LECTURER: Nghia Duong-Trung

NEURAL NETS AND DEEP LEARNING

WHO I AM

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  - Senior Researcher/Project Lead
- Current Employer: IU International University of Applied Sciences
  - Academic Teacher

- PostDoc (2020-2022) in Machine Learning at Technische Universität Berlin, Germany
- PhD (2014-2017) in Machine Learning at The Information Systems and Machine Learning Lab (ISMLL), University of Hildesheim, Germany
- MSc (2009-2011) in Software Engineering at Heilbronn University, Germany
- Profile: https://sites.google.com/ismll.de/duongtrungnghia/

- Course book: DLBDSNNDL01_Neural Nets and Deep Learning, provided by IU, myStudies
- Reading list DLBDSNNDL01, provided by IU, myStudies
- Additional teaching materials:

https://github.com/duongtrung/IU-DLBDSNNDL01_Neural_Nets_and_Deep_Learning

MACHINE LEARNING
TOPIC OUTLINE

UNIT 1

Introduction to Neural Networks

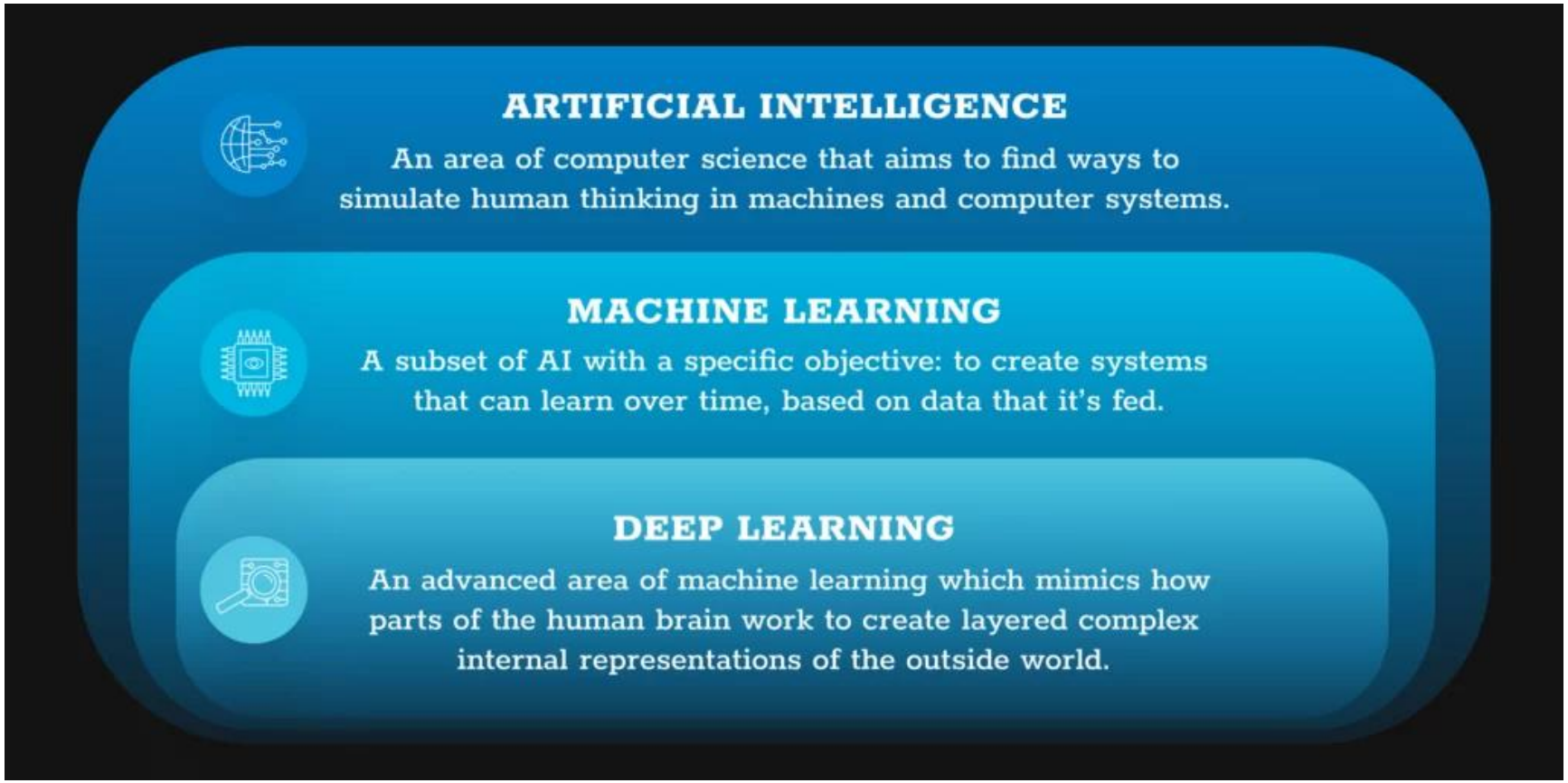
STUDY GOALS

- describe what neurons in the brain are.
- explain how neurons process information in a simple picture.
- understand what the receptive field is.
- recall how perceptrons were developed as the first artificial models of biological neurons.
- explain the relevance of multi-layer perceptrons as the precursors to modern artificial neural networks and deep learning architectures.

INTRODUCTION

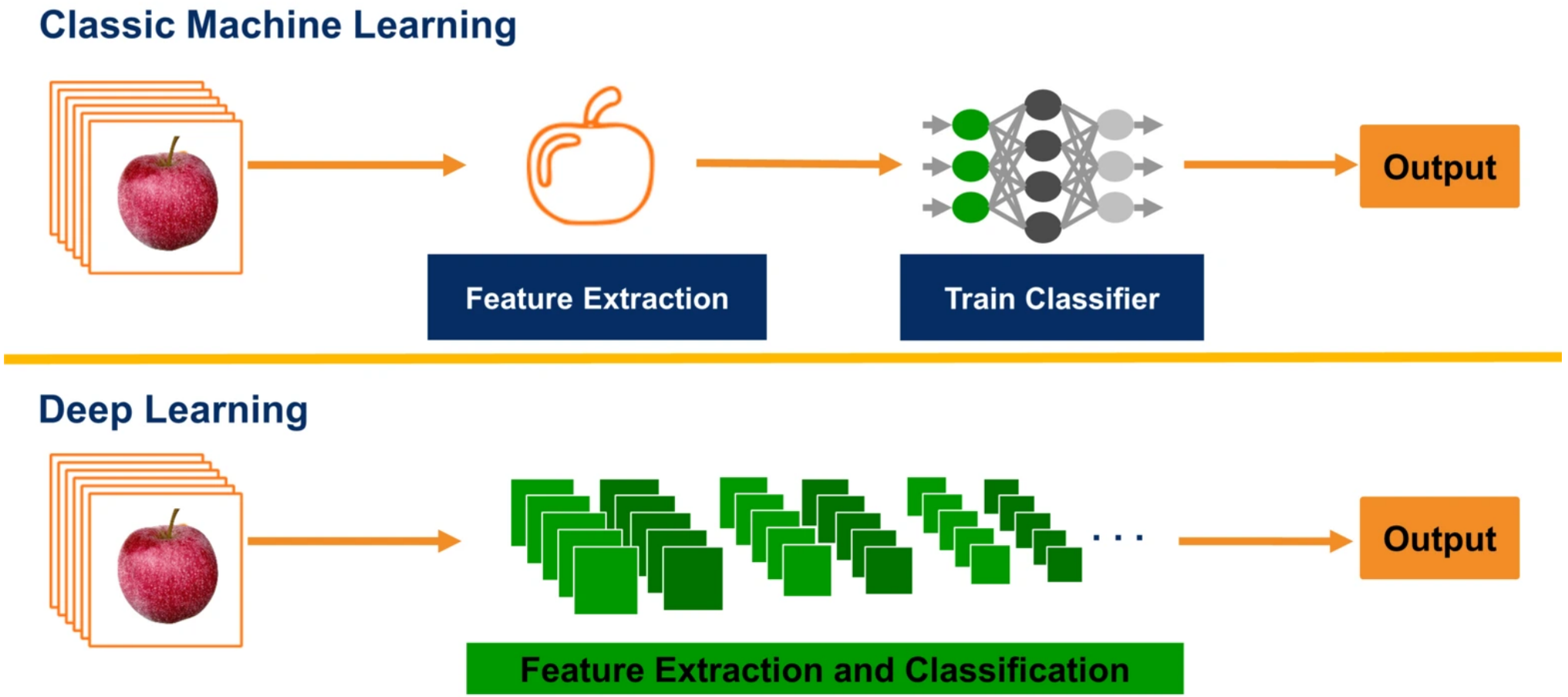
- Neural networks and deep learning have seen tremendous successes in recent years and are at the core of the **current technological revolution** in data science and artificial intelligence. Success stories are heard from all sectors and areas, both in research and industrial applications.
- Its application requires substantial processing power, using **GPUs** with a high-performance capacity to handle the enormous number of calculations needed.

DEEP LEARNING VS MACHINE LEARNING



https://netconomy.net/blog/machine-learning-deep-learning-differences-similarities/

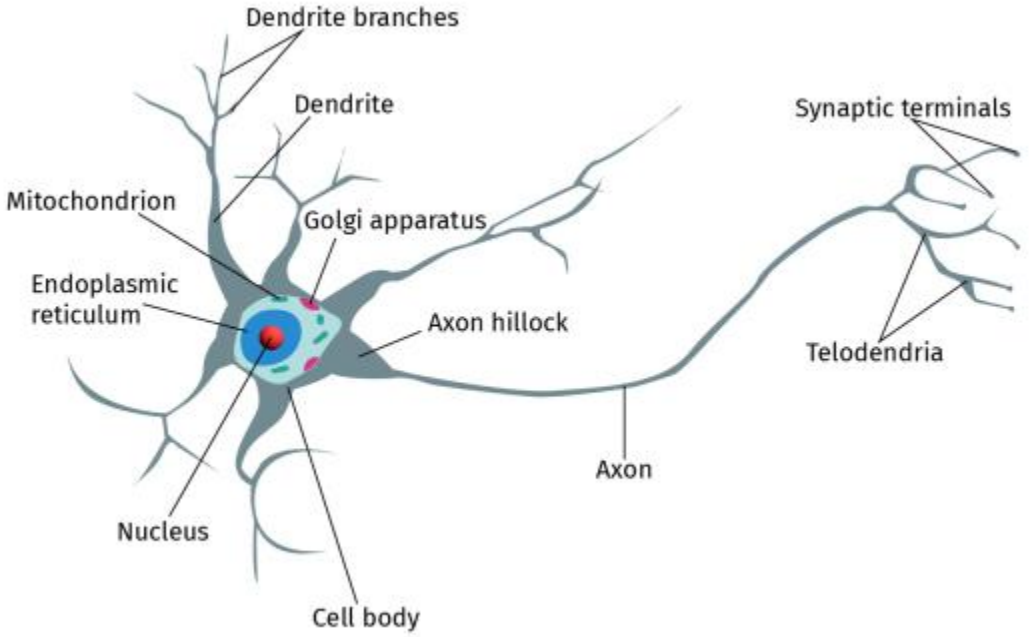
DEEP LEARNING VS MACHINE LEARNING



https://www.mvtec.com/technologies/deep-learning/classic-machine-vision-vs-deep-learning

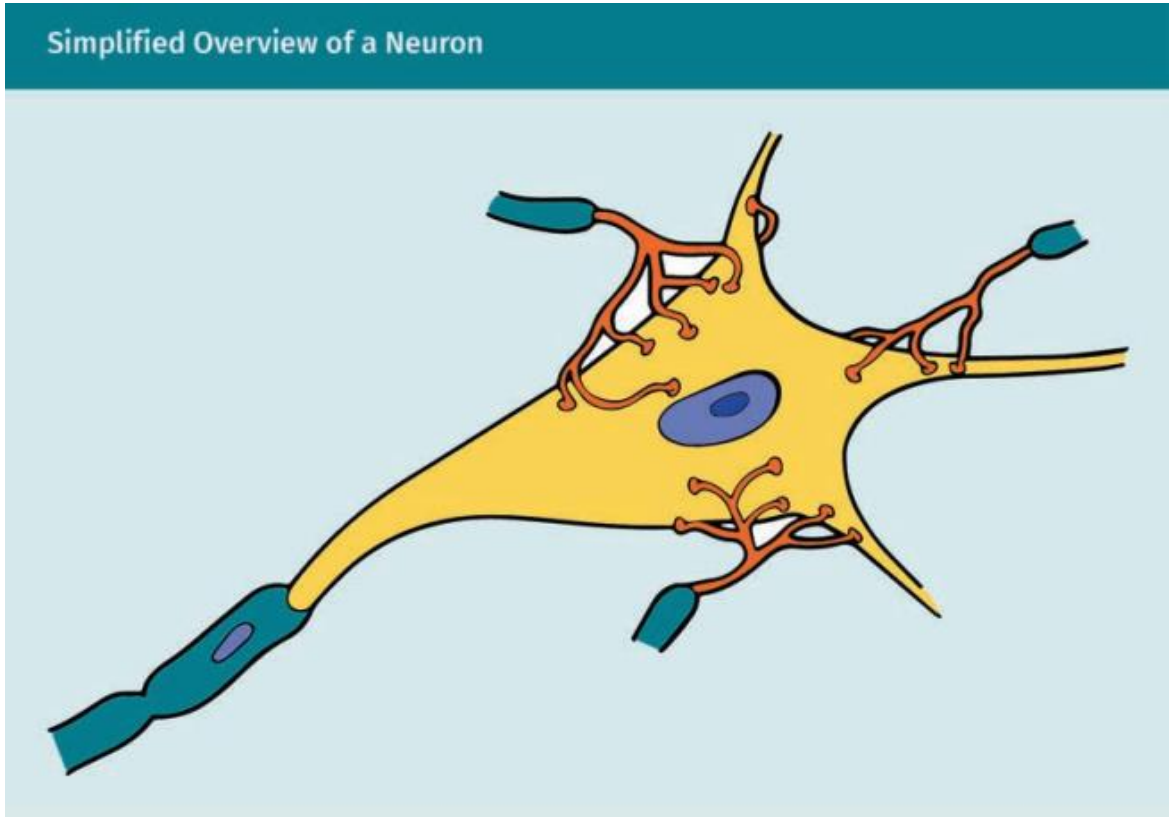
THE BIOLOGICAL NEURON

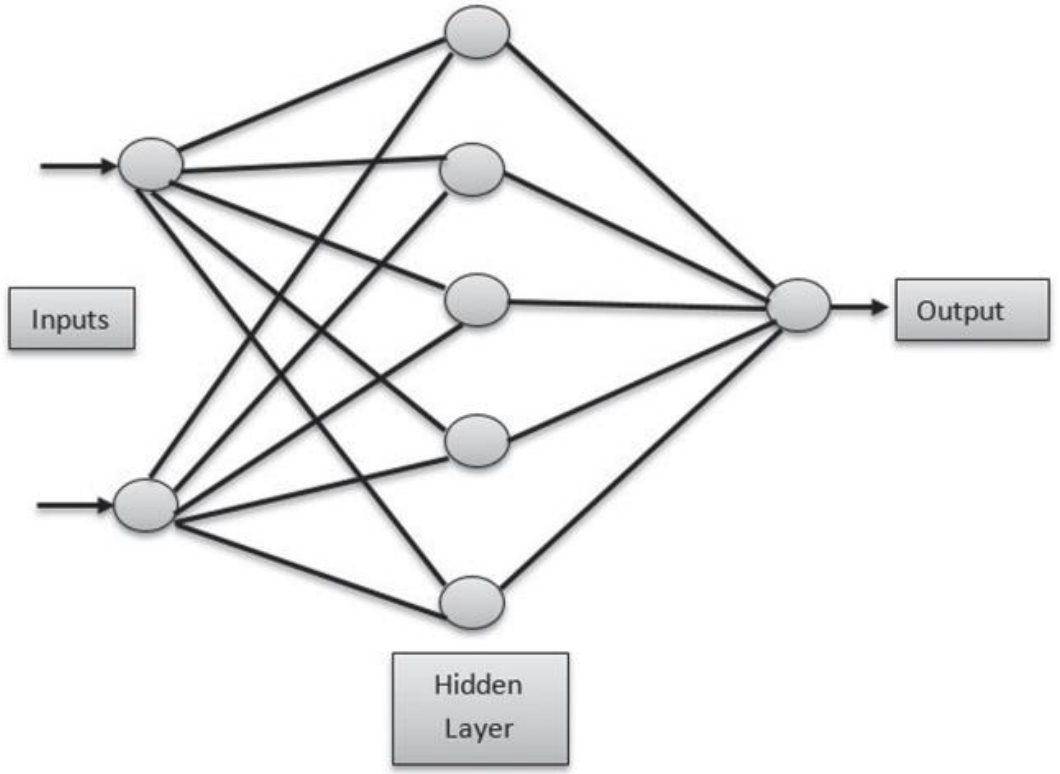
- A biological neuron has dendrites to collect the data from other neurons, and the data is processed by the nucleus .
- The processed information is passed through the transmission channel axon to the terminals for passing the information to the next neuron, and the chain continues.
- Deep Learning is trying to imitate the structure of a neuron in our brain.



Source: BruceBlaus (2013). CC BY 3.0

THE BIOLOGICAL BRAIN TO ARTIFICIAL NEURAL NETWORKS (ANN)

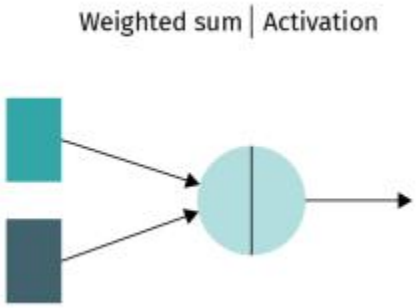


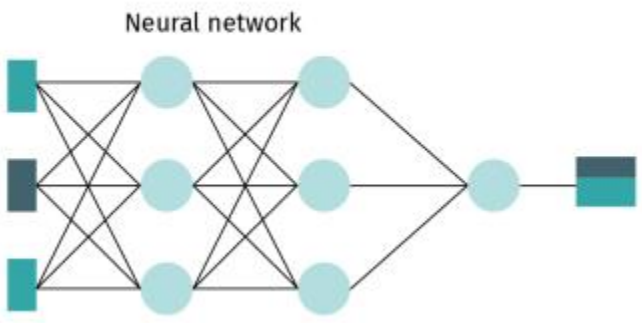


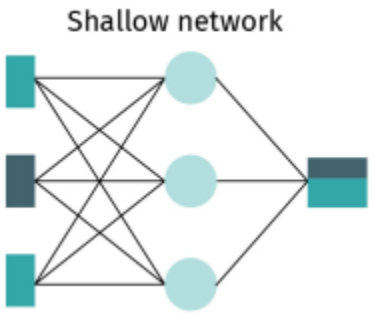
Vasudevan, S. K., Pulari, S. R., & Vasudevan, S. (2021). *Deep learning: a comprehensive guide*. CRC Press.
Zöller, 2022.

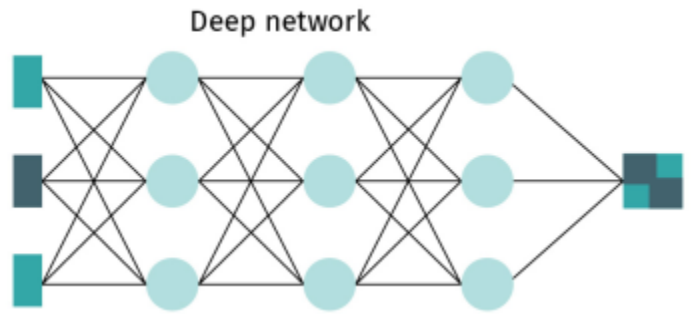
THE BIOLOGICAL BRAIN TO ARTIFICIAL NEURAL NETWORKS (ANN)

- Layers are the core building blocks of a neural network.
- A neural network contains many layers. Typically, each network has three types of layers: an input layer, an output layer, and at least one intermediate layer often known as hidden layer(s).
- Layers are combined into a network to allow it to map and represent the interactions between input and output data.
- The learning model defines the methodology used by the network to identify how to map input data to output targets.





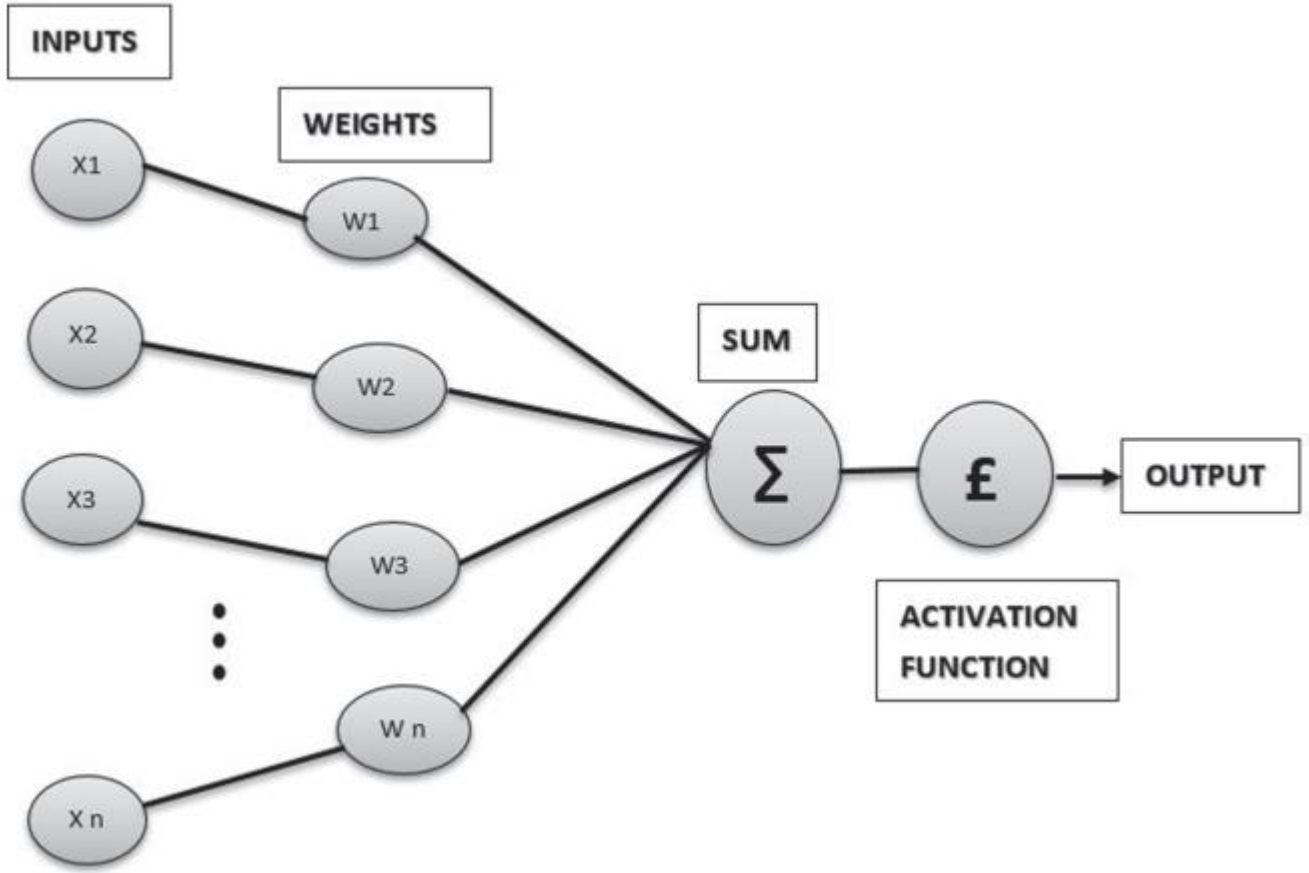




Source: Evis Plaku (2023), based on Amer (2022).

PERCEPTRON

- A neuron is the basic element in any artificial neural networks.
- Perceptron is the unit in the artificial neural network that
  acts as the computational unit for extracting features. This unit also acts as the major business logic to classify or predict from the input data fed to the system (Frank Rosenblatt, 1957).
- Multilevel perceptron, or MLP: feed forward networks with more than one hidden layer apart from the input layer and one output layer.

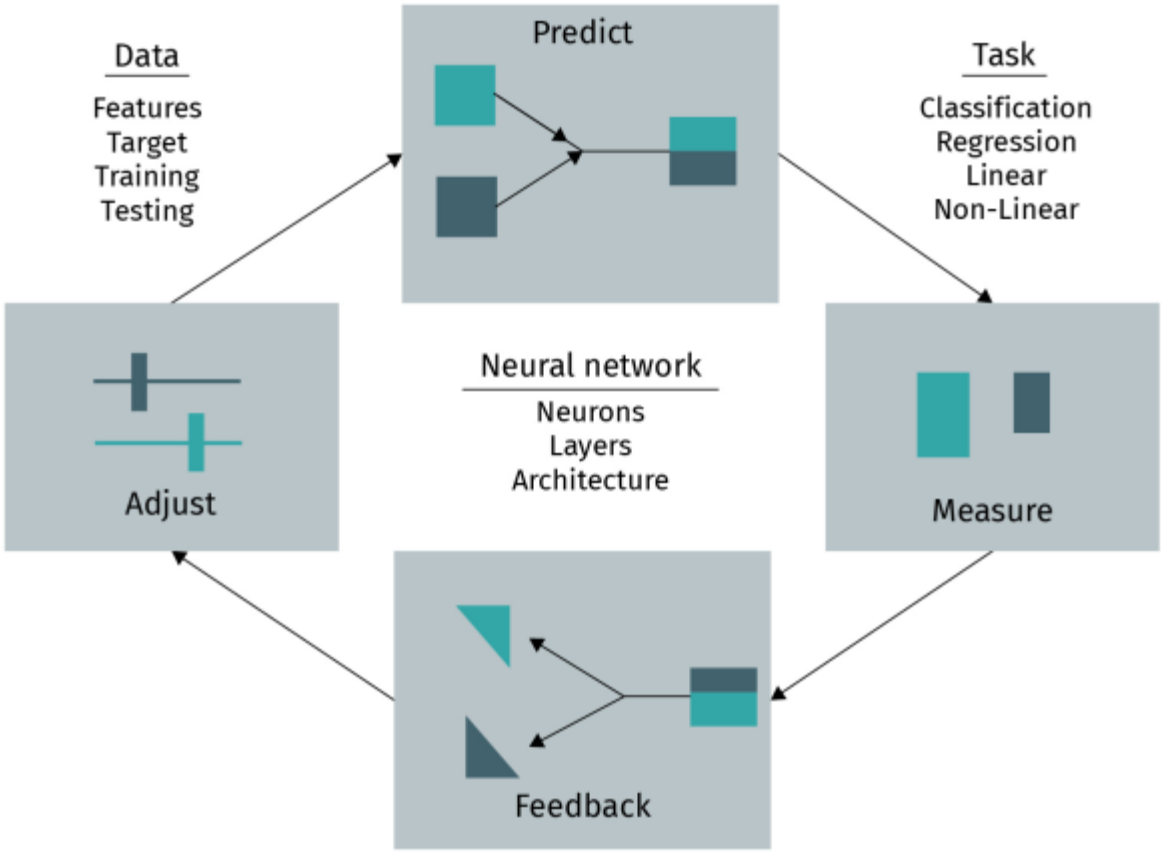


Vasudevan, S. K., Pulari, S. R., & Vasudevan, S. (2021). *Deep learning: a comprehensive guide*. CRC Press.

LOSS FUNCTIONS AND OPTIMIZERS

Equipping a neural network with learning capabilities requires careful consideration of two other fundamental components:

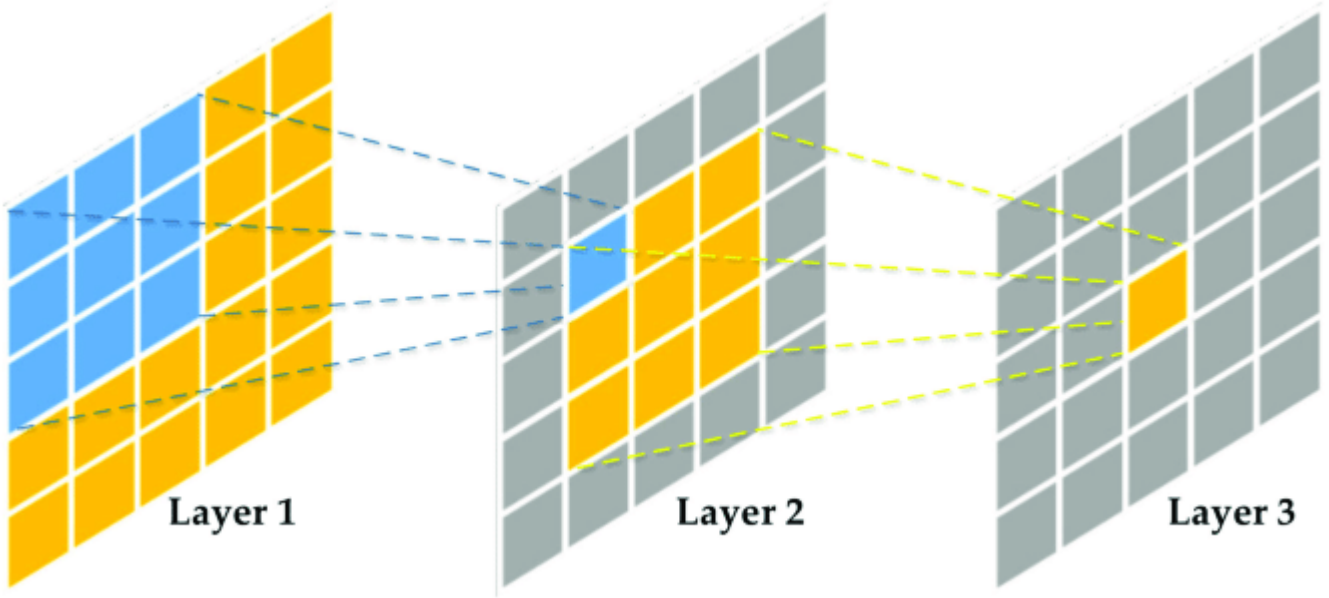
- The objective of the neural network is to minimize the loss function during the learning process.
- The optimization method determines how the neural network will be updated to accommodate the changes suggested by the loss function and, thus, enable learning.



Source: Evis Plaku (2023), based on Amer (2022)

THE RECEPTIVE FIELD

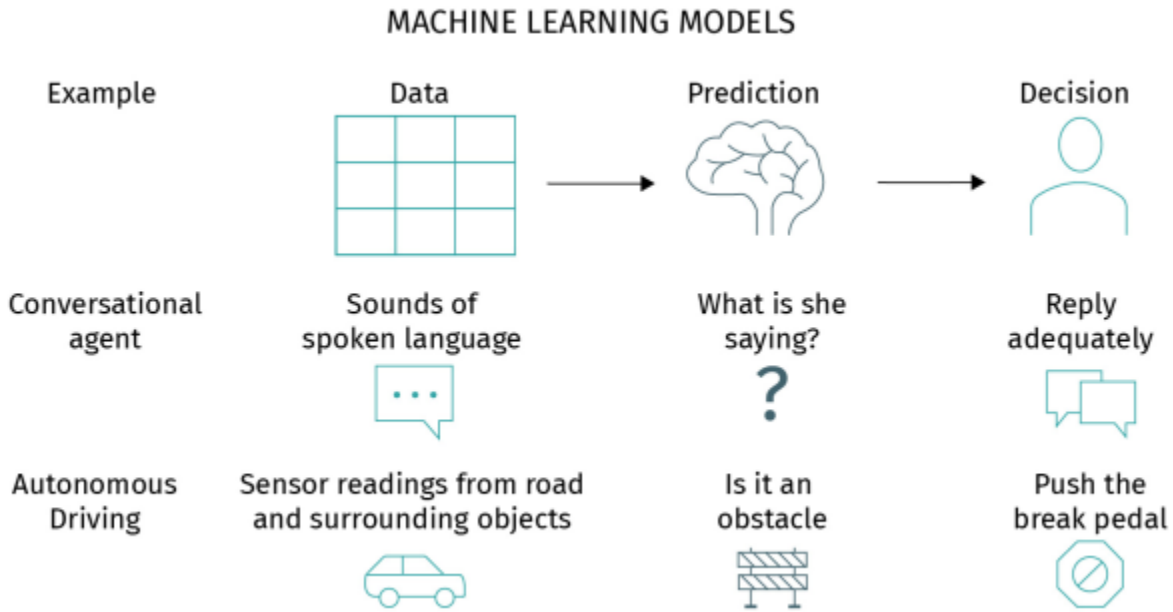
- The receptive field (of a biological neuron) is “the portion of the sensory space that can elicit neuronal responses, when stimulated”
- Based on the image, the entire area (the grid in the figure) an eye can see is called the field of view
- In a deep learning context, the Receptive Field is defined as the size of the region in the input that produces the feature



https://www.researchgate.net/figure/Schematic-diagram-of-the-receptive-field-in-CNNs_fig1_353545214

MACHINE LEARNING CATEGORIES

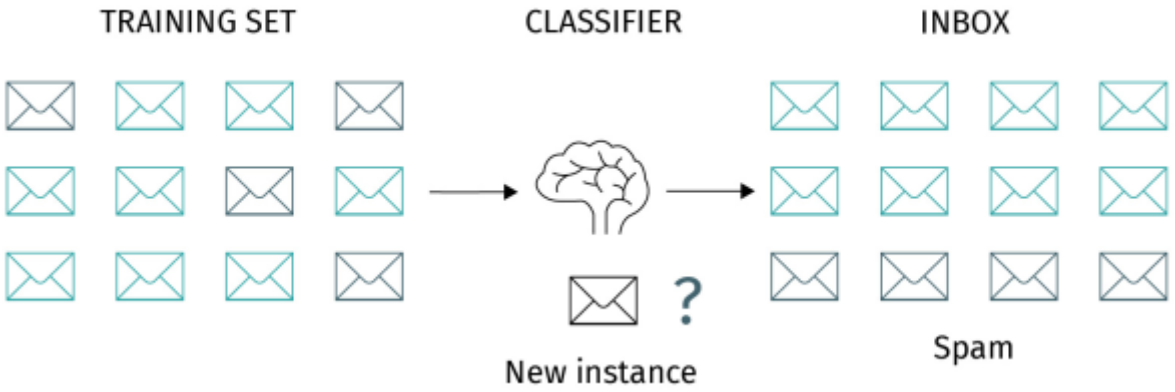
- Learning can take place in many different forms, three main phases are usually observed: (1) the computer agent receives data as input, (2) a prediction is made using the trained model, and (3) a decision or an action follows.

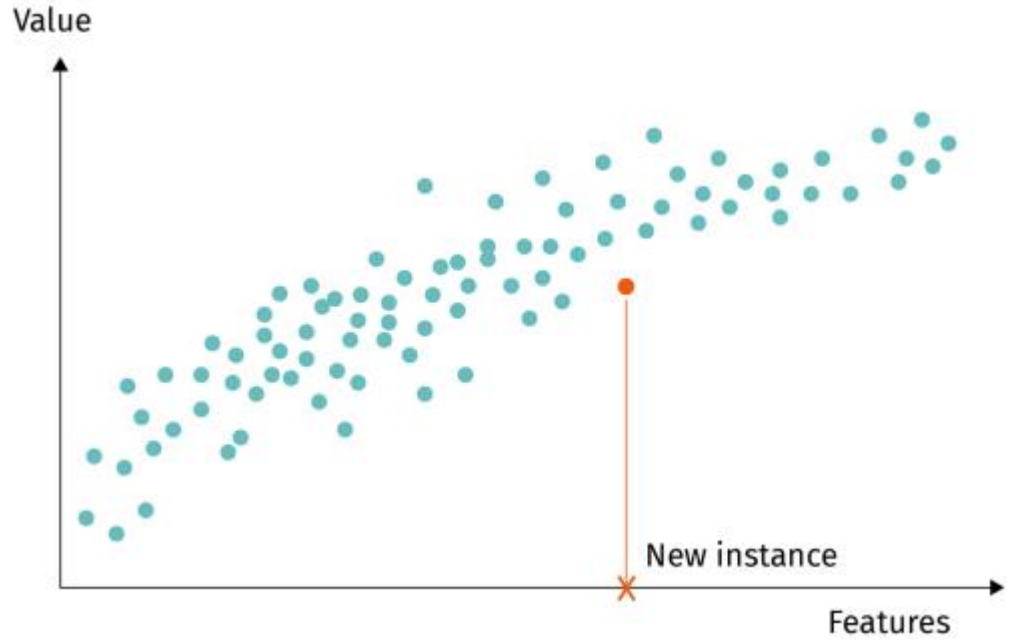


Source: Evis Plaku (2023).

SUPERVISED LEARNING

- Supervised learning is the most common case. Given a set of example training data, the objective is to map input data to known targets, often annotated by a (human) supervisor to denote the expected results.

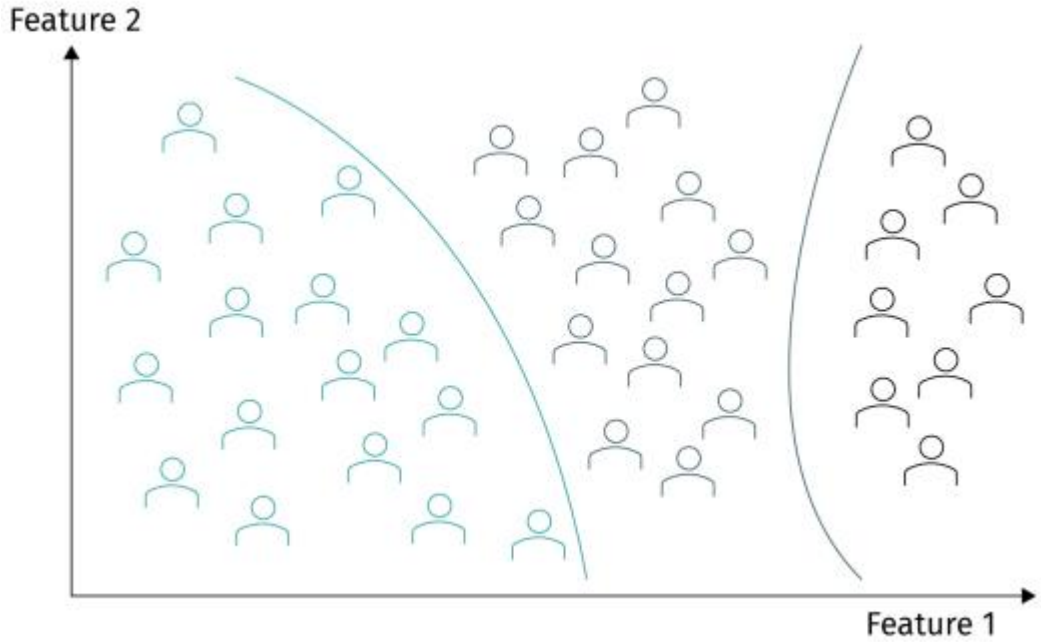




Source: Evis Plaku (2023).

UNSUPERVISED LEARNING

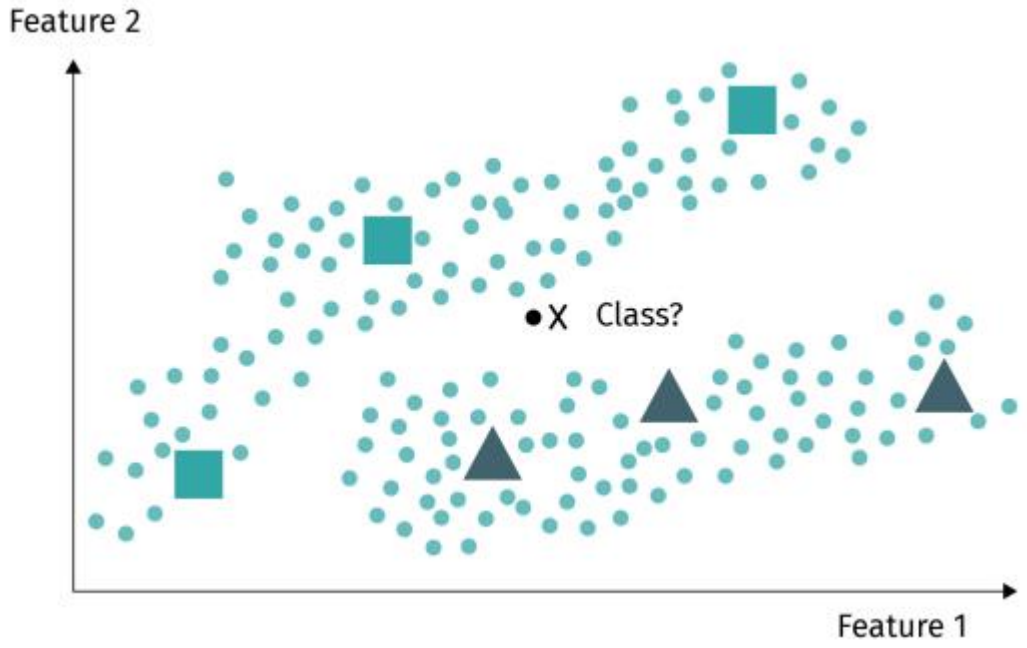
- Unsupervised learning algorithms do not require human (or otherwise) help to label the input data used during the training procedure. Rather, the system learns without a teacher. These algorithms work by discovering hidden patterns or by grouping the data into a set of related items while evaluating their properties.



Source: Evis Plaku (2023).

SEMI-SUPERVISED LEARNING

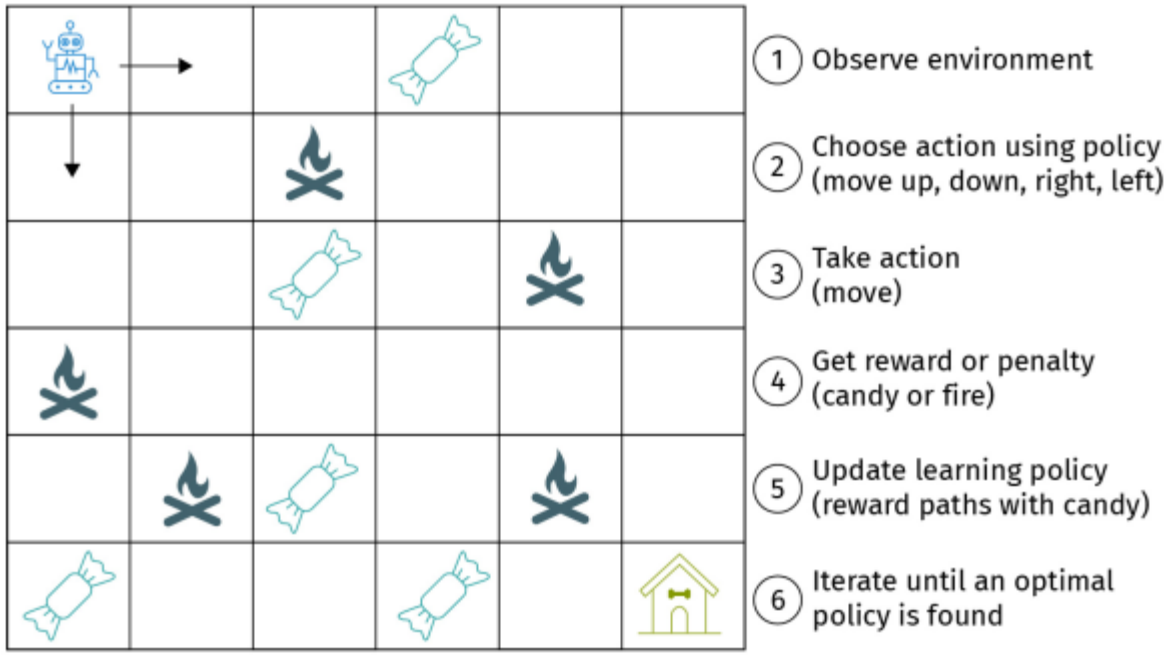
- Semi-supervised learning offers a happy trade-off between supervised and unsupervised learning. The training procedure uses a small set of labeled data for the classification process and a larger, unlabeled set for grouping features.



Source: Evis Plaku (2023).

REINFORCEMENT LEARNING

- Reinforcement learning is a machine learning model that trains a computer agent by rewarding desired behaviors and punishing undesired ones. Given an environment, the task of the computer agent is to perceive and interpret the environment and then take action. Considering the desired outcome, these actions will either be rewarded or punished. The agent will learn, by trial and error, an optimal strategy, known as a policy



Source: Evis Plaku (2023).

TRANSFER TASKS

- Prepare your machine for Deep Learning.
- Execute the notebook MLP.ipynb, PyTorch_ANN_MNIST.ipynb

APPLICATIONS OF DEEP LEARNING

Self Driving Cars
News Aggregation and Fraud News
Computer Vision
Natural Language Processing
Virtual Assistants
Entertainment
Visual Recognition
Fraud Detection
Healthcare
Personalization
Detecting Developmental Delay in Children

Colorization of Black and White images
Adding sounds to silent movies
Automatic Machine Translation
Automatic Handwriting Generation
Automatic Game Playing
Language Translations
Pixel Restoration
Photo Descriptions
Demographic and Election Predictions
Deep Dreaming

Source of the text: Zöller, 2022.

REVIEW STUDY GOALS

- describe what neurons in the brain are.
- explain how neurons process information in a simple picture.
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SESSION 1

Introduction to Neural Networks

TRANSFER TASKS

Select an exciting deep learning project idea and discuss about it.

- Identify your area of interest.
- Quick research existing projects.
- Define your project goals.
- Evaluate available resources and knowledge.
- Discuss the project idea.

- Work in group or individual.

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

1. How many groups of layers that deep learning algorithms are constructed?

a) 2
b) 3
c) 4
d) 5

2. Choosing a batch size that fits your RAM will lead to:

a) A more precise but slower update.
b) A less precise but faster update.
c) A less precise and slower update.
d) A more precise and faster update.

3. In which of the following applications can we use deep learning to solve the problem?

a) Protein structure prediction
b) Detection of exotic particles
c) Prediction of chemical reactions
d) All of the above

4. The number of nodes in the input layer is 10 and the hidden layer is 5. The maximum number of connections from the input layer to the hidden layer are :

a) 50
b) Less than 50
c) More than 50
d) It is a hyperparameter.

LEARNING CONTROL QUESTIONS

1. b
2. a
3. d
4. a

DISCLAIMER

- This is the modified version of the IU slides.
- I used it for my lectures at IU only.