Introduction to
Neural Networks

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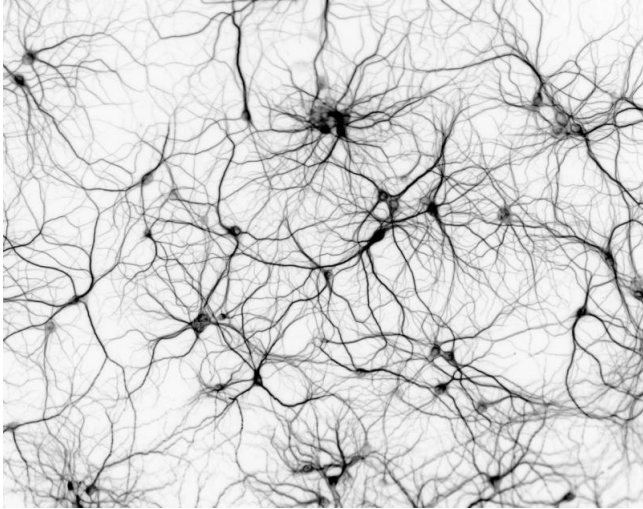
Outline

How does our brain work?

Biological neuron
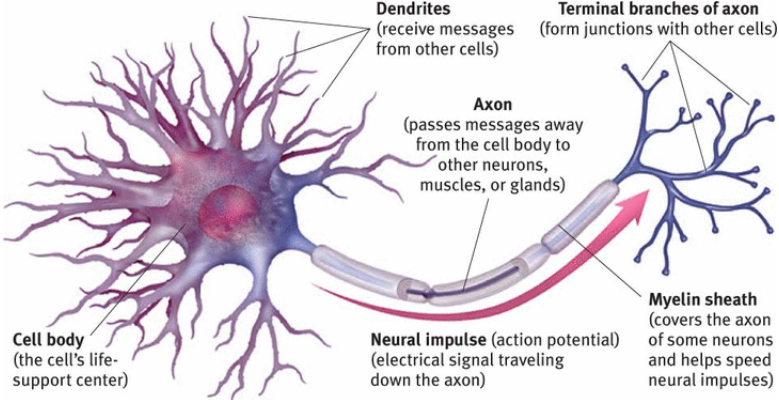
Comparison between brain and computer

|	**Brain**	**Computer**
No. of processing units	$\approx 10^{11}$	$\approx 10^{9}$
Type of processing units	Neurons	Transistors
Type of calculation	massively parallel	usually serial
Data storage	associative	address-based
Switching time	$\approx 10^{-3}$ s	$\approx 10^{-9}$ s
Possible switching operations	$\approx 10^{13}$ s^{-1}	$\approx 10^{18}$ s^{-1}
Actual switching operations	$\approx 10^{12}$ s^{-1}	$\approx 10^{10}$ s^{-1}

Quiz

Q1 [5 points]. Determine the animals on the pictures:
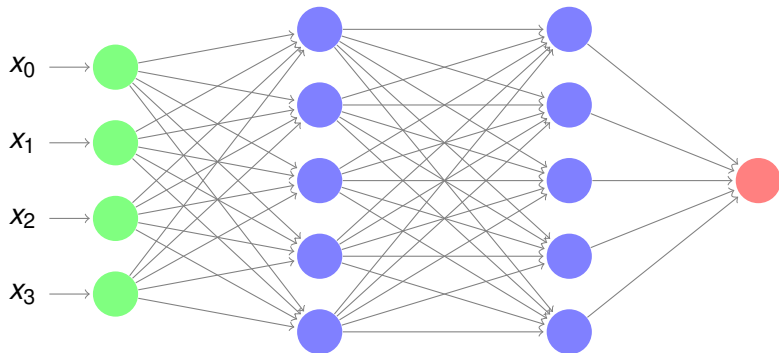

Q2 [5 points]. Find the answer without calculator:

$$\frac{12\,346\,238 \times 982\,283\,129 + 261\,123\,238}{239\,329} =$$
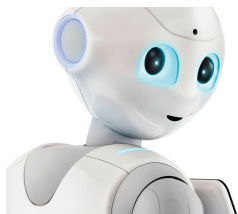
Artificial neural network
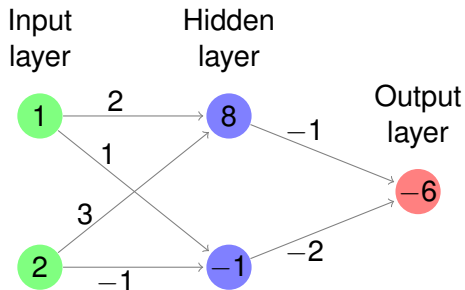
- $8 = 1 \cdot 2 + 2 \cdot 3$
- $-1 = 1 \cdot 1 + 2 \cdot (-1)$
- $-6 = 8 \cdot (-1) + (-1) \cdot (-2)$

Artificial neural network: components

- neurons
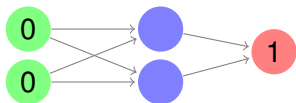- layers
- weights
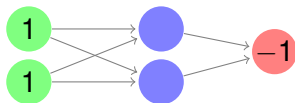- activation functions

Example 1: make a light robot

- ► both bulbs are off $\Rightarrow$ robot turns on the first bulb
- ► both bulbs are on $\Rightarrow$ robot turns off the second bulb
- ► otherwise $\Rightarrow$ robot does nothing

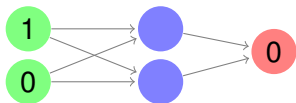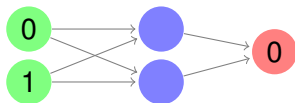# Example 2: solution with ANN

Bulbs are off:

Bulbs are on:

First bulb is on:

Second bulb is on:

Example 2: how to find weights

- Bulbs are off:
  $$1 = w_3 \cdot a(w_{11} \cdot 0 + w_{12} \cdot 0) + w_4 \cdot a(w_{21} \cdot 0 + w_{22} \cdot 0)$$

- Bulbs are on:
  $$-1 = w_3 \cdot a(w_{11} \cdot 1 + w_{12} \cdot 1) + w_4 \cdot a(w_{21} \cdot 1 + w_{22} \cdot 1)$$

- First bulb is on:
  $$0 = w_3 \cdot a(w_{11} \cdot 1 + w_{12} \cdot 0) + w_4 \cdot a(w_{21} \cdot 1 + w_{22} \cdot 0)$$

- Second bulb is on:
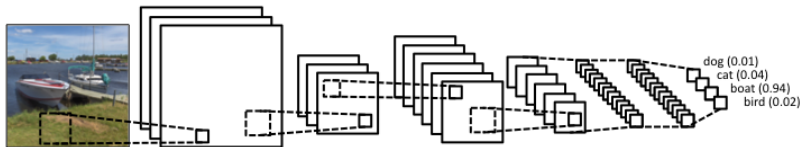 $$0 = w_3 \cdot a(w_{11} \cdot 0 + w_{12} \cdot 1) + w_4 \cdot a(w_{21} \cdot 0 + w_{22} \cdot 1)$$

Example 2: solve the Q1 for our Quiz

Q1 [5 points]. Determine the animals on the pictures:

Example 2: convolutional neural networks

- ▶ each picture can be represented as a matrix of pixels
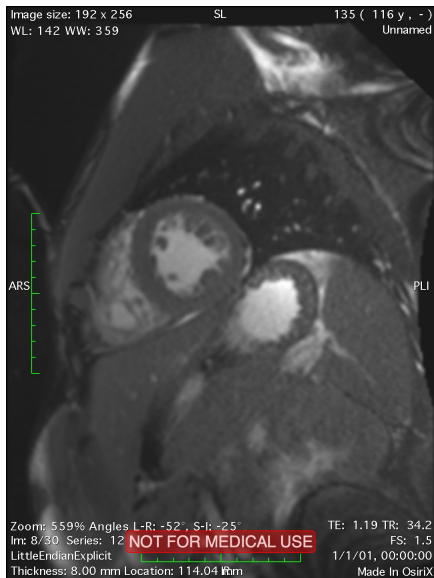
- ▶ CNN splits picture in patches:

dog (0.01)
cat (0.04)
boat (0.94)
bird (0.02)

- ▶ nice visualization

Where we can use neural networks?

- image recognition

- voice recognition

- text classification

- video recognition

- reinforcement learning

- . . .

Bonus example: left ventricle detection

Thank you! Questions?

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