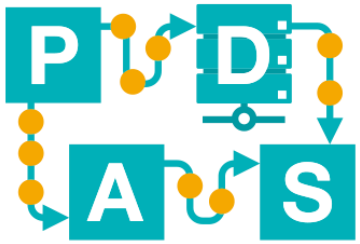
Neural Network (1/2)

Lecture 6 instruction

IDS-I-L6



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Exercise.1

- Imagine a simple single neuron
  - If it has 5 input and 1 output
    - each input can have value of 0 or 1

a. How many different input patterns are possible?

b. Can the patterns be formulized?

Solution.1

- **As you can see the inputs have binary pattern, so the pattern of input is:**
  - 2^n *where n is the number of the inputs*

	1	2	3	4	5	6	…	32
X1	0	1	0	0	0	0	…	1
X2	0	0	1	0	0	0	…	1
X3	0	0	0	1	0	0	…	1
X4	0	0	0	0	1	0	…	1
X5	0	0	0	0	0	1		1

Exercise.2

- **Consider three input for the previous neuron including following weights and activation function:**
  - **Ignore w_0**

$$w_1 = 2$$
$$w_2 = -4$$
$$w_3 = 1$$

$$f(x) = \begin{cases} \mathbf{0}, & x < 0 \\ \mathbf{1}, & x \geq 0 \end{cases}$$

  - **Calculate the output of the neurons**

pattern	p_1	p_2	p_3	p_4
x_1	1	0	1	1
x_2	0	1	0	1
x_3	0	1	1	1

Solution.2

- **Use the feedforward formula including sum of the inputs and apply the activation function:**
  - $p_1: a = 2 * 1 - 4 * 0 + 1 * 0 = 2,\ f(2) = 1$
  - $p_2: a = 2 * 0 - 4 * 1 + 1 * 1 = -3,\ f(-3) = 0$
  - $p_3: a = 2 * 1 - 4 * 0 + 1 * 1 = 3,\ f(3) = 1$
  - $p_4: a = 2 * 1 - 4 * 1 + 1 * 1 = -1,\ f(-1) = 0$

Exercise.3a

- **The main building blocks of any computational device are logical operators.**
  - **You have already seen representation of operator AND and OR in the lecture by a single neuron:**
    - **With the new activation function how the AND neuron works?**
    - **Try to find the weights to have the AND function.**

$$f(x) = \begin{cases} 0, & x < 2 \\ 1, & x \geq 2 \end{cases}$$

Solution.3a

- $p_1: a = 1 * 0 + 1 * 0 = 0,\ f(0) = 0$
- $p_2: a = 1 * 1 + 1 * 0 = 1,\ f(1) = 0$
- $p_3: a = 1 * 0 + 1 * 1 = 1,\ f(1) = 0$
- $p_4: a = 1 * 1 + 1 * 1 = 2,\ f(2) = 1$

$$f(x) = \begin{cases} 0, & x < 2 \\ 1, & x \geq 2 \end{cases}$$

Exercise.3b

- For the previous AND node, how to change the neuron parameters to have logical OR function?
  - Which parameters can be changed?
  - How to change them?
  - What are the possible solutions?

Solution.3b

- **Activation function and weights can be changed**
- **First solution:**
  - $p_1: a = 2 * 0 + 2 * 0 = 0,\ f(0) = 0$
  - $p_2: a = 2 * 1 + 2 * 0 = 2,\ f(1) = 1$
  - $p_3: a = 2 * 0 + 2 * 1 = 2,\ f(1) = 1$
  - $p_4: a = 2 * 1 + 2 * 1 = 4,\ f(2) = 1$

$$f(x) = \begin{cases} 0, & x < 2 \\ 1, & x \geq 2 \end{cases}$$

- **Second solution:**
  - **Changing activation function:**

$$f(x) = \begin{cases} 0, & x < 1 \\ 1, & x \geq 1 \end{cases}$$

  - **Check the functionality!**

Exercise.4

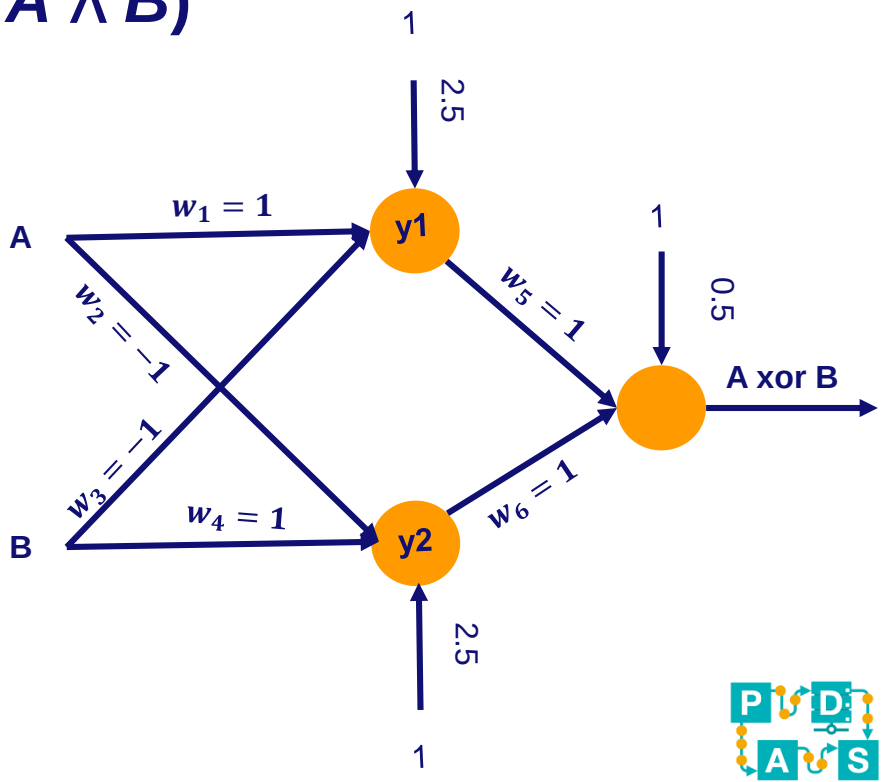
- **You have already seen the logical XOR neural network in the lecture.**
  - **XOR network can be created based on basic operators:**
    - **Such the one in the lecture**
    - **a) Try to create a neural network of XOR function(Not using first fact)**
    - **b)Take a way part! set different parameter for your network to act as XOR function**
    - **The activation function is a step function with threshold one.**

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

Solution.4

- ***A*** *xor* ***B*** **= (*A* ∧ ¬ *B*) ∨ (¬ *A* ∧ *B*)**

$$f(x) = \begin{cases} 0, & x < 1 \\ 1, & x \geq 1 \end{cases}$$



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Exercise.5

- **Imagine a car renting company wants to deploy a new system for assessing worthiness of its customers.**
  - **The new system is using feed forward neural network as a supervised learning algorithm.**
- **Suggest what should the company do before the system can be used?**

Solution.5

- First thing in order to have a supervised learning is some historical data about its customer.
- This data will be used as training set for neural network
  - The amount of data and the extensiveness of data is very important
  - The network is not be able to predict and works accurate for the customer that their similar situation were not in the historical data.

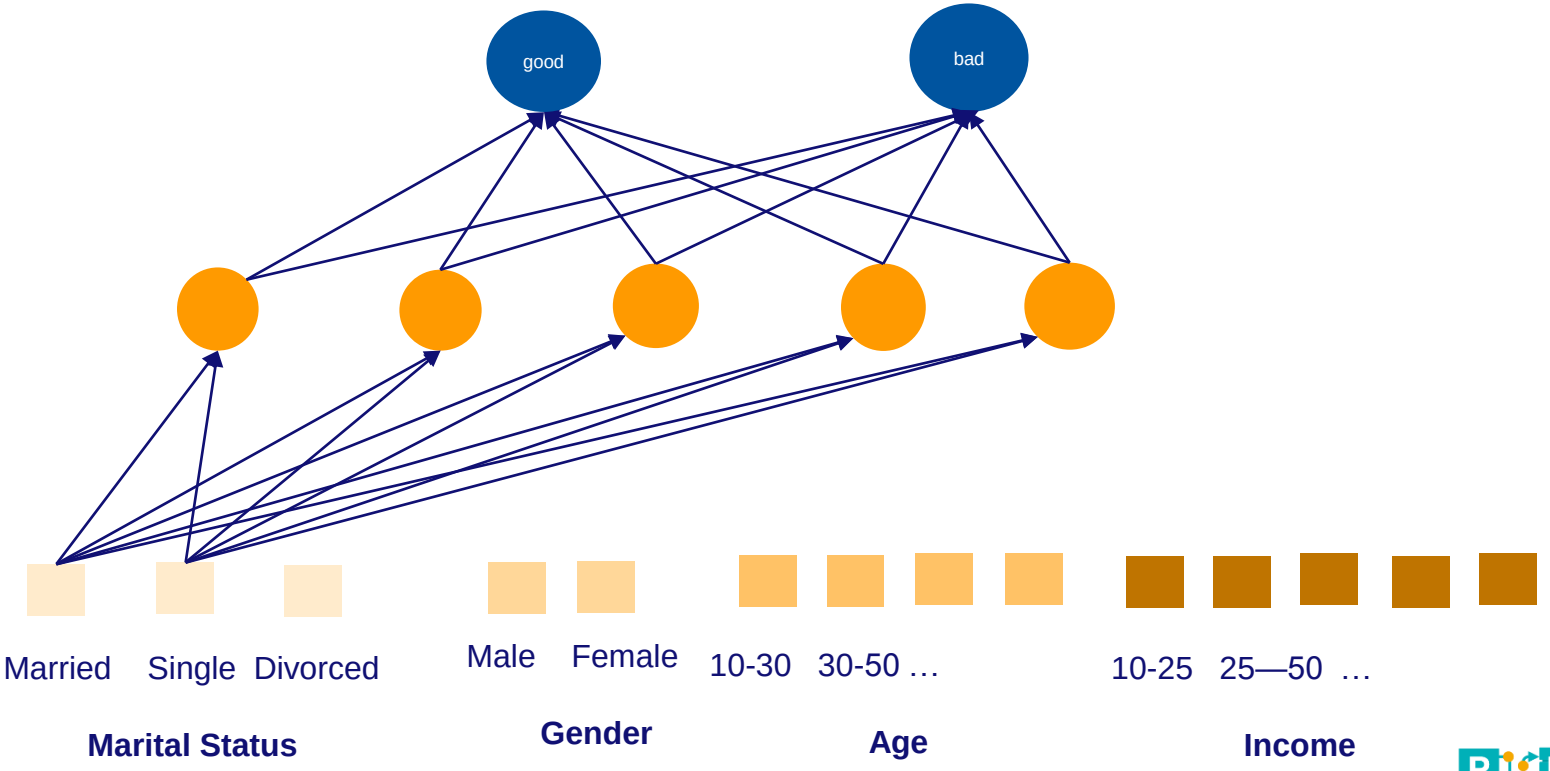
Exercise.6

- Now imagine the previous car company
  - If we want to classify potential company customers as good customers or bad ones for renting high price car with special offers:
  - We have a training dataset describing past customers using the following attributes:
    - Age {[18..30], [30..50], [50..65],[65+]},
    - Marital status {married, single, divorced},
    - Gender {male, female},
    - Income {[10K..25K], [25K..50K], [50K..65K], [65K..100K], [100K+]}.
- Design a neural network in order to predict the good customers?

Solution.6

- We have two output classes good and bad
  - Then two nodes in the output layer
  - We have 4 variables
    - for each: {3,2,4,5} values
  - We would have 14 neurons in the input layer
  - In the hidden layer we probably can have less number than input
    - However there is no predefined answer

Solution.6



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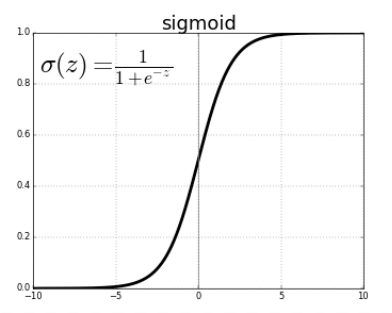
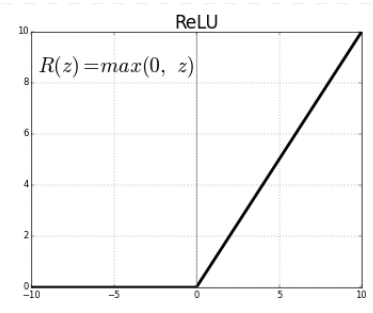
Exercise.7

- **Assume that we have a two-layer network:**
  - **one hidden layer**
  - **Assume that we use activation function Relu such as below in the hidden layer and no activation function at the output layer.**
  - **Write down the equation for the output of the jth node at the hidden layer.**





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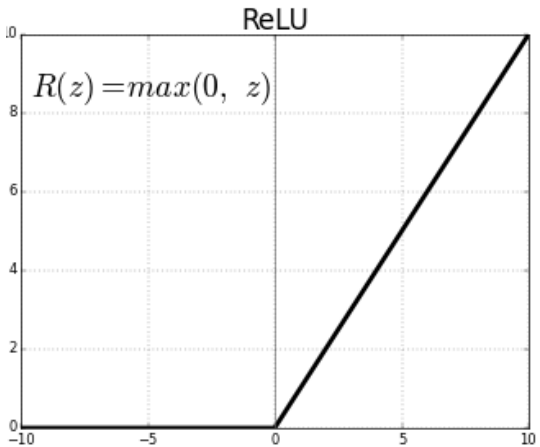
Solution.7

$$output\ of\ jth\ neuron\ in\ the\ hidden\ layer = max(0, w_0 * x_0 + w_{j1} * x_1 + \cdots)$$



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