 = \frac{30 \times 100 + 1230}{300} = 14.1$$

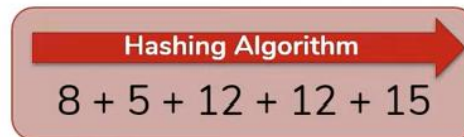$$x_1 = 200, \; x_2 = \frac{30 \times 200 + 1230}{300} = 24.1$$

Initial hyperplane does not separate the two classes.

- [(131) Hashing, Hashing Algorithms, and Collisions - Cryptography - Practical TLS –](#) YouTube
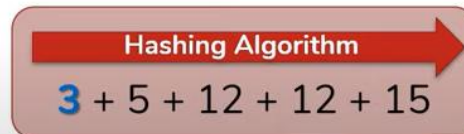- (https://www.youtube.com/watch?v=HHQ2QP_upGM)

Hashing

- Algorithm which takes as input a message of arbitrary length and produces as output a "fingerprint" of the original message
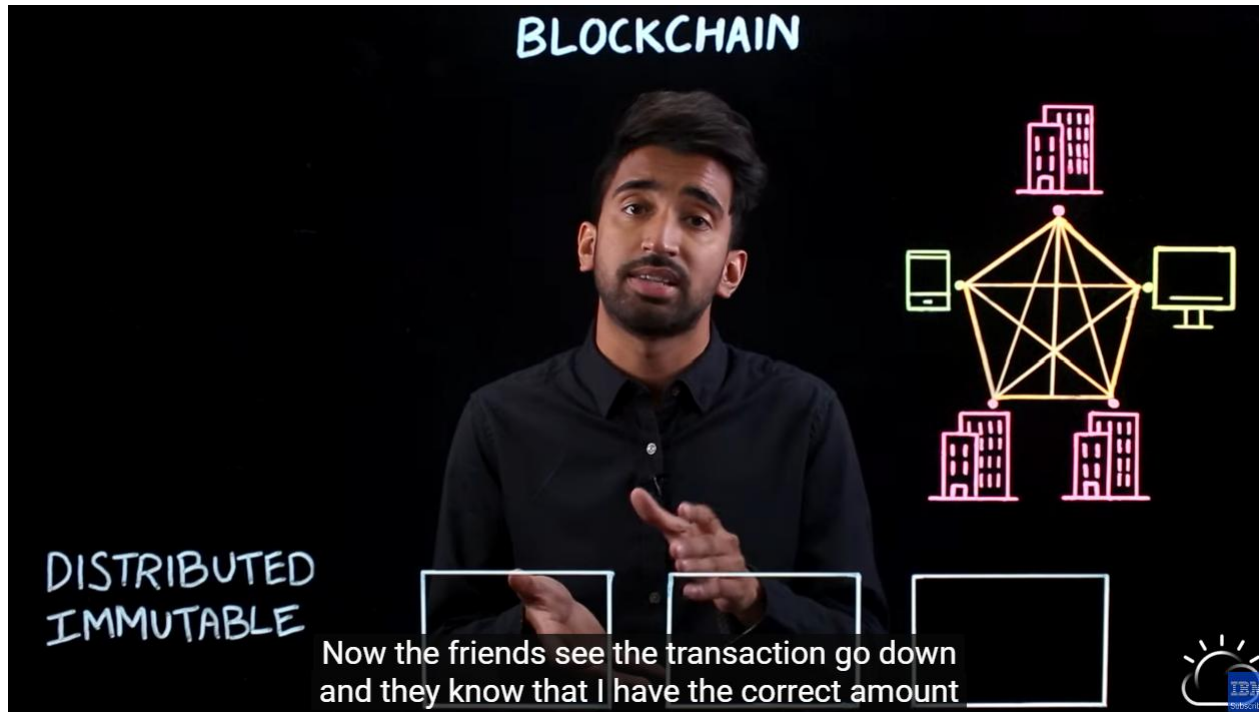
hello → Hashing Algorithm
8 + 5 + 12 + 12 + 15 → 52

cello → Hashing Algorithm
3 + 5 + 12 + 12 + 15 → 47

- If original data is changed, resulting digest will be different

[Cryptographic Hash Functions | Coursera](#)

- [(131) Blockchain Explained – YouTube](#)
- (https://www.youtube.com/watch?v=QphJEO9ZX6s)

[How transactions are verified in Bitcoin Blockchain - Longest chain rule explained (youtube.com)](#)

Technology Usage   **Blockchain**

- A blockchain is a chain of blocks containing information, originally intended for timestamping digital documents securely.

- Each block contains data, a unique hash, and the hash of the previous block, creating an immutable chain.

- Tampering with a single block invalidates all subsequent blocks due to the hash chain, ensuring data integrity.

- Proof-of-work slows down block creation, making it difficult to tamper with the chain, enhancing security.

- Distributed peer-to-peer networks ensure consensus, making it extremely challenging to tamper with a blockchain.

- Blockchains evolve beyond cryptocurrencies, enabling applications like smart contracts and diverse data storage.

Blockchain in DT

- [What will we learn about blockchain? | Coursera](#)
- **Enhanced security:** Blockchain provides a secure and tamper-proof way to store and verify data.
  - This enhances the security of digital transactions, records, and sensitive information, reducing the risk of fraud and unauthorized access.
- **Improved transparency and trust:** Blockchain's decentralized nature and transparent ledger enable increased transparency and trust among participants.
  - It allows for real-time visibility into transactions and data, reducing the need for intermediaries and enhancing trust in digital interactions.

Blockchain in DT

- **Streamlined processes and efficiency:** Blockchain can automate and streamline processes by eliminating manual and time-consuming tasks.
  - Smart contracts, powered by blockchain, enable self-executing agreements with predefined rules, reducing the need for intermediaries and improving efficiency.

- **Cost reduction:** By eliminating intermediaries and automating processes, blockchain can help reduce costs associated with traditional systems.
  - It eliminates the need for third-party verification, reconciliation, and other administrative tasks, resulting in cost savings for businesses.

VR, AR and MR in DT

- [What will we learn about virtual, mixed, and augmented reality? | Coursera](#)

- Apply insights from examples to envisioning the technologies in your own environment

- Explain the technologies, market trends, and real world examples of virtual and augmented reality for customer engagement.

VR, AR and MR in DT

- Introduction to virtual reality (VR) and augmented reality (AR) technologies.

- Real-world examples of successful VR and AR applications in marketing and advertisement.

- Importance of customer experience and engagement in today's market.

- Statistics showing that VR experiences make customers feel more engaged and perceive brands as forward-thinking.

- Discussion on current market trends and mixed reality experiences.

- Encouragement to explore and envision new collaboration, communication, marketing, and advertisement scenarios using VR and AR.

VR, AR and MR in DT

- **Virtual Reality (VR):** Immersive technology that creates a simulated environment, allowing users to interact with a computer-generated world.

- **Augmented Reality (AR):** Technology that overlays digital information onto the real world, enhancing the user's perception and interaction with their surroundings.

- **Mixed Reality (MR):** A combination of virtual and augmented reality, where digital content is seamlessly integrated into the real world, allowing users to interact with both.

VR, AR and MR in DT

Technology	Definition	User Experience	Examples
Virtual Reality (VR)	VR replicates an environment, real or imagined, and simulates a user's physical presence and environment to allow for user interaction and a sensory experience.	Users are fully immersed in a virtual environment and can only see the virtual world and objects.	Gaming, training simulations, virtual tours.
Augmented Reality (AR)	AR overlays digital content onto the real world, enhancing the user's perception and interaction with their surroundings.	Users can see and experience the real world along with virtual objects or information.	Pokemon Go, Snapchat filters, furniture placement apps.
Mixed Reality (MR)	MR merges the real world and virtual world to create new environments and visualizations where physical and digital objects coexist and interact in real time.	Users experience a blend of the real and virtual worlds, with virtual objects interacting with the real world and vice versa.	Architectural design, industrial training simulations, interactive storytelling experiences.

IoT in DT

- [What will we learn about Internet of Things? | Coursera](#)

- **Transformation of Experiences:** IoT technologies are revolutionizing consumer experiences and business processes by allowing everyday products to connect to the internet and exchange data.

- **Enhanced Marketing:** Marketers gain valuable context about customers, enabling them to deliver more relevant messages and increase engagement.

- **Data Utilization:** The rapid adoption of IoT generates vast amounts of data, which can be analyzed using big data and artificial intelligence for new insights.

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IoT in DT

- **Security Challenges:** Managing and securing IoT devices and data presents challenges that can be addressed by blockchain technology.

- **AI Integration:** By combining IoT data with machine learning and AI, businesses can improve market forecasting, automate processes, enhance decision-making, and support customer service.

- **Use Cases:** The module explores use cases that demonstrate how consumer-facing brands leverage IoT to create value for both businesses and consumers.

- **Engagement:** Participants are encouraged to ask questions and engage in discussions to enhance collective learning.

[Please complete the 3 modules in: Introduction to DT - Technology Usage | Coursera](#)

Introduction to DT - Technology Usage

Instructor:

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3 modules
Gain insight into a topic and learn the fundamentals.

There are 3 modules in this course

This course provides a comprehensive introduction to the Internet of Things (IoT). Students will identify the different technologies that are part of IoT, including IoT itself. The course covers various applications created under the IoT concept, highlighting real-world examples and case studies. Additionally, learners will explore the implications of IoT in businesses, understanding how IoT can transform industries and drive innovation. The course also includes a historical overview of the internet, providing context for the evolution of IoT.

Blockchain technology applications and crypto currencies
Module 1 • 32 minutes to complete

AUGMENTED, VIRTUAL AND MIXED REALITY
Module 2 • 17 minutes to complete

INTERNET OF THINGS
Module 3 • 31 minutes to complete

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