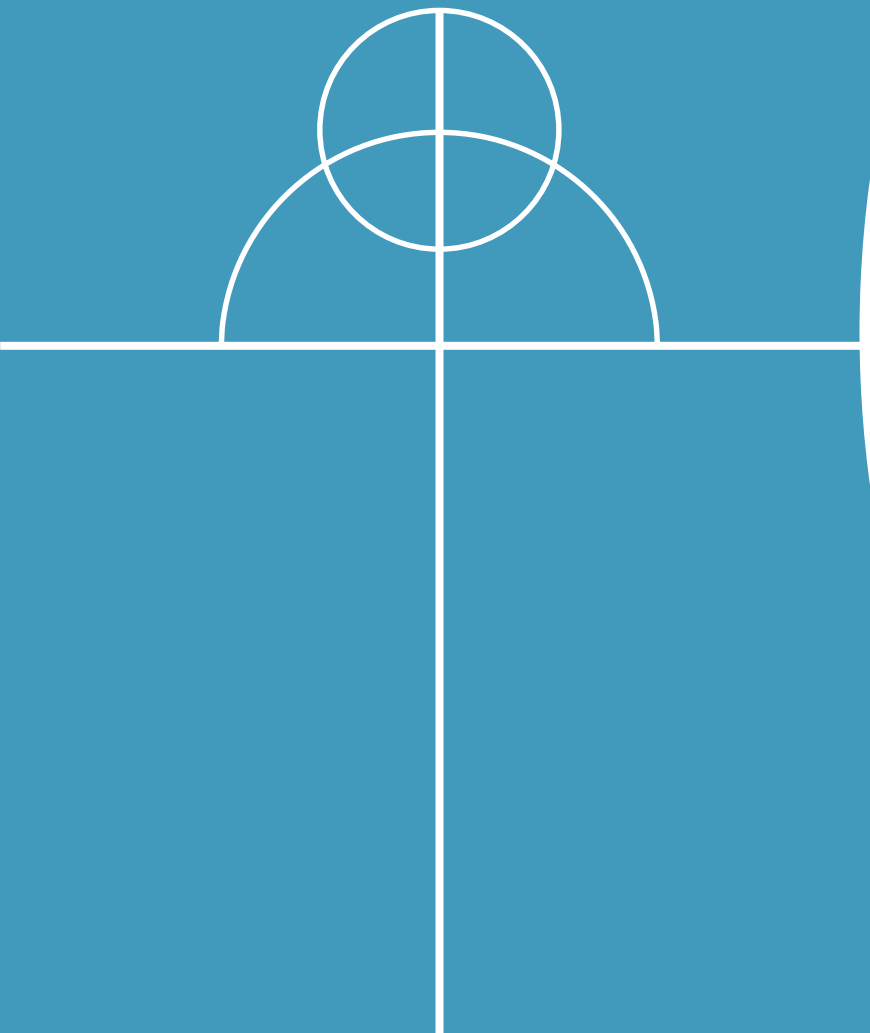

rethinking
insurance



June 2020

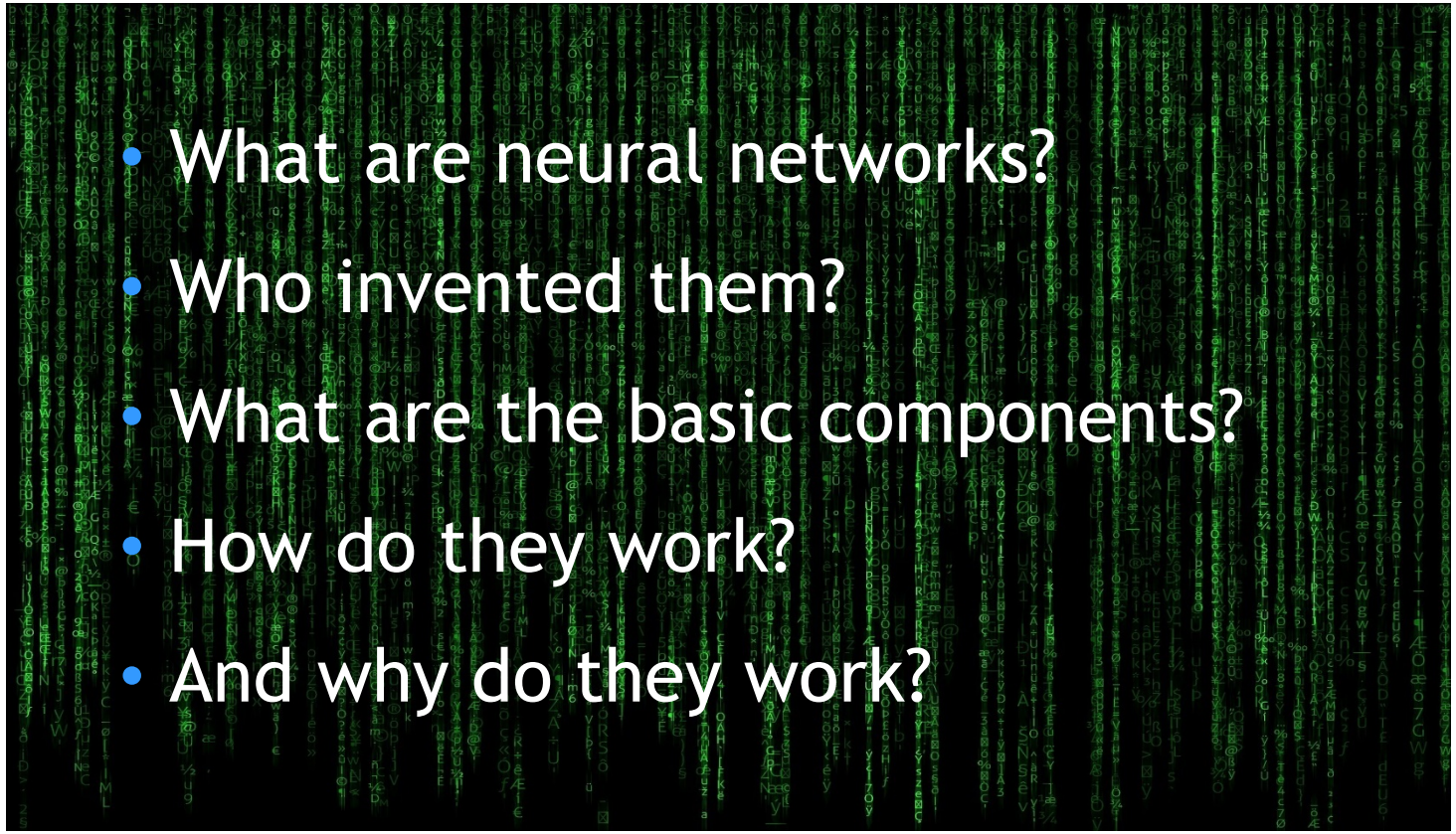
Artificial neural networks basics, part 1 - forwardpass

An elementary introduction

Dr. Stefan Nörtemann, msg life central europe

Introduction

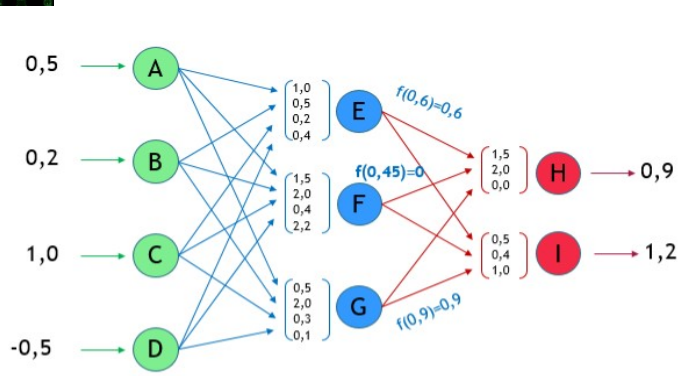
What's this about?



Introduction

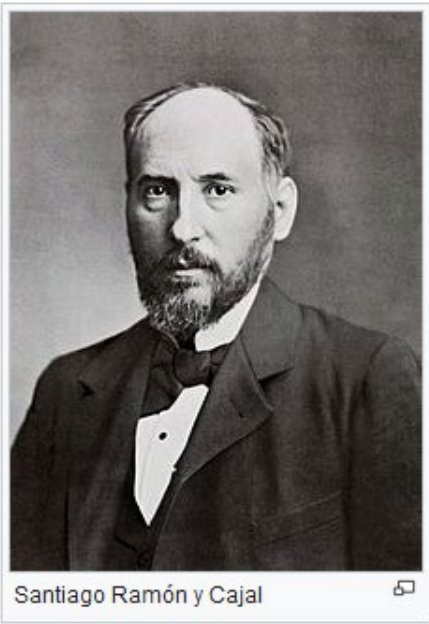
What's this about?

- What are neural networks?
- Who invented them?
- What are the basic components?
- How do they work?
- And why do they work?

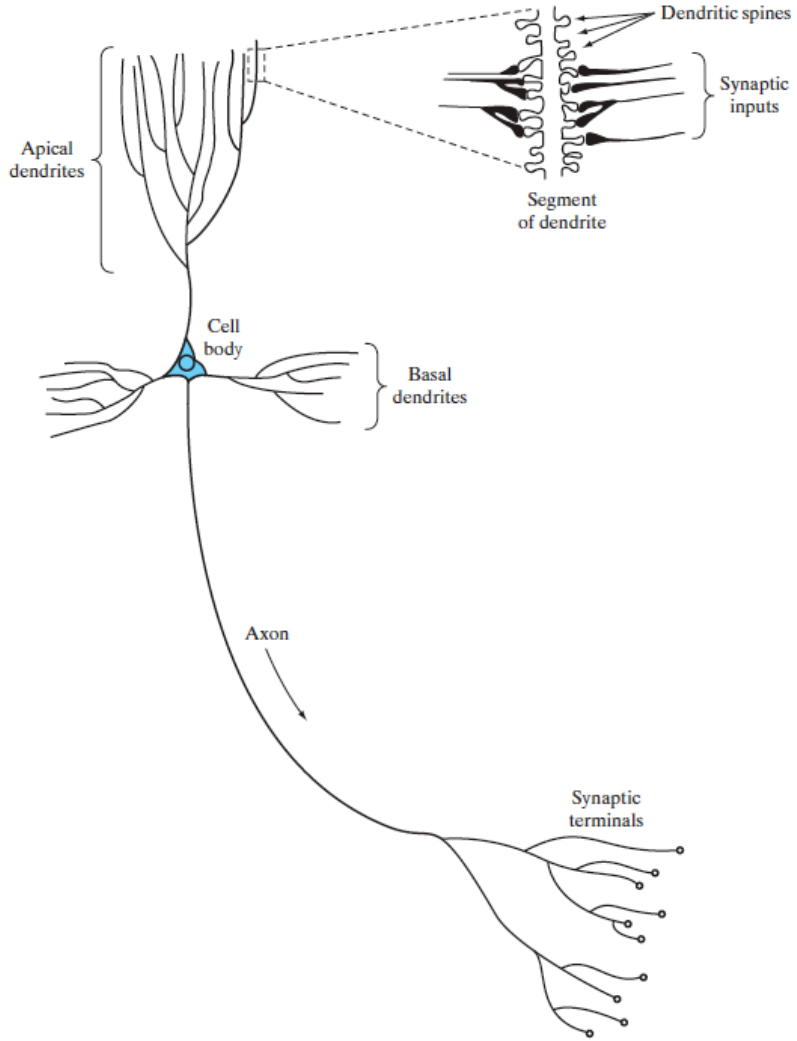


Neuronal networks

Motivation from brain research


Santiago Ramón y Cajal

- Ramón y Cajál (1911): The idea of neurons
- The brain as an extremely efficient computer
- Imitation of intelligence



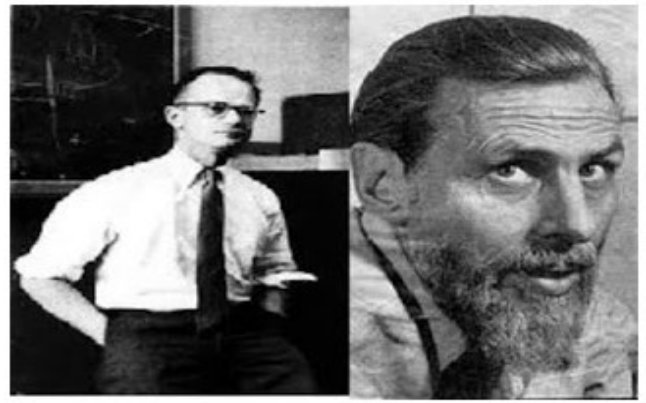
Picture source: Wikipedia

Quelle: Haykin: Neural Networks and Learning Machines, Pearson, 2009

Neural Networks & Deep Learning

Warren McCulloch & Walter Pitts, 1943

- first idea for an artificial neural network, consisting of linked elementary units
- for the calculation of logical and arithmetic functions



Warren McCulloch and Walter Pitts

Frank Rosenblatt, 1958

- Neurocomputer *Marc I Perceptron:* Multi-Layer Perceptron
- Idea: Very many calculation units that only become "intelligent" through their interaction

Frank Rosenblatt

➢ Since then a constant up and down: hypes and disillusions

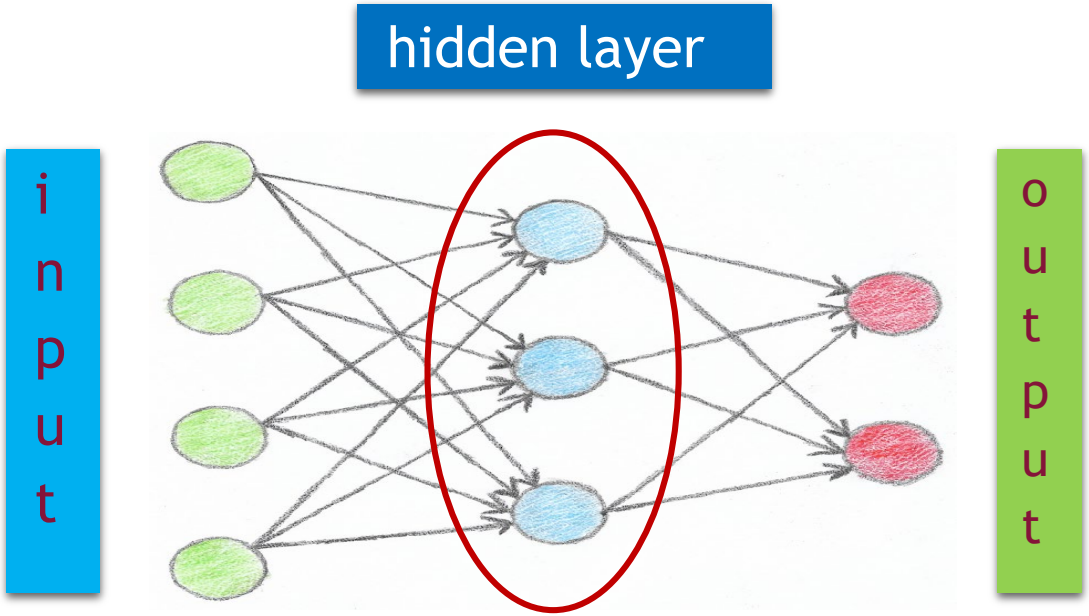
➢ Boom for about 10 years due to the enormous increase in computing capacity

Quelle: Haykin: Neural Networks and Learning Machines, Pearson, 2009

Picture sources: https://ptihiup2018.blogspot.com/2019/07/artifical-neural-network.html & Wikipedia

kNN: Input - Hidden layers - Output

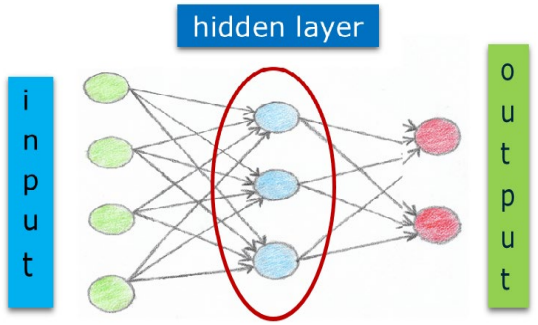
- idea: "make it like the human brain"
- method: Linking of so-called artificial neurons (units)
- components: input units, hidden layer, output units
- connections: exchange of data (= numbers) between the units



- each connection has a weight (which can "change")
- in each unit an input is processed and an output is generated, which can again be an input for a downstream unit.

Graphic: David J. Nörtemann

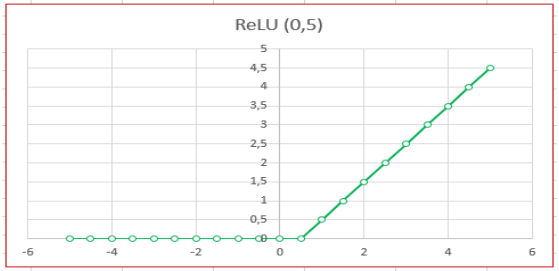
kNN: Activation function(s)

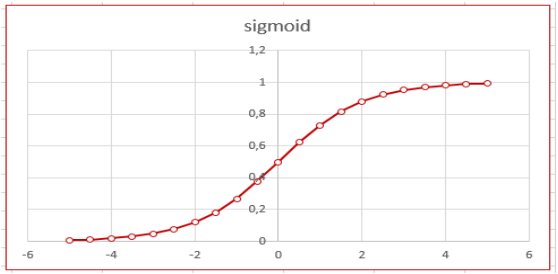


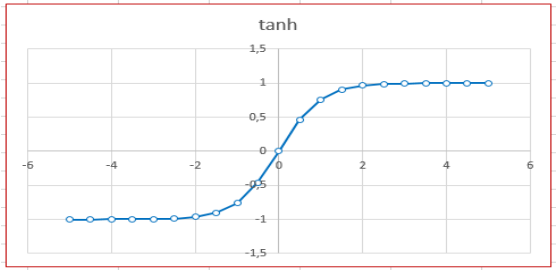
The output of a unit is calculated from the sum of the weighted input values, possibly a bias b and a so-called activation function f.

Examples of activation functions

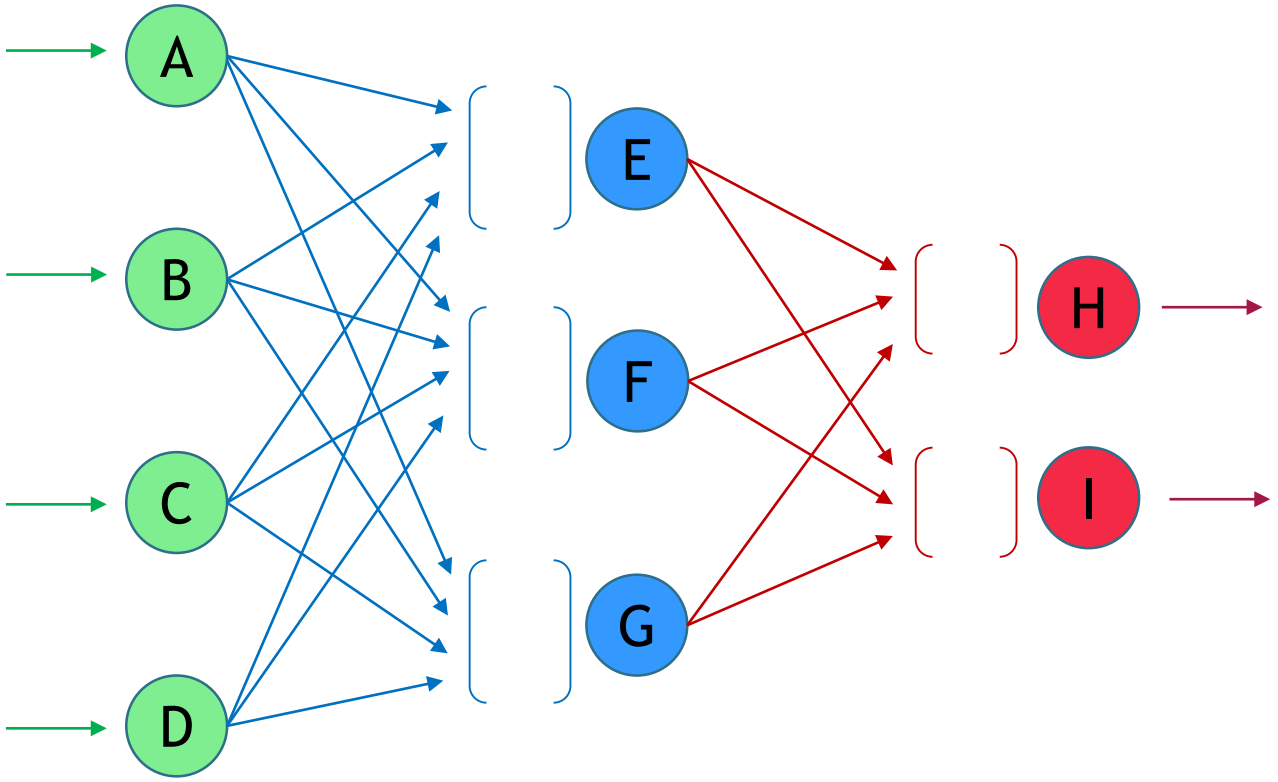
- Rectified Linear Unit (ReLU) $\boldsymbol{f(x,\theta) = \max(0, x - \theta)}$
- Sigmoid function $f(x) = \frac{1}{1+e^{-x}}$
- hyperbolic tangent $f(x) = \tanh(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$
- Logistic $\boldsymbol{f(x,\theta) = \frac{1}{1+e^{-(x-\theta)}}}$
- Leaky ReLU $\boldsymbol{f(x,\theta) = \max(\alpha(x-\theta),\ x-\theta), \alpha > 0}$ small
- …



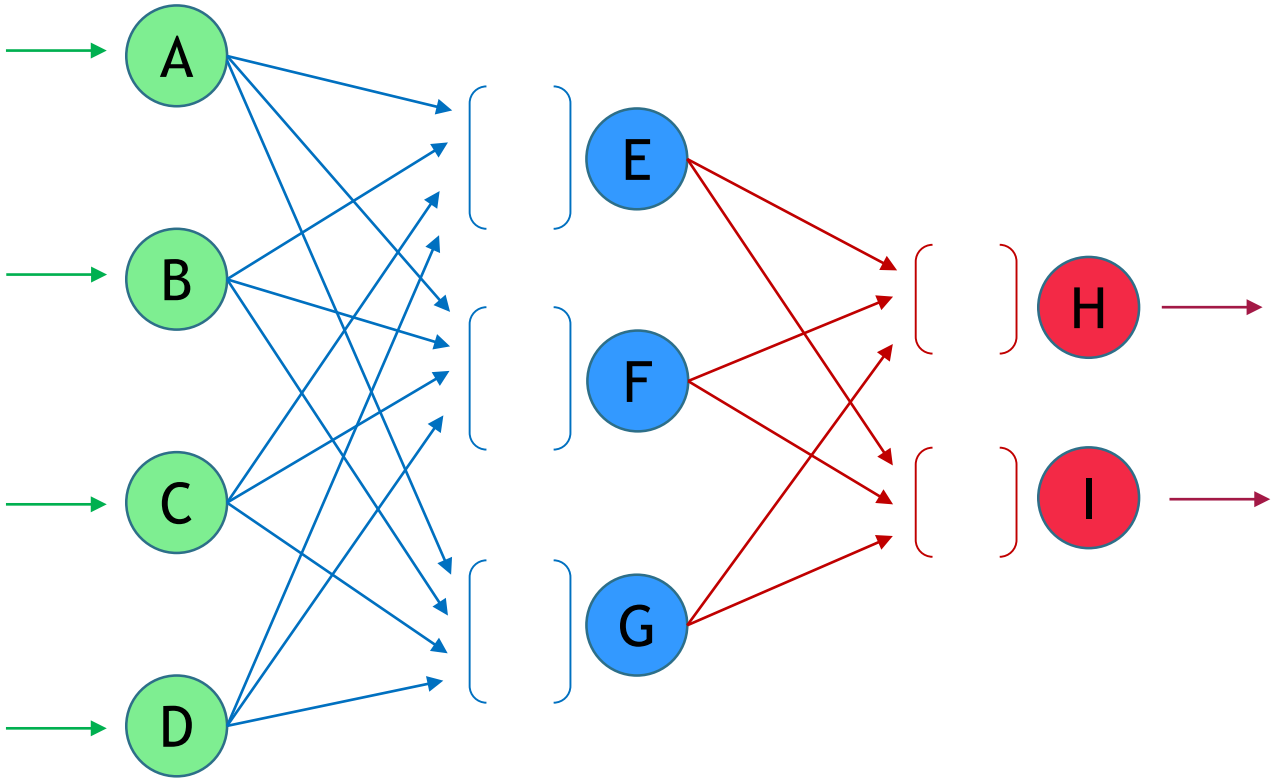




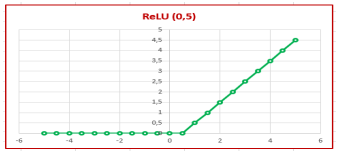
A simple example



A simple example

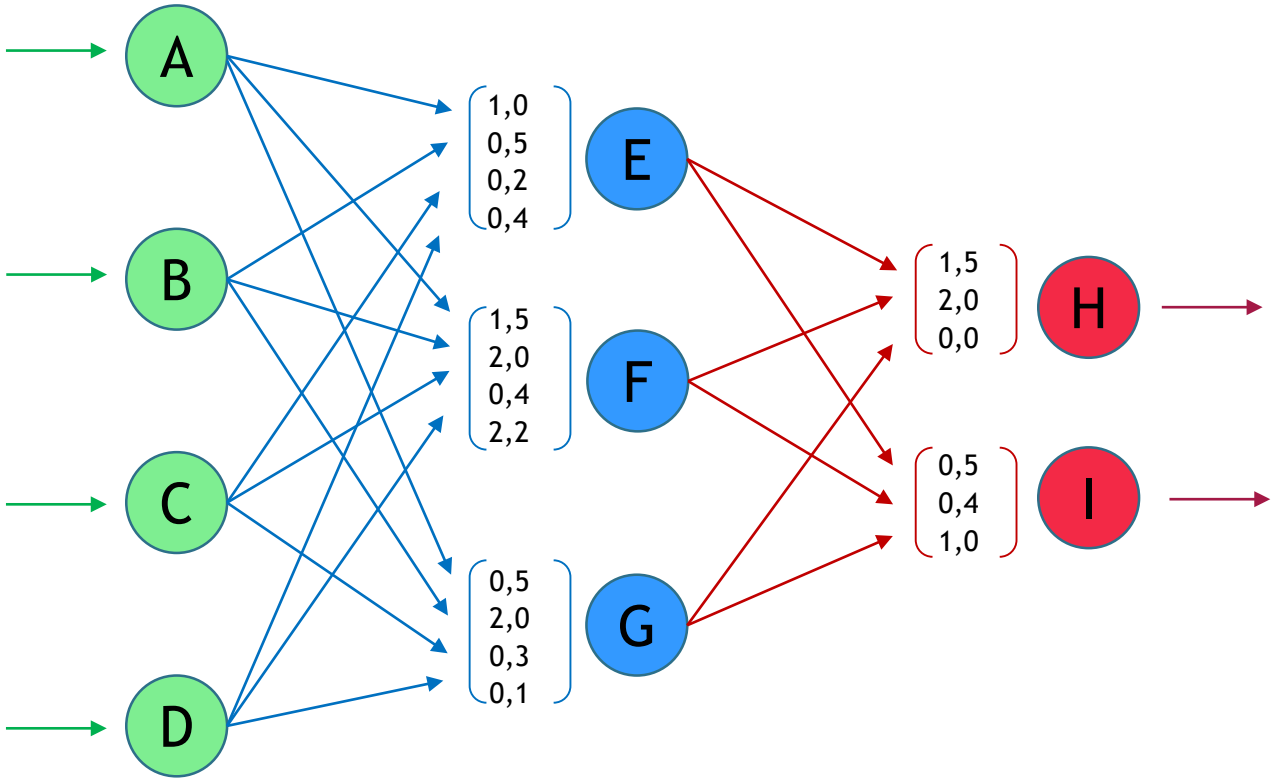


Activation function: f = ReLU (0.5)



,no bias (so that the graphic does not become too confusing).

A simple example



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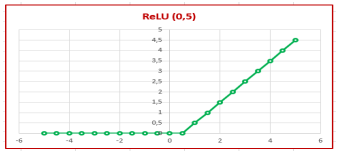

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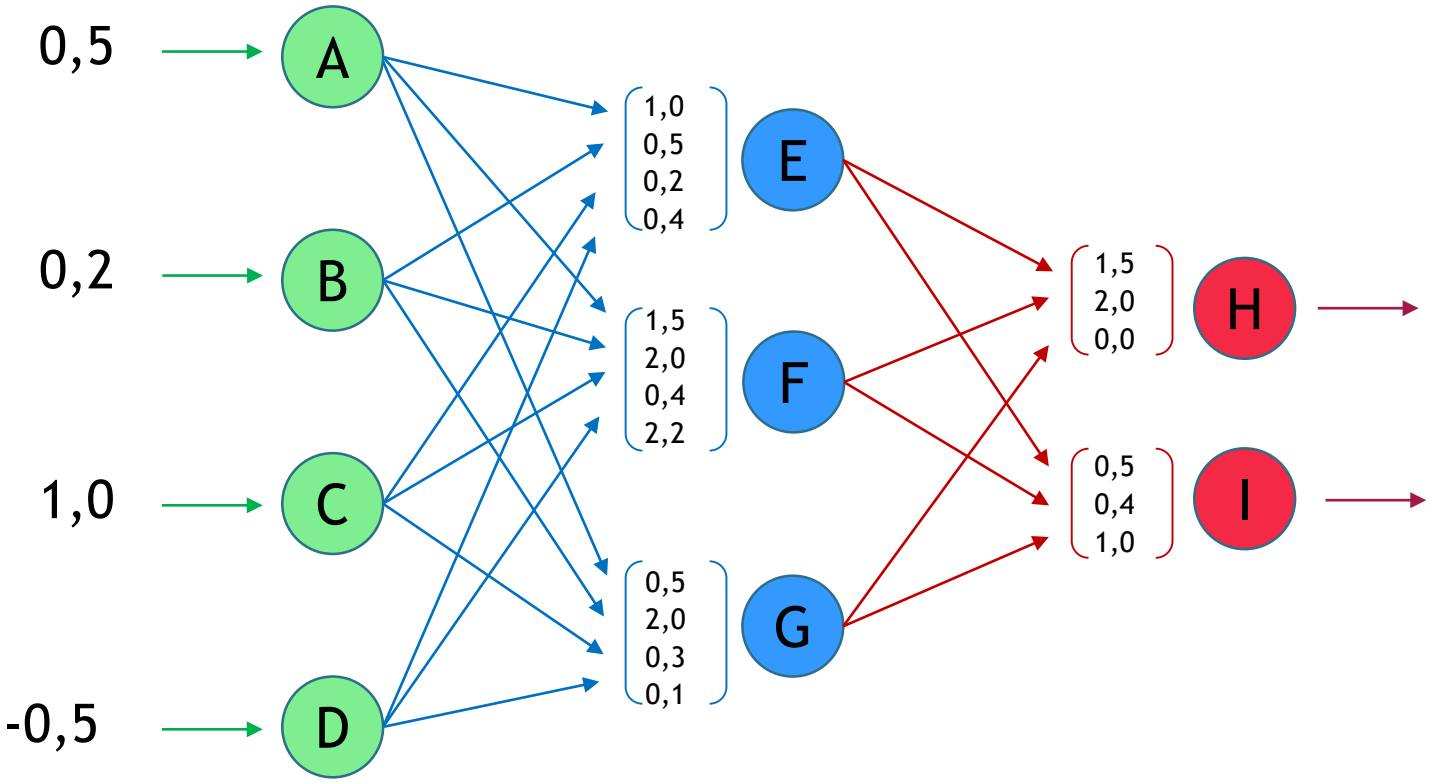

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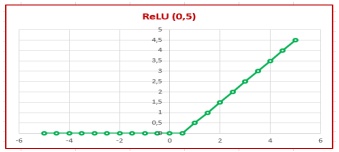

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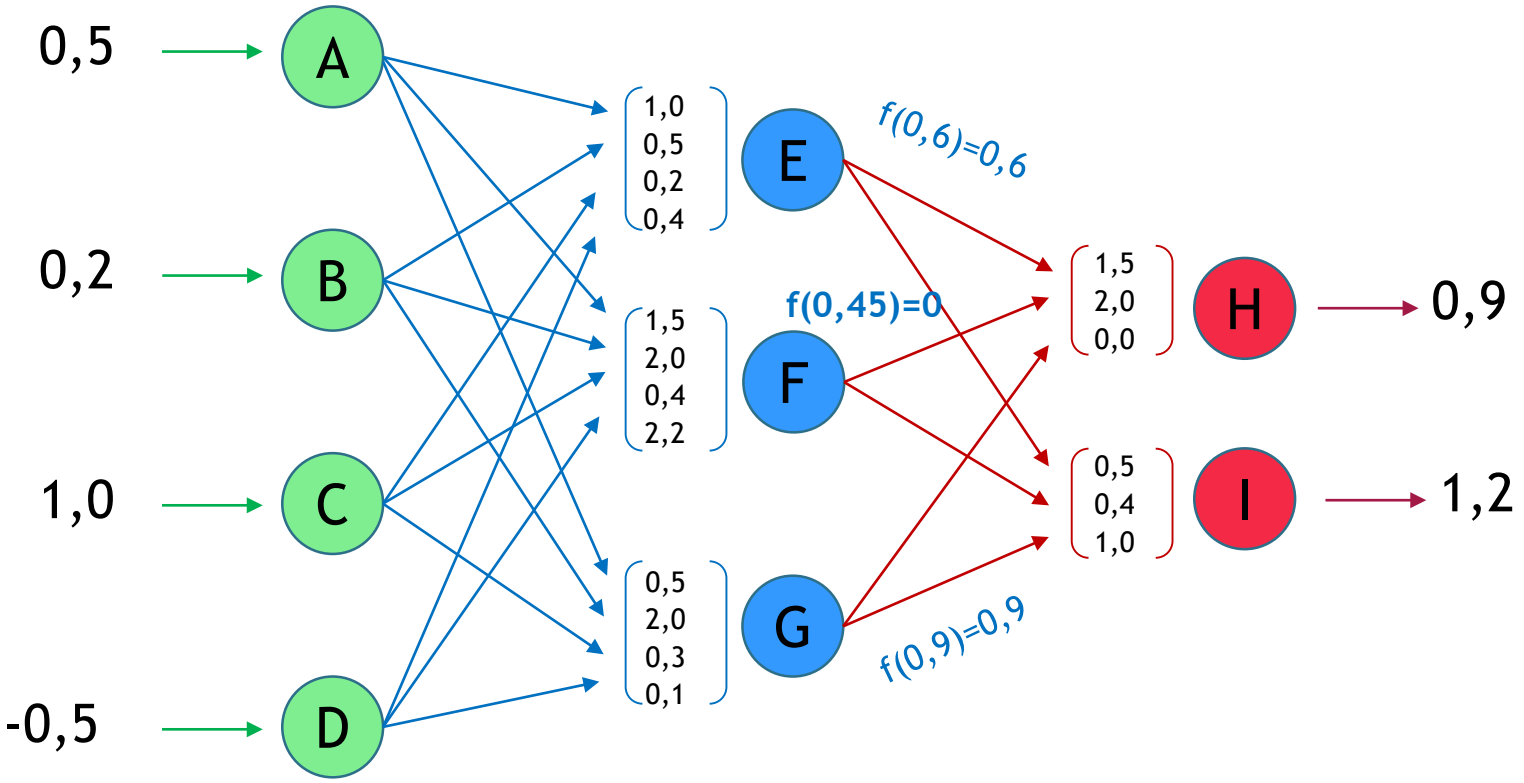
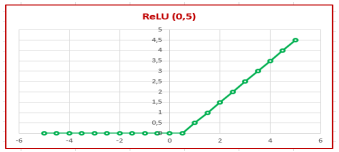
Forward propagation



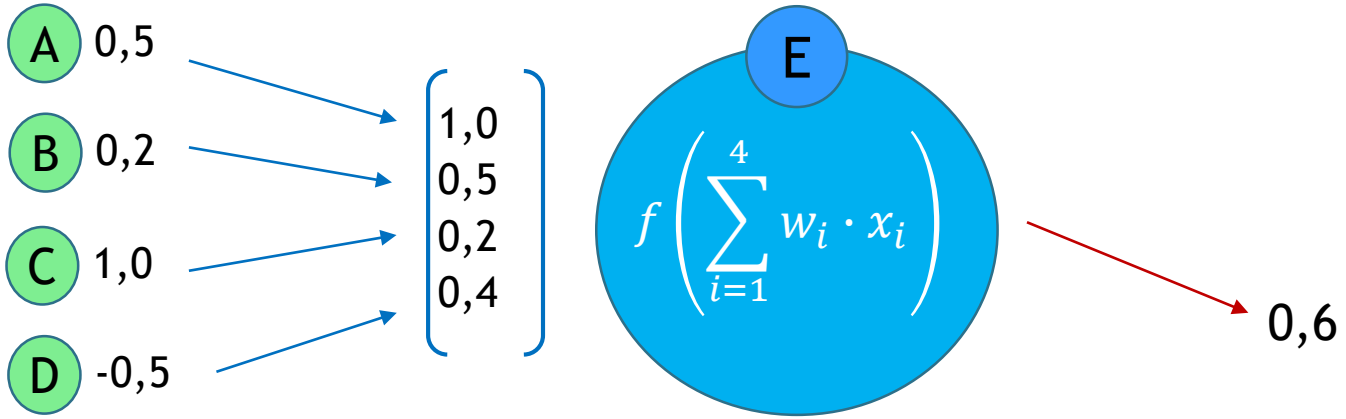
Activation function: f = ReLU (0.5)



,no bias (so that the graphic does not become too confusing).

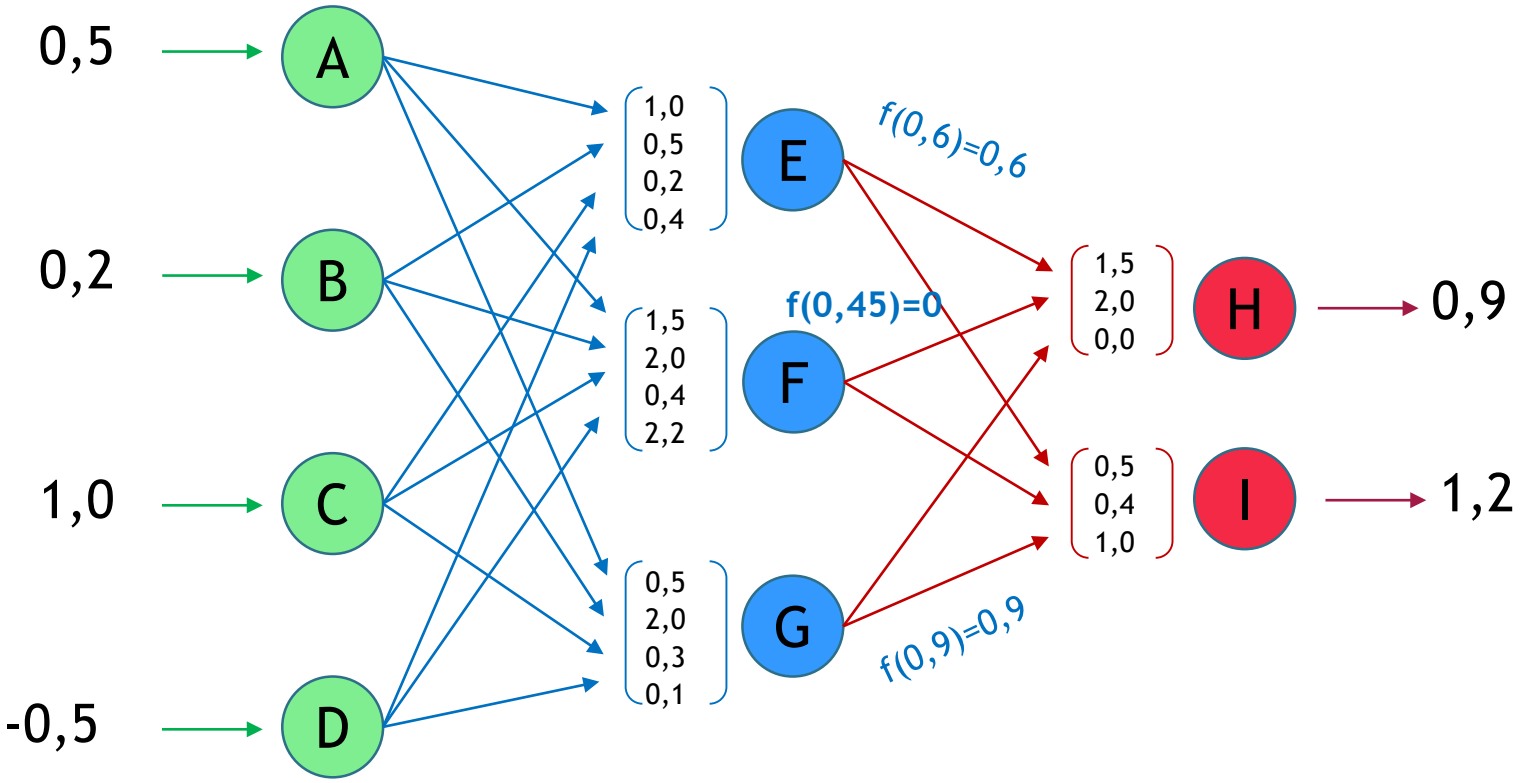
Zoom into the unit E

Activation function: f = ReLU (0.5)

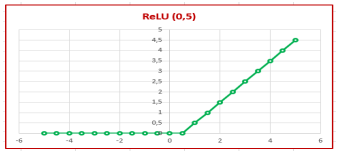


$$f\left(\sum_{i=1}^{4} w_i \cdot x_i\right) = f(0{,}5 \cdot 1 + 0{,}2 \cdot 0{,}5 + 1 \cdot 0{,}2 + (-0{,}5) \cdot 0{,}4) = f(0{,}6) = \mathbf{0{,}6}$$

Forward propagation



Activation function: f = ReLU (0.5)



,no bias (so that the graphic does not become too confusing).

Excursus: Matrix notation - forward propagation

$$I = \begin{pmatrix} 0{,}5 \\ 0{,}2 \\ 1{,}0 \\ -0{,}5 \end{pmatrix} \qquad W_{Input,hidden} = \begin{pmatrix} 1{,}0 & 0{,}5 & 0{,}2 & 0{,}4 \\ 1{,}5 & 2{,}0 & 0{,}4 & 2{,}2 \\ 0{,}5 & 2{,}0 & 0{,}3 & 0{,}1 \end{pmatrix} \qquad W_{hidden,Output} = \begin{pmatrix} 1{,}5 & 2{,}0 & 0 \\ 0{,}5 & 0{,}4 & 1{,}0 \end{pmatrix}$$

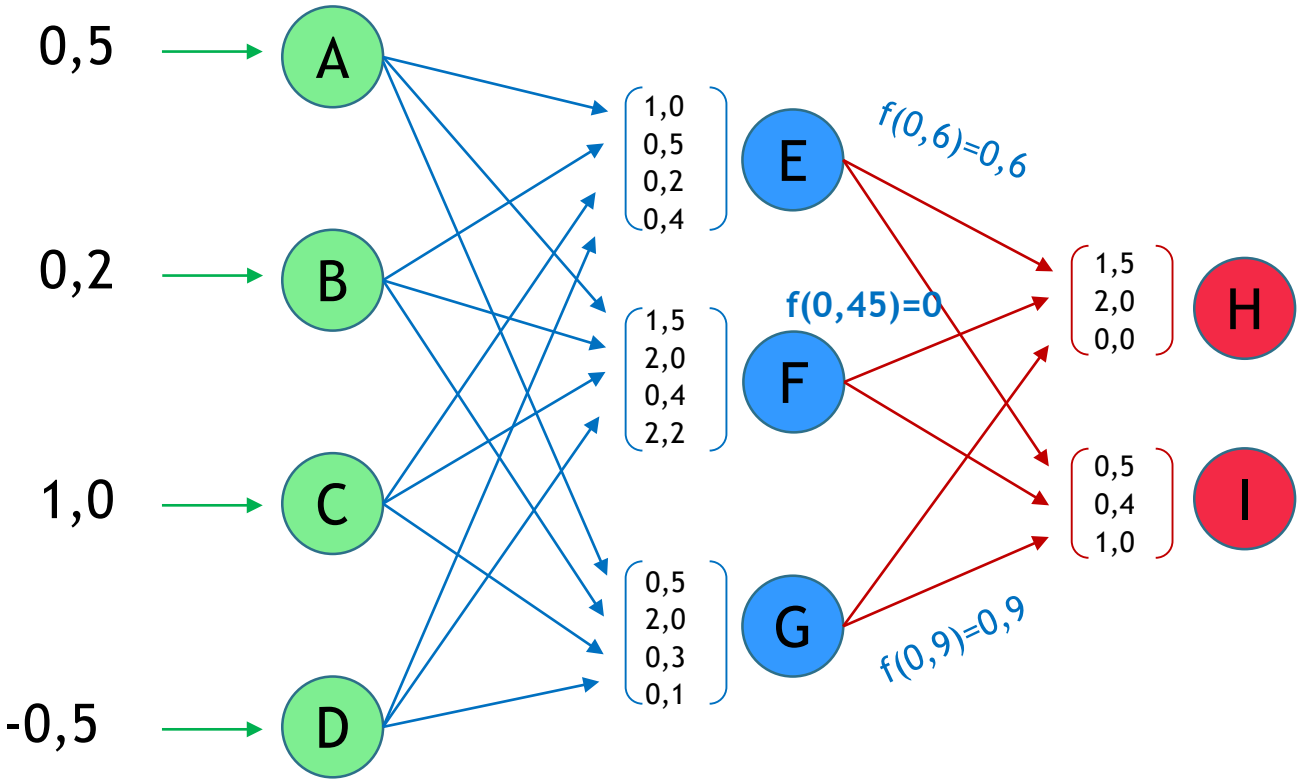
$$X_{hidden} = W_{Input,hidden} \cdot I = \begin{pmatrix} 1{,}0 & 0{,}5 & 0{,}2 & 0{,}4 \\ 1{,}5 & 2{,}0 & 0{,}4 & 2{,}2 \\ 0{,}5 & 2{,}0 & 0{,}3 & 0{,}1 \end{pmatrix} \cdot \begin{pmatrix} 0{,}5 \\ 0{,}2 \\ 1{,}0 \\ -0{,}5 \end{pmatrix} = \begin{pmatrix} 0{,}6 \\ 0{,}45 \\ 0{,}9 \end{pmatrix}$$

$$Out_{hidden} = f(X_{hidden}) = f\left(\begin{pmatrix} 0{,}6 \\ 0{,}45 \\ 0{,}9 \end{pmatrix}\right) = \begin{pmatrix} 0{,}6 \\ 0 \\ 0{,}9 \end{pmatrix}$$

$$X_{Output} = W_{hidden,Output} \cdot Out_{hidden} = \begin{pmatrix} 1{,}5 & 2{,}0 & 0 \\ 0{,}5 & 0{,}4 & 1{,}0 \end{pmatrix} \cdot \begin{pmatrix} 0{,}6 \\ 0 \\ 0{,}9 \end{pmatrix} = \begin{pmatrix} 0{,}9 \\ 1{,}2 \end{pmatrix}$$

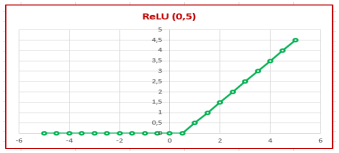
$$\textbf{Output} = f(X_{Output}) = f\left(\begin{pmatrix} 0{,}9 \\ 1{,}2 \end{pmatrix}\right) = \begin{pmatrix} 0{,}9 \\ 1{,}2 \end{pmatrix}$$

Error analysis



	expected:	Error^2
H	1,5	$(1,5 - 0,9)^2 = 0,36$
		+
I	2,0	$(2,0 - 1,2)^2 = 0,64$
		= 1,0

Activation function: f = ReLU (0.5)



,no bias (so that the graphic does not become too confusing).

So what now?

- Now we know how to process an input and generate an output from it.
- We also know the output we would like to have.
- What can we do so that the generated output matches or at least comes close to the expected one?

➢ This will occupy the topic in my next lecture.

➢ Also here on actuview.

Thank you for
your attention

Let us talk to one another

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