

**LECTURER: Nghia Duong-Trung**

# DEEP LEARNING

## WHO I AM

- Name: Dr. Nghia Duong-Trung
- Senior Researcher / Project Lead @ The German Research Center for Artificial Intelligence (DFKI GmbH)
- Academic Teacher @ IU
  - Teaching courses: Machine Learning, Deep Learning, Artificial Intelligence, Data Science, Data Utilization, Neural Nets and Deep Learning, Introduction to Computer Science
  - Thesis Supervision.
- Profile: <https://sites.google.com/ismll.de/duongtrungnghia/>

## INTRODUCTION TO DEEP LEARNING\_DLMDSDL01

- Course book: Deep Learning\_DLMDSDL01, provided by IU, myCampus.
- Basic Reading, provided by IU, myCampus.
- Video gallery: myCampus.
- Oral assignment, provided by IU, myCampus.
- Online tests and evaluation, provided by IU, myCampus.
- Additional teaching materials:

<https://github.com/duongtrung/IU-DeepLearning-DLMDSDL01>

The GitHub repository is the additional teaching materials, consisting of extra slides regarding the current information on the learning domain. It helps students in discussion and group work. It does not necessarily reflect new questions in examination, and it does not present the IU on those extra content.

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**Introduction to Neural Networks and Deep Learning**

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1

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**Network Architectures**

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**Neural Network Training**

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**Alternative Training Methods**

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4

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**Further Network Architectures**

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5

## UNIT 1

# Introduction to Neural Networks and Deep Learning

## STUDY GOALS

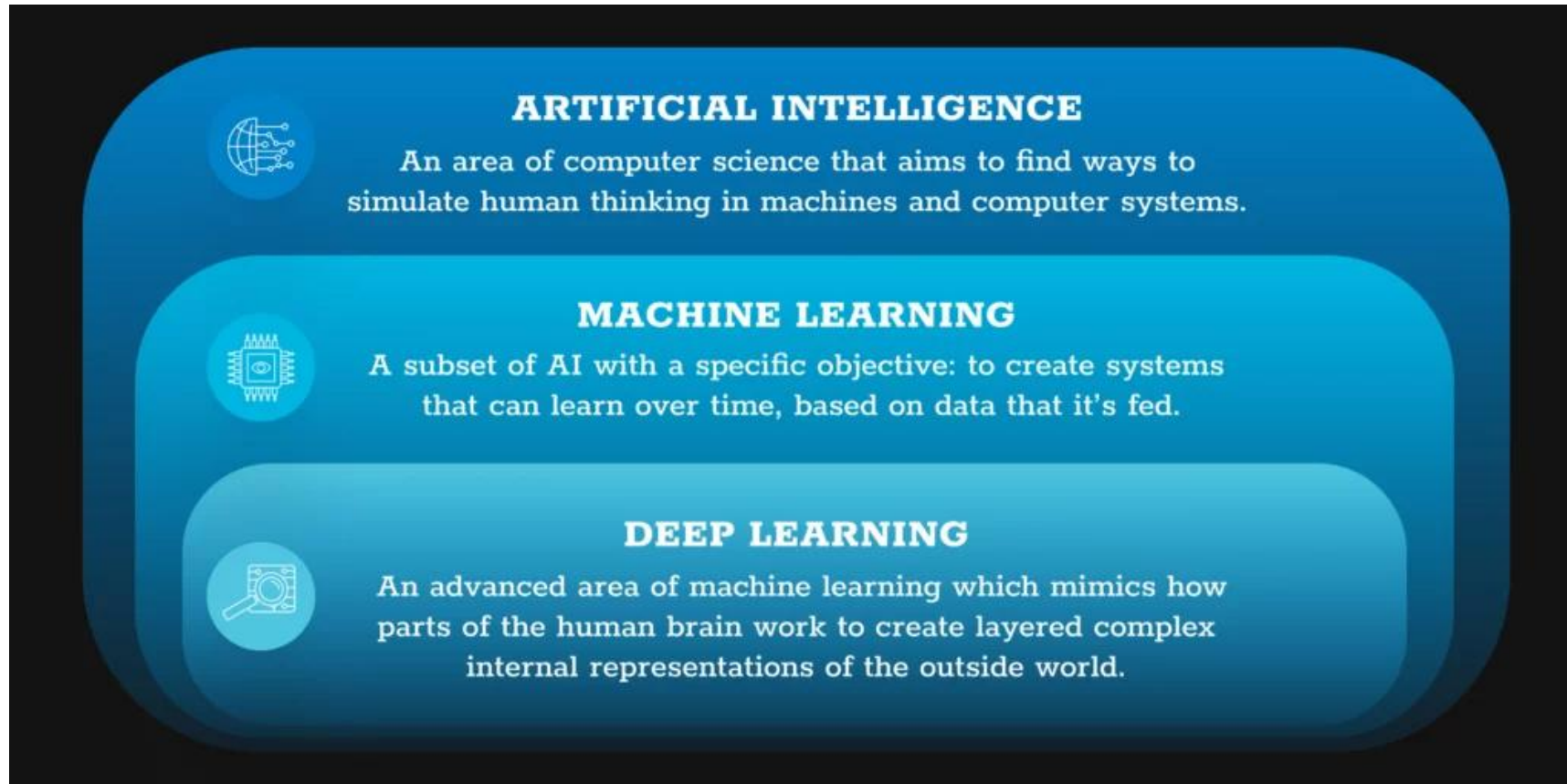


- describe what neurons in the brain are.
- explain how neurons process information in a simple picture.
- understand what the receptive field is.
- recall how perceptrons were developed as the first artificial models of biological neurons.
- explain the relevance of multi-layer perceptrons as the precursors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

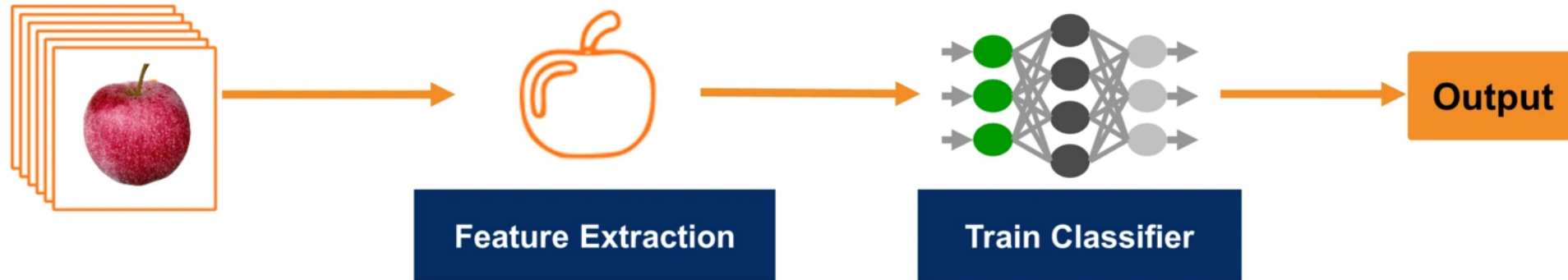
## DEEP LEARNING VS MACHINE LEARNING





## DEEP LEARNING VS MACHINE LEARNING

### Classic Machine Learning

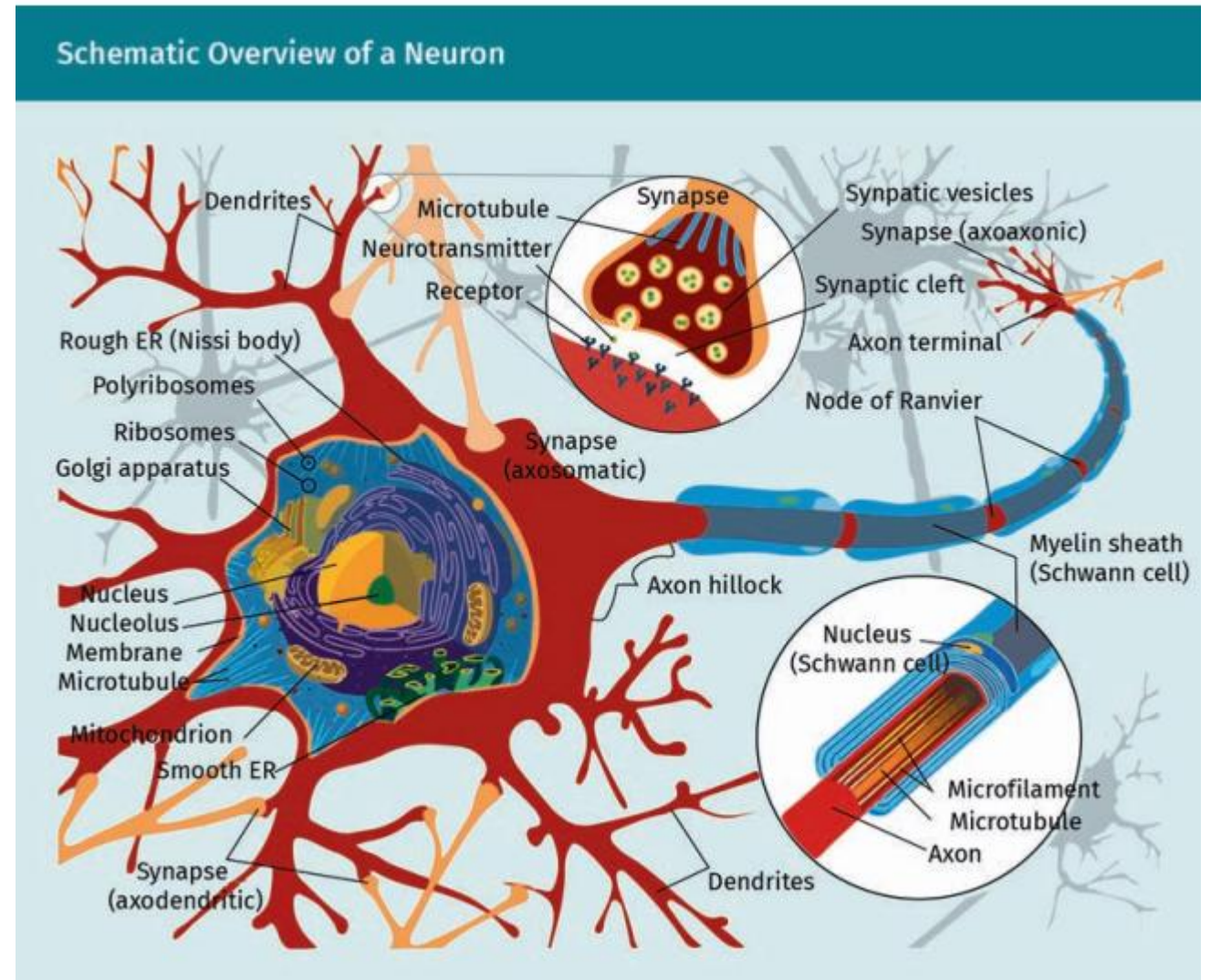


### Deep Learning

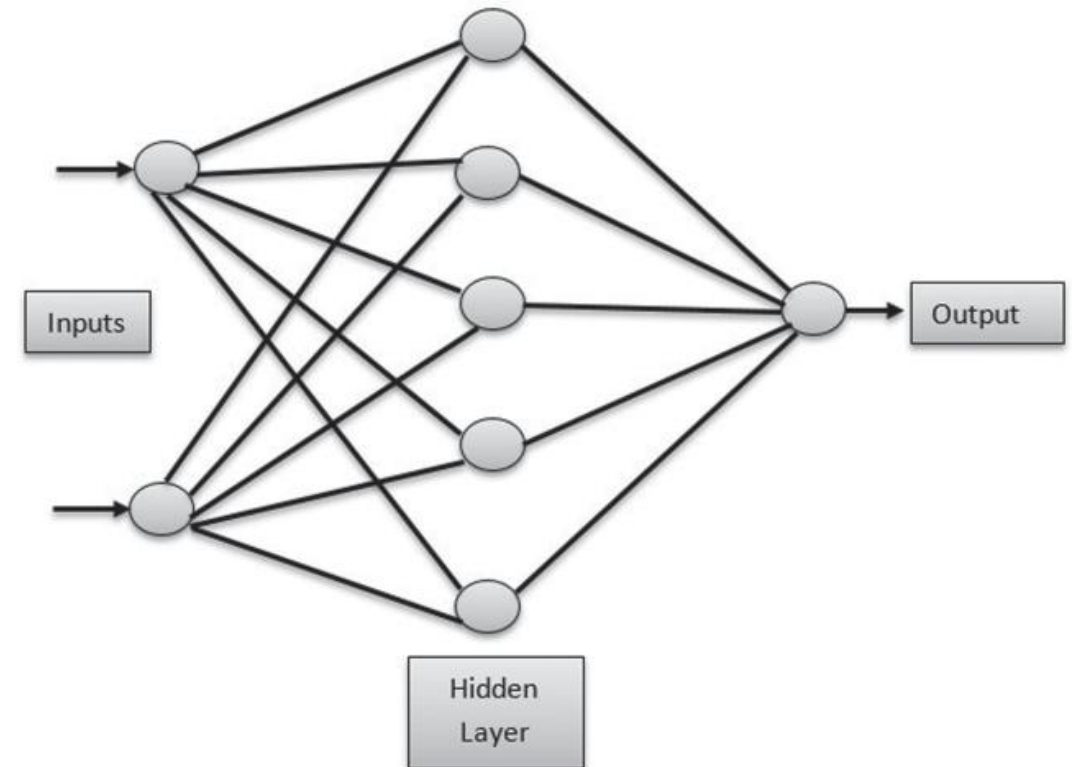
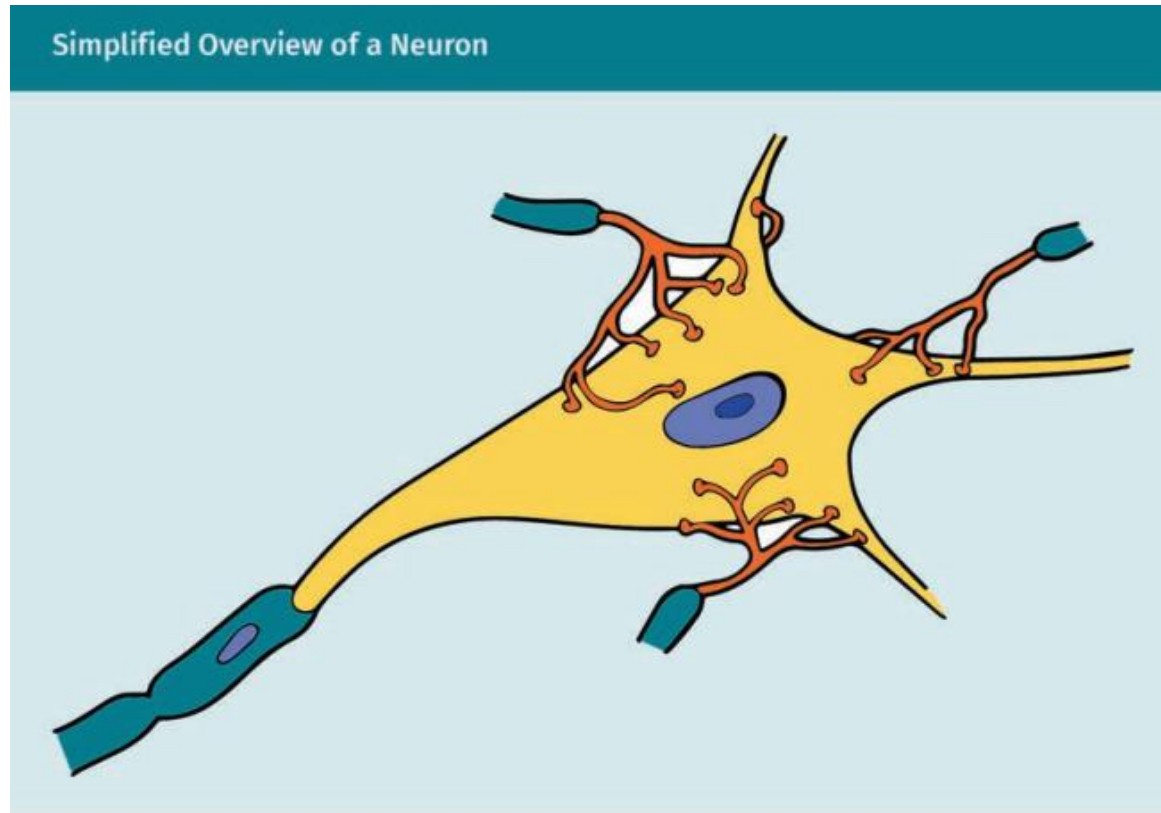


## THE BIOLOGICAL NEURON

- 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.

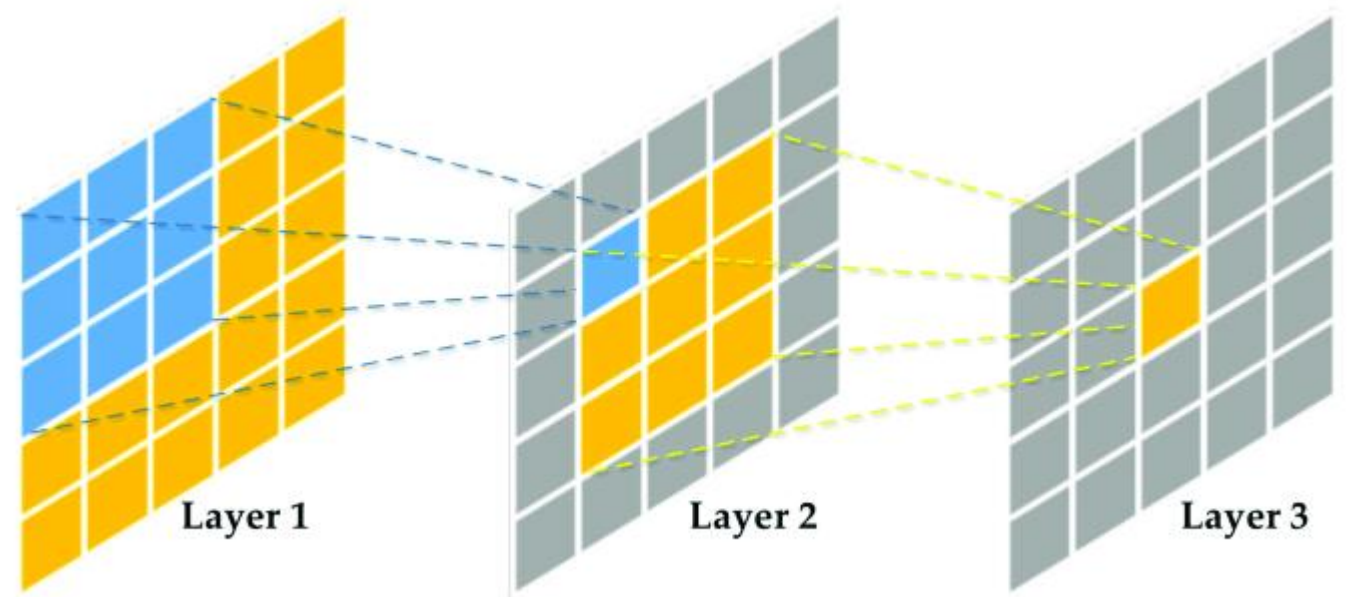


## THE BIOLOGICAL BRAIN



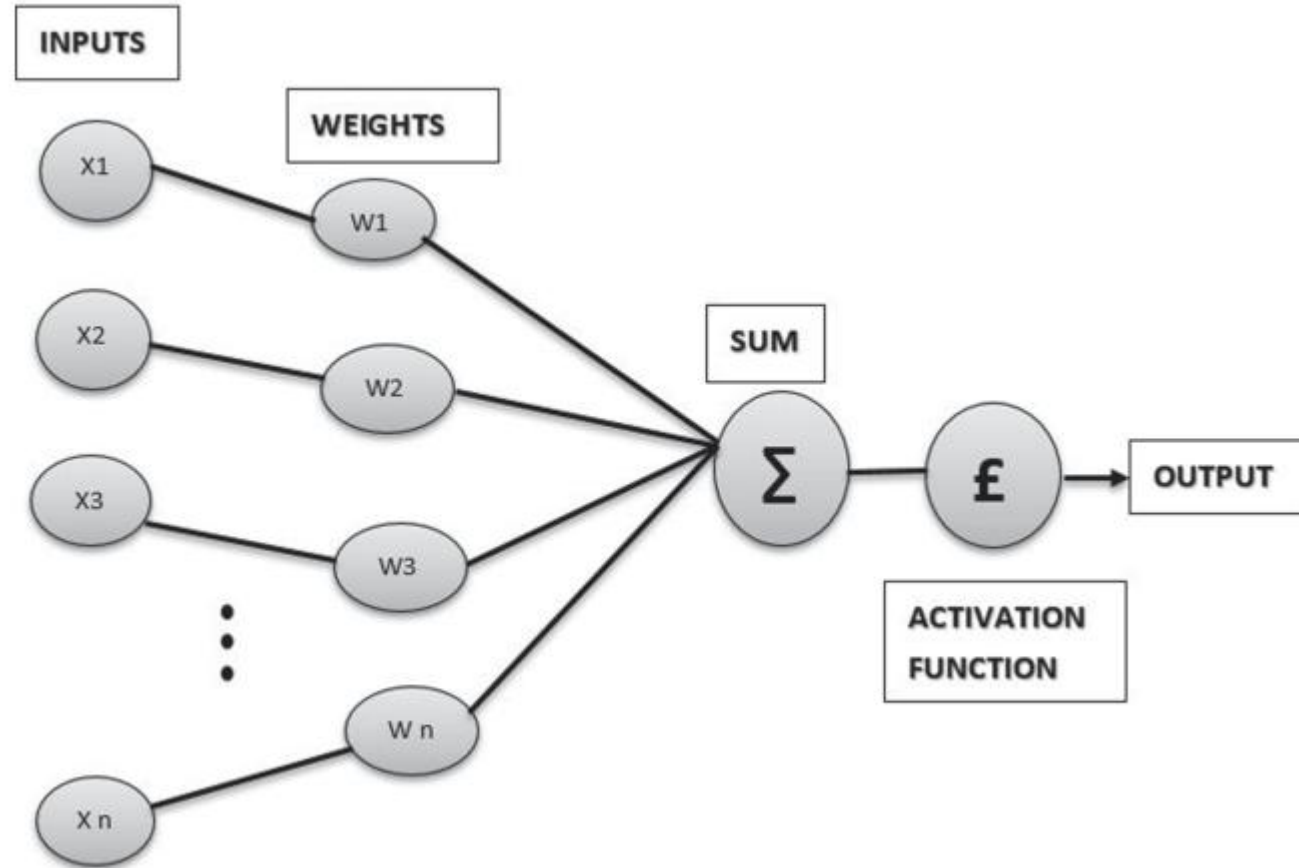
## THE RECEPTIVE FIELD

- 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



## 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.





## MLP: CONCEPT

- **What is an MLP?** A stack of fully-connected (dense) layers that transform an input vector  $x \in \mathbb{R}^d$  into logits  $z \in \mathbb{R}^C$  for  $C$  classes.
- For layer  $\ell$ :  $h^{(\ell)} = f(W^{(\ell)}h^{(\ell-1)} + b^{(\ell)})$  where  $h^{(0)} = x$ ,  $f$  is a nonlinearity (ReLU/tanh), and the final layer usually omits  $f$  to output logits  $z$ . Softmax turns logits into class probabilities.
- **Loss (classification):** cross-entropy  $\mathcal{L} = -\frac{1}{N} \sum_{i=1}^N \sum_{c=1}^C y_{ic} \log(\text{softmax}(z_i)_c)$
- **Optimization:** minimize  $\mathcal{L}$  using SGD/Adam by backpropagating gradients (chain rule) and updating weights.

MLP

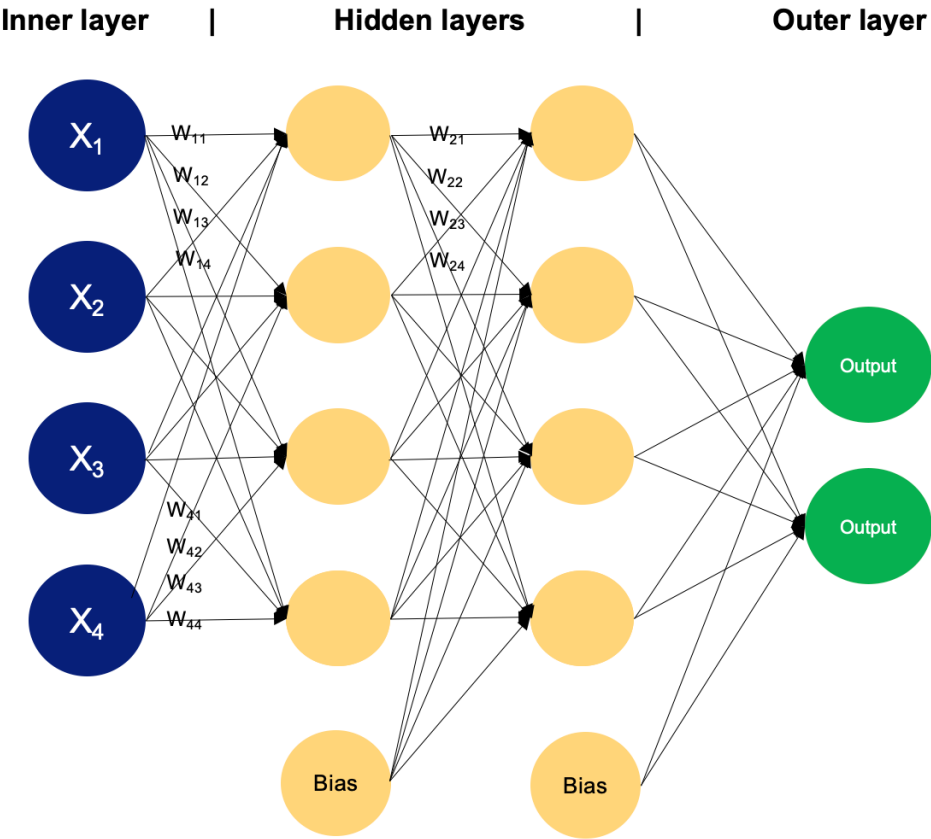


Image source: <https://medium.com/@kisetzuu/multilayer-perceptrons-mcp-for-nonlinear-classification-a-case-study-on-handwritten-digit-2925b5d41908>

## TRANSFER TASKS

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

## REVIEW STUDY GOALS



- describe what neurons in the brain are.
- explain how neurons process information in a simple picture.
- understand what the receptive field is.
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**SESSION 1**

# **Introduction to Neural Networks and Deep Learning**

## 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.

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