Higher Institute of Technological Studies of Bizerte

AY: 2022-2023 | **M1-S1: Dept. of Electrical Engineering**
Exam | AI-ECUE122 | **Teacher: A. Mhamdi**
27/01/23 (09:00→10:30) | **Time Limit: $1\frac{1}{2}$ h**

This document contains **5** pages numbered from **1/5** to **5/5**. As soon as it is handed over to you, make sure that it is complete. The **4** tasks are independent and can be treated in the order that suits you.

The following rules apply:

❶ **A handwritten double-sided A4** sheet is permitted.

❷ **Any electronic material**, except basic calculator, is prohibited.

❸ **Mysterious or unsupported answers** will not receive full credit.

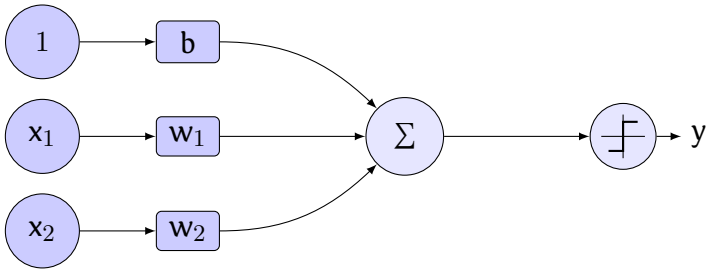
❹ **Label all relevant aspects** of the graph, if you are asked to draw one.

❺ **Hand in your answer sheets** at the end of the exam.

Task N°1

⌛ 20mn | (4 points)

We consider the vastly simplified model of real neuron, also known as **Threshold Logic Unit**. The processing element sums the weighted inputs $w_1x_1 + w_2x_2$, add a bias b and then applies a non linear activation function. The output transmits $+1$ *if and only if* the input is positive. Otherwise, it transmits -1.



Use bipolar data instead of binary data for the inputs x_1 and x_2, *i.e.* ± 1. Weights and bias are all set initially to zero: $w_1 = w_2 = b = 0$.

Consider the problem approximating an $\vee$ **(OR)** gate, according to **Hebbian** learning rule. Reproduce and fill in the following table on your answer sheet.

x_1	x_2	b	y	Δw_1	Δw_2	Δb	w_1	w_2	b
-1	-1	1	-1	1	1	-1	1	1	-1
-1	1	1	1	-1	1	1	0	2	0
1	-1	1	1	1	-1	1	1	1	1
1	1	1	1	1	1	1	2	2	2

Task №2

⏳ 15mn | (4 points)

Perform the following arithmetic operations.

(a) (1 point) $[0,\ 1] + [-6,\ 5] =$ [-6, 6]

(b) (1 point) $[0,\ 1] - [-6,\ 5] =$ [-5, 7]

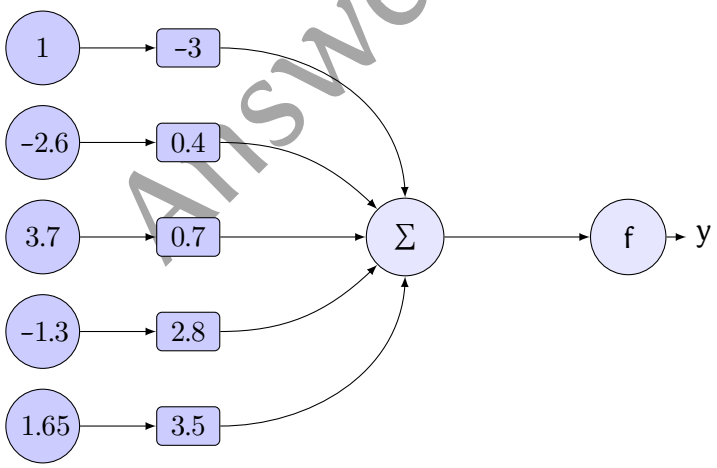
(c) (1 point) $[3,\ 4] \times [2,\ 2] =$ [6, 8]

(d) (1 point) $[4,\ 10] \div [1,\ 2] =$ [2, 10]

Task №3

⏳ 25mn | (6 points)

(a) (2 points) Compute the output being fired by the following neuron. f designates the tanh function.



The output is given by:

$$y = \tanh(-3 \times 1 - 2.6 \times 0.4 + 3.7 \times 0.7 - 1.3 \times 2.8 + 1.65 \times 3.5) = \tanh(0.685)$$

It yields:

$$y = 0.594760307$$

(b) (1 point) What is the machine learning library we used in `Julia` to train artificial neural networks.

Flux

(c) (1 point) Given the code snippet as shown in Fig. 1, p. 4. Explain why are there 75 trainable parameters in `model`.

Total number of trainable parameters is

$$5 \times 8 + 8 + 8 \times 3 + 3 \;=\; 75$$

(d) (1 point) What does the factor $w_{3,1}^{(1)}$ refer to, and what is its value.

$w_{3,1}^{(1)}$ designates the synaptic weight that connects the first input to the third neuron of the hidden layer. Its values is:

$$w_{3,1}^{(1)} \;=\; 0.503822$$

(e) (1 point) What is the value of synaptic weight between neuron #7 of the hidden layer and neuron #2 of the output layer.

The synaptic weight is denoted by $w_{2,7}^{(2)}$, and is given by:

$$w_{2,7}^{(2)} \;=\; -0.568683$$

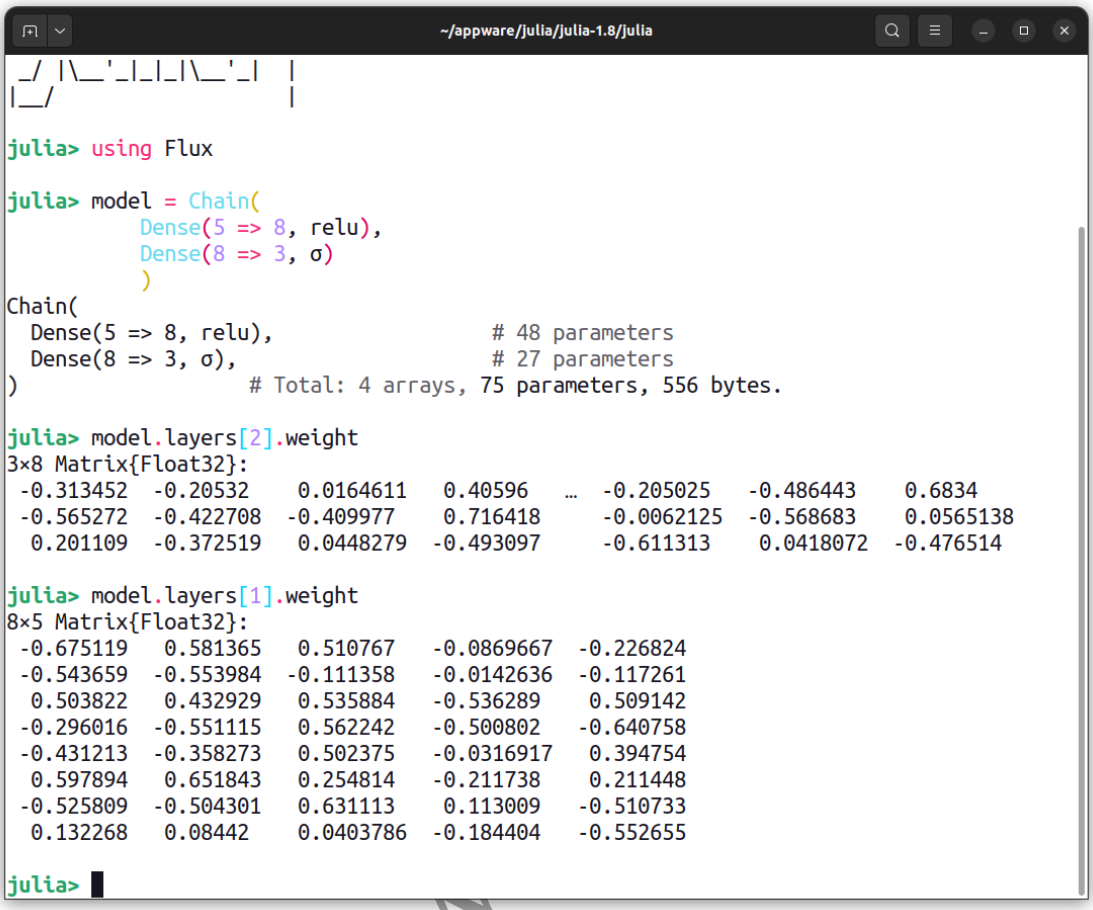


Fig. 1. Julia REPL

Task №4

⏳ 30mn | (6 points)

Suppose we have three fuzzy predicates: $\mathcal{A}$, $\mathcal{B}$ and C described by these trapezoidal fuzzy sets:

$\mathcal{A}$ $\Pi\,(1,\ 2,\ 5,\ 7)$

$\mathcal{B}$ $\Pi\,(4,\ 12,\ 15,\ 16)$

C $\Pi\,(7,\ 8,\ 9,\ 12)$

x and y are fuzzy variables, each one ranges between 0 and 16. Given the following three rules:

$\mathfrak{R}_1$ $(\text{x is } \mathcal{A} \vee \text{x is } \mathcal{B}) \wedge !(\text{y is } C) \rightarrow \text{u} = 9$

$\mathfrak{R}_2$ $!(\text{x is } \mathcal{B}) \wedge (\text{y is } C) \rightarrow \text{u} = 3$

$\mathfrak{R}_3$ $(\text{x is } \mathcal{B} \vee \text{x is } C) \wedge !(\text{y is } \mathcal{A}) \rightarrow \text{u} = 16$

Compute the degree of satisfaction for $\text{x} = 6$ & $\text{y} = 10$.

$\mathfrak{R}_1$ $(\mu_{\mathcal{A}}(6) \max \mu_{\mathcal{B}}(6)) \min (1 - \mu_C(10)) = (0.5 \max 0.12) \min (1 - 2/3) = 1/3$

$\mathfrak{R}_2$ $(1 - \mu_{\mathcal{B}}(6)) \min \mu_C(10) = (1 - 1/4) \min 2/3 = 2/3$

$\mathfrak{R}_3$ $(\mu_{\mathcal{B}}(6) \max \mu_C(6)) \min (1 - \mu_{\mathcal{A}}(y)) = (1/4 \max 0) \min (1 - 0) = 1/4$

The final result is:

$$u^\star = \frac{1/3 \times 9 + 2/3 \times 3 + 1/4 \times 16}{1/3 + 2/3 + 1/4} = 7.2$$