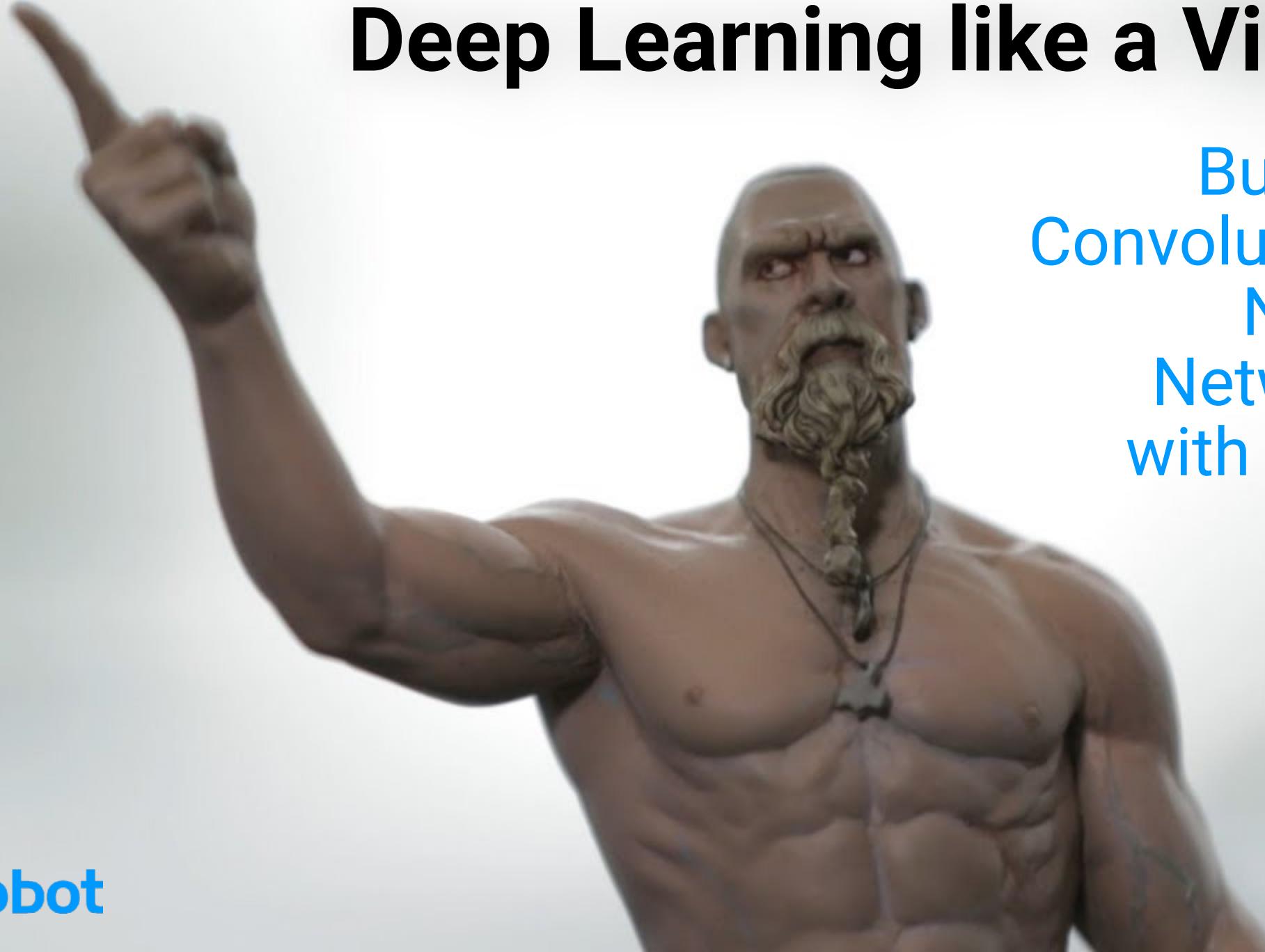


# Deep Learning like a Viking



Building  
Convolutional  
Neural  
Networks  
with Keras



# **Guy Royse**

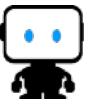
Developer Evangelist  
DataRobot

 @guyroyse

 [github.com/guyroyse](https://github.com/guyroyse)

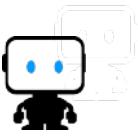


| \* + + ↑ ↘



# IANADS

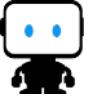
# The Younger Futhark



|    |    |       |    |       |      |        |        |     |    |     |     |       |       |      |    |   |   |   |
|----|----|-------|----|-------|------|--------|--------|-----|----|-----|-----|-------|-------|------|----|---|---|---|
| ᚠ  | ᚢ  | ᚦ     | ᚩ  | ᚪ     | ᚱ    | ᚴ      | *      | ᚴ   | *  | ᚦ   | ᛁ   | ᛏ     | ᚦ     | ᚦ    | ᚢ  | ᚦ | ᚱ | ᚦ |
| fe | ur | thurs | as | reith | kaun | hagall | nauthr | isa | ar | sol | tyr | bjork | mathr | logr | yr |   |   |   |

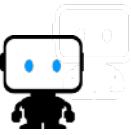
ᚫ\* | \* | ᚮ\*

(Kai Rais)



# Lingsberg Runestones

Danr and Húskarl and Sveinn and Holmfríðr, the mother and (her) sons, had this stone erected in memory of Halfdan, the father of Danr and his brothers; and Holmfríðr in memory of her husbandman.

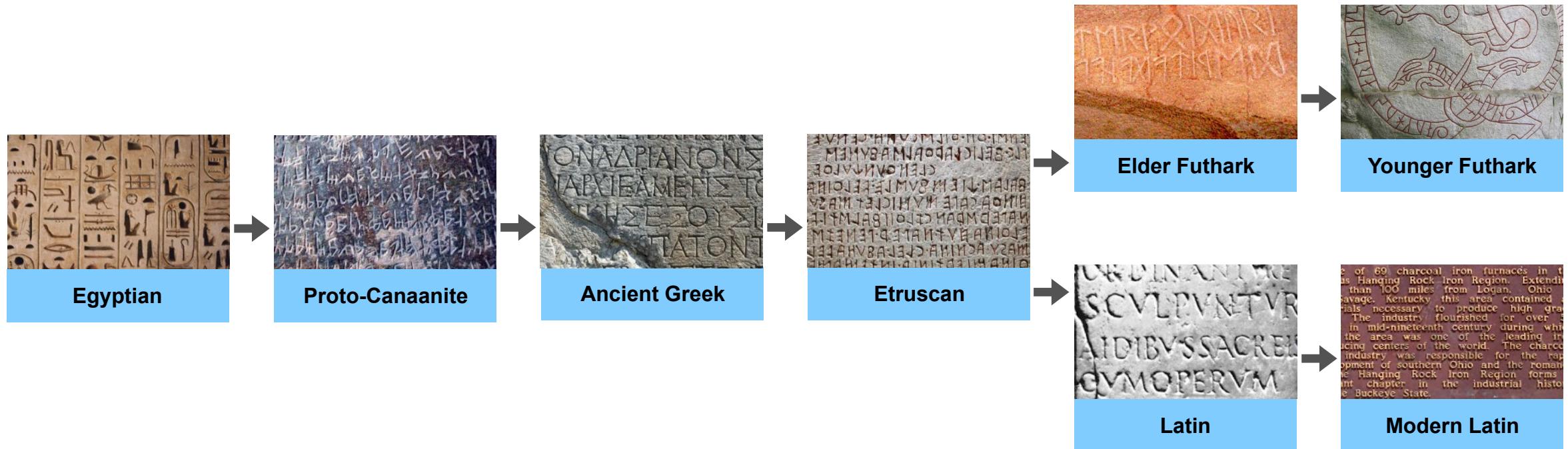
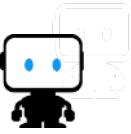


# Younger Futhark vs. Latin & Greek

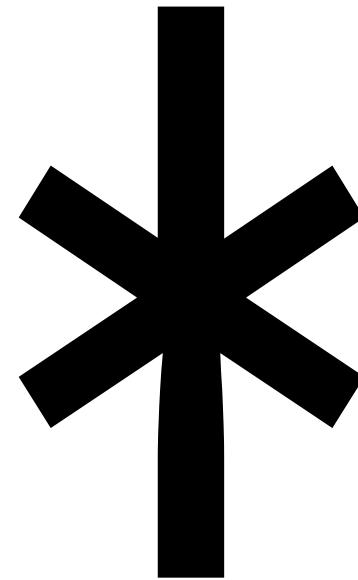
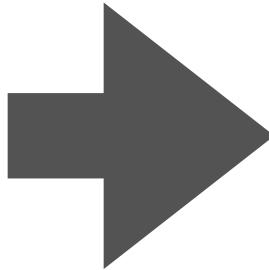
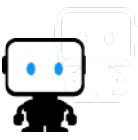
|    |    |       |    |       |      |        |        |     |    |     |     |       |       |      |    |   |   |   |   |   |
|----|----|-------|----|-------|------|--------|--------|-----|----|-----|-----|-------|-------|------|----|---|---|---|---|---|
| ᚠ  | ᚢ  | ᚦ     | ᚩ  | *     | ᚱ    | ᚴ      | *      | ᛖ   | ᛁ  | ᷃   | ᷅   | ᛏ     | ᷇     | ᷉    | ᷊  | ᷋ | ᷌ | ᷍ | ᷏ | ᷎ |
| fe | ur | thurs | as | reith | kaun | hagall | nauthr | isa | ar | sol | tyr | bjork | mathr | logr | yr |   |   |   |   |   |

|   |   |   |  |   |  |  |   |  |   |   |   |  |   |  |  |  |  |  |  |  |
|---|---|---|--|---|--|--|---|--|---|---|---|--|---|--|--|--|--|--|--|--|
| F | U |   |  | R |  |  | I |  | S | T | B |  | L |  |  |  |  |  |  |  |
|   |   | Θ |  | P |  |  | I |  | Σ | T | B |  | Λ |  |  |  |  |  |  |  |

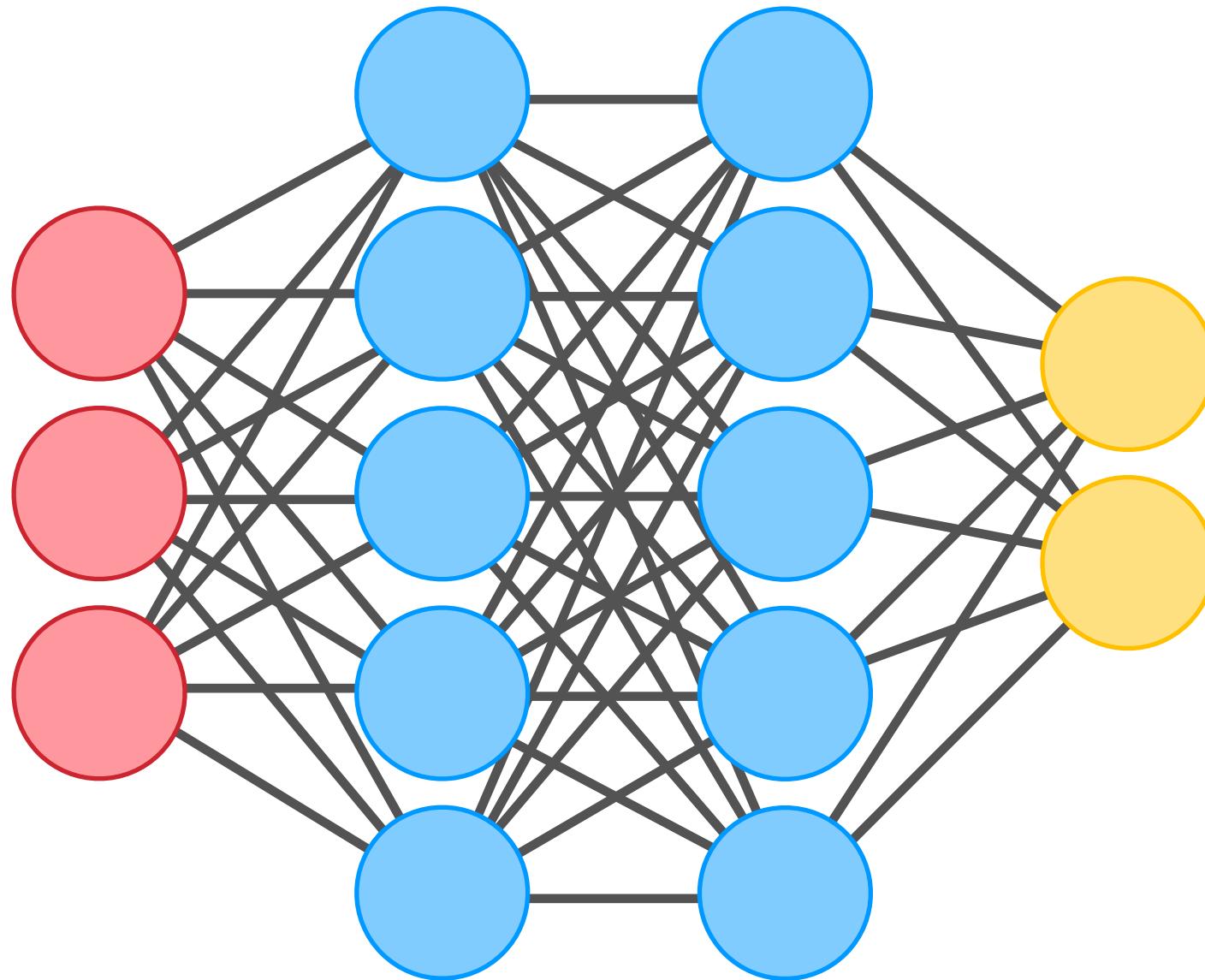
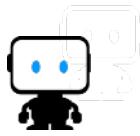
# Common Ancestors



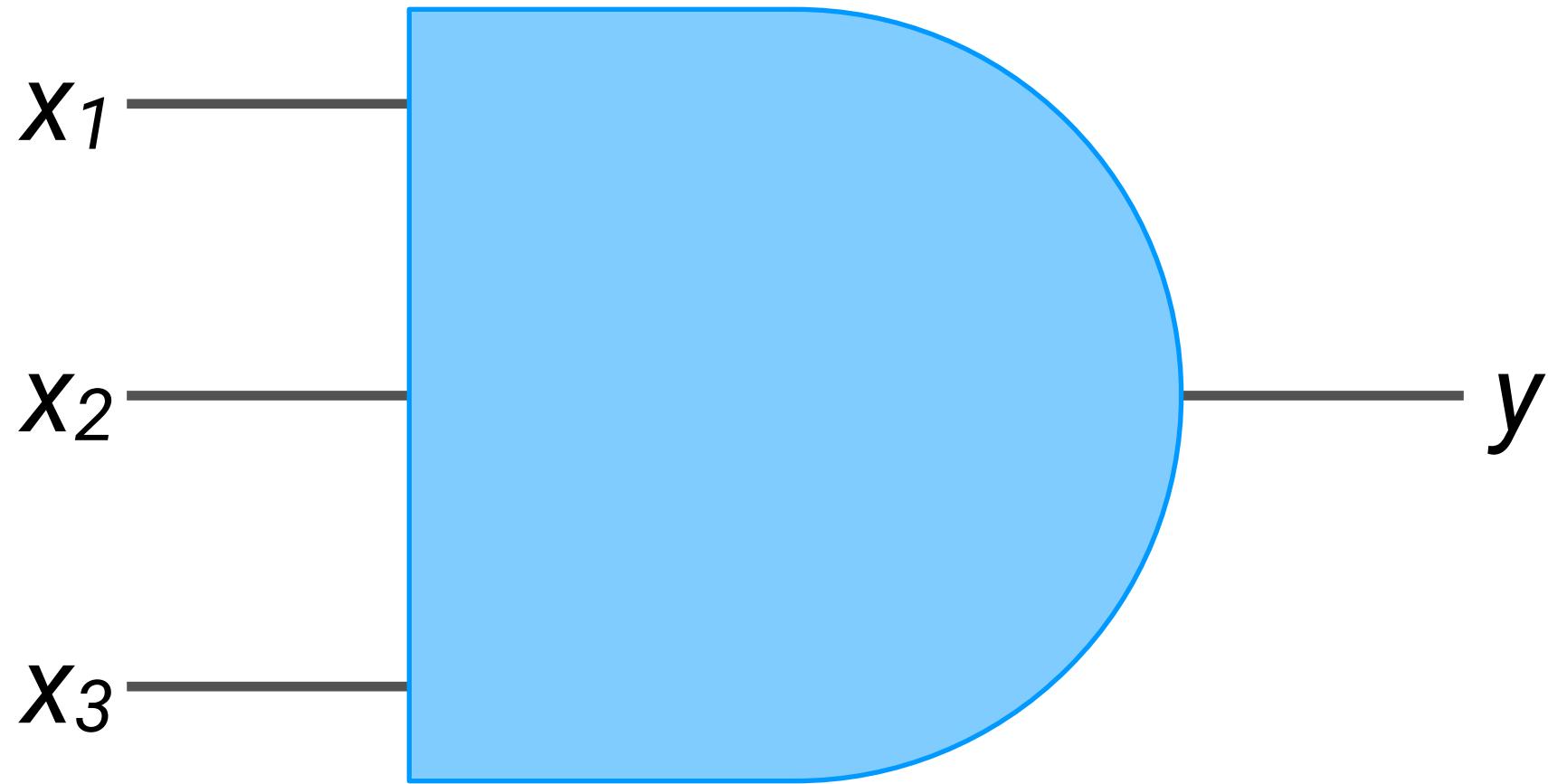
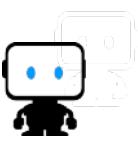
# Recognizing Runes



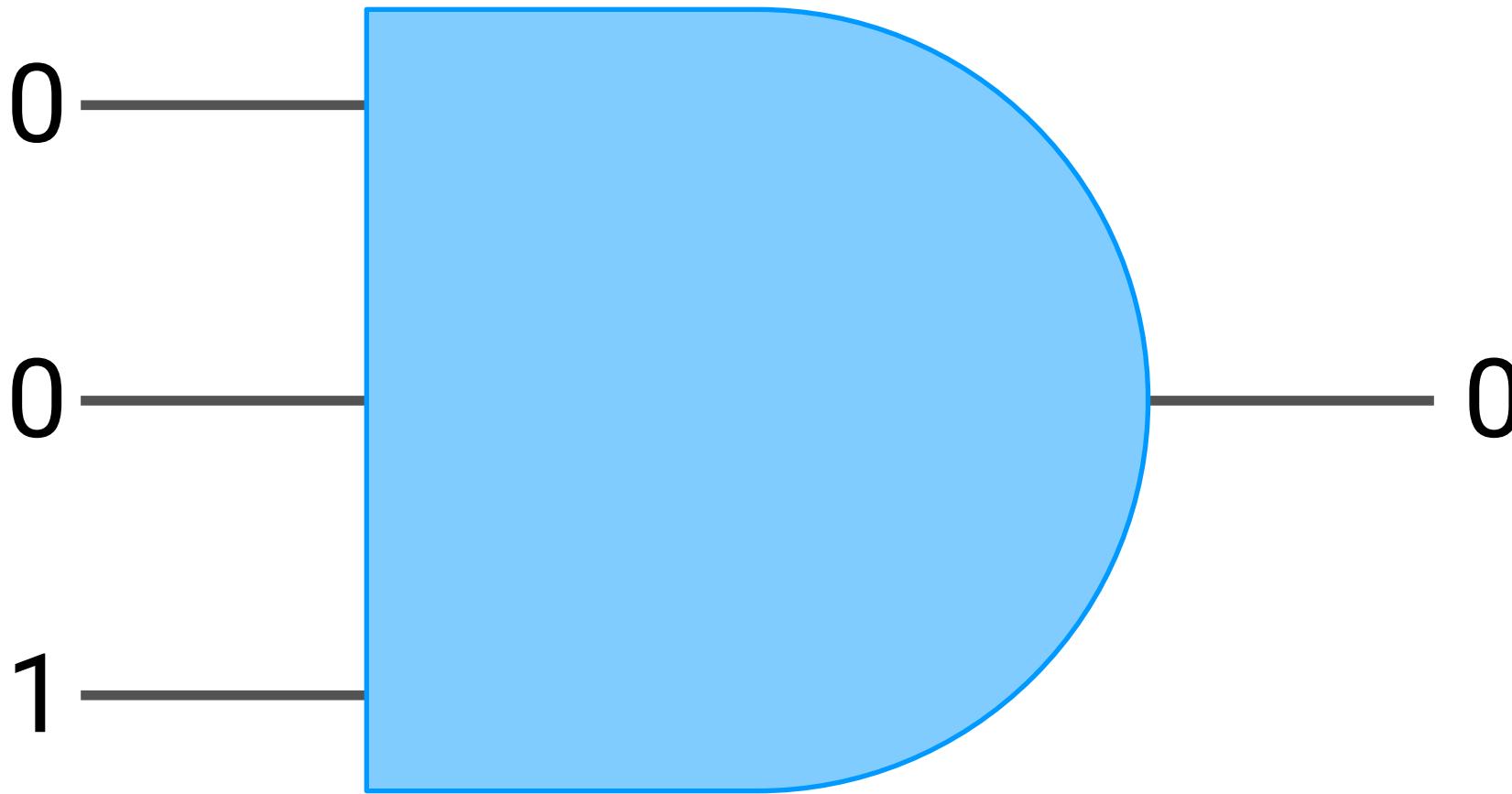
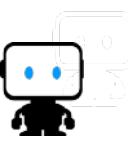
# Neural Networks



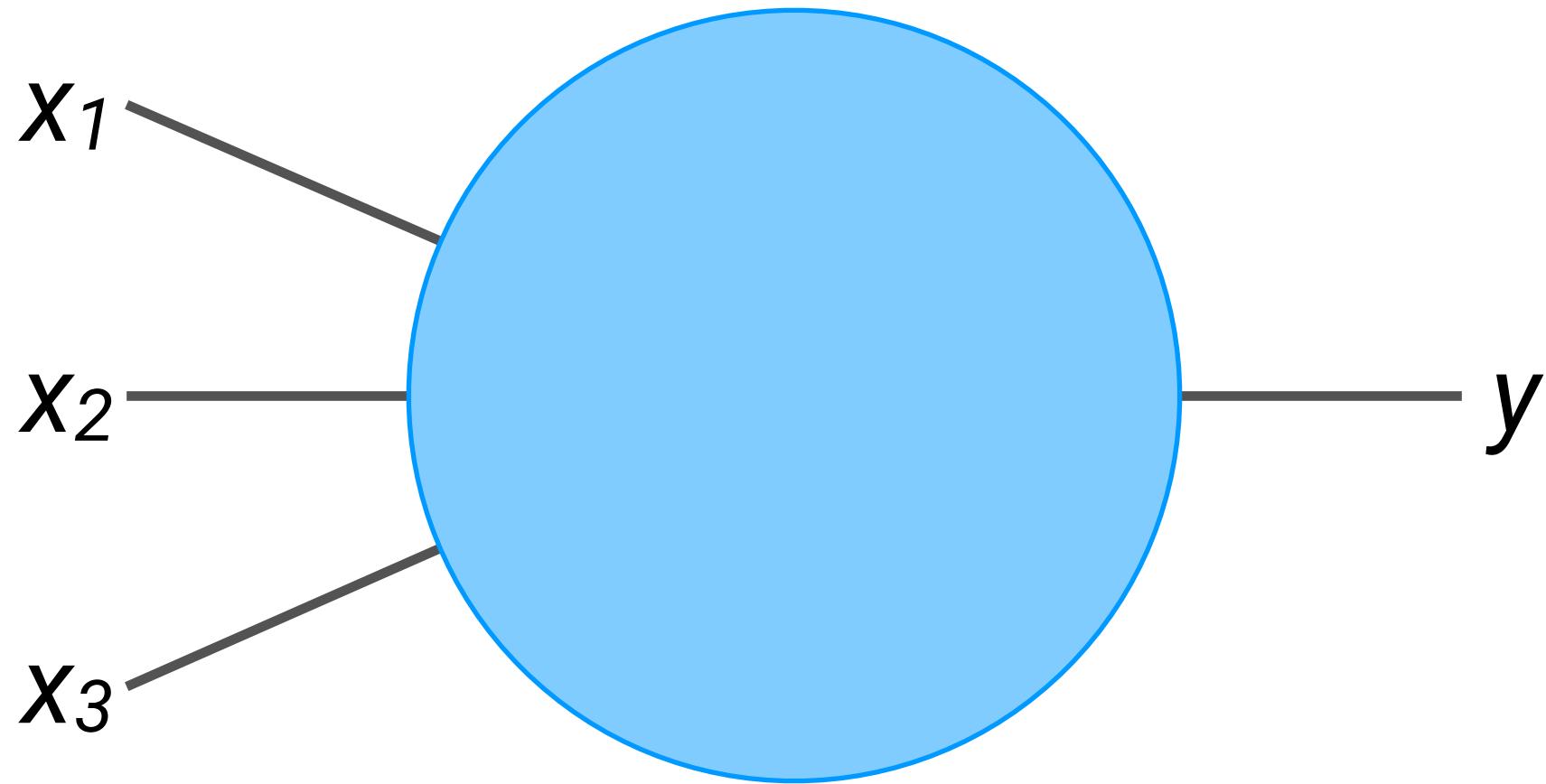
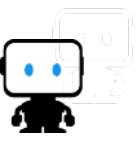
# Logic Gates



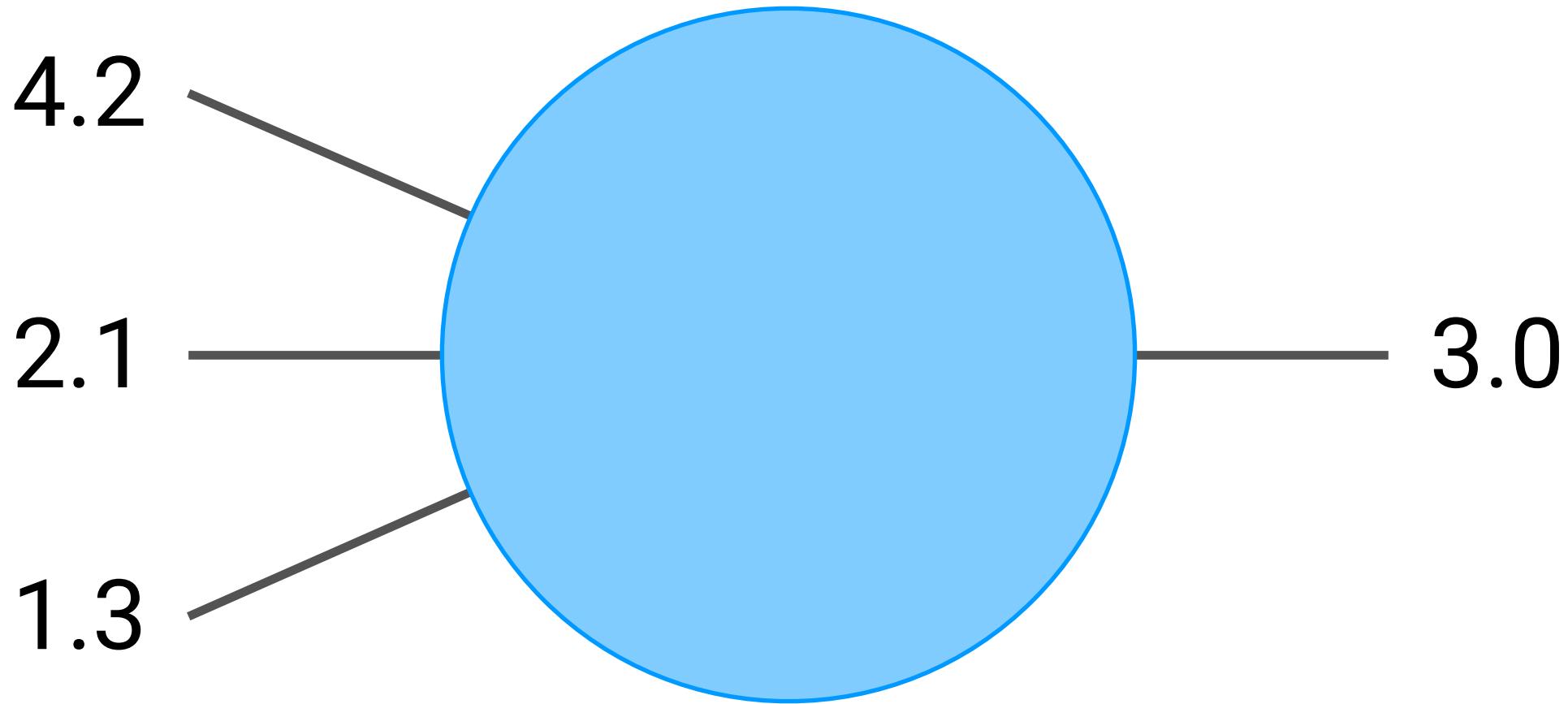
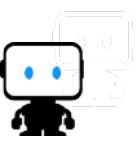
# Logic Gates with Actual Numbers



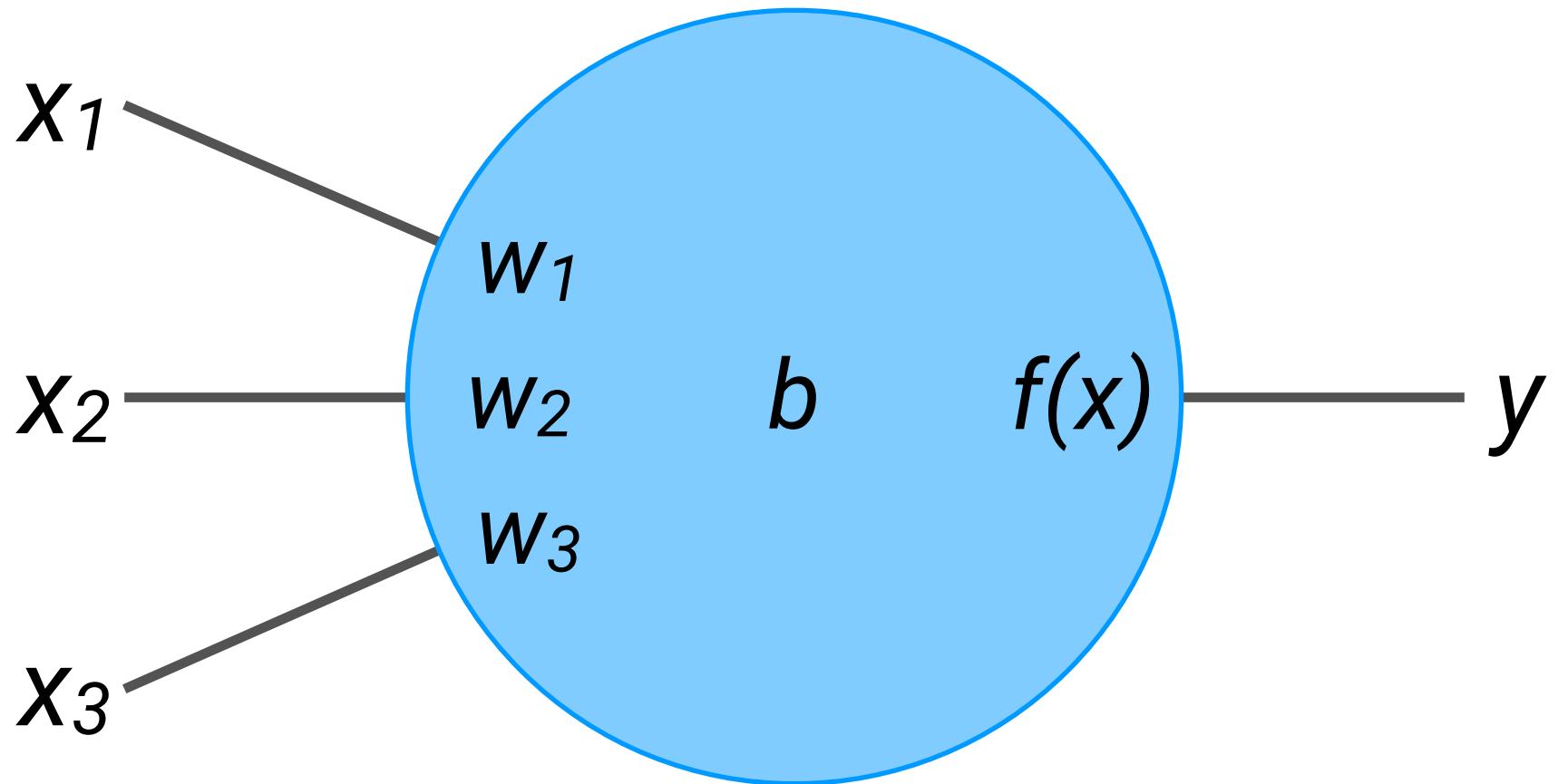
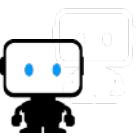
# Neurons

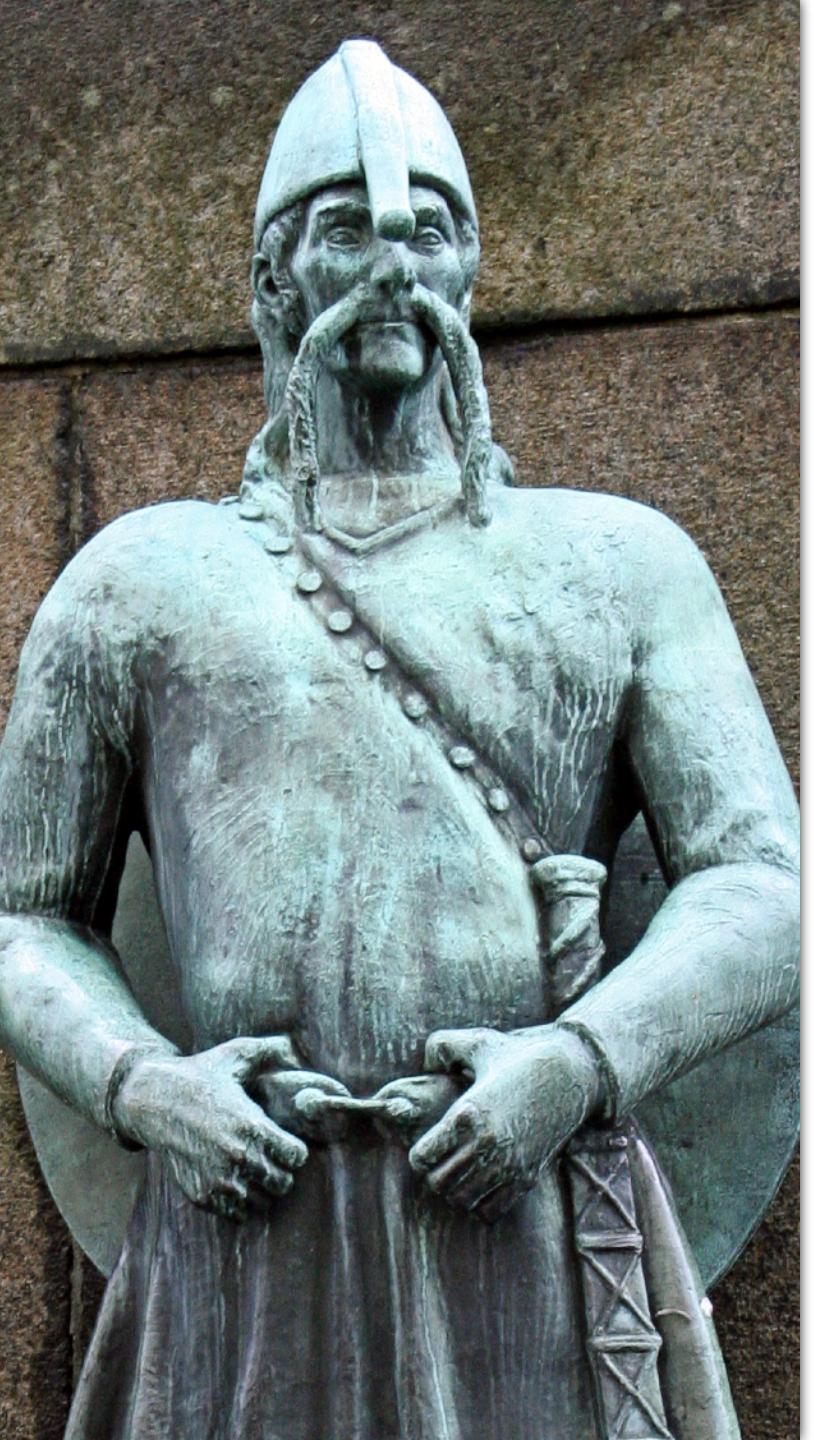


# Neurons with Actual Numbers

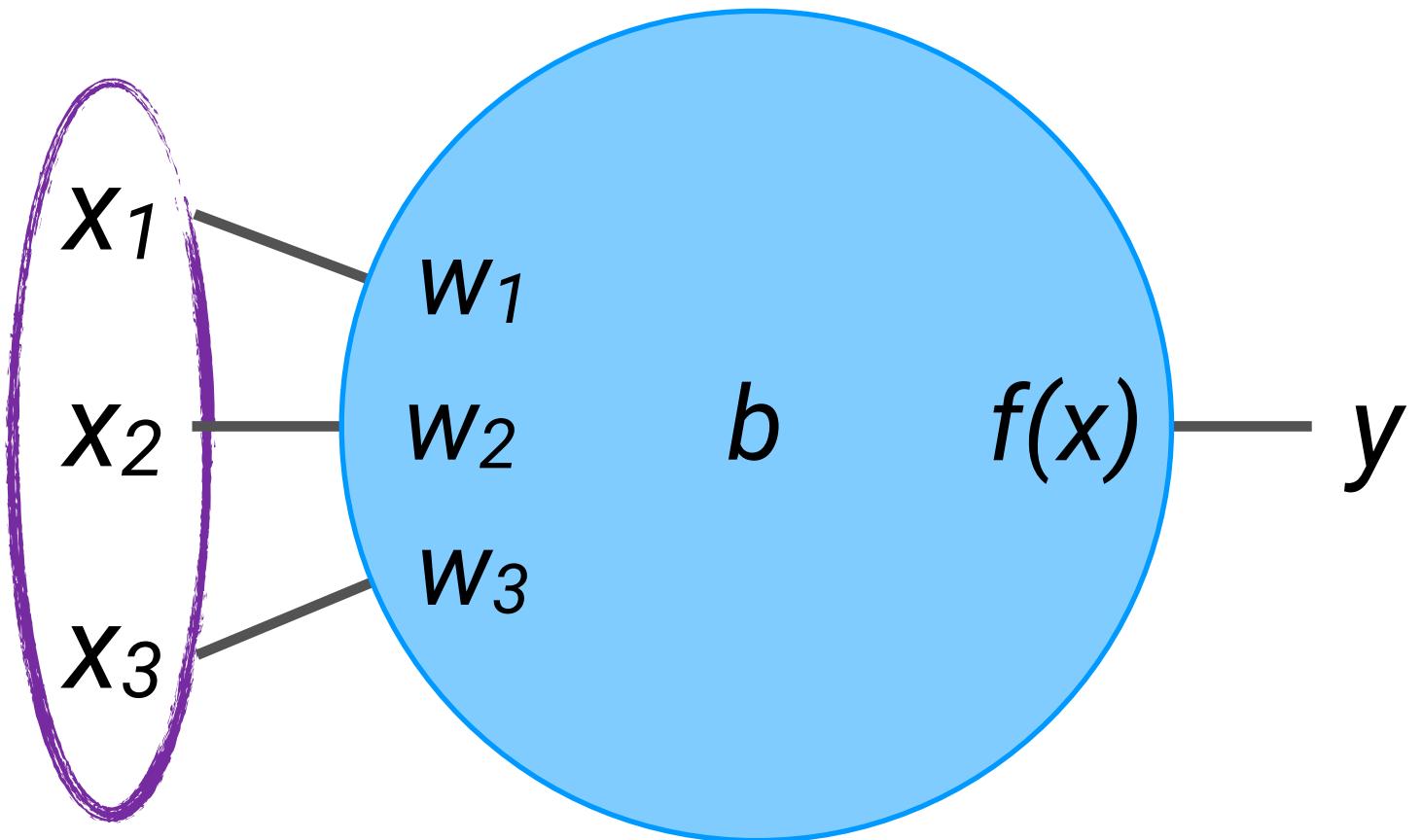


# Inside a Neuron

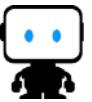




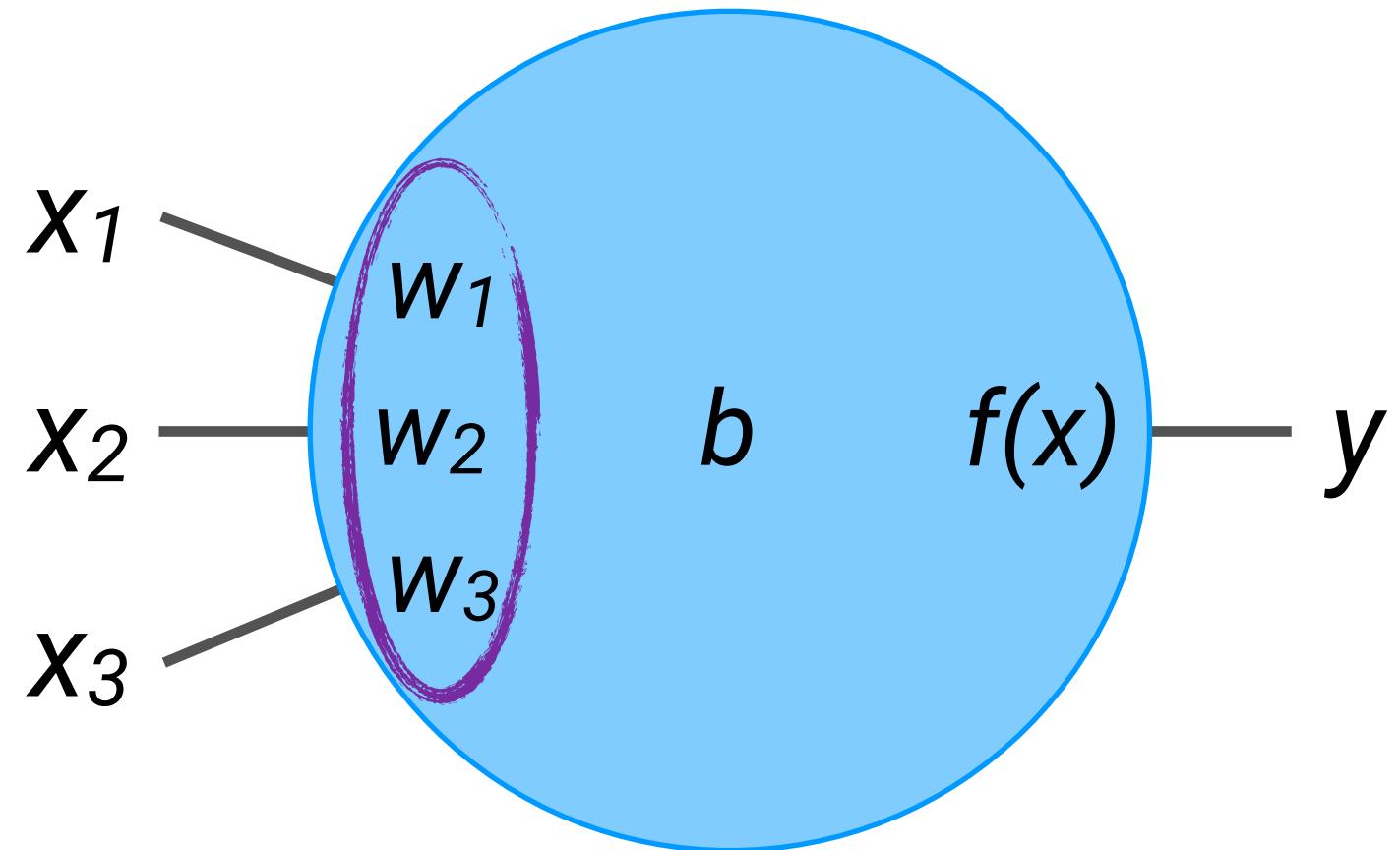
# Inputs



The values coming into the neuron.



# Weights

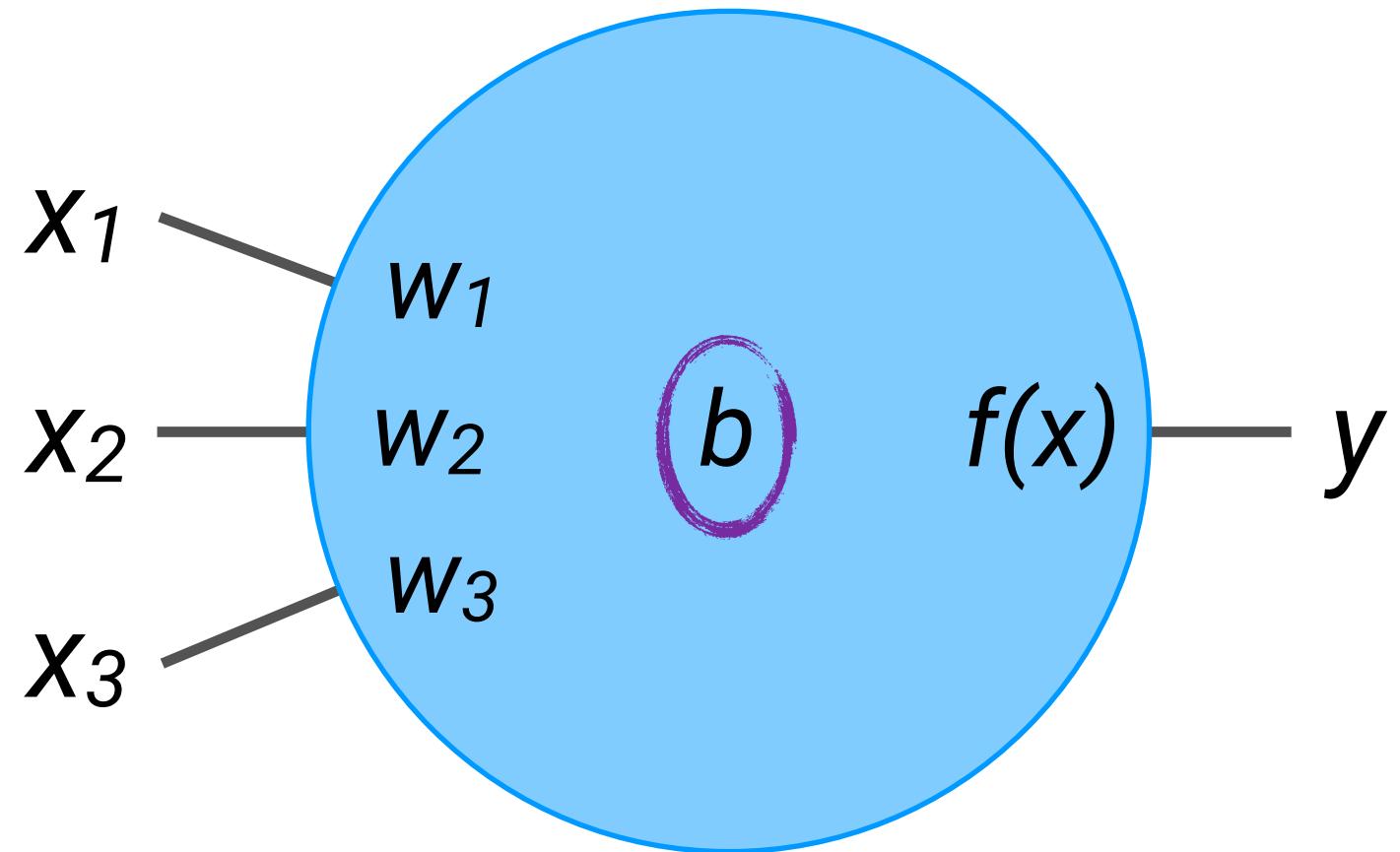


Makes an input more or less important.



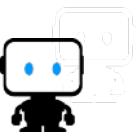


# Bias



Makes the sum of the inputs more or less important.

# The Math So Far

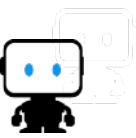


$$x_1w_1 + x_2w_2 + x_3w_3 + b$$

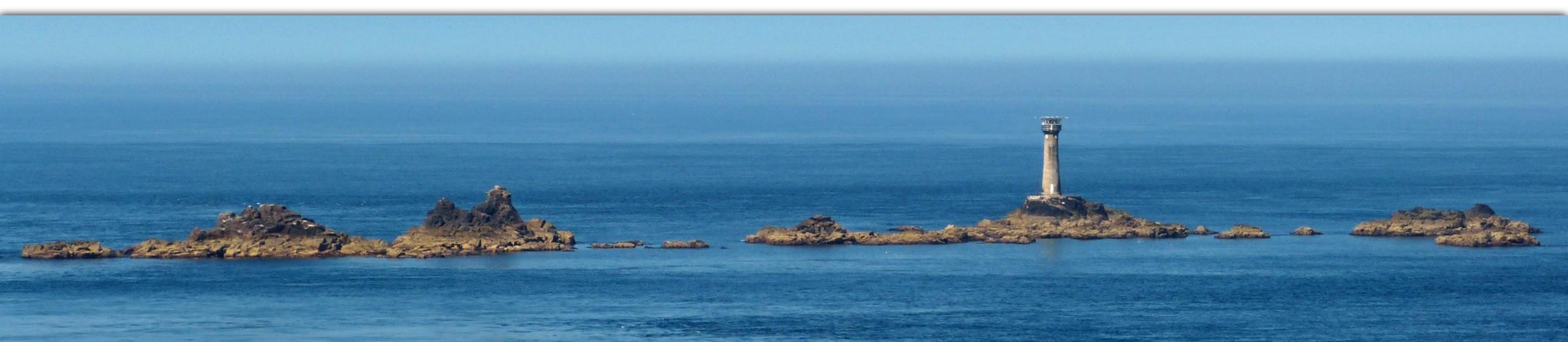
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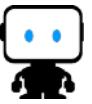


# Even Mathier

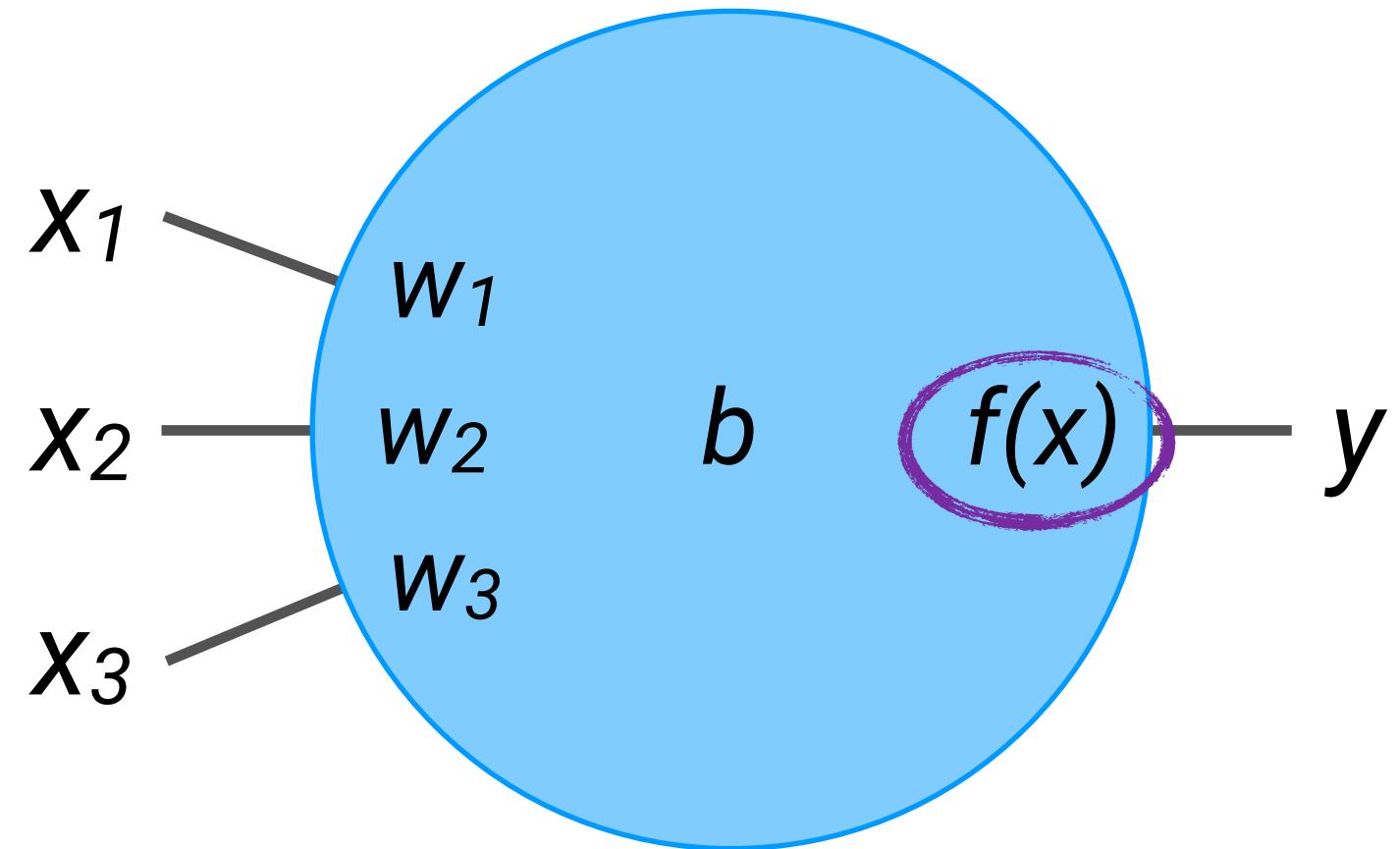


$$\sum_i x_i w_i + b$$





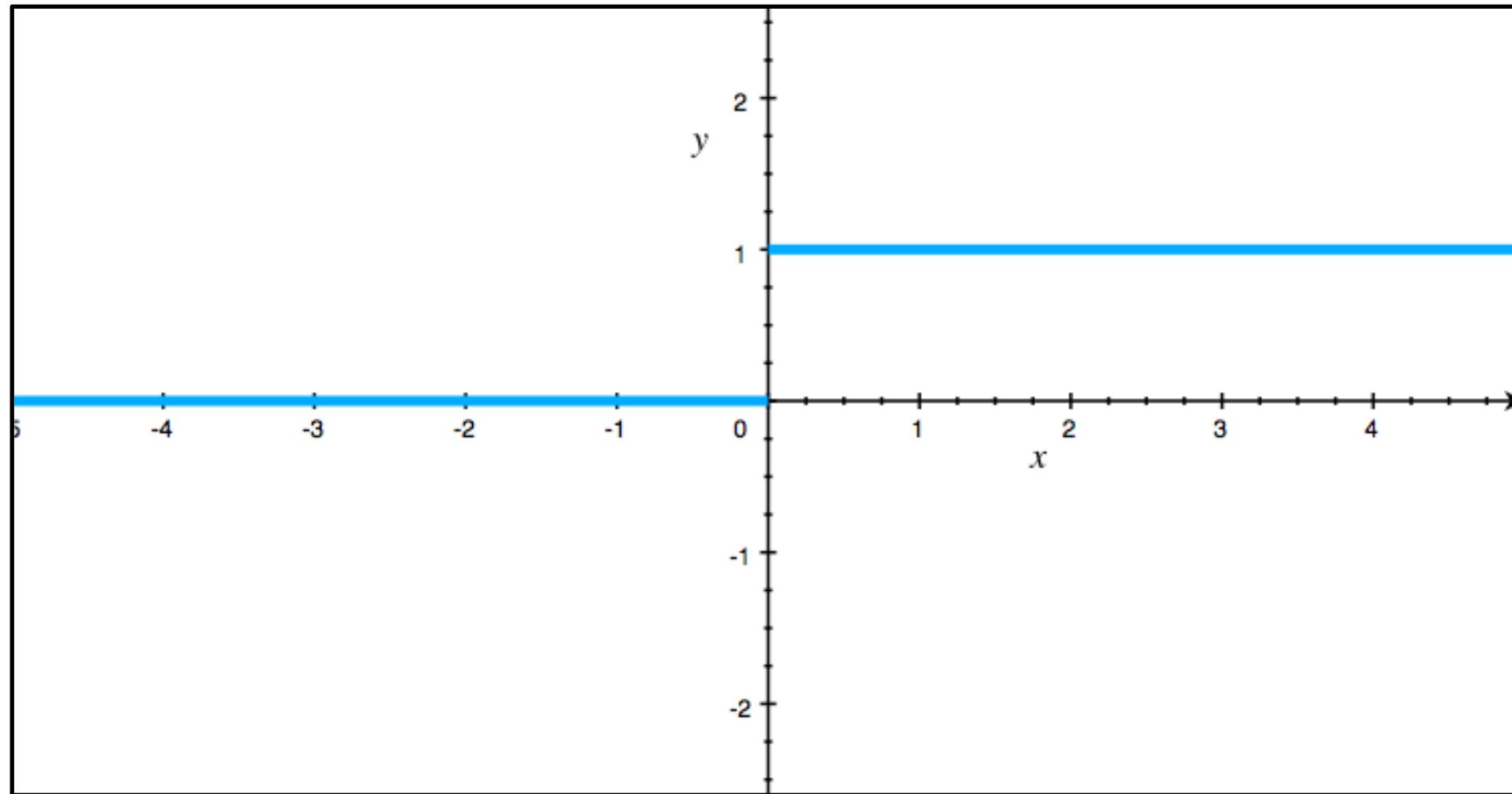
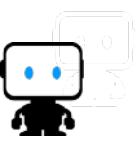
# Activation Function



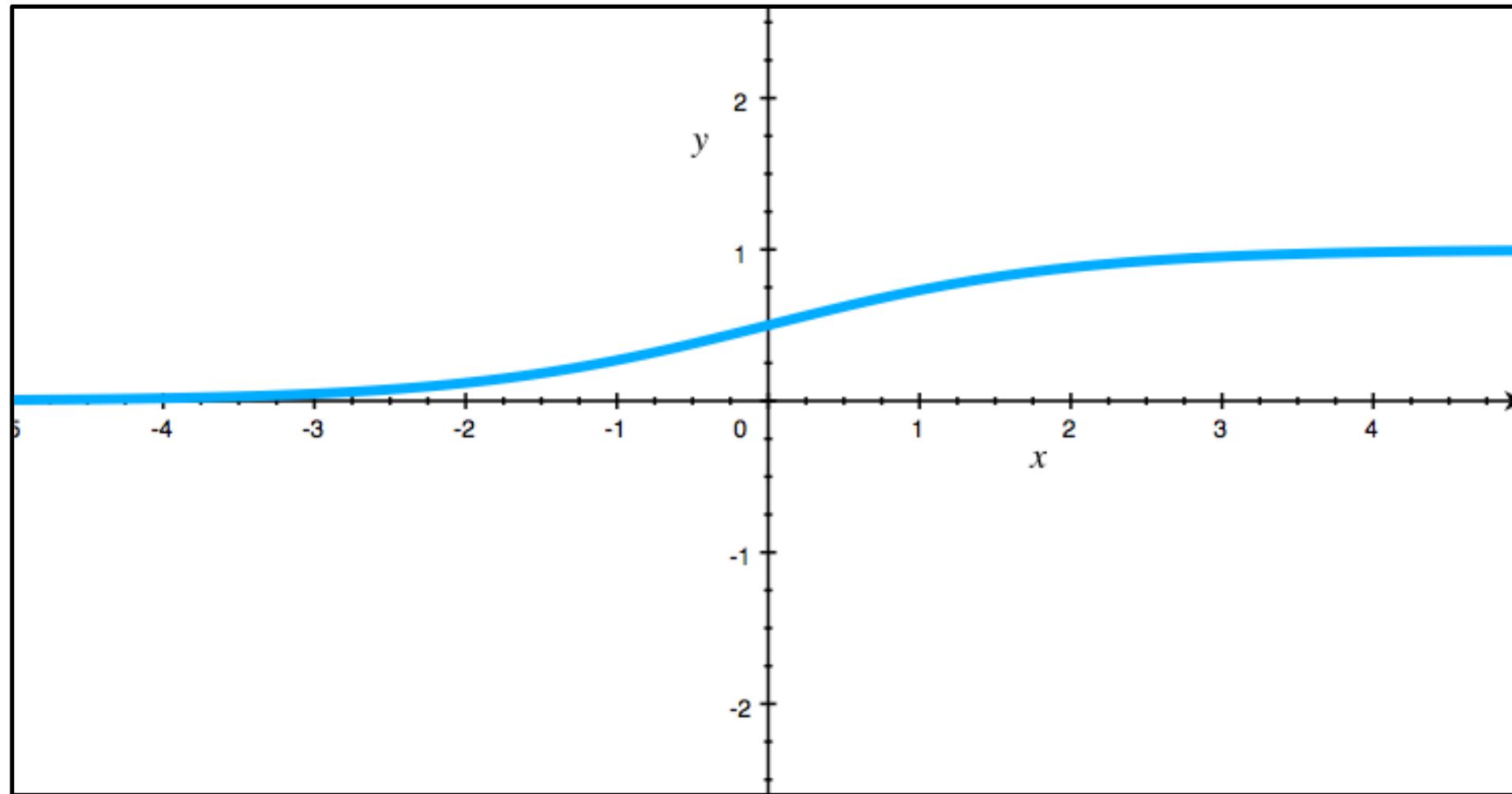
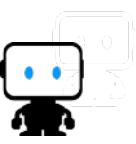
Adjusts the output of the neuron.



# Step Function



# Sigmoid Function



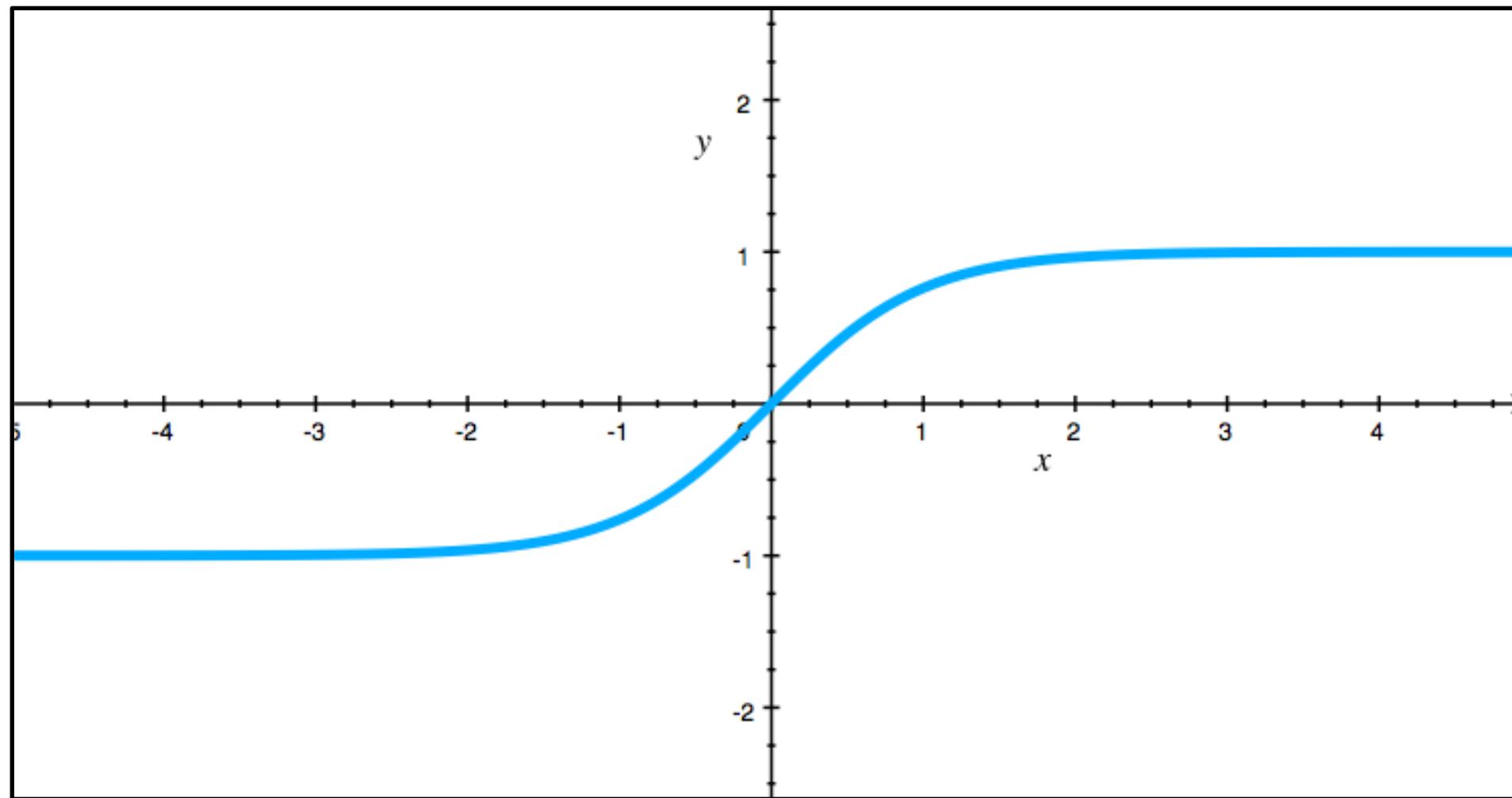
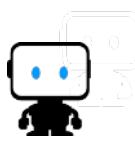


Σ

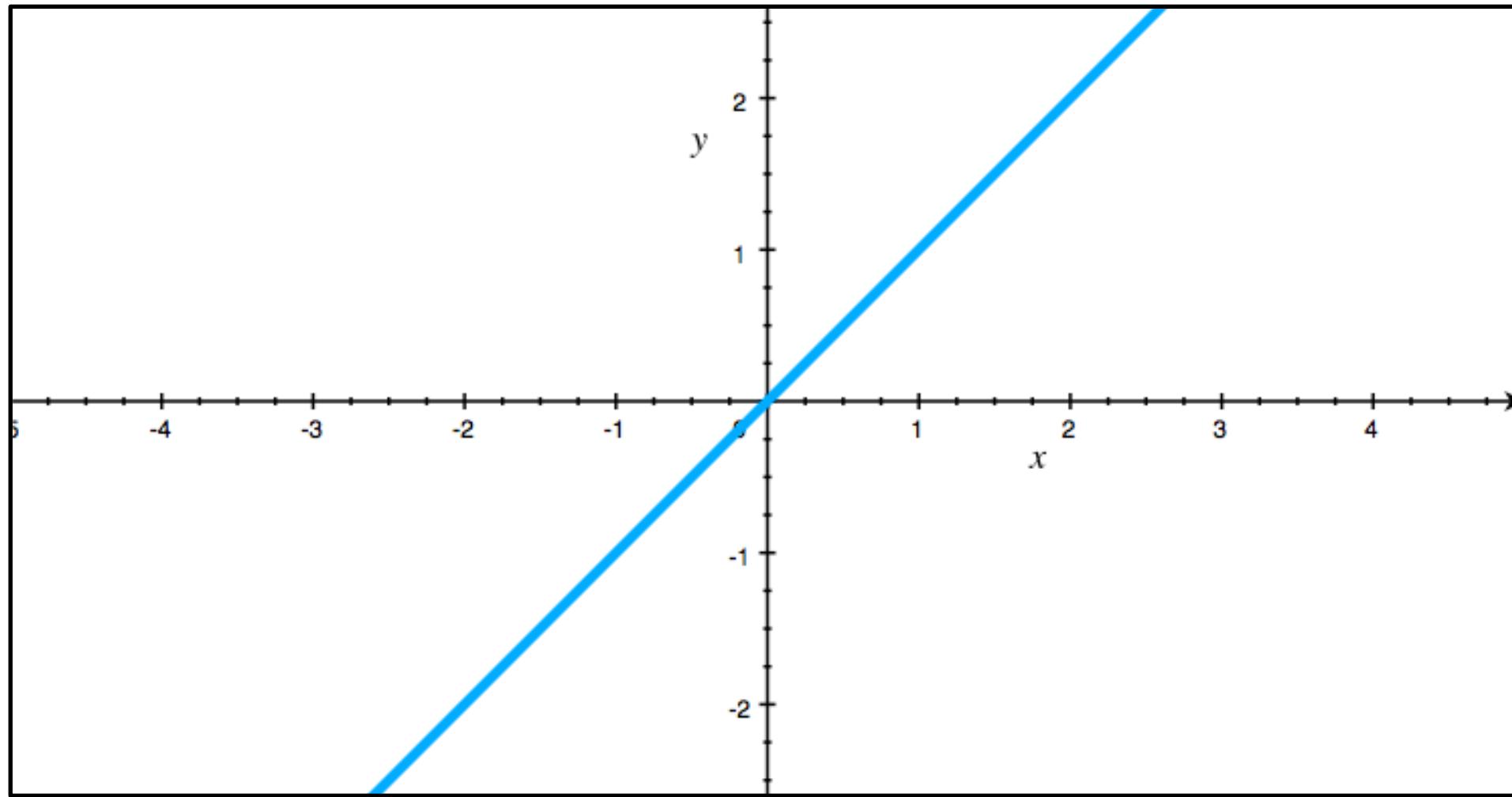
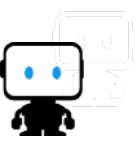
S

↳

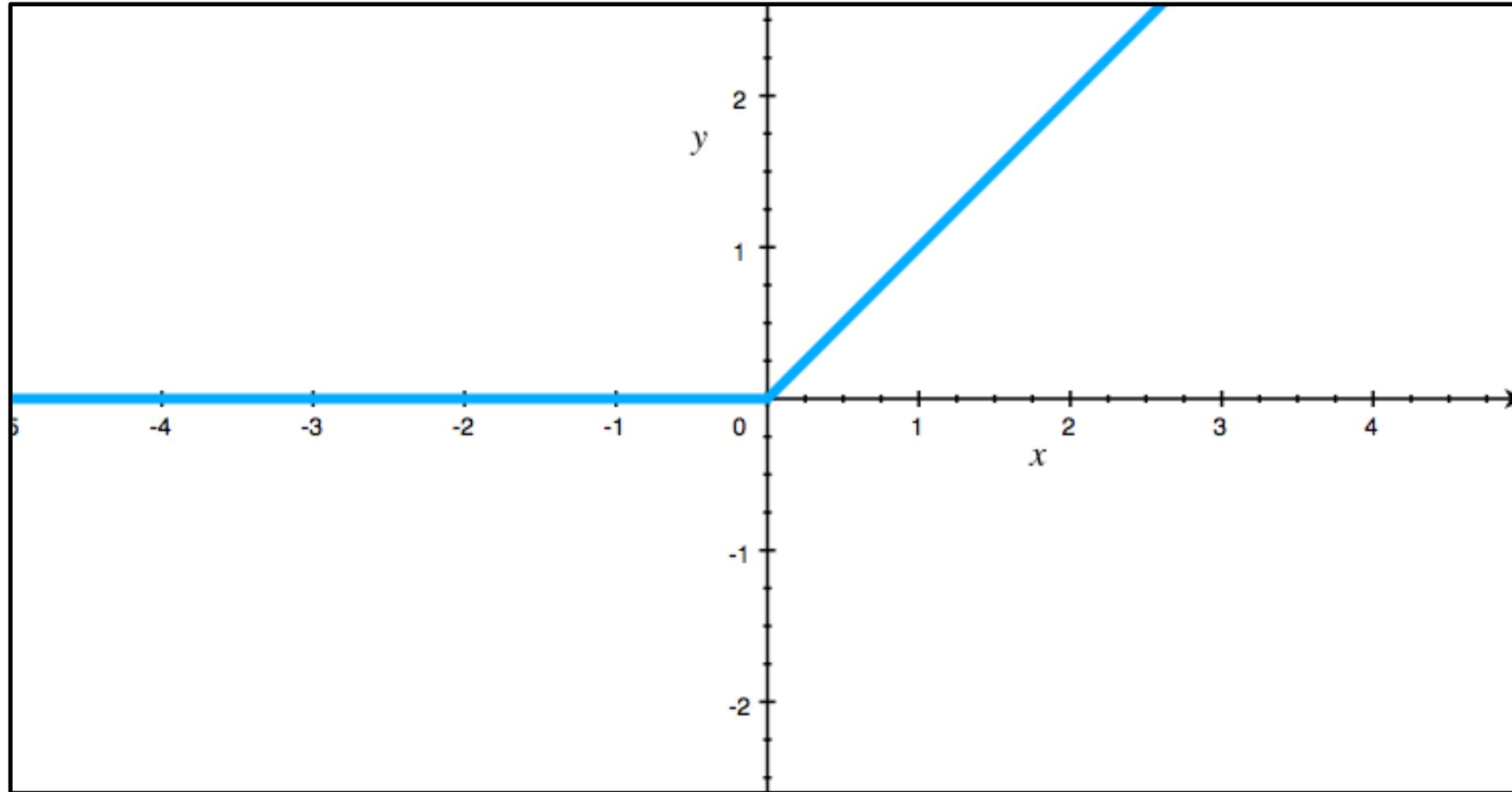
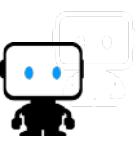
# tanh Function

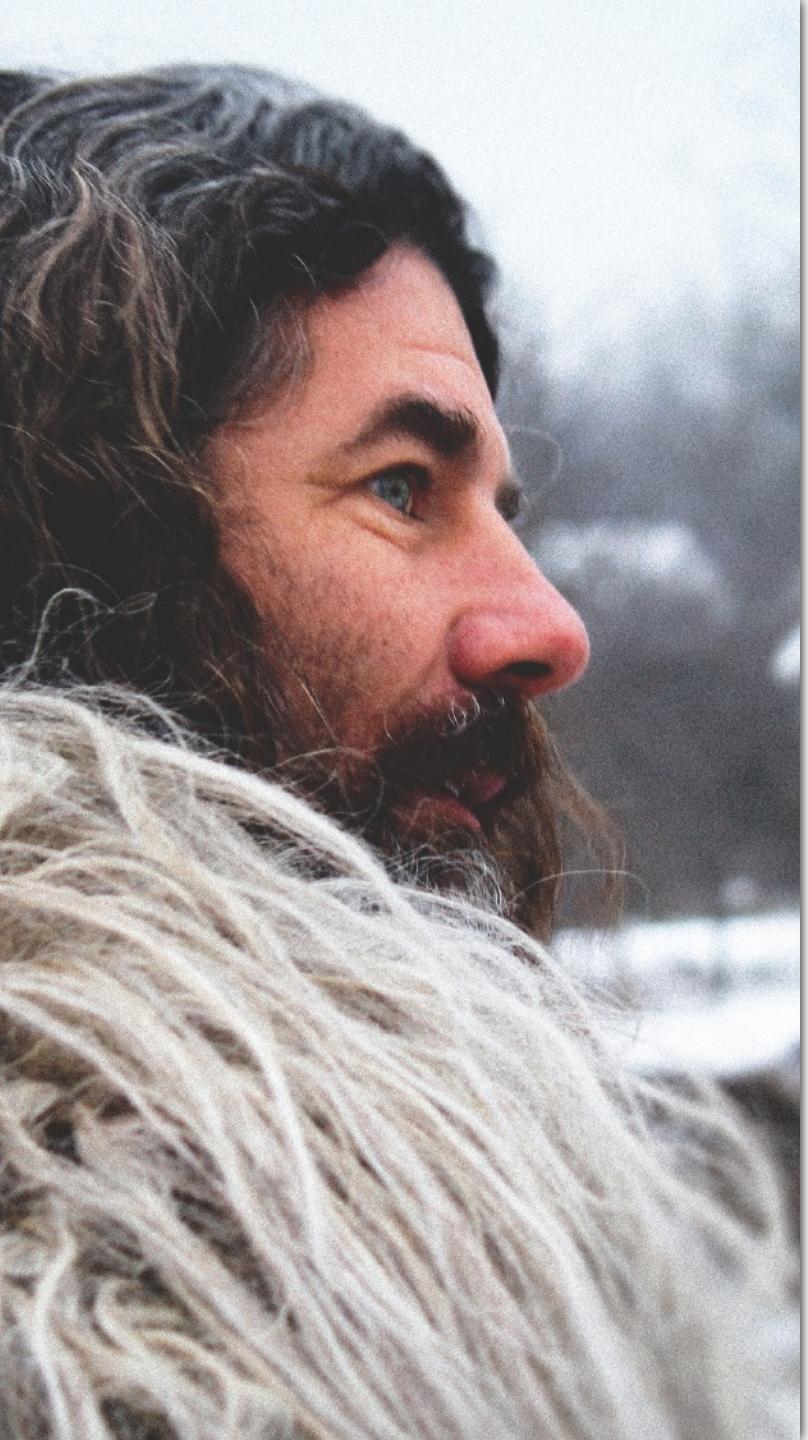


# Linear Function

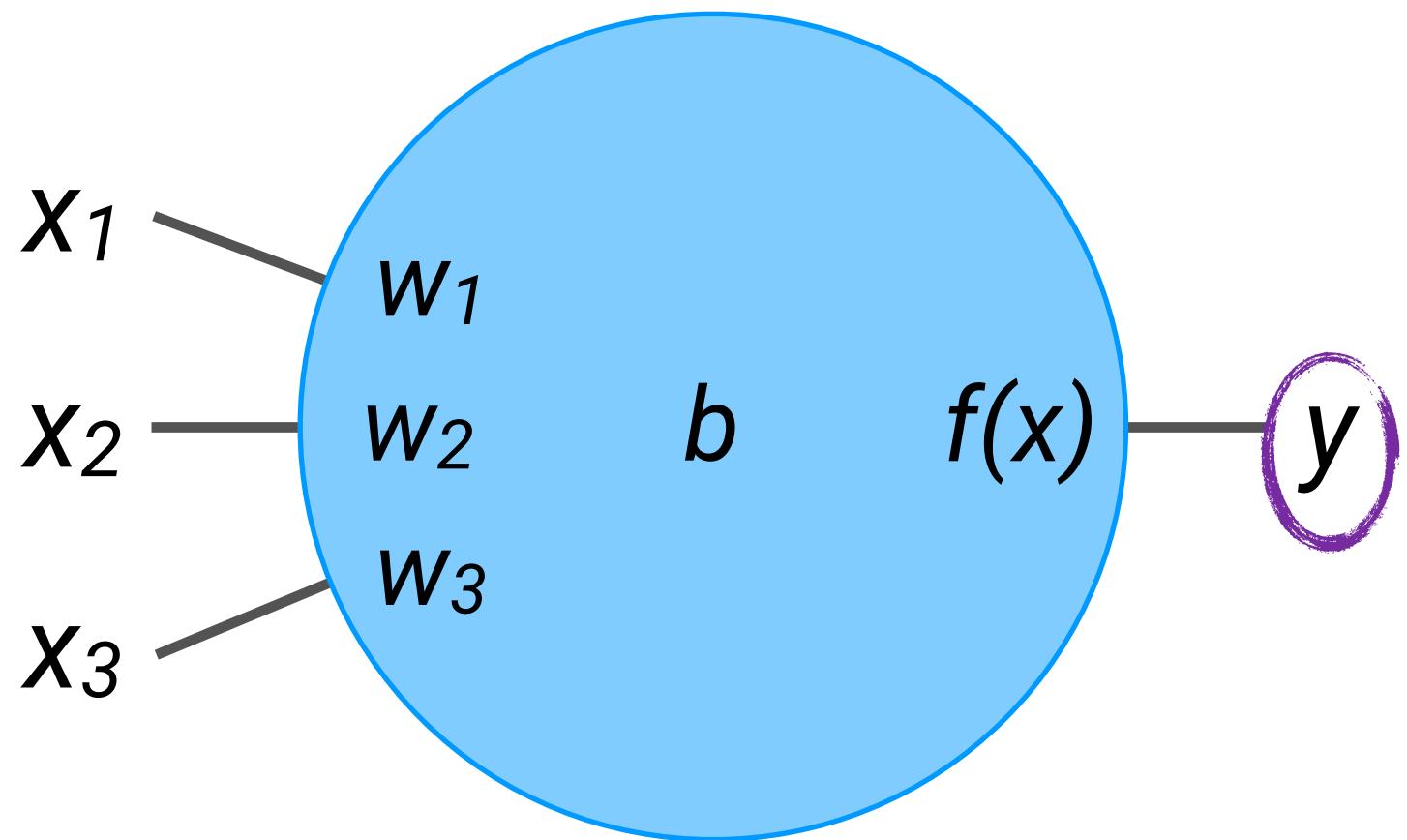


# Rectified Linear Units (ReLU)



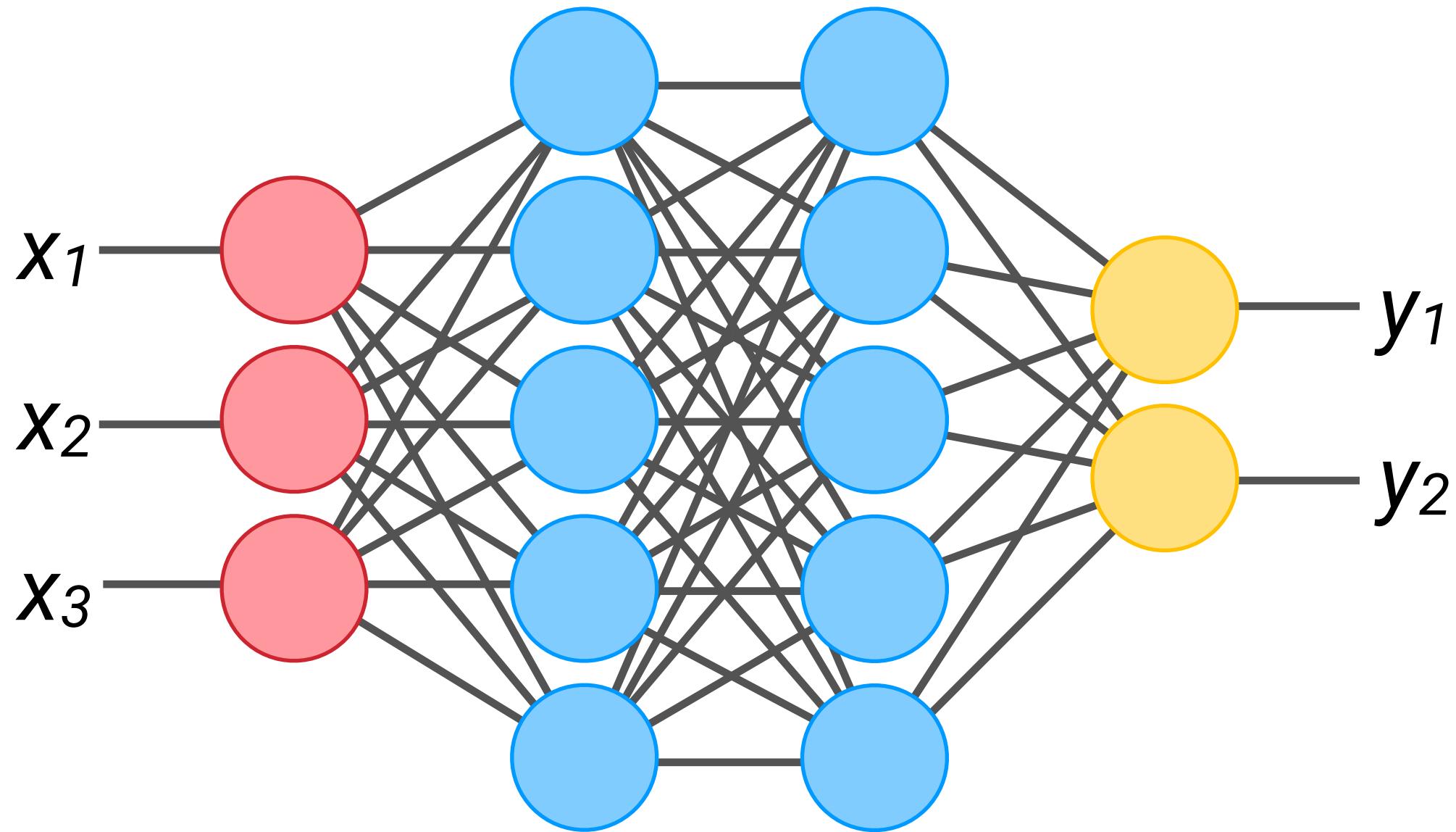
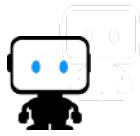


# Output

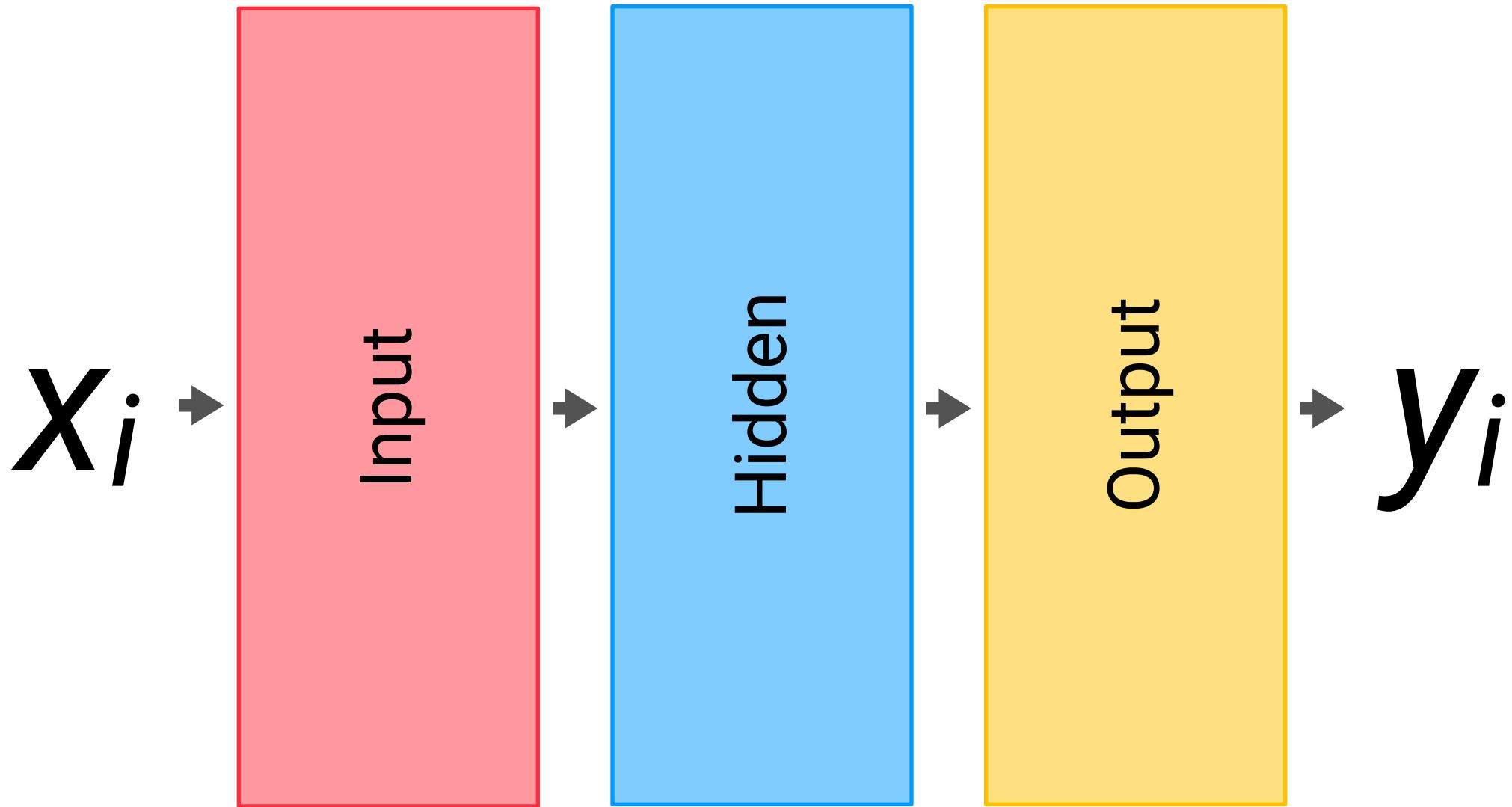
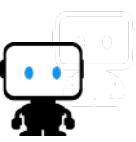


The value leaving the neuron.

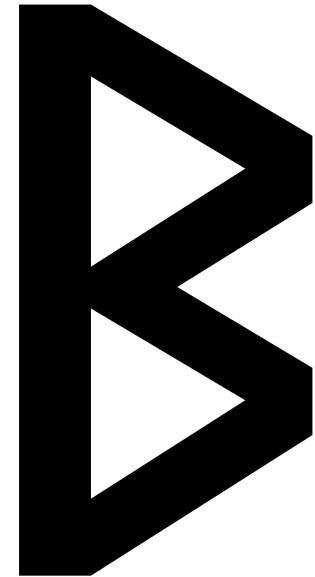
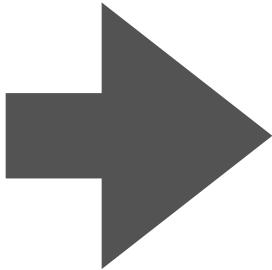
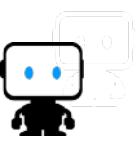
# Neural Networks



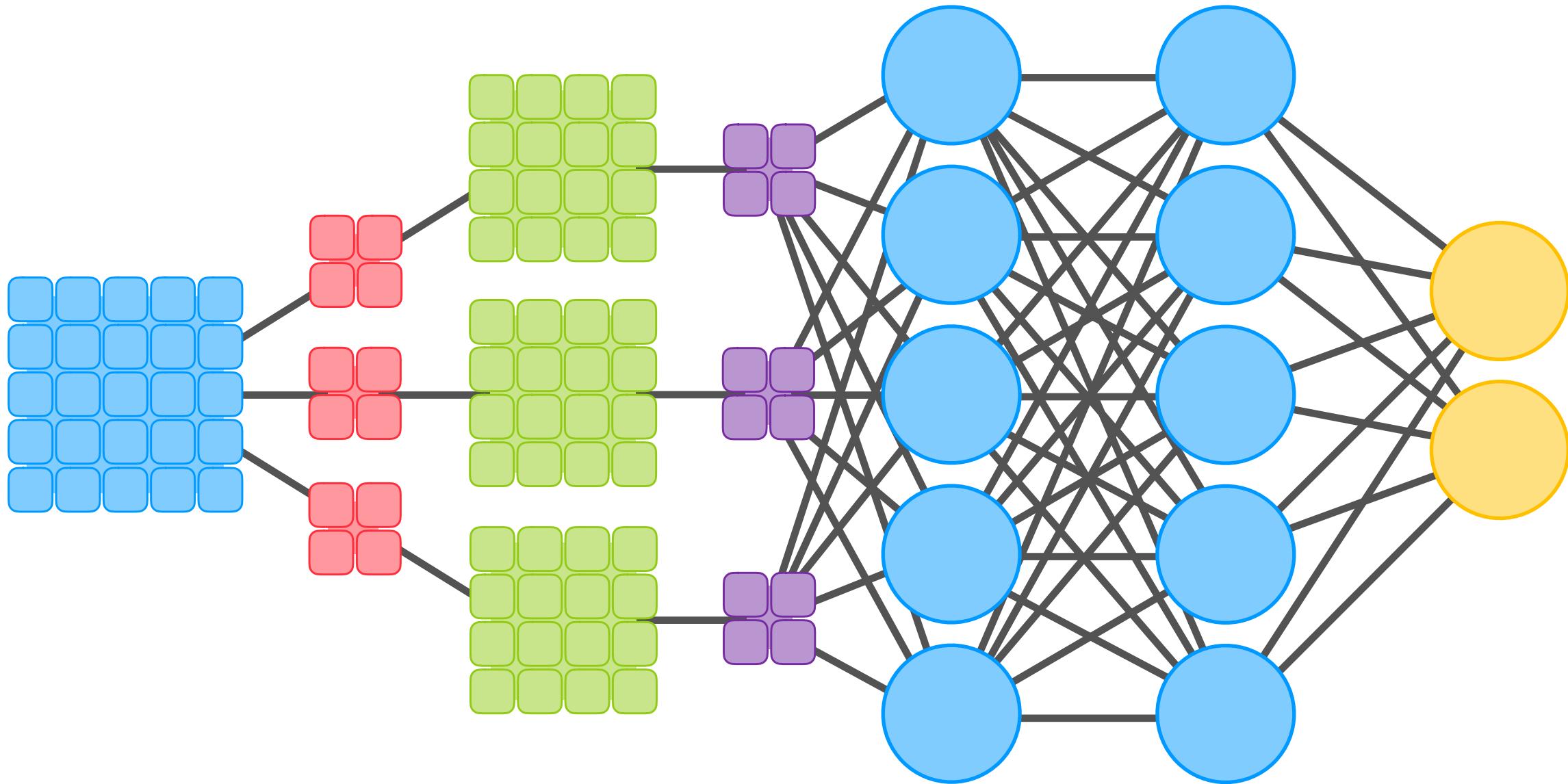
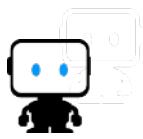
# Layers of a Neural Network



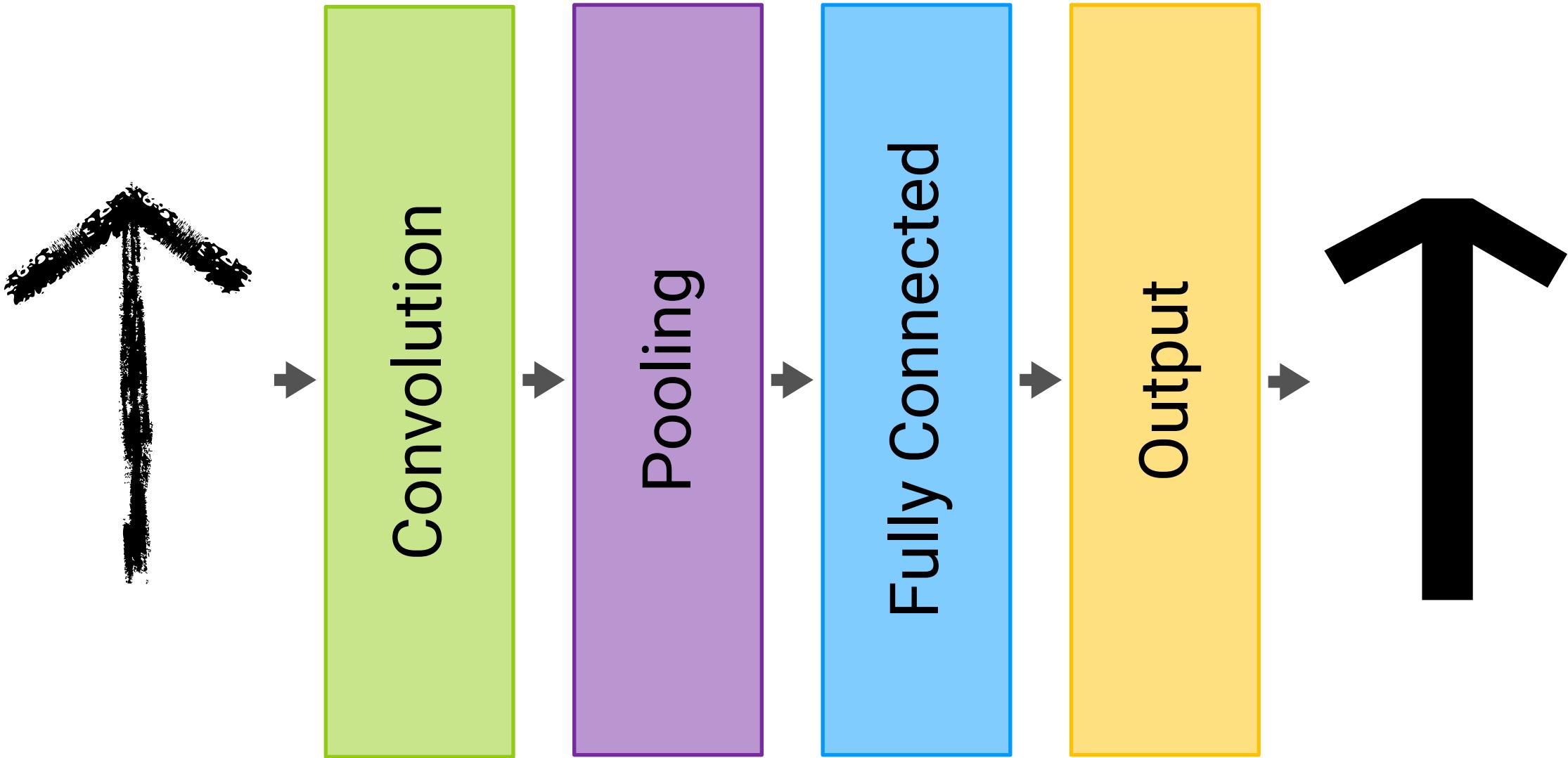
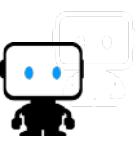
# Bad at Recognizing Runes



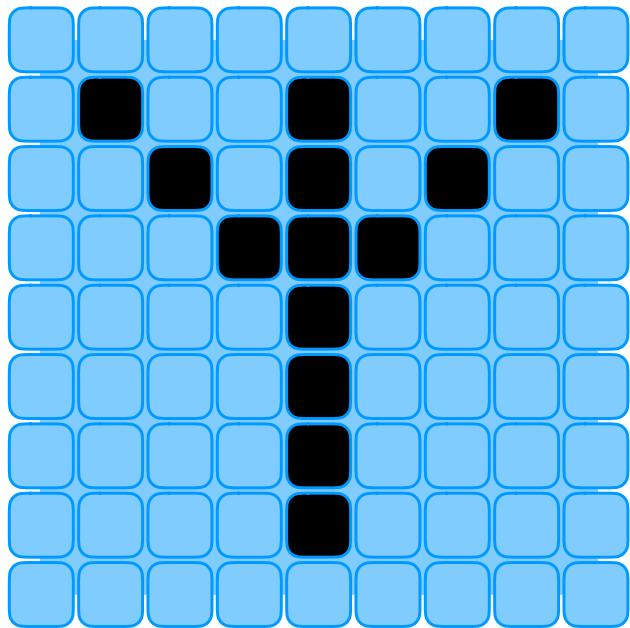
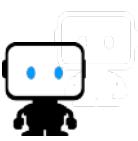
# Convolutional Neural Networks



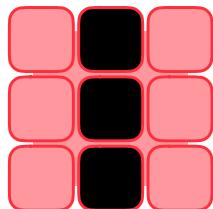
# Layers of a Convolutional Neural Network



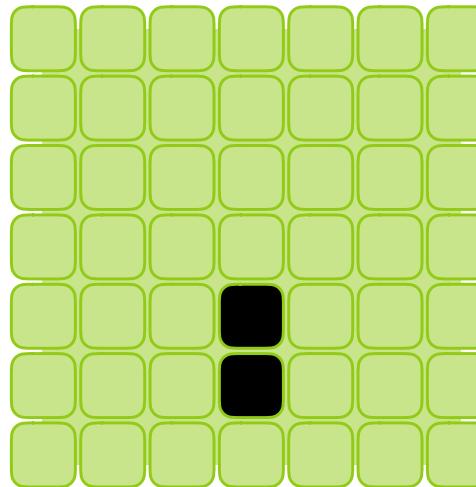
# Convolutions



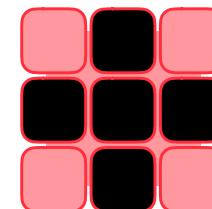
Input



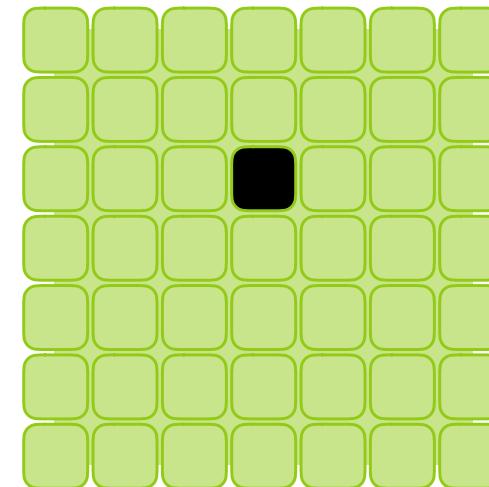
Filter



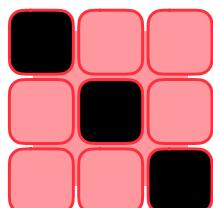
Output



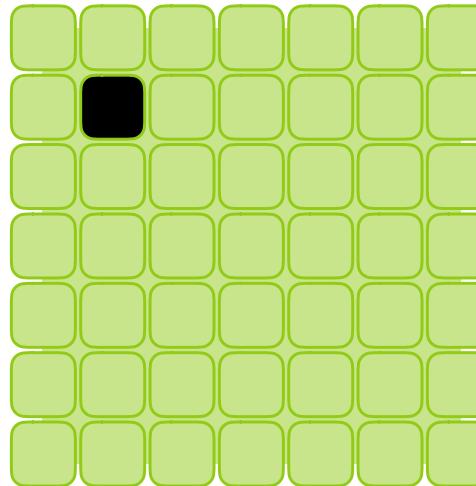
Filter



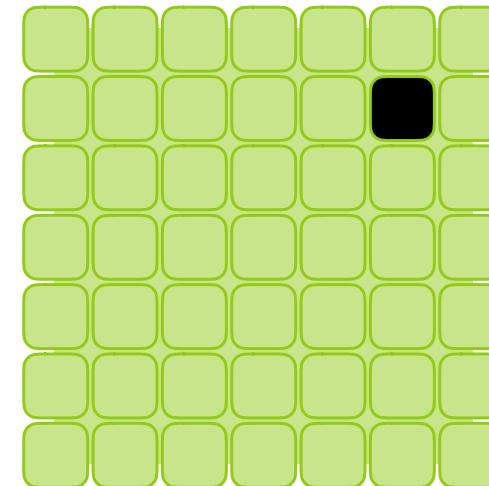
Output



Filter

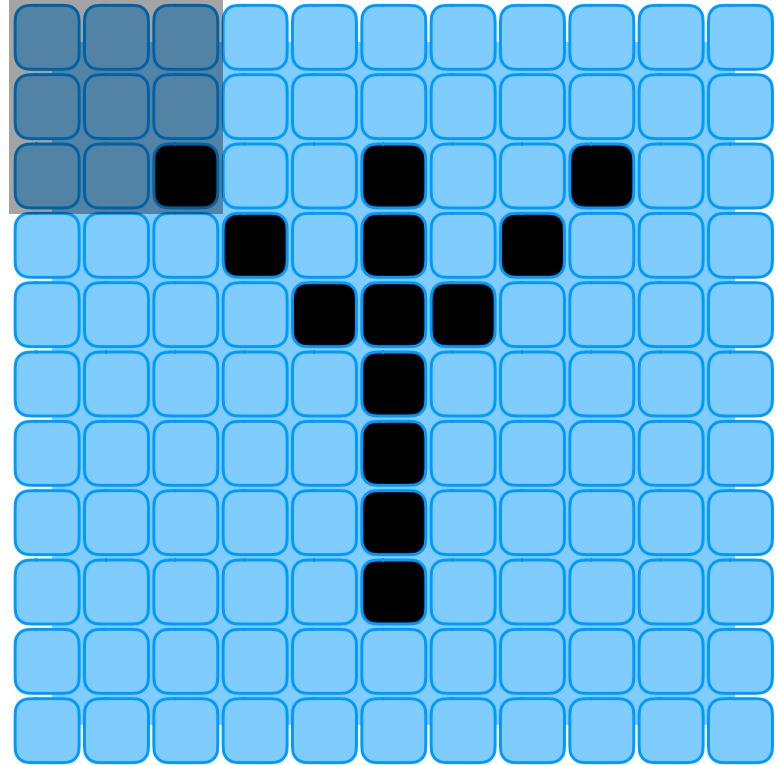
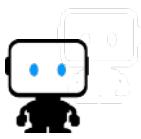


Output

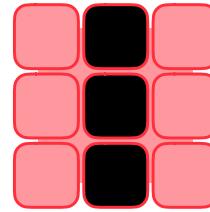


Output

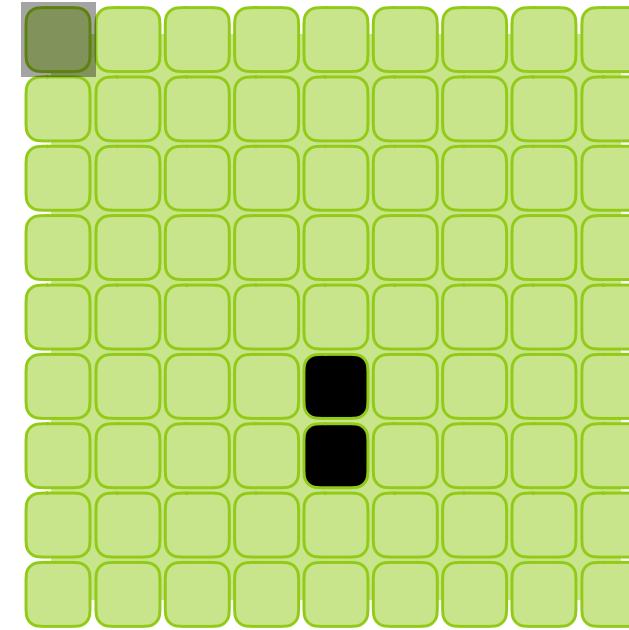
# Convolutions with Fancy Animation



Input

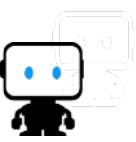


Filter



Output

# Convolutions with Numbers



|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Input

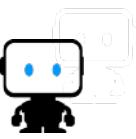
|    |   |    |
|----|---|----|
| -1 | 1 | -1 |
| -1 | 1 | -1 |
| -1 | 1 | -1 |
| -1 |   |    |

Filter

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Output

# Convolutions with Familiar Looking Numbers



$X_i$

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

$$\sum_i X_i W_i + b$$

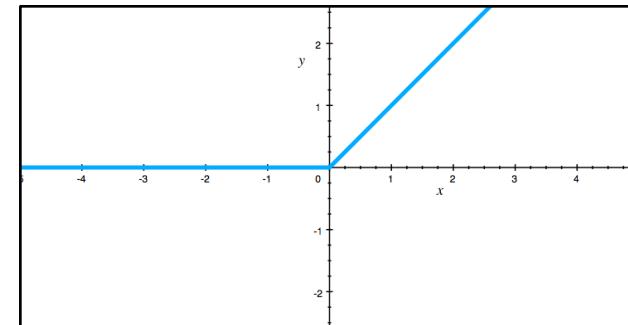
$W_i$

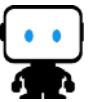
|    |   |    |
|----|---|----|
| -1 | 1 | -1 |
| -1 | 1 | -1 |
| -1 | 1 | -1 |

$$b$$

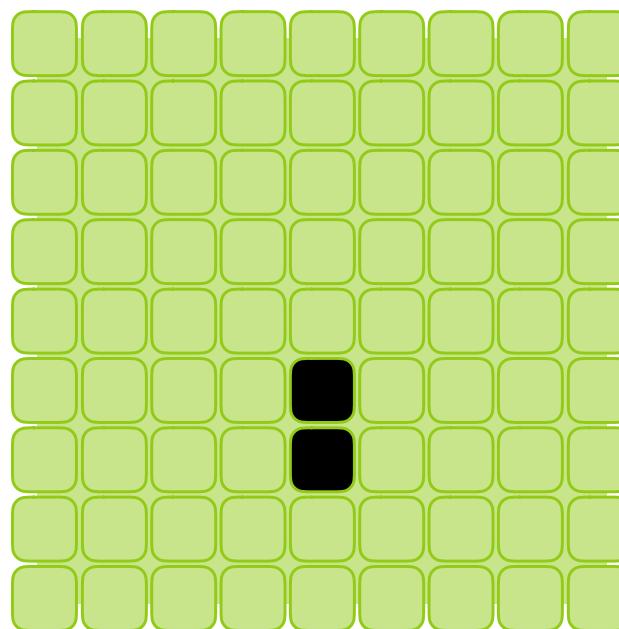
$y_i$

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



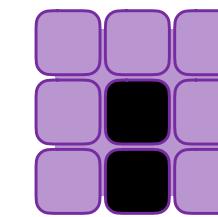


# Pooling



Output

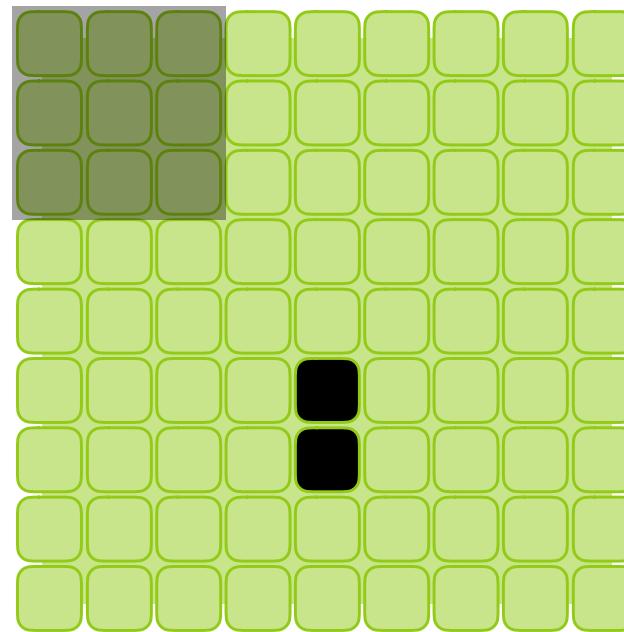
$3 \times 3$



Pooled

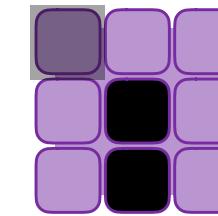


# Pooling with Fancy Animation



Output

$3 \times 3$



Pooled



# Pooling with Numbers



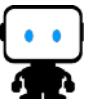
|   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Output

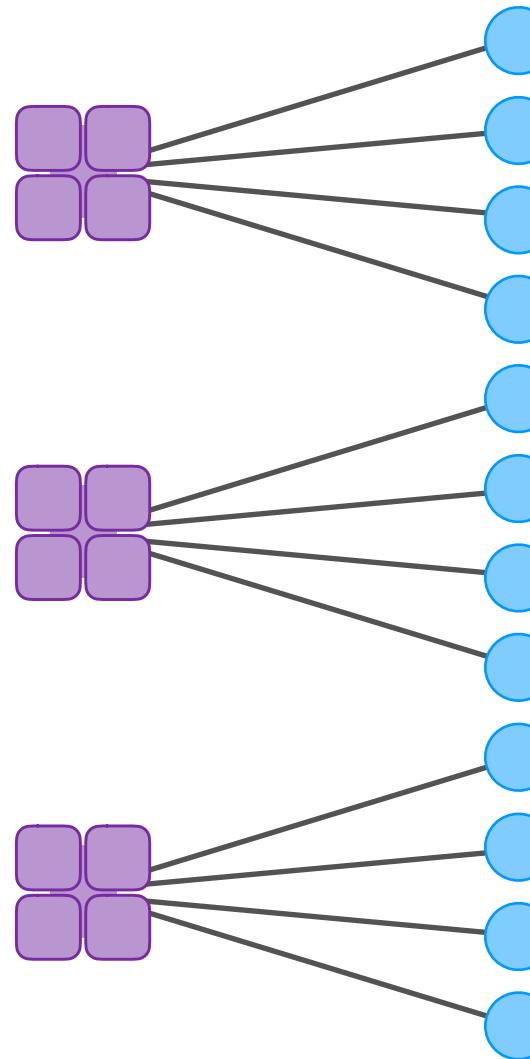
3 x 3

|   |   |   |
|---|---|---|
| 0 | 1 | 0 |
| 0 | 2 | 0 |
| 0 | 2 | 0 |

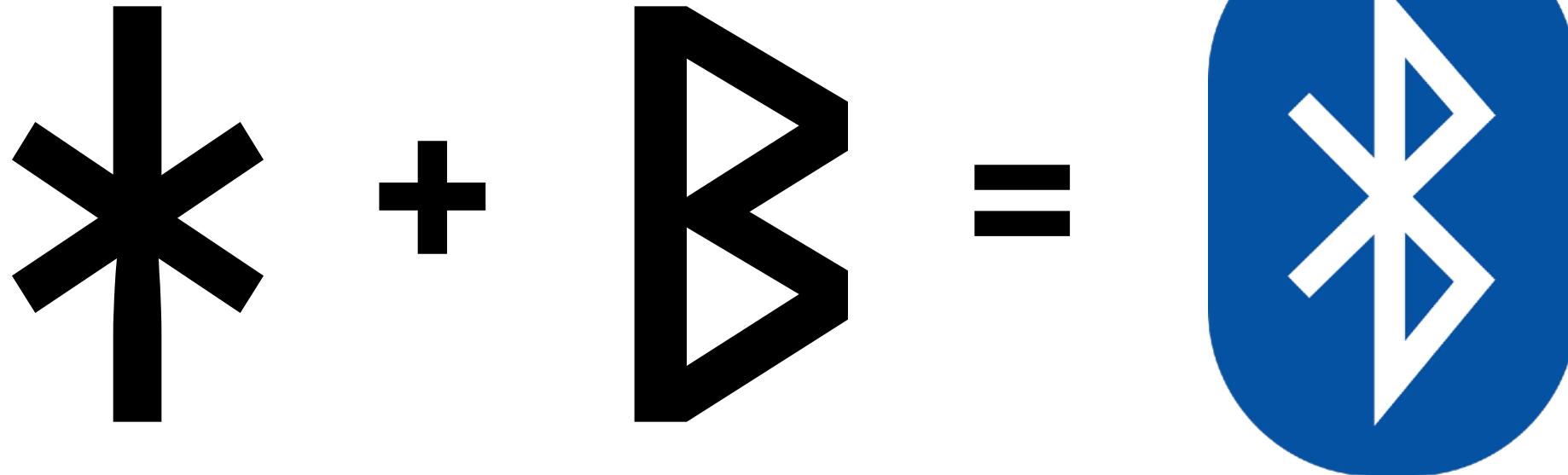
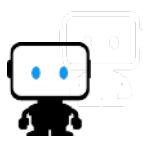
Pooled



# Flattening

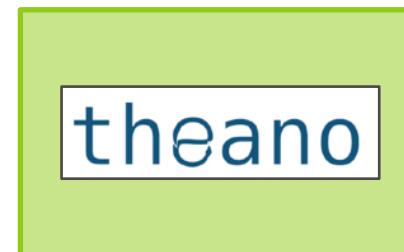


# Harald Bluetooth





# Keras



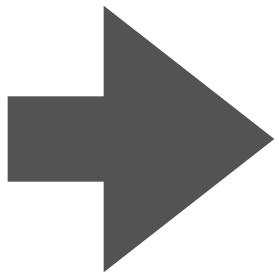


```
model = Sequential()  
  
model.add(Conv2D(48, (3, 3), activation='relu', input_shape=(1, 24, 24)))  
model.add(Conv2D(24, (3, 3), activation='relu'))  
model.add(MaxPooling2D(pool_size=(2,2)))  
model.add(Flatten())  
model.add(Dense(128, activation='relu'))  
model.add(Dense(16, activation='softmax'))  
  
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=[ 'accuracy'])  
model.fit(X_train, Y_train, batch_size=32, epochs=20, verbose=1)
```



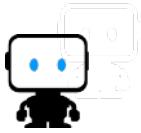


↑ | Ψ \*



Demo

(Tima)



# Resources

## Keras

<https://keras.io/>

## Microsoft CNTK

<https://www.microsoft.com/en-us/cognitive-toolkit/>

## TensorFlow

<https://www.tensorflow.org/>

## Theano

<http://www.deeplearning.net/software/theano/>

## Flask

<http://flask.pocoo.org/>

## VanillaJS

<http://vanilla-js.com/>

## Younger Futhark

[https://en.wikipedia.org/wiki/Younger\\_Futhark](https://en.wikipedia.org/wiki/Younger_Futhark)

## Neural Network Zoo

<http://www.asimovinstitute.org/neural-network-zoo/>

## A Beginner's Guide to Neural Networks

<https://towardsdatascience.com/a-beginners-guide-to-neural-networks-b6be0d442fa4>

## Hacker's Guide to Neural Networks

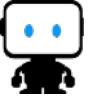
<http://karpathy.github.io/neuralnets/>

## CS231n Convolutional Neural Networks for Visual Recognition

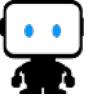
<http://cs231n.github.io/convolutional-networks/>

## An Intuitive Guide to Convolutional Neural Networks

<https://medium.freecodecamp.org/an-intuitive-guide-to-convolutional-neural-networks-260c2de0a050>



**[https://github.com/guyroyse/  
deep-learning-like-a-viking](https://github.com/guyroyse/deep-learning-like-a-viking)**



# Questions?



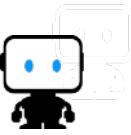
# **Guy Royse**

Developer Evangelist  
DataRobot

 @guyroyse

 [github.com/guyroyse](https://github.com/guyroyse)

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- <https://www.flickr.com/photos/wwarby/23841229208/>
- <https://www.flickr.com/photos/hesim/6553273471/>



Data**Robot**