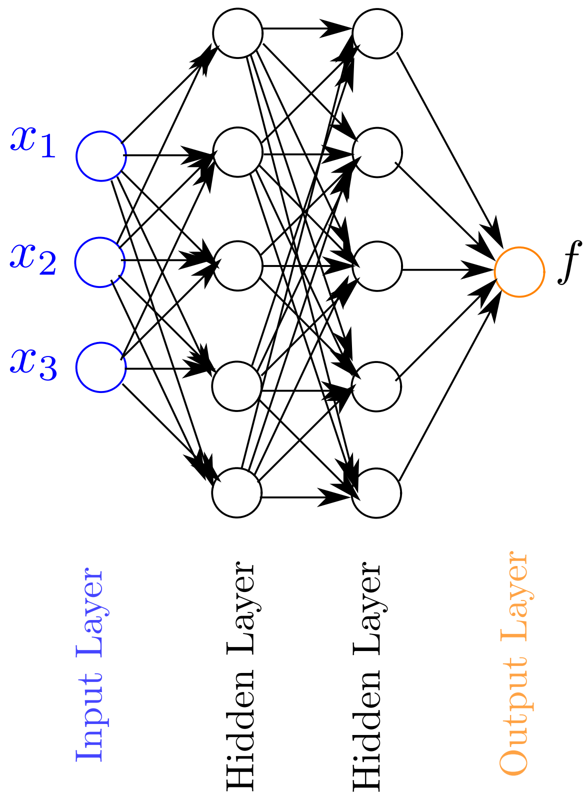
5. Introduction to Deep Neural Networks

Introduction and Motivation to Deep Neural Networks

Video
Download video file

Transcripts
Download SubRip (.srt) file
Download Text (.txt) file

A **deep (feedforward) neural network** refers to a neural network that contains not only the input and output layers, but also hidden layers in between. For example, below is a deep feedfoward neural network of 2 hidden layers, with each hidden layer consisting of 5 units:



One of the main advantages of deep neural networks is that in many cases, they can learn to extract very complex and sophisticated features from just the raw features presented to them as their input. For instance, in the context of image recognition, neural networks can extract the features that differentiate a cat from a dog based only on the raw pixel data presented to them from images.

The initial few layers of a neural networks typically capture the simpler and smaller features whereas the later layers use information from these low-level features to identify more complex and sophisticated features.

Representation Power of Neural Networks: 1

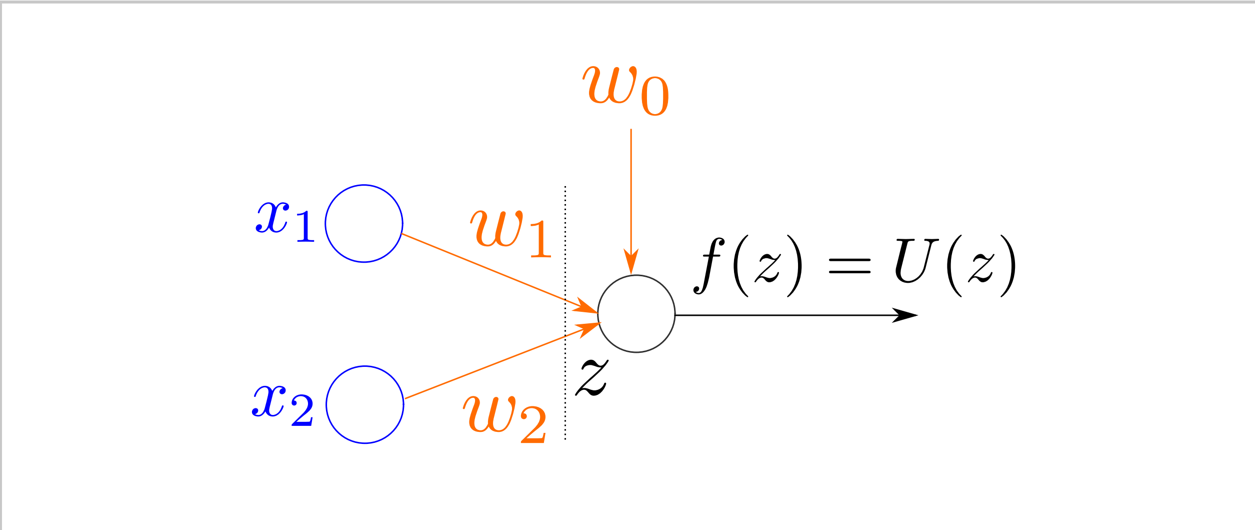
3/3 points (graded)

In these two problems, we are going to explore how a neural network can represent any given binary functions. We will start in this problem by building the logic NAND function using a simple neural network.

The logic NAND function is defined as

$$y = \text{NOT}\,(x_1 \ \text{AND} \ x_2)$$

where x_1 and $x_2 \in \{0,1\}$ are binary inputs (and 1 denotes True and 0 denotes False).



We will use the above simple neural network with $z = w_1x_1 + w_2x_2 + w_0$ and the activation function $f$chosen to be the unit step function $U(z)$:

$$U(z) = \begin{cases} 0 & z \leq 0 \\ 1 & z > 0 \end{cases}.$$

Find w_0, w_1, and w_2 such that the output of the neural network $y = U(z)$ gives the NAND function as a function of x_1 and x_2.
(Different correct answers will be accepted.)

$w_0 =$ 3 **Answer:** See solution

$w_1 =$ -2 **Answer:** See solution

$w_2 =$ -1 **Answer:** See solution

Solution:

The NAND function outputs the following:

$$\mathrm{NAND}\,(x_1, x_2) \;=\; \begin{cases} 0 & \text{if } \;(x_1,\, x_2) = (1,1) \\ 1 & \text{otherwise} \end{cases}.$$

Since the activation function is the step function $U\,(z)$, we need $z =\leq 0$ when $(x_1,\, x_2) = (1,1)\,,$ and $z > 0$ for $(x_1,\, x_2) = (0,0)\,,\ (0,1)\,,$ or $(1,0)$. Since $z = w_0 + w_1 x_1 + w_2 x_2,$ the above conditions tranlate to the following inequalities

$$\begin{aligned} w_0 + w_1 + w_2 &\leq 0 \\ w_0 &> 0 \\ w_0 + w_1 &> 0 \\ w_0 + w_2 &> 0. \end{aligned}$$

A valid example is $w_0 = 3, w_1 = -2, w_2 = -2$.

Submit

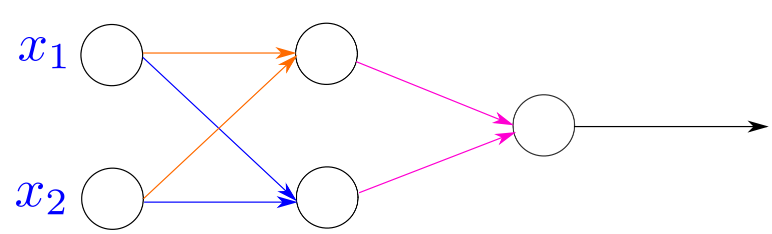
You have used 1 of 3 attempts

Answers are displayed within the problem

Representation Power of Neural Networks: 2

1/2 points (graded)

Using the NAND function only as the basic neural network unit, we can build larger neural networks to implement other logic functions. For example, the follow neural network implements the logic AND function:

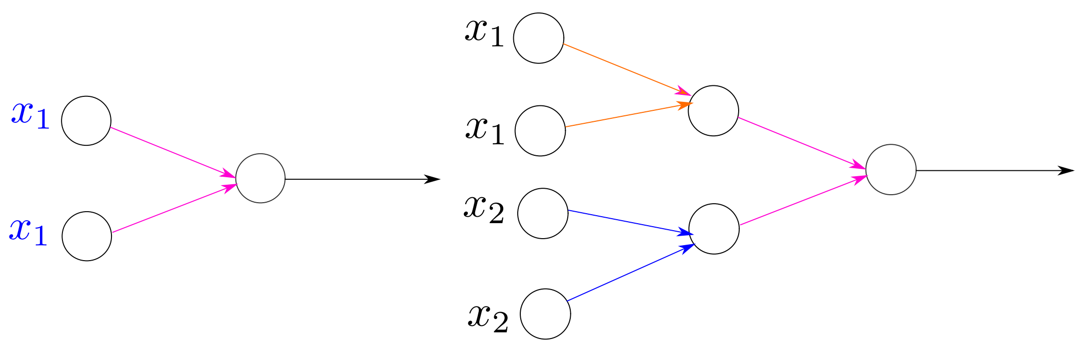


Note: Here, each pair of edges of the same color along with the nodes they are connected to form a neural network unit that represents the NAND function. (They do not represent values of inputs or outputs). In the example above, x_1 and x_2 are inputs to two NAND units, and are connected to output of respective units by the blue and orange arrows.

(Check that these output the correct values.)

Which logic function does each of the following neural networks implement?

(Choose one for each column.)



◯ AND function	◯ AND function
◯ NOT function ✔	◯ NOT function
◯ OR function	◉ OR function
◉ XOR function	◯ XOR function
✖	✔

Solution:

NAND function is known as a universal logic function, which can be used to implement any boolean functions, including also XOR, without the use of any other type of function (except for the identity and zero function). Use De Morgan's law in boolean algebra.

$$\mathrm{NOT}\,(x_1 \;\mathrm{AND}\; x_1) = \mathrm{NOT}\; x_1,$$

and

$$\text{NOT}\,(\,\text{NOT}\ \ (x_1)\ \ \text{AND NOT}\,(x_2)) = \text{NOT}\,(\,\text{NOT}\,(x_1\ \text{OR}\ x_2)) = x_1\ \text{OR}\ x_2.$$

Submit You have used 2 of 2 attempts

Answers are displayed within the problem

Discussion

Hide Discussion

Topic: Unit 3 Neural networks (2.5 weeks):Lecture 8. Introduction to Feedforward Neural Networks / 5. Introduction to Deep Neural Networks

Add a Post

Show all posts by recent activity

? Representation Power of Neural Networks:2 2
Hello, i don´t understand the logic behind the drawings and the functions AND, OR, NOT and XOR , ...

[STAFF] error in grading 1st question 1
The grading on the 1st question seems to be wrong (or the formulation has an error).

? Video quesiton 1
Does the width of the network include the input an output layer. I.e does the picture in the example...

Learn About Verified Certificates