École nationale supérieure
d'ingénieurs sud Alsace

Neural Networks in Haskell

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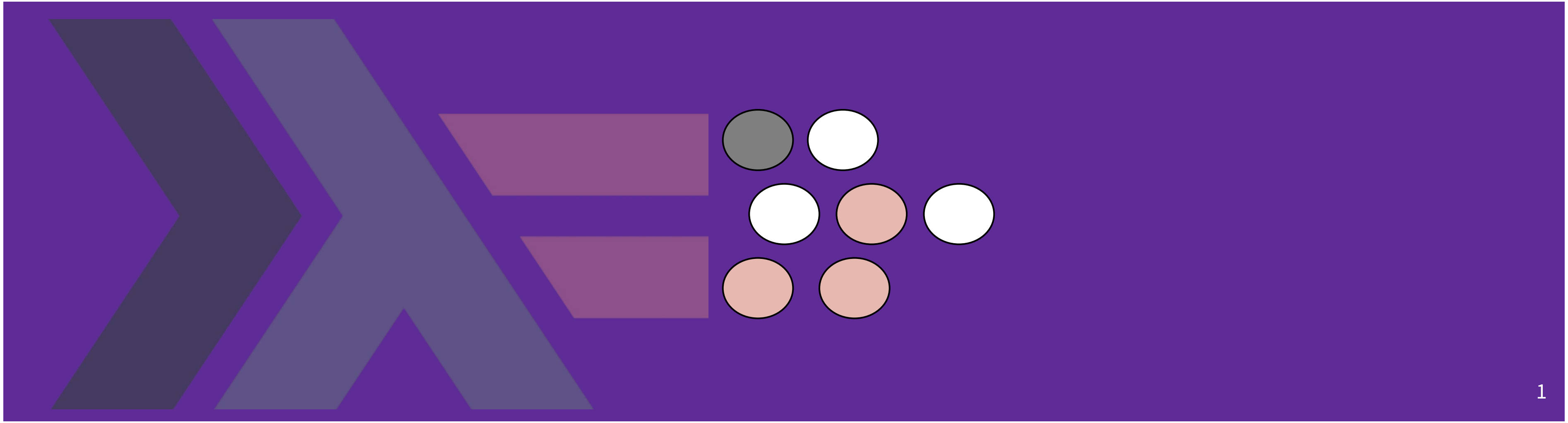


CONTENT :

1- The Project

2- Why Haskell (Models/equations)

3- Results/demo

4- Perspective

WHAT IS THE PROJECT ABOUT

The Implementation of Neural Networks using Haskell

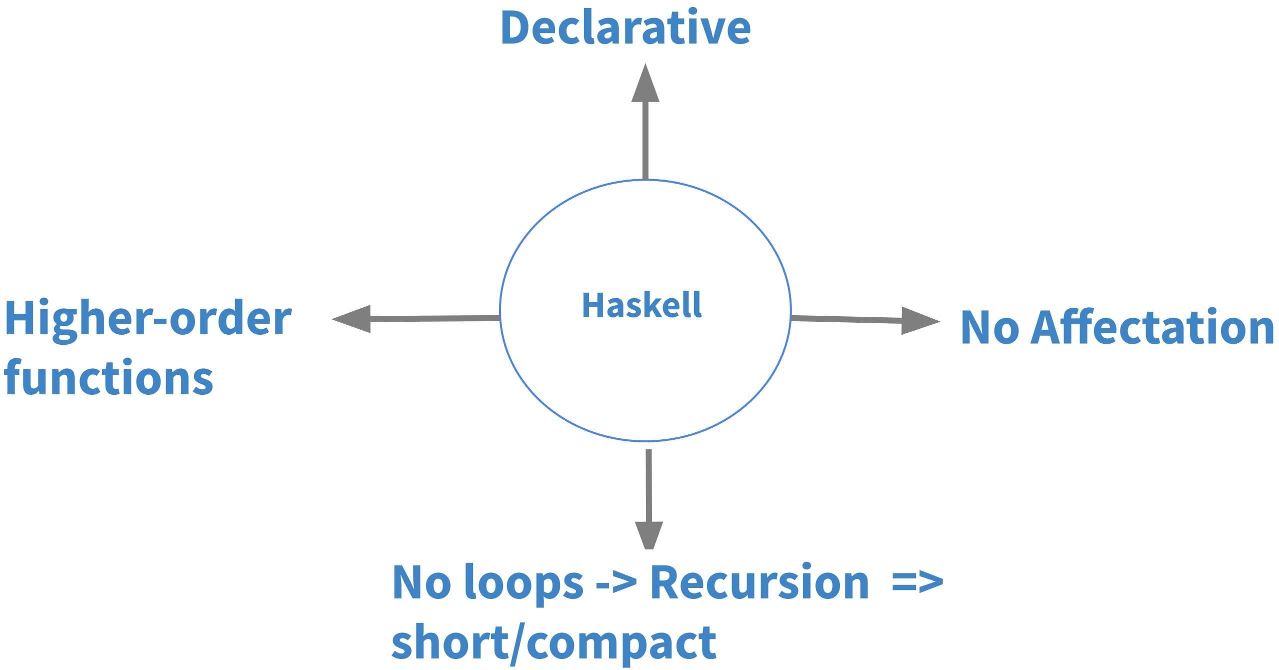
Basic examples

Advanced examples ANN

Performances

- Steps Needed :
  - Clean Data
  - Neural Network
  - Data analysis

WHY HASKELL ?



Haskell

Declarative

Higher-order functions

No Affectation

No loops -> Recursion => short/compact

WHY HASKELL ?

Examples : only 3 operators needed !

- **zipWith (*) [x1,x2,...,xn] [y1,y2,...,yn] = [x1*y1,x2*y2,...,xn*yn]**
- **map f [x1,x2,...,xn] = [f(x1), f(x2),...,f(xn)]**
- **foldr1 + [x1,x2,...,xn] = [x1+x2+x3....+xn]**

WHY HASKELL ?

Examples : Basic Function

mult X Y = zipWith (*) [x1,x2,...,xn] [y1,y2,...,yn] = [x1*y1,x2*y2,...,xn*yn]

add X Y = zipWith (+)[x1,x2,...,xn] [y1,y2,...,yn] = [x1+y1,x2+y2,...,xn+yn]

minus X Y= zipWith (-)[x1,x2,...,xn] [y1,y2,...,yn] = [x1-y1,x2-y2,...,xn-yn]

sum X = foldr1 (+) X

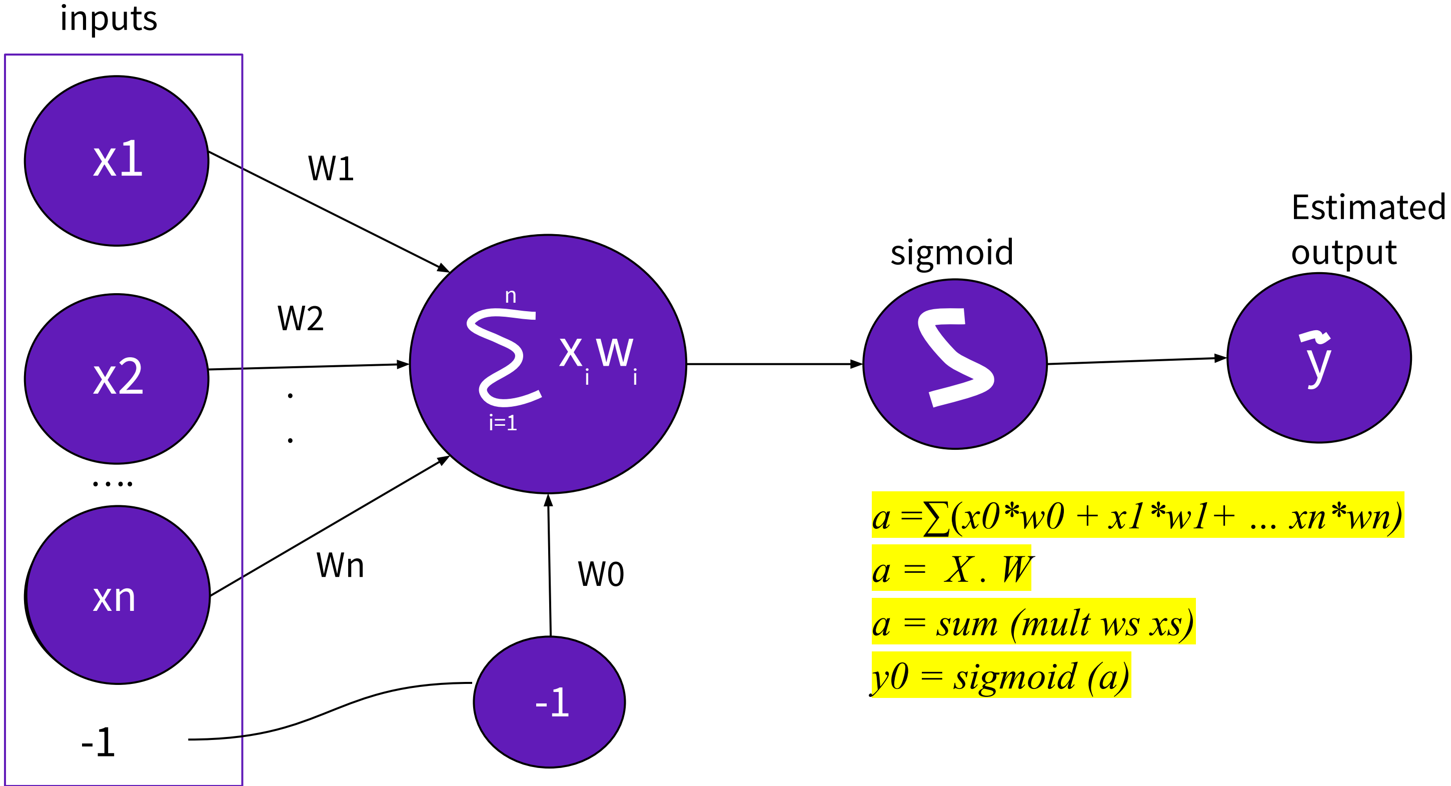
WHY HASKELL ?

Examples : Function

addMatrix X Y = zipWith (add) [X1,X2,...,Xn] [Y1,Y2,...,Yn] = [add X1 Y1,add X2 Y2,...,add Xn Yn]

WHY HASKELL ?

Models/equations for Neural Networks => Perceptron



*a =∑(x0*w0 + x1*w1+ … xn*wn)*

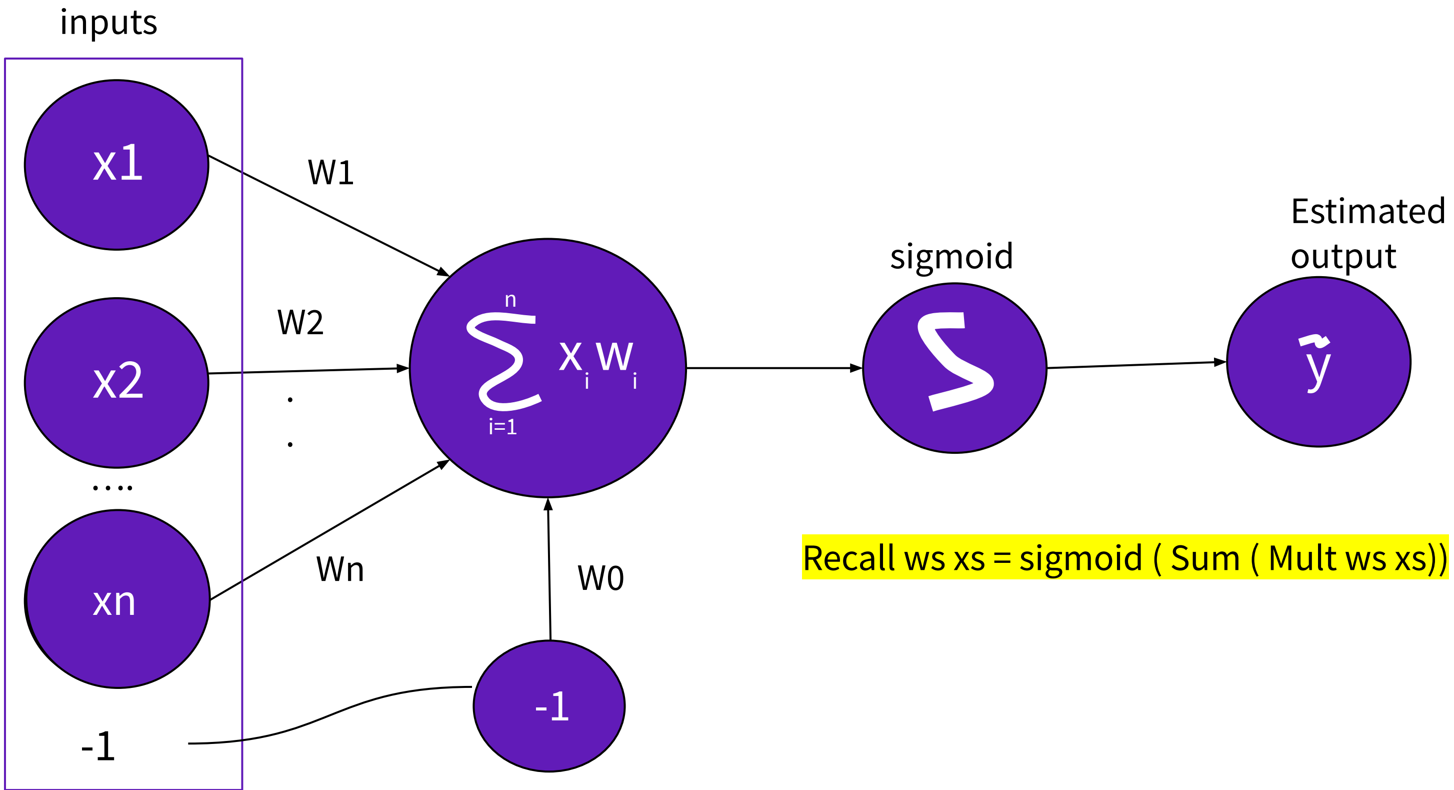
a = X . W

a = sum (mult ws xs)

y0 = sigmoid (a)

WHY HASKELL ?

Models/equations for Neural Networks => Perceptron



Recall ws xs = sigmoid (Sum (Mult ws xs))

WHY HASKELL ?

Models/equations for Neural Networks => Learning / Adaptation

$$error\ e = \frac{(\tilde{y} - y)^2}{2}$$

$$\frac{\partial e}{\partial w} = \frac{\partial e}{\partial \tilde{y}} \cdot \frac{\partial \tilde{y}}{\partial a} \cdot \frac{\partial a}{\partial w}$$

$$\frac{\partial e}{\partial \tilde{y}} = \tilde{y} - y \qquad \frac{\partial \tilde{y}}{\partial a} = sig'(a) \qquad \frac{\partial a}{\partial w} = xs$$

$$\partial e = \tilde{y} - y \qquad \partial \tilde{y} = sig'(a) \quad \partial a = shif\ t\ (xs) \quad \partial w = mult\ (\partial e \cdot \partial \tilde{y})\ xs$$

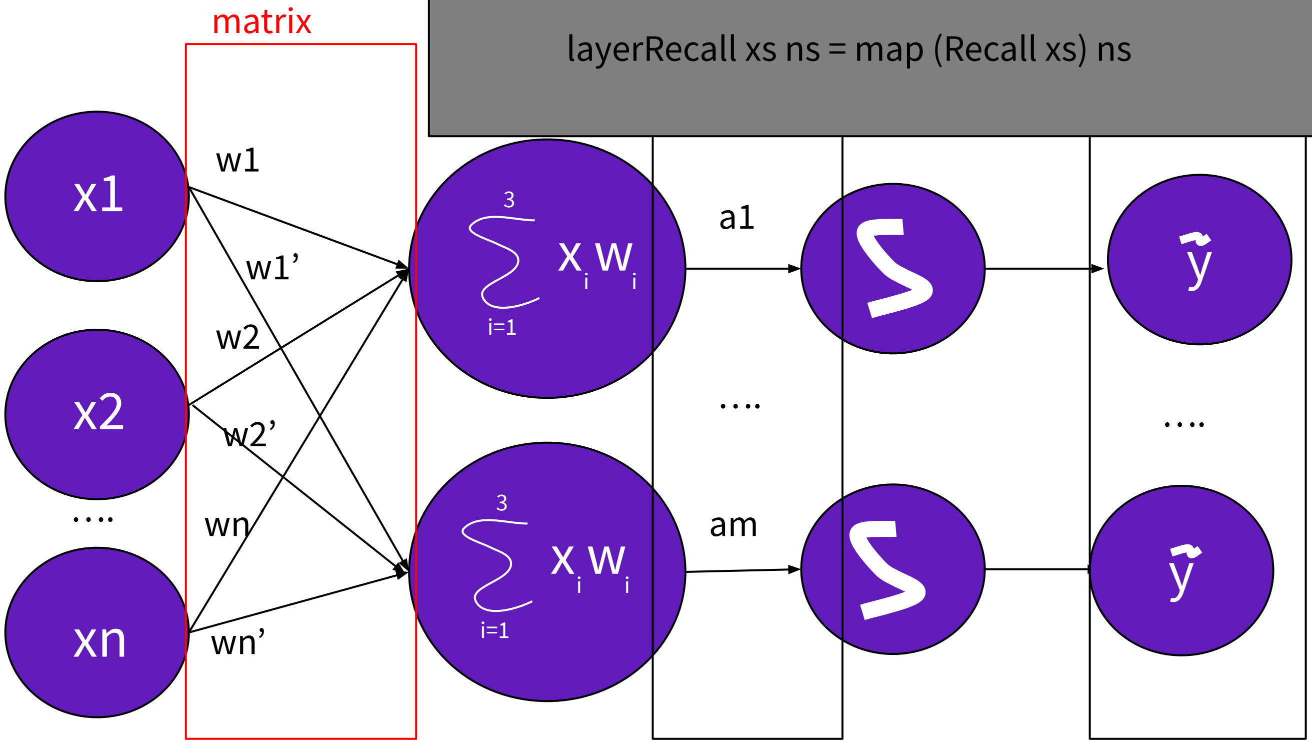
$$sig'(x) = sig(x) * (1 - sig(x))$$

Update Neuron = zipWith (+) ws (map (0.01*err) (-1:xs))

WHY HASKELL ?

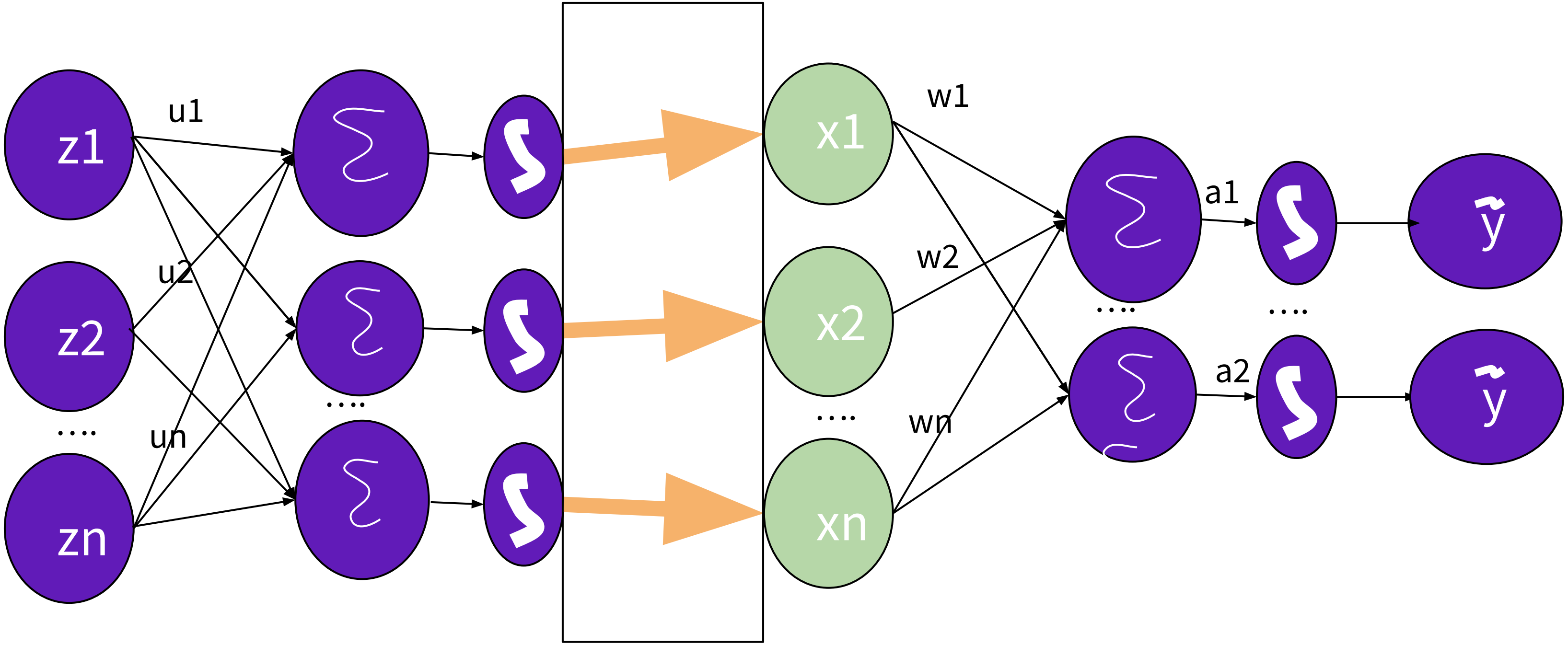
Models/equations for Neural Networks => Layer

```
layerRecall xs ns = map (Recall xs) ns
```



WHY HASKELL ?

Models/equations for Neural Networks => Net



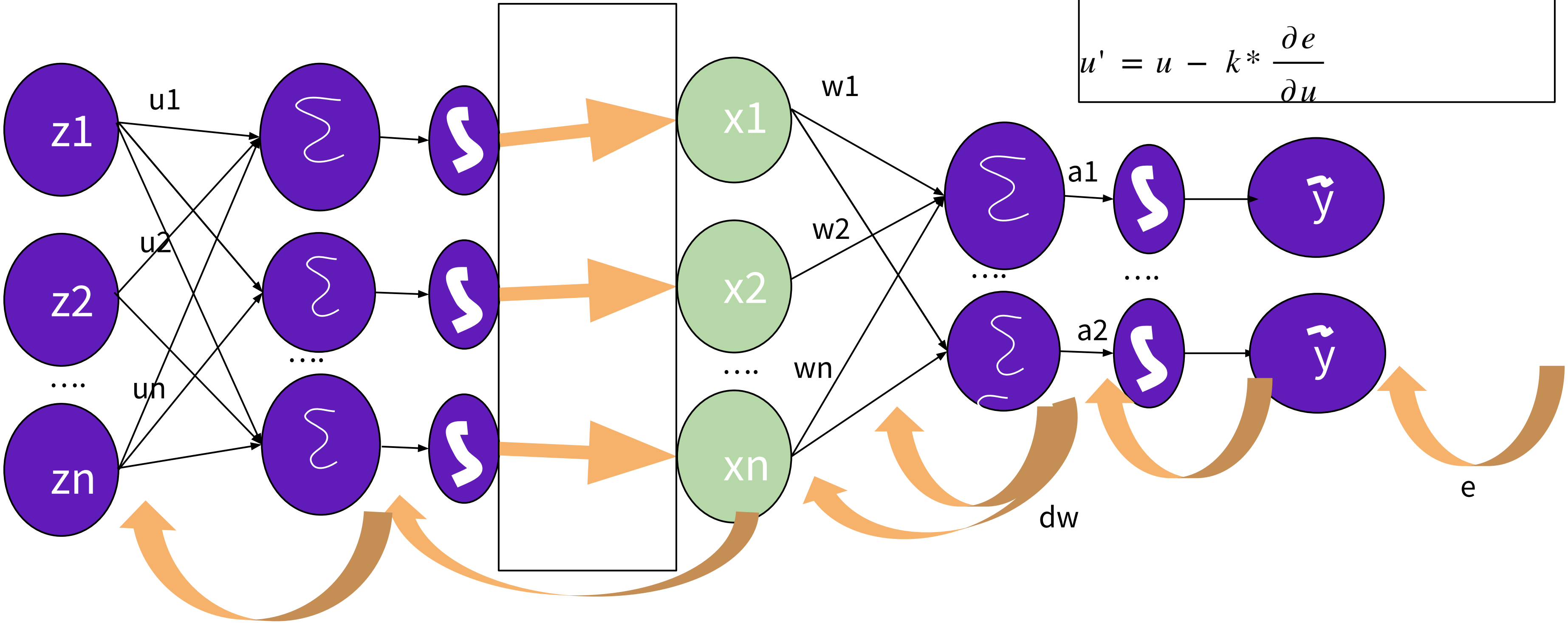
WHY HASKELL ?

Models/equations for Neural Networks

$$error\ e = \frac{(\tilde{y} - y)^2}{2}$$

$$\frac{\partial e}{\partial u} = \frac{\partial e}{\partial \tilde{y}} \cdot \frac{\partial \tilde{y}}{\partial a} \cdot \frac{\partial a}{\partial x} \cdot \frac{\partial x}{\partial b} \cdot \frac{\partial b}{\partial u}$$

$$u' = u - k * \frac{\partial e}{\partial u}$$



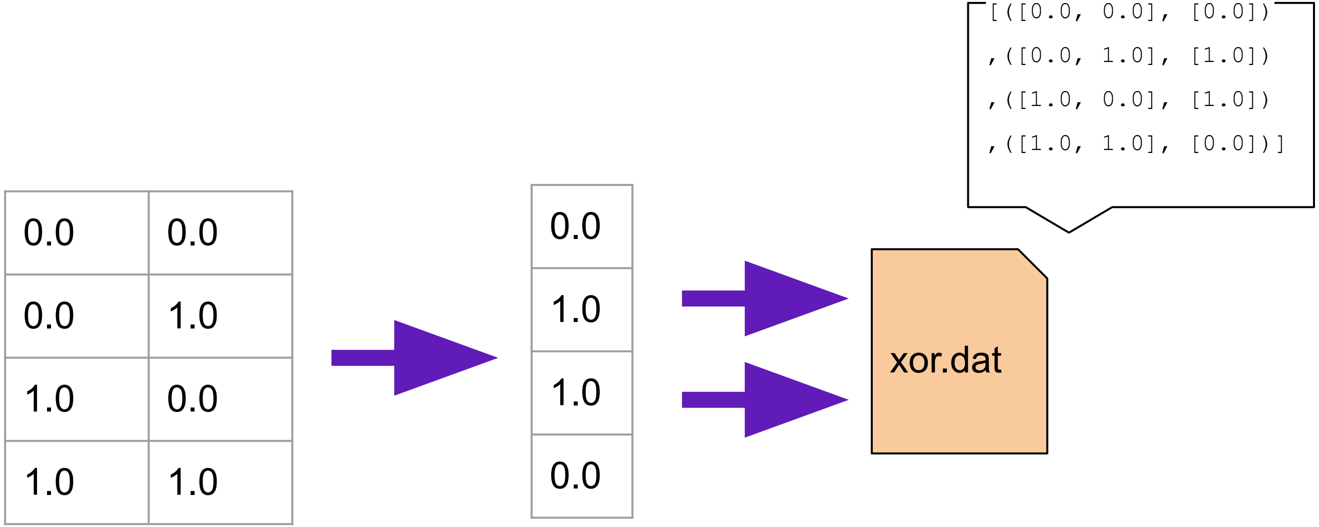
RESULTS/DEMO

3 examples XOR, AUTO_ENCODER and DIGIT_RECOGNITION Result in Binary.

```
3 Commands in terminal :

./build                        -> construction d’un reseau

./remind or ./remindsimple     -> pour le calcul à partir d’un  input

./learn or ./learnsimple       -> pour le learn avec normalement une boucle
```

RESULTS/DEMO

Demo XOR Net : organising data



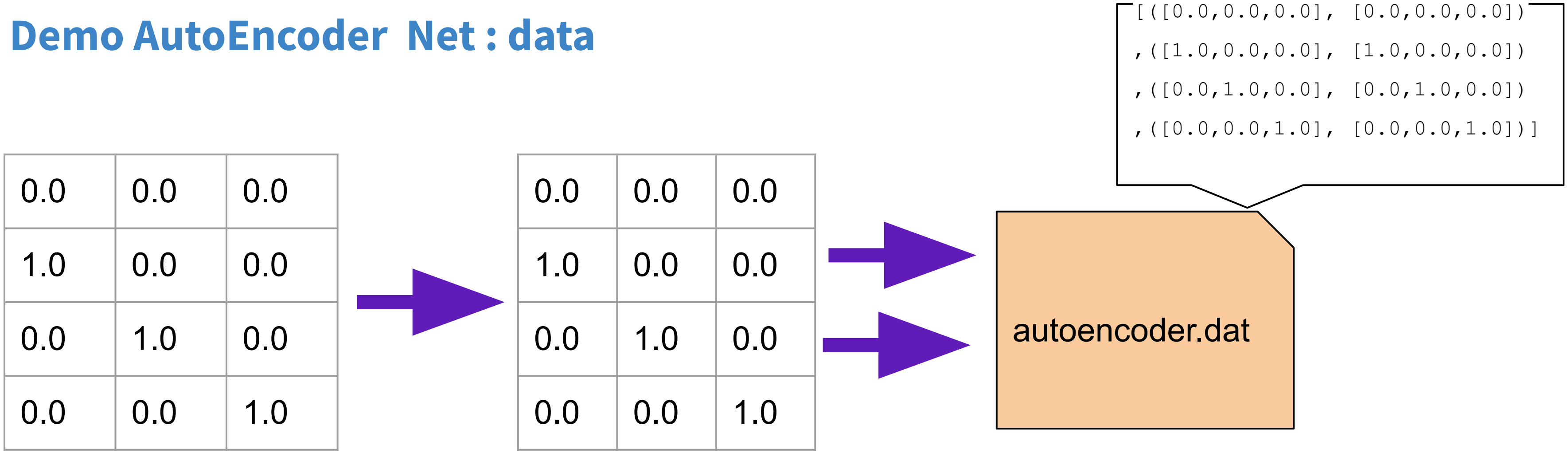
0.0	0.0
0.0	1.0
1.0	0.0
1.0	1.0

0.0
1.0
1.0
0.0

```
[([0.0, 0.0], [0.0])
,([0.0, 1.0], [1.0])
,([1.0, 0.0], [1.0])
,([1.0, 1.0], [0.0])]
```

RESULTS/DEMO

Demo AutoEncoder Net : data



0.0	0.0	0.0
1.0	0.0	0.0
0.0	1.0	0.0
0.0	0.0	1.0

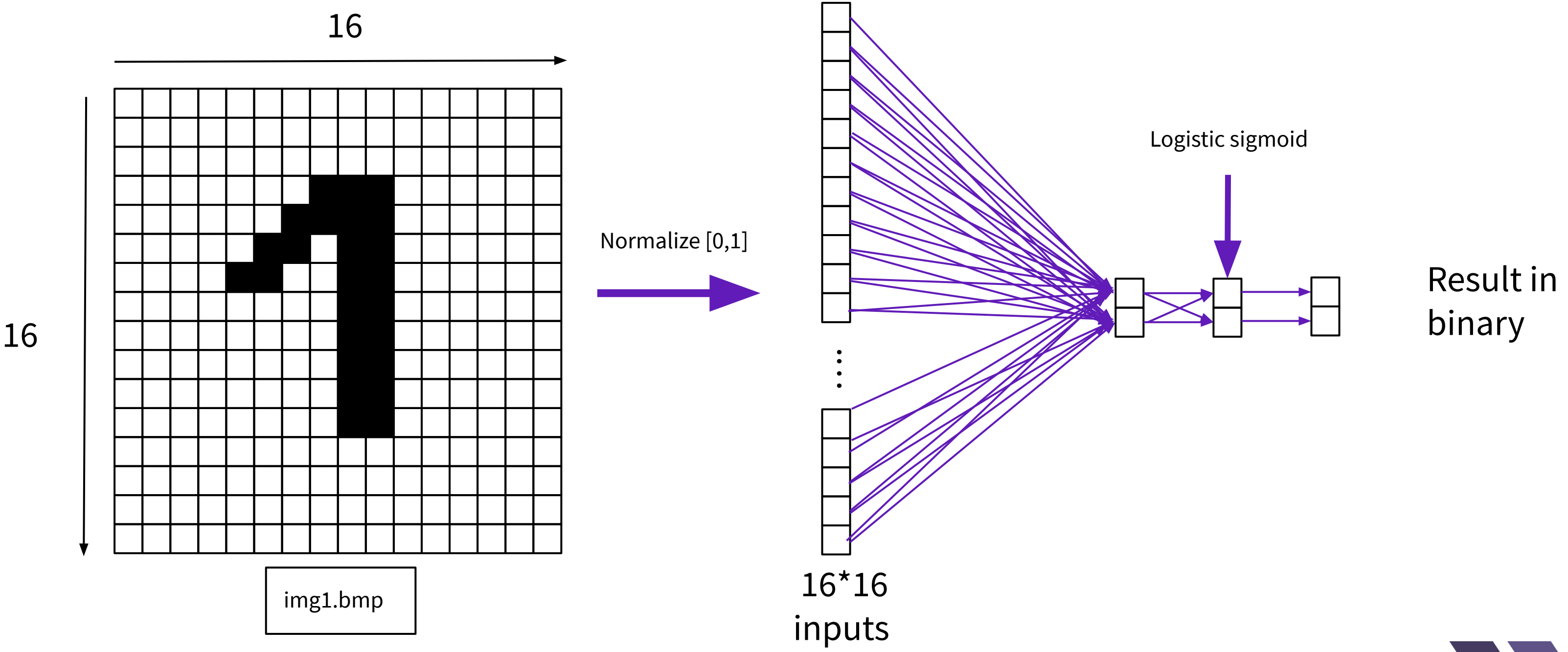
0.0	0.0	0.0
1.0	0.0	0.0
0.0	1.0	0.0
0.0	0.0	1.0

autoencoder.dat

```
[([0.0,0.0,0.0], [0.0,0.0,0.0])
,([1.0,0.0,0.0], [1.0,0.0,0.0])
,([0.0,1.0,0.0], [0.0,1.0,0.0])
,([0.0,0.0,1.0], [0.0,0.0,1.0])]
```

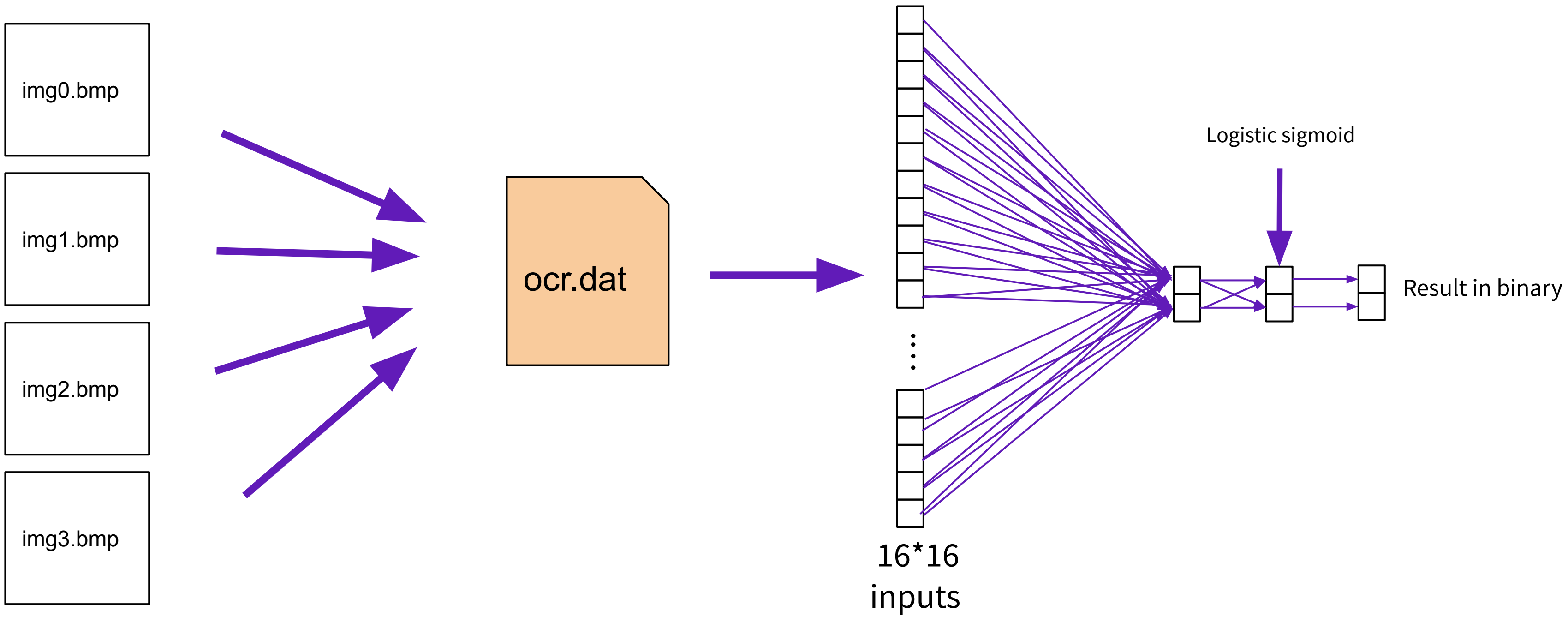
RESULTS/DEMO

Demo Digit GraySCale Recognition Net : how it works



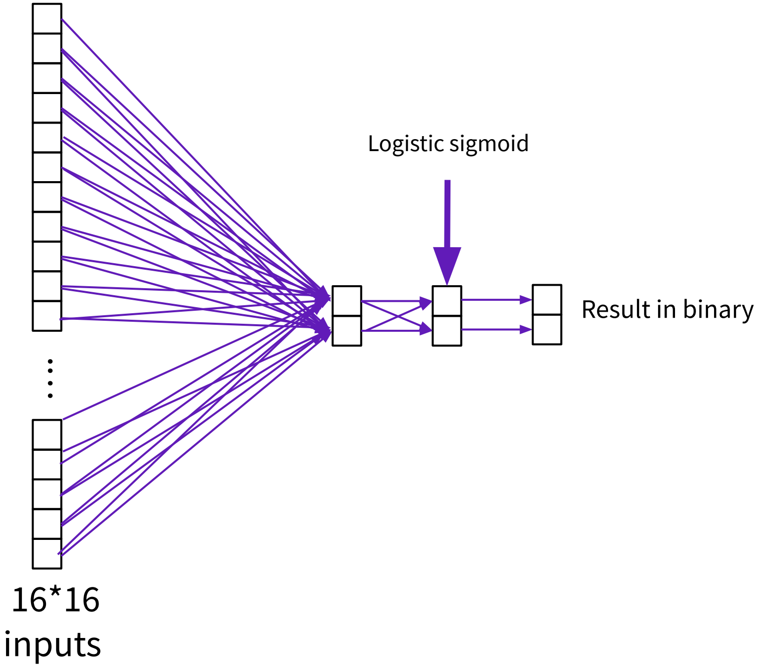
RESULTS/DEMO

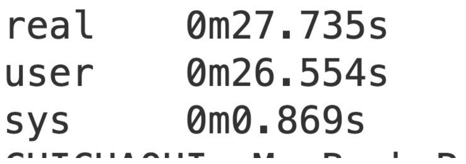
Demo Digit GraySCale Recognition   Net : training data



RESULTS/DEMO

Demo Digit GrayScale Recognition Net : performance





```
real	0m27.735s
user	0m26.554s
sys	0m0.869s
```

20 510 bytes (49 KB on disk)

Reprise :

By other data science enthusiast

More Exciting Examples to implement

To help : documentation available

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THANK YOU

ANY QUESTIONS ?