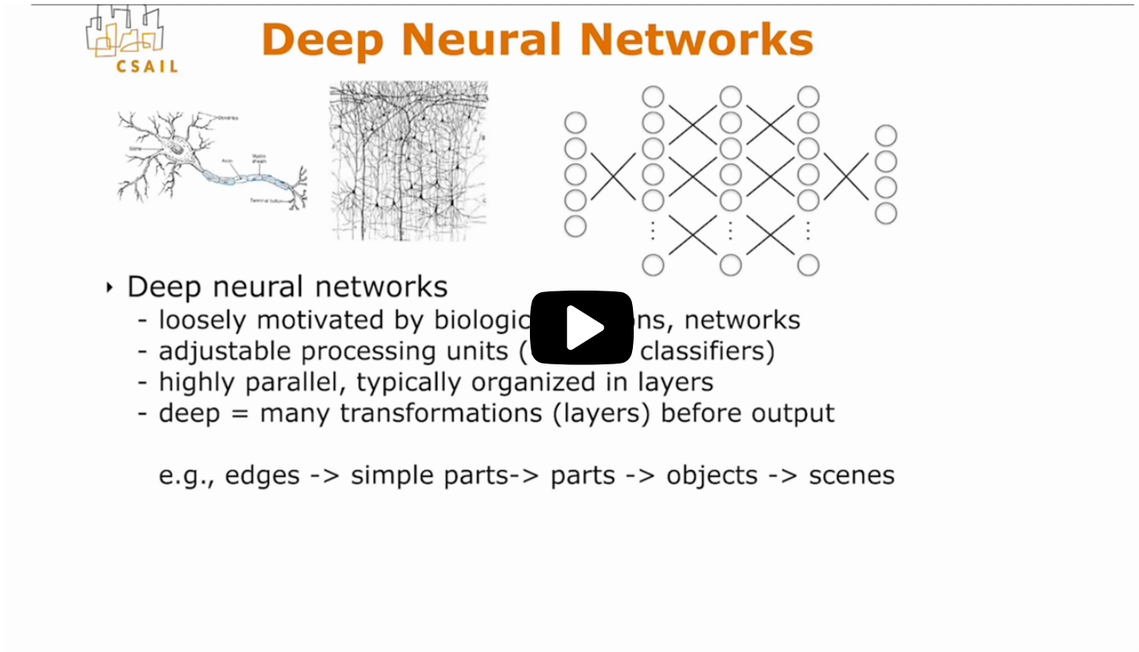
5. Introduction to Deep Neural Networks
Introduction and Motivation to Deep Neural Networks



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Start of transcript. Skip to the end.

So we will connect these abstract little neurons into highly parallel architectures.
And in deep forward neuron networks, these units are arranged in layers, from the input layer, where each unit holds the input coordinate, through various hidden layer transformations until the actual output of the model.
Now, in this layerwise computation, each unit in particular layer takes input

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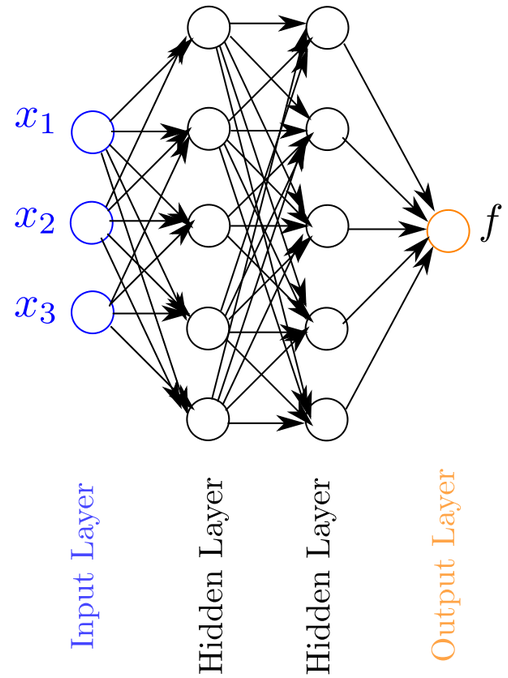
A **deep (feedforward) neural network** refers to a neural network that contains not only the input and output layers, but also hidden layers in between. For example, below is a deep feedfoward neural network of 2 hidden layers, with each hidden layer consisting of 5 units:



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

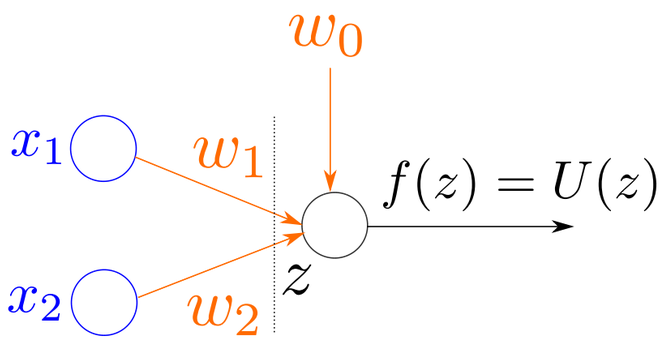
3/3 points (graded)

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 $z = w_1 x_1 + w_2 x_2 + w_0$ 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 gives the NAND function as a function of x_1 and x_2.
(Different correct answers will be accepted.)

$w_0 =$ 2 ✔ **Answer:** See solution

$w_1 =$ -1 ✔ **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 $w_0 = 3, w_1 = -2, w_2 = -2$.

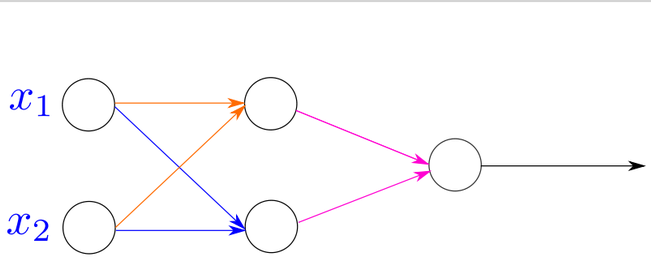
Submit You have used 2 of 3 attempts

Answers are displayed within the problem

Representation Power of Neural Networks: 2

2/2 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:

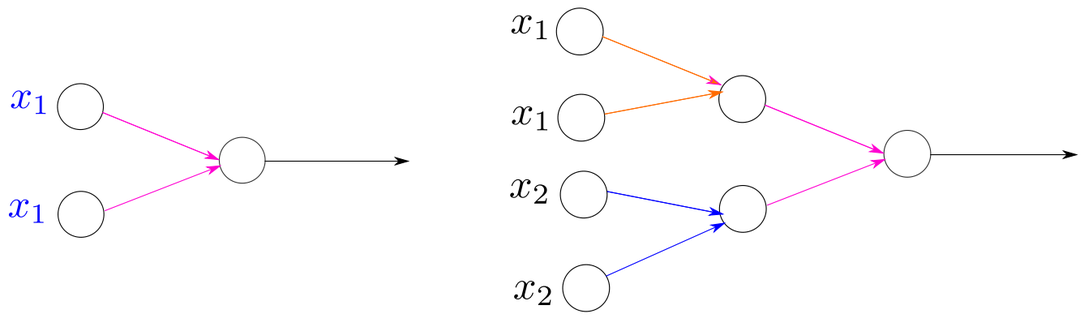


Here, each pair of edges of the same color along with the nodes they are connected to form a neural network unit that represents the NAND function.

(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
- ☐ NOT function ✔
- ☐ OR function
- ☐ XOR function

✔

- ○ AND function
- ○ NOT function
- ◉ OR 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).

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

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? Representation Power of Neural Networks: 2: left column allows for multiple choices 1

?	Representation Power of Neural Networks: 1 What is y? Is it the same as U(z)? Or is z=y?	2
	Step function definition Community TA	5
	[Staff] Representation Power of Neural Networks: 2 - answer format It seemed a bit odd that for the first configuration tick boxes are used and for the second configuration radio buttons. No big deal, but perhaps an item for the list of small fix... Community TA	1
	question2 what is the activation function used? question2 what is the activation function used? If it is the same as last question, why the left one is not NAND?	3
	a problem about refresh the page Neural Networks: 1 the first I typed in the wrong answer, but the second time I typed in the right answer, because I saw ☑。 After I refresh the page my answer changed to t...	1
	[Staff] Solutions for Representation Power of Neural Networks: 1 Hi, I think the grader does not accept all different answers. I tried 3 solutions which all behave exactly like the valid example shown in the answer. Maybe there is a bug in the ...	17
	Color representation not sure I understand the color representation. In the first column we have two times the X1, with pink colors... assuming that x1 can be 0, or 1... then how to understand that...	2

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