The National University of Computer and Emerging Sciences

Introduction To Neural Networks

Machine Learning for Data Science

Dr. Akhtar Jamil

Department of Computer Science

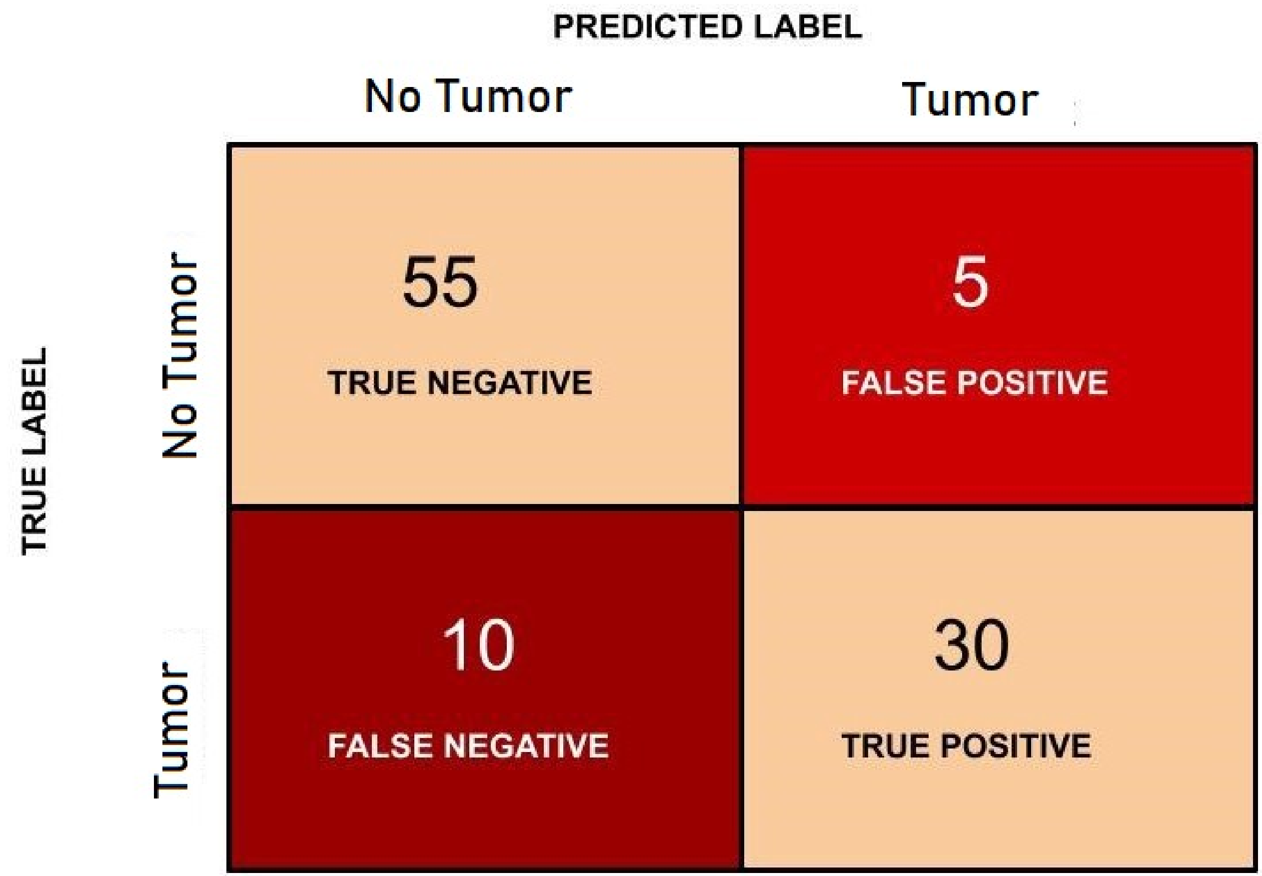
Goals

- Quantitative Evaluation of ML models.
- History of Artificial Neural Networks
- Biological Networks
- What is an Artificial Neural Networks?
- How it works?

Performance Evaluation of a machine learning model

- Different metrics can be used to produce the quantitative results for a model.
- Classification:
  - We commonly use Precision, Recall, f-Measure, Accuracy.
- Regression
  - R Square, Mean Square Error(MSE), Root Mean Square Error(RMSE), Mean Absolute Error(MAE)

Performance Evaluation of a machine learning model



Performance Evaluation of a machine learning model

$$\text{Precision} = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

$$\text{Recall} = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

$$\text{F1} = 2 \times \frac{Precision * Recall}{Precision + Recall}$$

$$Accuracy = \frac{TN + TP}{TN + FP + TP + FN}$$

Performance Evaluation of a machine learning model

- A **true positive (TP)** is an outcome where the model *correctly* predicts the *positive* class.
- **True negative** (TN) is an outcome where the model *correctly* predicts the *negative* class.
- A **false positive** is an outcome where the model *incorrectly* predicts the *positive* class. **False negative** is an outcome where the model *incorrectly* predicts the *negative* class.

History of the Artificial Neural Networks

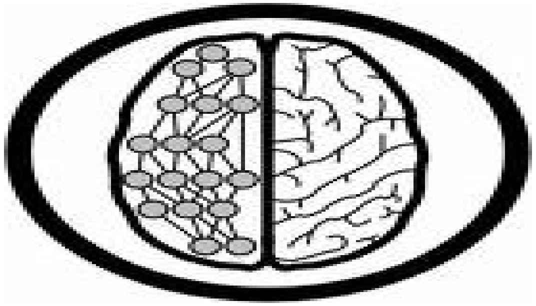
- The history of the ANNs stems from the 1940s, the decade of the first electronic computer.
- However, the first important step took place in 1957 when Rosenblatt introduced the first concrete neural model, the perceptron.
- Rosenblatt also took part in constructing the first successful neurocomputer, the Mark I Perceptron.

History of Artificial Neural Networks

Since then, research on artificial neural networks has remained active, leading to many new network types, as well as hybrid algorithms and hardware for neural information processing.

How do ANNs work?

- An artificial neural network (ANN) strives to simulate the information processing capabilities of its Human Brain.
- ANNs are typically composed of a great number of interconnected artificial neurons.
- The artificial neurons are the processing units
  - Simplified models of their biological counterparts.
- ANN is a technique for solving problems by constructing software that works like our brains.



How do our brains work?

- The Brain is a massively parallel information processing system.
- Our brains are a huge network of processing elements called neurons.
- A typical brain contains a network of 10 billion
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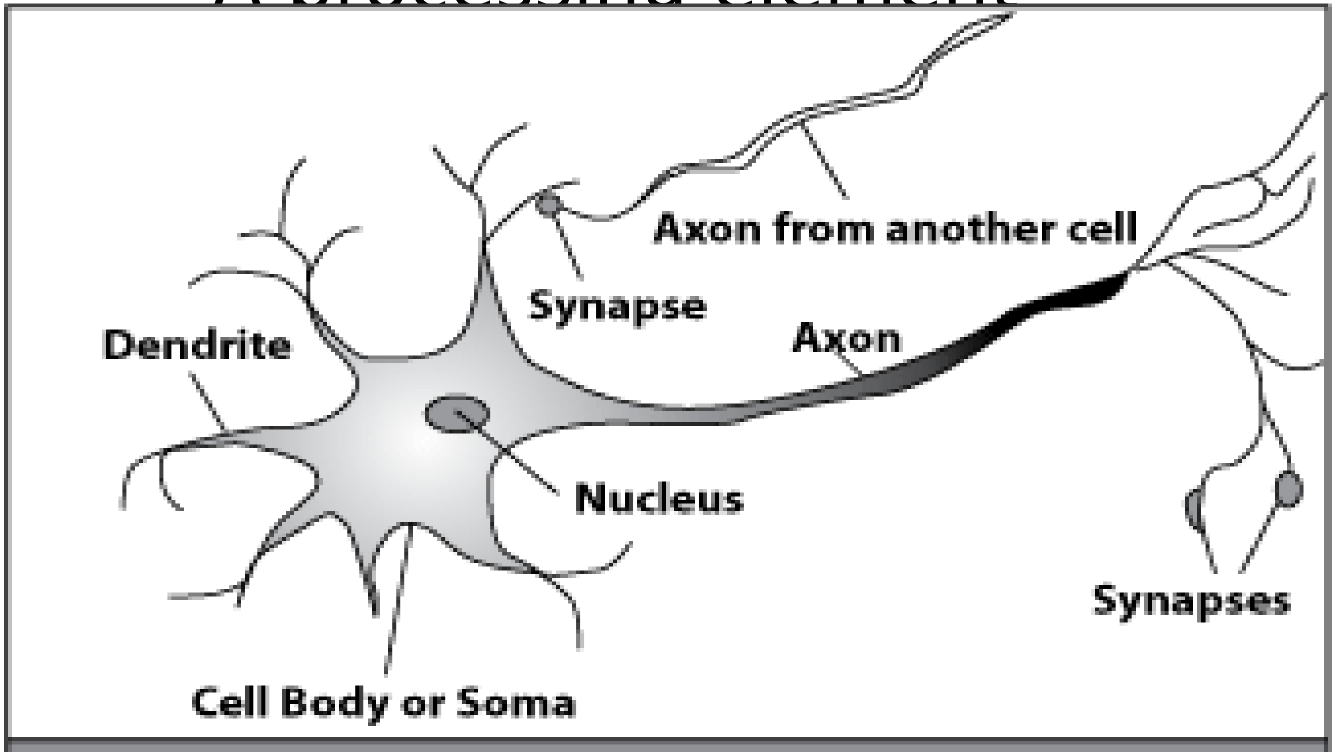
How do our brains work?

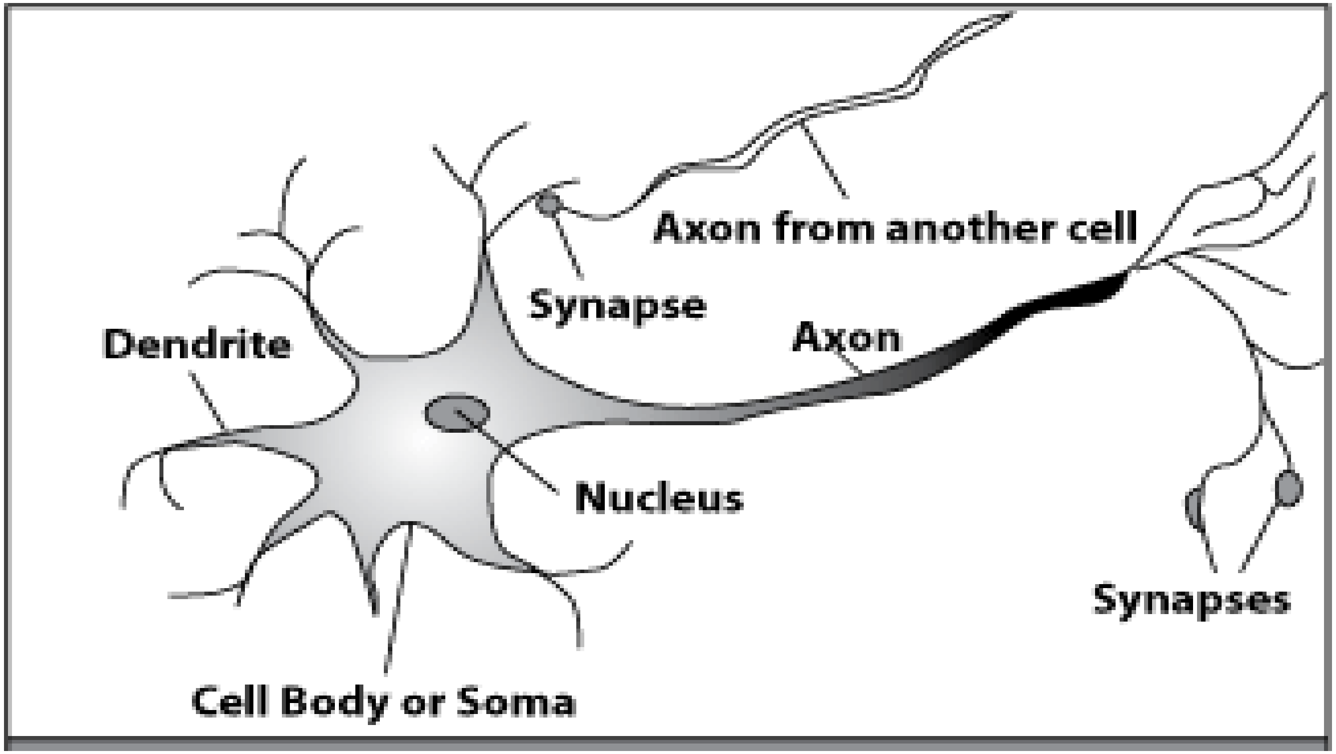
- A processing element



Dendrites: Input
Cell body: Processor
Synaptic: Link
Axon: Output

How do our brains work?

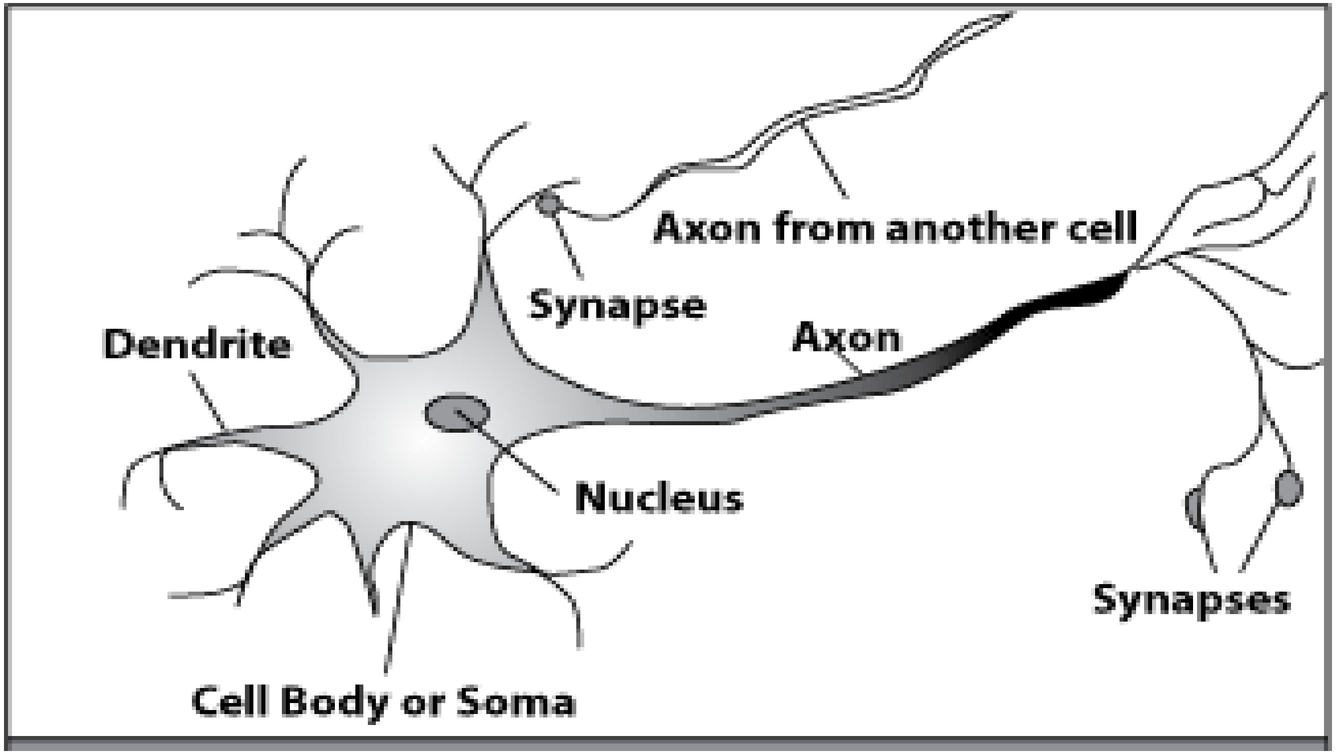
- A processing element



A neuron is connected to other neurons through *synapses*

How do our brains work?

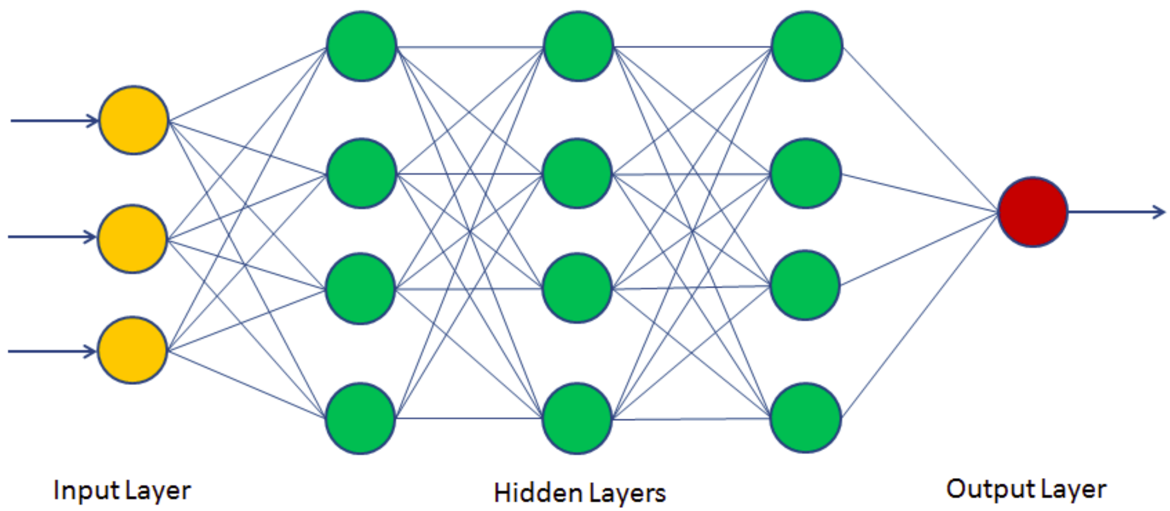
- A processing element



This link is called a synapse. The strength of the signal that reaches the next neuron depends on factors such as the amount of neurotransmitter available.

Artificial Neural Network

- An artificial neural network consists of a number of simple processing units which communicate by sending signals to each other over a large number of weighted connections.

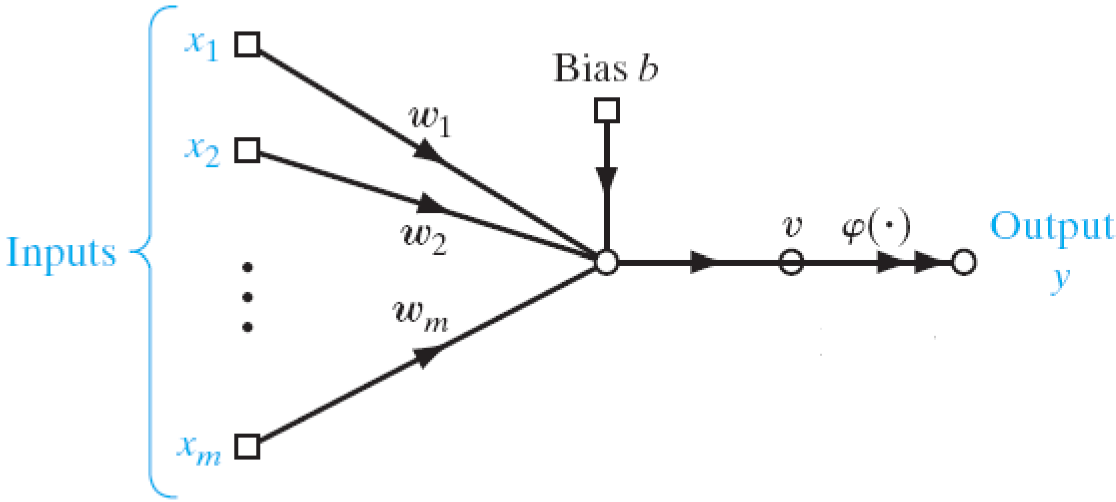


Artificial Neural Networks

- The “building blocks” of neural networks are the **neurons**.
  - In technical systems, we also refer to them as **units** or **nodes**.
- Basically, each neuron
  - receives **input** from many other neurons.
  - changes its internal state (**activation**) based on the current input.
  - sends **one output signal** to many other neurons, possibly including its input neurons (recurrent network).

Rosenblatt's perceptron model

- Rosenblatt's original perceptron model contained only one layer.
- From this, a multi-layered model was derived in 1960.
- The input is summed after multiplying with weights and the output is produced with as positive or negative



Rosenblatt's perceptron model

- At first, the use of the multi-layer perceptron (MLP) was complicated by the lack of an appropriate learning algorithm.
- In 1974, Werbos came to introduce a so-called backpropagation algorithm for the three-layered perceptron network.

Rosenblatt's perceptron model

- The synaptic weights of the perceptron are denoted by w1,w2, ...,w_m.
- The inputs applied to the perceptron are denoted by $x1$, $x2$, ..., x_m.
- The externally applied bias is denoted by *b.*
- *The output can be calculated by:*

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

Rosenblatt's perceptron model

- In the simplest form of the perceptron, there are two decision regions
- separated by a *hyperplane*, which is defined by

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

Rosenblatt's perceptron model

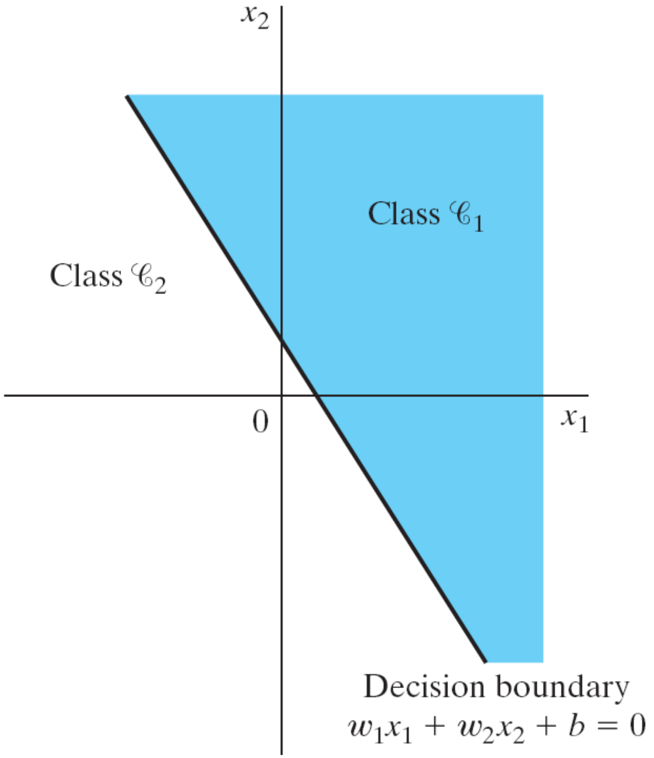
$$\mathrm{sgn}(v) = \begin{cases} +1 & \text{if } v > 0 \\ -1 & \text{if } v < 0 \end{cases}$$

the *quantized response* $y(n)$ of the perceptron in the compact form

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

Rosenblatt's perceptron model

- Decision boundary



Thank You

References

- Chapter 1, Neural Networks and Learning Machines, Simon Haykin