

Fundamentals of Neural Networks

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Figure 1: A self-driving car.

Credit: Marc van der Chijs / CC BY-ND 2.0

Introduction



Figure 2: A digital assistant.

Credit: Kārlis Dambrāns / CC BY 2.0

Introduction



Airplane



Car



Person

Figure 3: Object detection in images.

Credit: Lu et. al¹

¹"1-HKUST: Object Detection in ILSVRC 2014", *CoRR*, vol. abs/1409.6155, 2014

Outline

1. The Perceptron
2. Feedforward Neural Networks
 - Architecture
 - Mathematical formulation
3. Training Feedforward Neural Networks
 - Cost functions
 - Stochastic Gradient Descent
 - Back-propagation
4. Extensions

The Perceptron

Example Task

- Predict whether an input image of a handwritten digit shows a zero or another digit

MNIST Data Sample

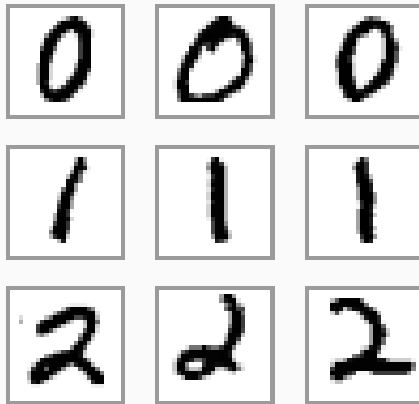


Figure 4: Examples from the MNIST database.

Credit: Josef Steppan / CC BY-SA 4.0

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- **Idea:** Assign a weight to every input pixel

The perceptron accepts n input values and computes an output value \hat{y} :

$$\begin{aligned}\hat{y} &= \text{sign} \left(\sum_{i=1}^n w_i x_i \right) \\ &\equiv \hat{y} = \text{sign}(\mathbf{w}^\top \mathbf{x})\end{aligned}\tag{1}$$

Visual Representation

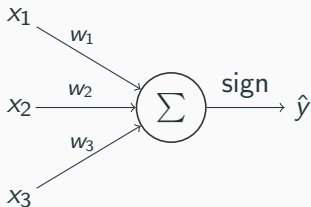


Figure 5: A visual representation of the perceptron model.

Shortcomings of the Perceptron

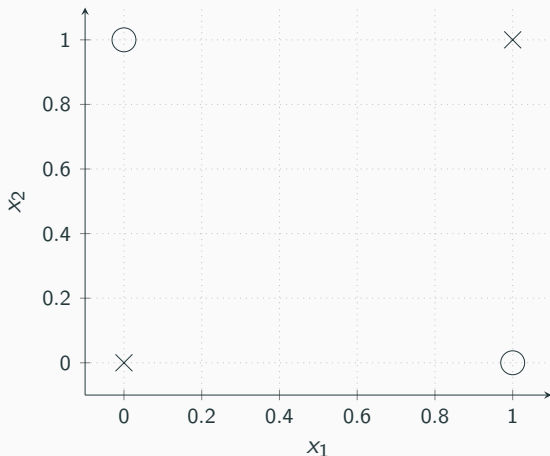


Figure 6: The perceptron cannot learn the XOR function since the data is not linearly separable.

Feedforward Neural Networks

Networks of perceptron-like units

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Training Feedforward Neural Networks

Extensions

Thank you!