LECTURER: TAI LE QUY

ARTIFICIAL INTELLIGENCE

TOPIC OUTLINE

UNIT 3

NEUROSCIENCE AND COGNITIVE SCIENCE

On completion of this unit, you will have learned …

- … how neuroscience describes the anatomical and physiological composition of the brain.
- … how cognitive science unites different scientific disciplines in the search for models of cognitive processes.
- … some of the most salient relations and connections between neuroscience, cognitive science, and artificial intelligence, together with their implications for human and machine intelligence.

EXPLAIN SIMPLY

1. Explain why neuroscience and cognitive science play a major role in the field of artificial intelligence.
2. What is cognitive bias? Can you think of a potential cognitive bias in the context of artificial intelligence?
3. Describe the concept of General Adversarial Networks (GANs).

DEFINITION OF BASIC TERMS

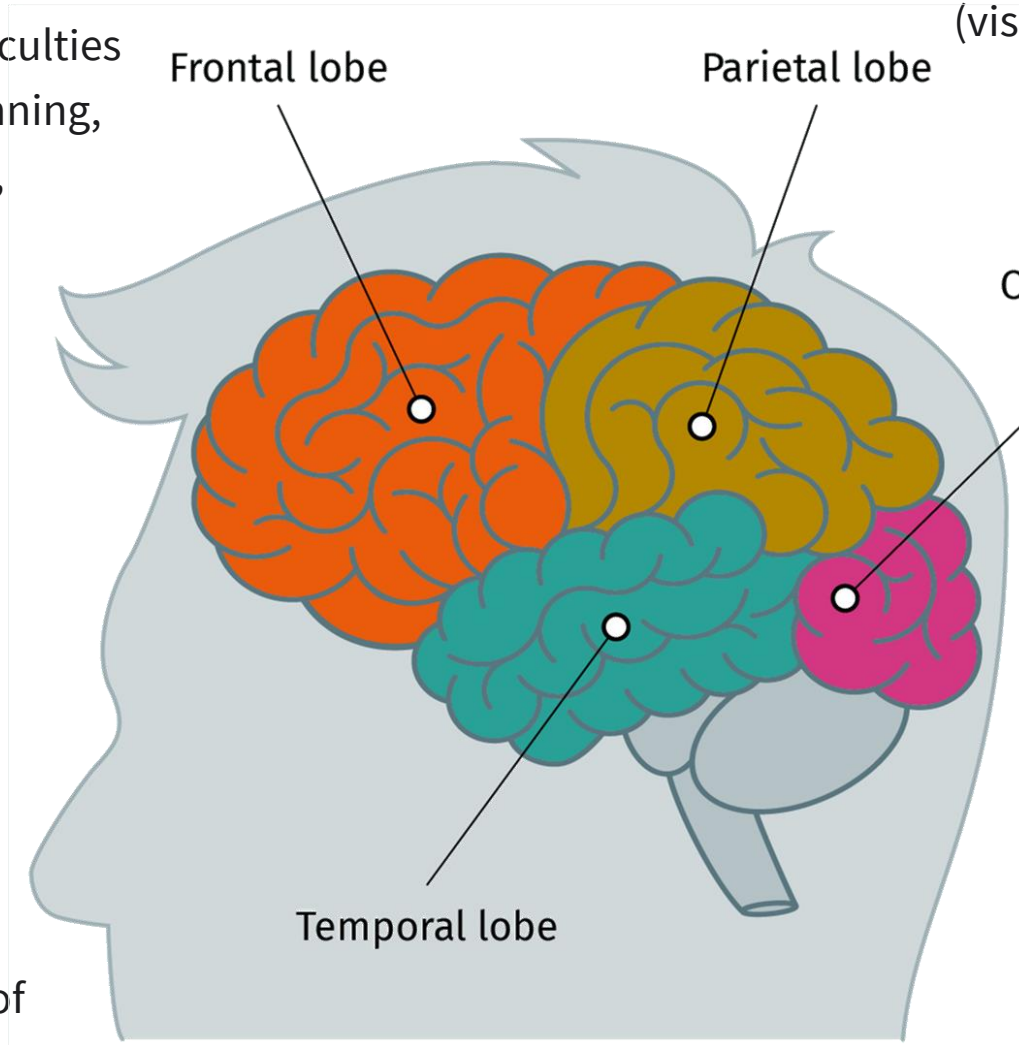
Neuroscience = study of human/animal nervous systems (e.g., anatomy and physiology)

Cognitive science = aiming to model and understand cognitive functions (e.g., behavior, intelligence, memory)

Artifical intelligence = mechanical reproduction of intelligent behavior

Higher mental faculties (judgement, planning, problem-solving, intelligence)

Interpretation of sensory input (vision, touch signals)

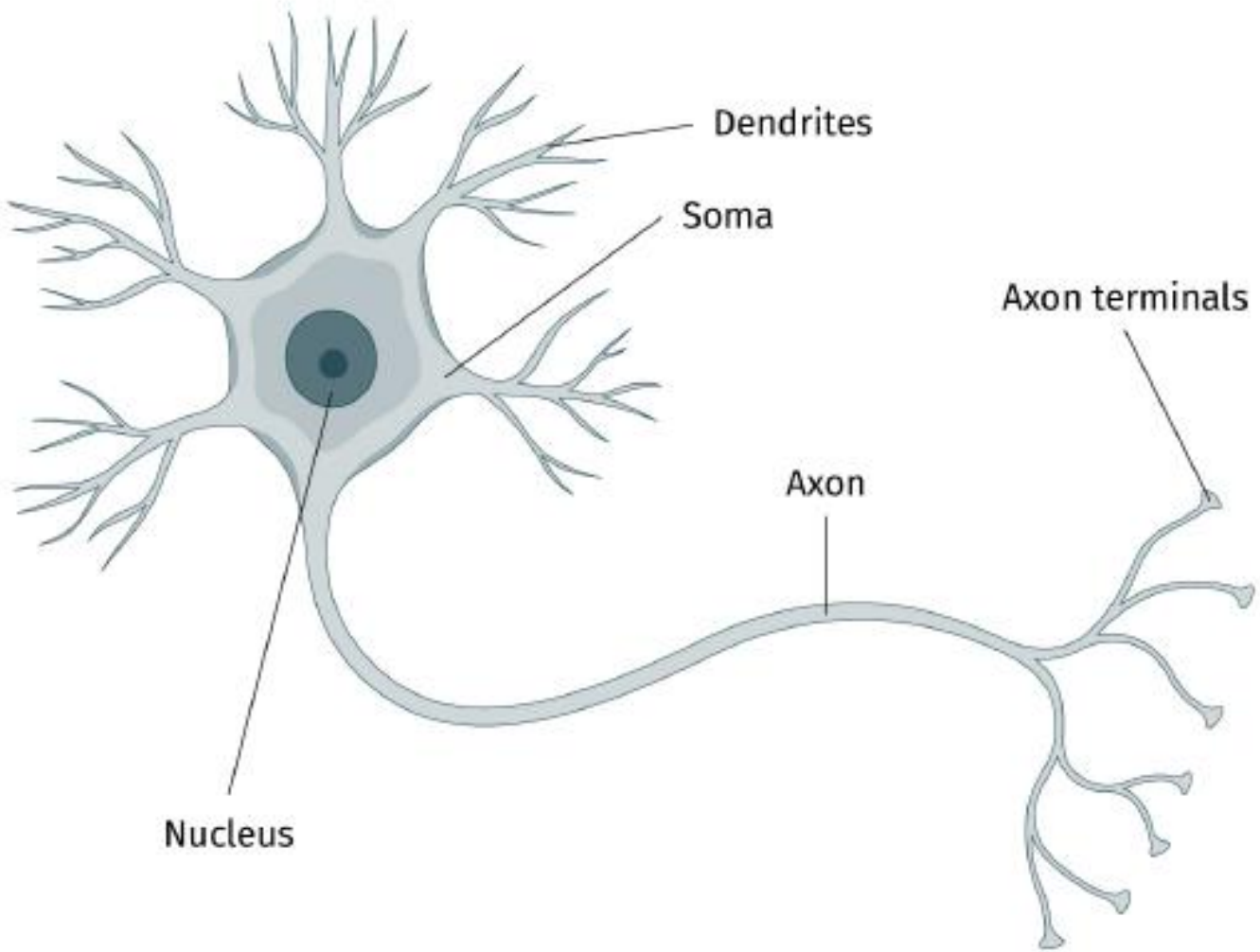


Visual processing and interpretation

Understanding of language and formation (recognition of objects)

Source of the graphic: Course Book DLMAIAI01, p.41

A NEURON



Source of image: Course book

– An interconnected network of neurons controls the functioning of our body's routine needs, such as breathing, blood pressure, and mobility.

  - Vision (sight)
  - Audition (hearing)
  - Gustation (taste)
  - Olfaction (smell)
  - Tactition (touch)
  - Thermoception (temperature)
  - Nociception (pain)
  - Equilibrioception (balance)
  - Proprioception (body awareness)

- Cognition: Mental process of gaining knowledge and understanding as a result of thinking, experience, and the senses.
- Cognitive processes:
  - Behavior, intelligence, language, memory, perception, emotion, reasoning, learning
- Related disciplines:
  - Philosophy, psychology, neuroscience, linguistics, anthropology, **artificial intelligence**

MAIN APPROACHES IN COGNITIVE SCIENCE

BRAIN IMAGING

TRACING OF NEURAL ACTIVITY

BEHAVIORAL EXPERIMENTS

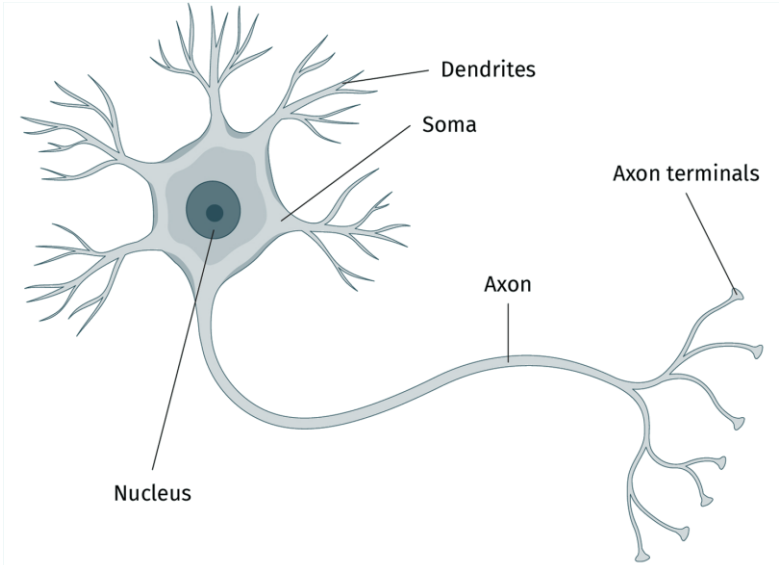
DRAW CONCLUSIONS ABOUT THE PROCESSING OF STIMULI

SIMULATION VIA COMPUTATIONAL MODELING

VERIFY THEORETICAL IDEAS BY COMPARING OUTCOMES WITH REAL-WORLD BEHAVIORAL DATA

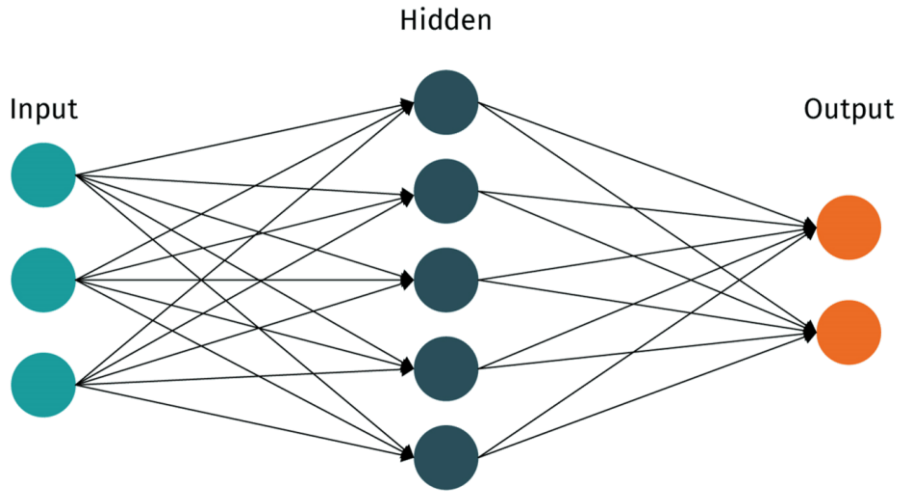
- Cognition is achieved by employing computational procedures on mental constructs (likened to data structures in computer science)
- Influences the thinking in many associated subject areas
- However, cognitive science has only recently considered the role of emotion in human thinking and the problem of consciousness

The human brain is composed of 86 billion neurons responsible for information processing.



Perception of inputs and cognition process

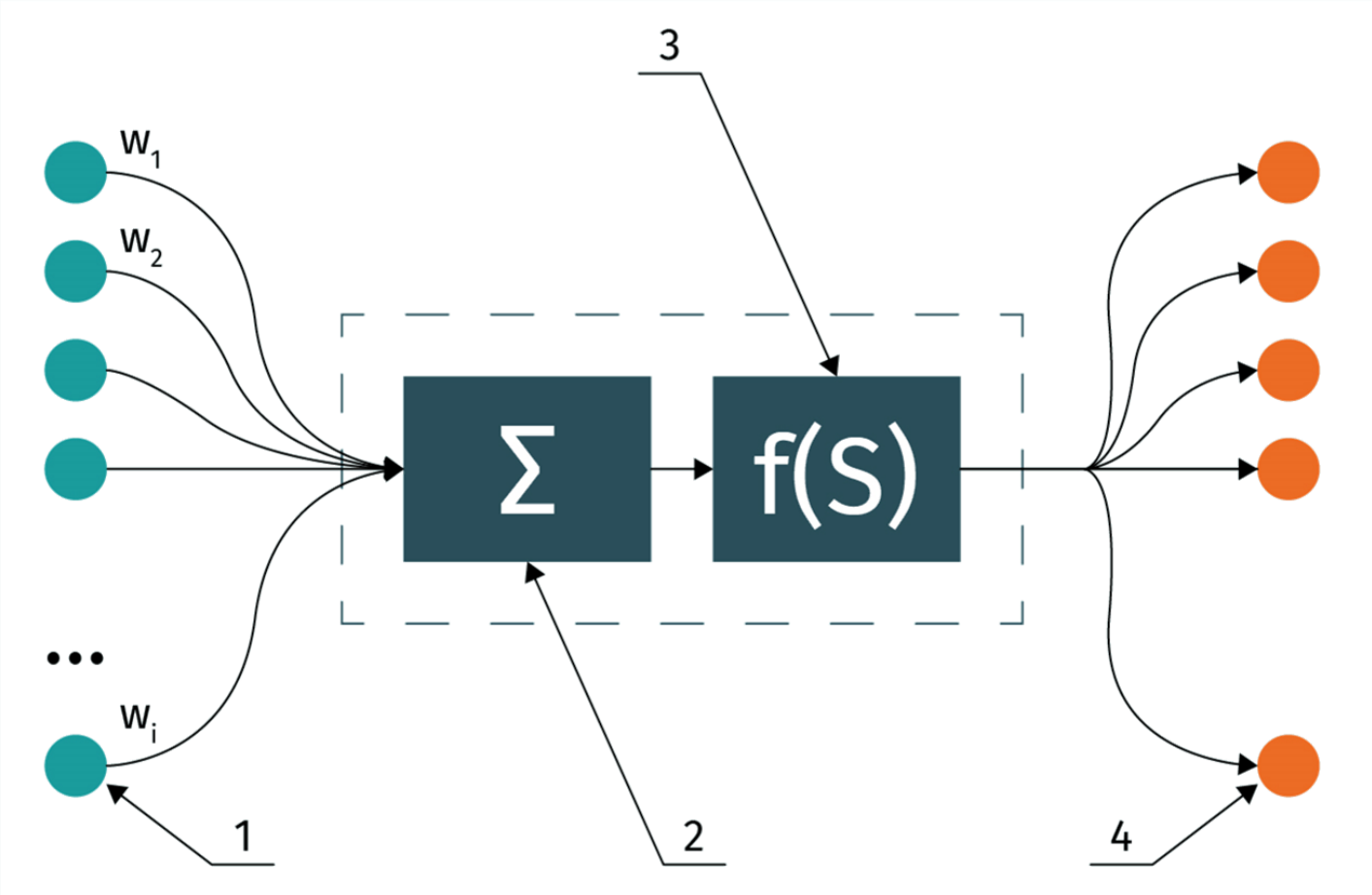
Artificial Neural Network



Source of the graphics: Course Book DLMAIAI01, p.42

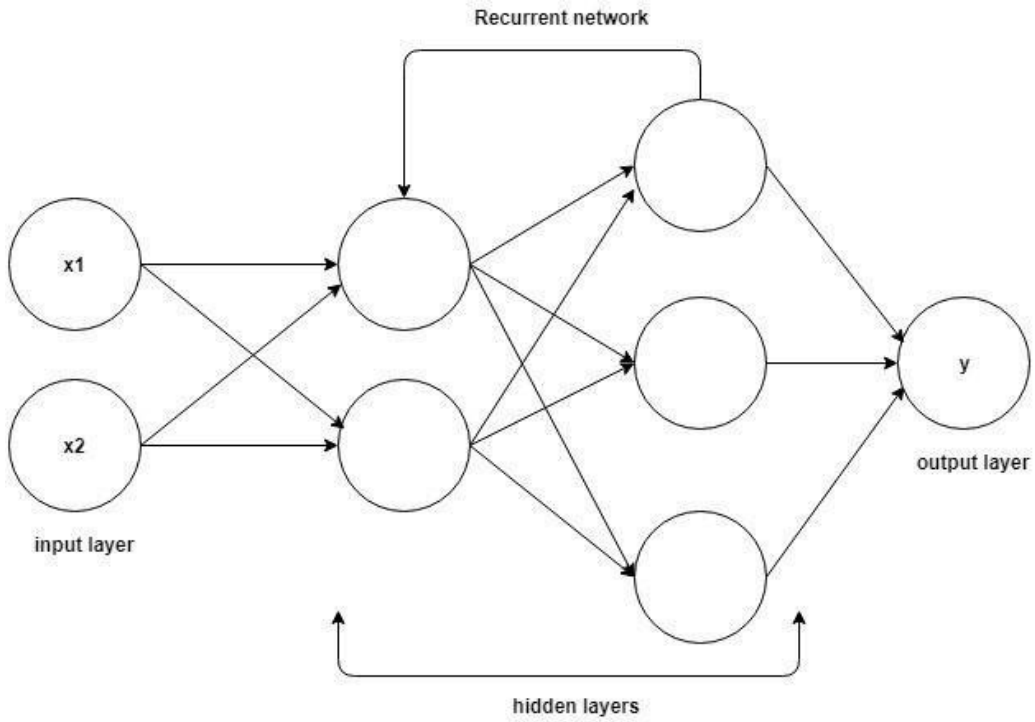
- Computational model of neural activity (Warren McCulloch and Walter Pitts in the 1940s)
  - The cell receives input in the form of electrochemical signals from other neurons that are located upstream in the information processing flow.
  - It then modulates the input according to how often two nerve cells are activated together.
  - The more often this happens, the greater the upregulation of the connection between the neurons.
  - If the total excitation exceeds some predefined threshold, each neuron takes the sum of all its inputs weighted in this manner and sends an impulse along the axon, its outgoing connection.

1. Receive input (weight parameter w_i)
2. Weighted sums are computed
3. Activation function is applied to sum
4. Distributed to output neurons



Source of the graphic Course Book DLMAIAI01, p. 48

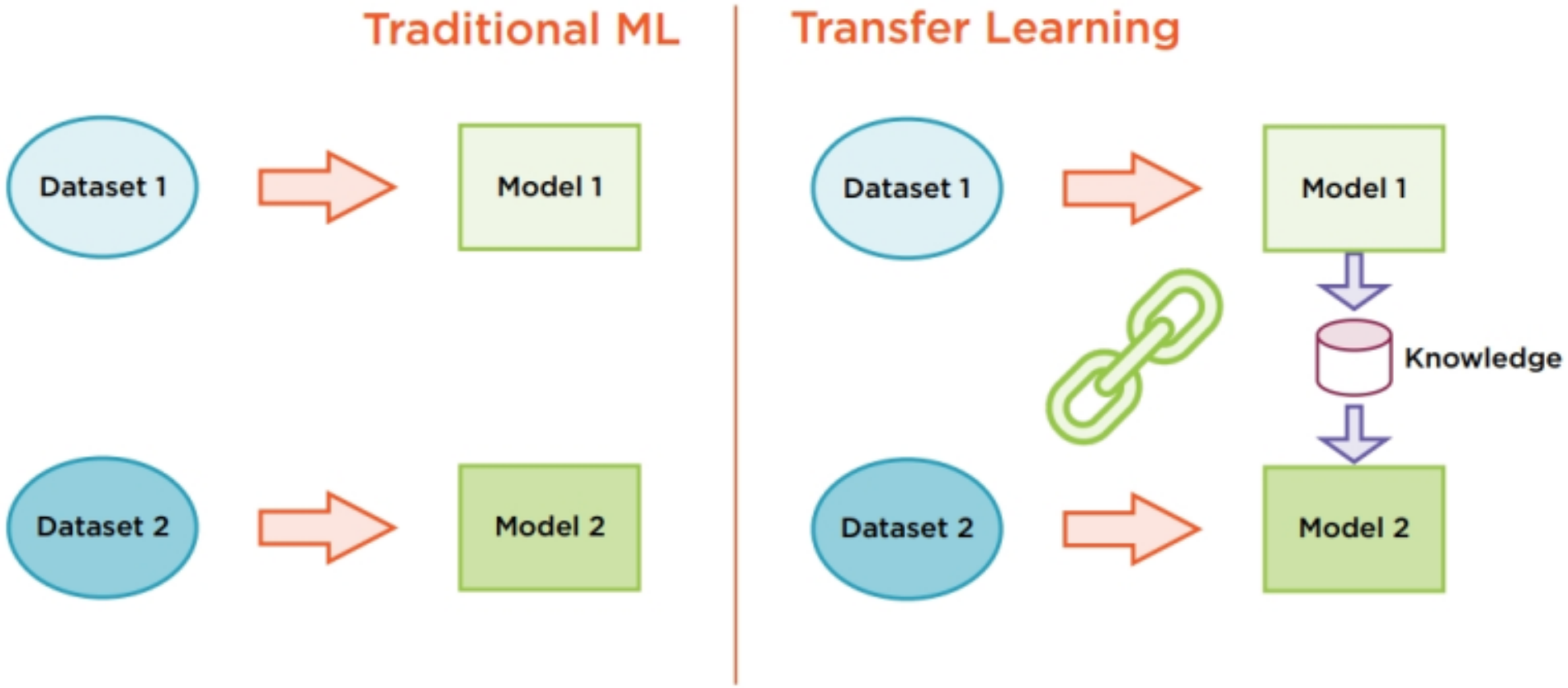
- Feed forward approach
  - Flow of information, only proceeds in one direction—upstream to downstream
- Recurrent approach
  - Flow of information follows a directed graph where the succession of nodes along the graph encodes the temporal succession of processing steps performed by the network



Source of image: Suresh Anand Mathavan, 2020

- Transfer learning is the reuse of a pre-trained model on a new problem
  - Machine exploits the knowledge gained from a previous task to improve generalization about another.
  - Eg. in training a classifier to predict whether an image contains food, you could use the knowledge it gained during training to recognize drinks.
  - Benefit: Avoid designing a model from scratch

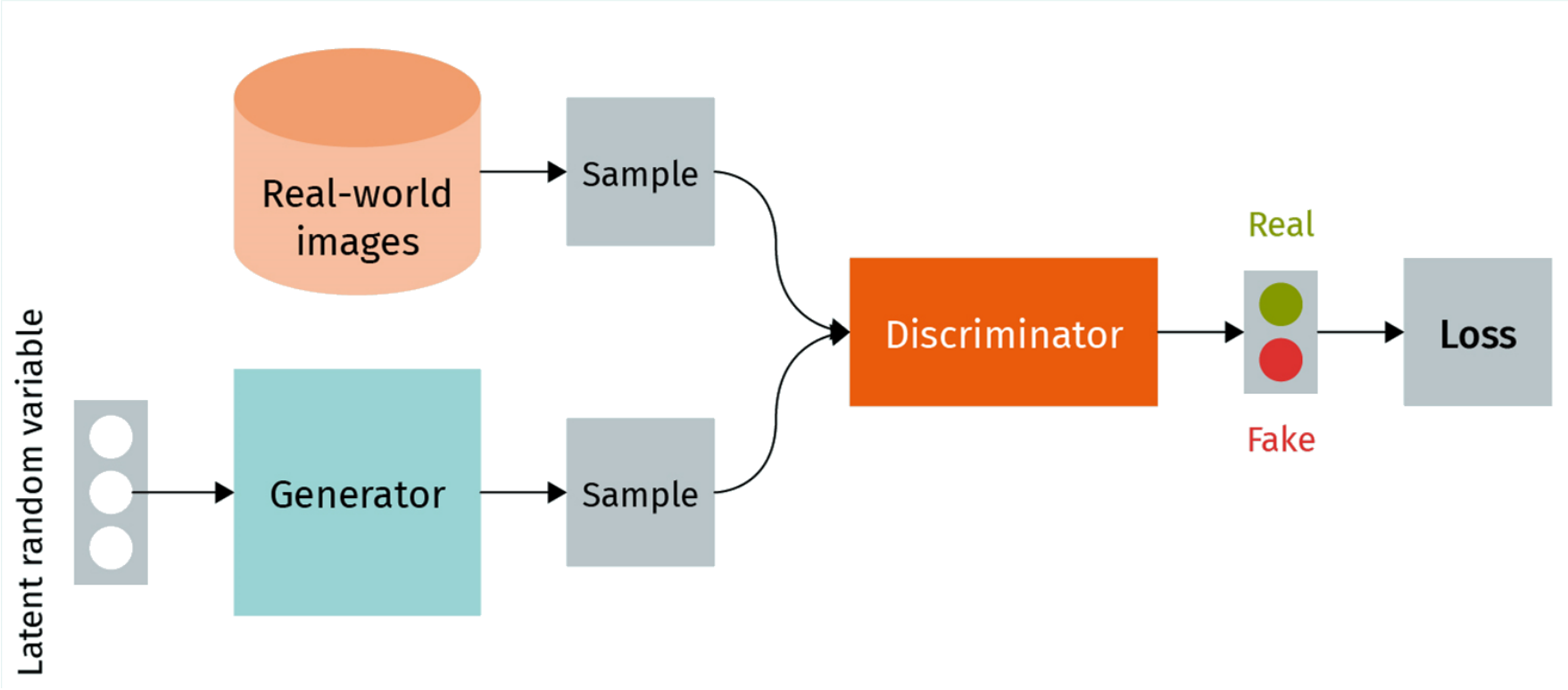
TRANSFER LEARNING



- In 2014, a paper on generative adversarial networks (GANS) was published by Ian Goodfellow and his colleagues. This research paper proposed a new framework for unsupervised learning, in which two neural networks are trained to complete against each other
- GANs becomes one of the most popular and widely-used types if neural networks for generative modeling.
- Useful for data augmentation, reinforcement learning and semi-supervised learning techniques
- https://arxiv.org/abs/1406.2661

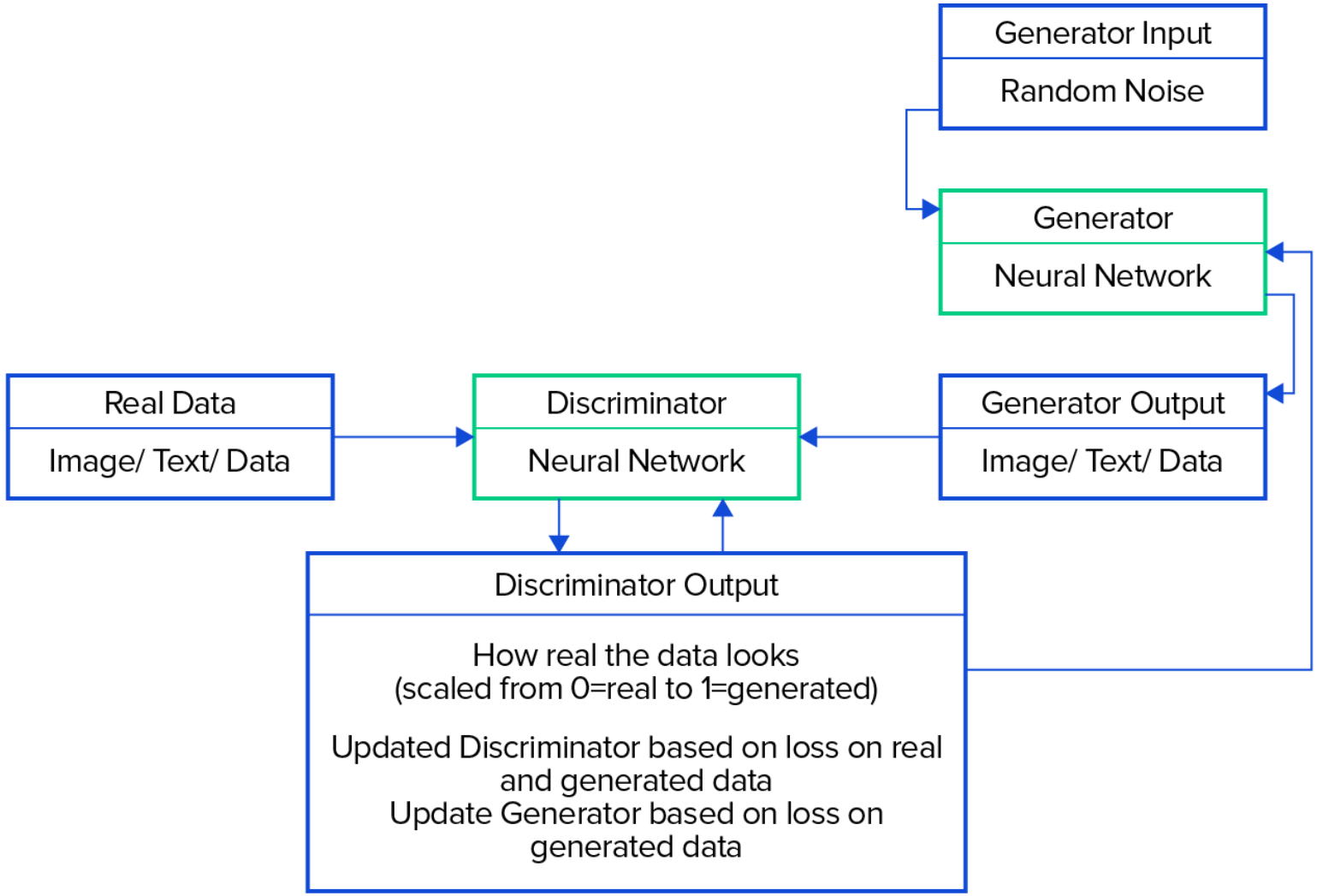
Transfer learning: take trained model and adjust it to new use case with small dataset

Generative Adversarial Networks: (GANs) generate new data with same statistics



Source of the graphic: Course Book DLMAIAI01, p. 52

GANS


Generator Input
Random Noise
Generator
Neural Network
Real Data
Image/ Text/ Data
Discriminator
Neural Network
Generator Output
Image/ Text/ Data
Discriminator Output
How real the data looks
(scaled from 0=real to 1=generated)
Updated Discriminator based on loss on real and generated data
Update Generator based on loss on generated data

GANS

GANS APPLICATIONS

- Generate Examples for Image Datasets
- Generate Photographs of Human Faces
- Generate Realistic Photographs
- Generate Cartoon Characters
- Image-to-Image Translation
- Text-to-Image Translation
- Semantic-Image-to-Photo Translation
- Face Frontal View Generation
- Generate New Human Poses
- Photos to Emojis
- Photograph Editing
- Face Aging
- Photo Blending
- Super Resolution
- Photo Inpainting
- Clothing Translation
- Video Prediction
- 3D Object Generation

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SESSION 3

TRANSFER TASK

Discuss the concept of transfer learning.

Can you think of potential advantages for businesses and scientists?

GANs applications

- Work in group:
  - Select one application of GANs
  - Discuss:
    - Advantages/disadvantages
    - Necessary requirements to develop that application

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

1. What is the purpose of the activation function of the neuron?

   a) It always passes on a signal.
   b) It sends a signal down the axon if a threshold on the inputs is met.
   c) It always blocks a signal.
   d) It never modifies a signal strength.

2. In brain anatomy, the notion of lobes refers to…

a) large-scale compartmentalizations of the brain.
b) the hemisphere split of the brain.
c) anatomic details of dendrites.
d) parts of the peripheral nervous system.

3. Current neural network models as used in artificial intelligence are…

   a) an exact replication of biological neural networks.
   b) not related to biological neural networks at all.
   c) a mostly accurate analogue of biological neural networks.
   d) a coarse analogue to biological neural networks.