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DM534 - Introduction to Computer Science

Study group with supervision, Week 41, Autumn 2016

Exercise 1. Logical Functions and Perceptrons

(Based on Slide 54.)
Perceptrons can be used to compute the elementary logical functions that we usually think of as underlying computation. Examples of these functions are AND, OR and NOT.

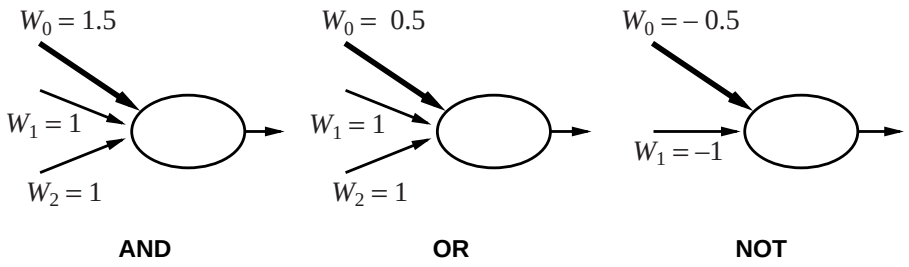


Figure 1: Logical functions and perceptrons. Exercise Exercise 1..

In class, we carried out the verification that the right most perceptron in Figure 1 is a correct representation of the AND operator.

- Verify that the perceptrons given for the OR and NOT cases in Figure 1 are also correct representations of the corresponding logical functions.
- Are these perceptrons unique for the expression of AND, OR and NOT, respectively? If not can you find others?
- Design a perceptron that implements the logical function NAND.

  In the training session we will see that there are also Boolean functions that cannot be represented by a single perceptron alone.

Exercise 2. Multilayer Perceptrons

(Based on Slides 66, 67.)
Determine the Boolean Function represented by the perceptron in Figure 2:

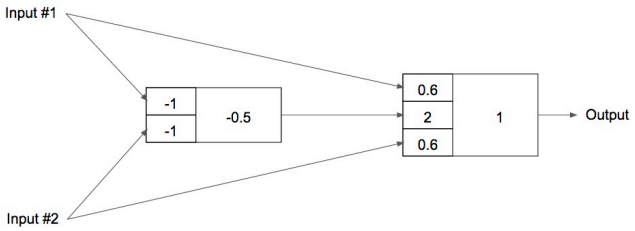


Figure 2: . The multilayer perceptron of Exercise 2.

Exercise 3. Training Artificial Neural Networks by Hand

Set the weights in such a way that the network in Figure 3 represent the XOR logical operator.

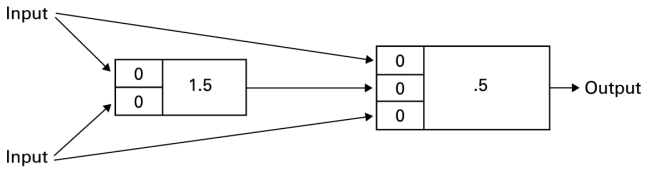


Figure 3: The figure of Exercise 3.

Exercise 4. Decision Making by Neural Networks

A way to think about the perceptron is that it is a device that makes decisions by weighting up evidence. Suppose the weekend is coming up and you've heard that there's going to be a food festival in Svendborg. You like food and are trying to decide whether or not to go to the festival. You might make your decision by weighting up three factors:

- Is the weather good?
- Does your friend also want to come?
- Is the festival near public transit? (You don't own a car).

Use a perceptron to model this kind of decision-making.

Then, suppose you absolutely adore food, so much so that you're happy to go to the festival even if your friend is not coming and the festival is hard to reach by public transport. But perhaps you really loathe bad weather and there's no way you'd go to the festival if the weather is bad. Use this information to decide the weights in the perceptron you modeled.

Exercise 5. Architecture of Neural Networks for Handwritten Digits Recognition

(Based on Slides 65-69)
Figure 4 shows a general structure of a feed-forward neural network. Somewhat confusingly, and for historical reasons, such *multiple layer networks* are sometimes called *multilayer perceptrons* or MLPs, despite being made up of sigmoid neurons, not perceptrons. The latter use a step function as activation function while the former use a sigmoid (also called logistic) function.
The leftmost layer in this network is called the *input layer*, and the neurons within the layer are called *input neurons*. The notation for input neurons, in which we have an output, but no inputs, is a shorthand. It doesn't actually mean a perceptron with no inputs. It's better to think of input neurons as not really being neurons at all, but rather special units which are simply defined to output the desired values, which are the inputs to the network. The rightmost or *output layer* contains the *output neurons*, or, as in this case, a single output neuron. The middle layer is called a *hidden layer*, since the neurons in this layer are neither inputs nor outputs. The term "hidden" perhaps sounds a little mysterious but it really means nothing more than "not an input or an output". The network in the figure has just a single hidden layer, but some networks can have multiple hidden layers.

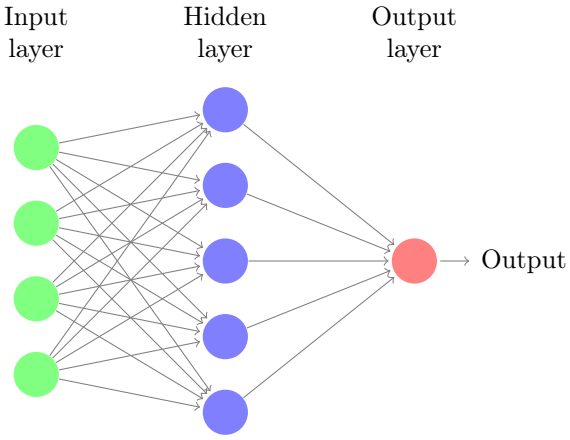


Figure 4: The architecture of neural networks. Exercise 5.

The design of the input and output layers in a network is often straightforward. For example, suppose we're trying to determine whether a handwritten image depicts a "9" or not. A natural way to design the network is to encode the intensities of the image pixels into the input neurons. If the image is a 64×64 greyscale image, then we'd have $4096 = 64 \times 64$ input neurons, with the greyscale intensities scaled appropriately between 0 and 1. The output layer will contain just a single neuron, with output values of less than 0.5 indicating "input image is not a 9", and values greater than 0.5 indicating "input image is a 9".

Discuss shortly how to design a neural network for handwritten digit recognition. Assume that the handwritten digits have already being segmented and focus on the problem of recognizing all 10 individual digits like those from the training set shown in Figure 5. Assume that all images are 28×28 greyscale images. Specify how your network will predict the digit. You do not need to discuss how to train the network.

Figure 5: A sample of handwritten digits taken from the MNIST database (Mixed National Institute of Standards and Technology database). MNIST is a large database of handwritten digits that is commonly used for training various image processing systems. Exercise 5.

Exercise 6. Benefits and Risks of AI

How can we ensure that AI develops in a way that is trustworthy and beneficial to human kind? Below you find four topics to discuss. Initially, you gather in pairs and discuss for 15-20 minutes about the four topics. Each pair has to write down a statement for each of the four topics. The statements can be questions on the topic aimed at deepening the understanding of the situation and the underlying assumptions or they can be presenting a point of view that the pair can explain and defend. As a starting point you should make sure that you understand the text reported under the topic and the assumptions it is based on; then, consider the technical part to assess feasibility and finally lead towards more philosophical inquiries.
After this initial phase, the written statements are made circulating among the members of the group and each member votes for the statement that he/she thinks is the most interesting to bring up for group discussion because likely to engage the members in alternative perspectives. The time left is used by discussing the chosen statement.
The group supervisor controls the time and helps bringing up new elements in the discussion if it stagnates.

Topic 1 How artificial Intelligence changes the job market.

"Machines could take 50% of the jobs in the next 30 years."

[Moshe Vardi, Prof. of CS, Rice University]

"Job loss by 2035: USA 47%, GB 35%, DK 31%"

[C.Frey and M.Osbourne, 2013 "The future of employment" and Cevea "Fremtidens job".]

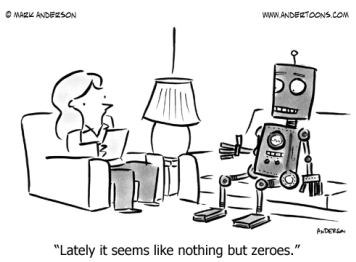
"AI will change the character of jobs rather than replace jobs."

Topic 2 Interaction between humans and artificial intelligence

"We should consider AI as our teammate rather than as our tool"

Empirical findings in social robotics show that people:

- seek intimacy with a machine that... can have no feeling
- treat them not only as pets but as potential friends, confidants, and even romantic partners... (apparently) without caring what these artificial intelligences "know" or "understand" of the human moments we might 'share' with them.
- deem the performance of connections be connection enough



[Sherry Turkle, "Alone Together", 2011]

Other empirical findings show that humans tend to trust computers more than other humans.

Description problem: which kind of interactions are going on between a human and a social robot?

Regulation problem: which kind of human-robot interactions should we allow or even promote and which should we ban?

[Johanna Seibt, Prof. of Philosophy at Aarhus University]

Topic 3 Artificial Intelligence and big data

"Let's share all our personal data and AI will tell us how to improve lives"

Topic 4 "Killer robots"

Who must be claimed responsible? The user, the roboticist that constructed the machine/drone/car? The robot? Can morality be programmed?

The regulation problem.

The research problem: should AI research in military applications be banned?

Sources
Future of Life Institute: `http://futureoflife.org/`
Partnership on AI (Google, Facebook, Amazon, IBM and Microsoft) `http://www.partnershiponai.org/`
European Conference of Artificial Intelligence, 2016 `http://www.ecai2016.org/`