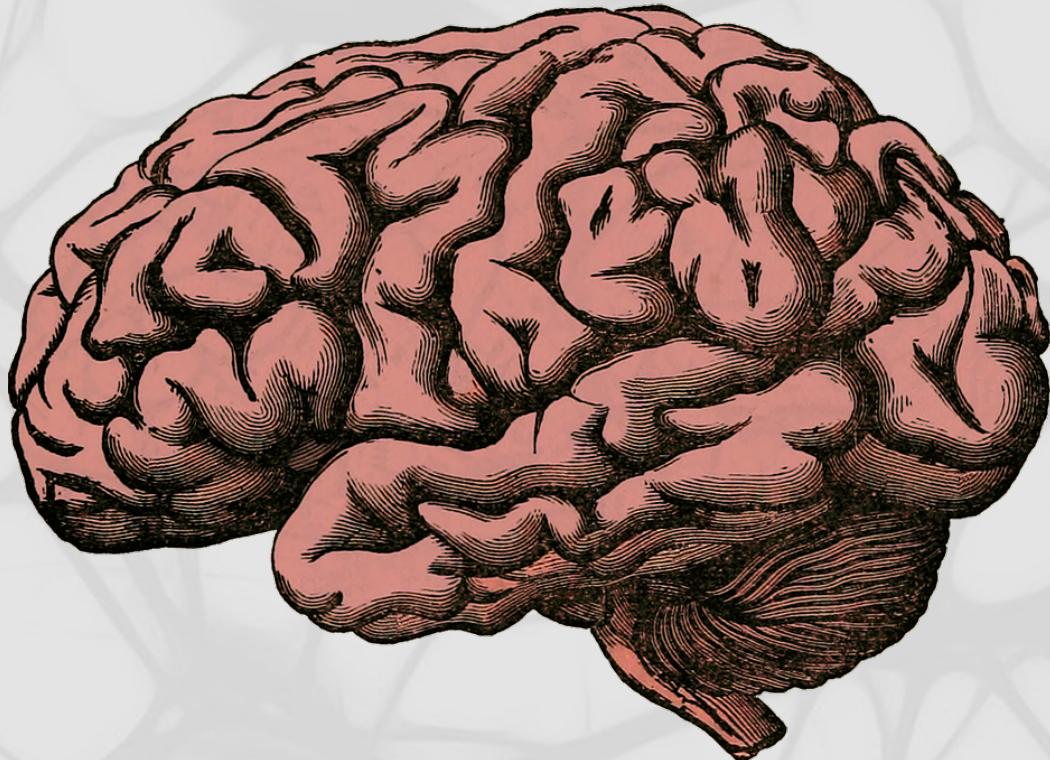


# **Umelý neurón**

+ Prehľad neurónových sietí

Miroslav Hájek,  
septima 2017/18

# Inšpirácia prírodou

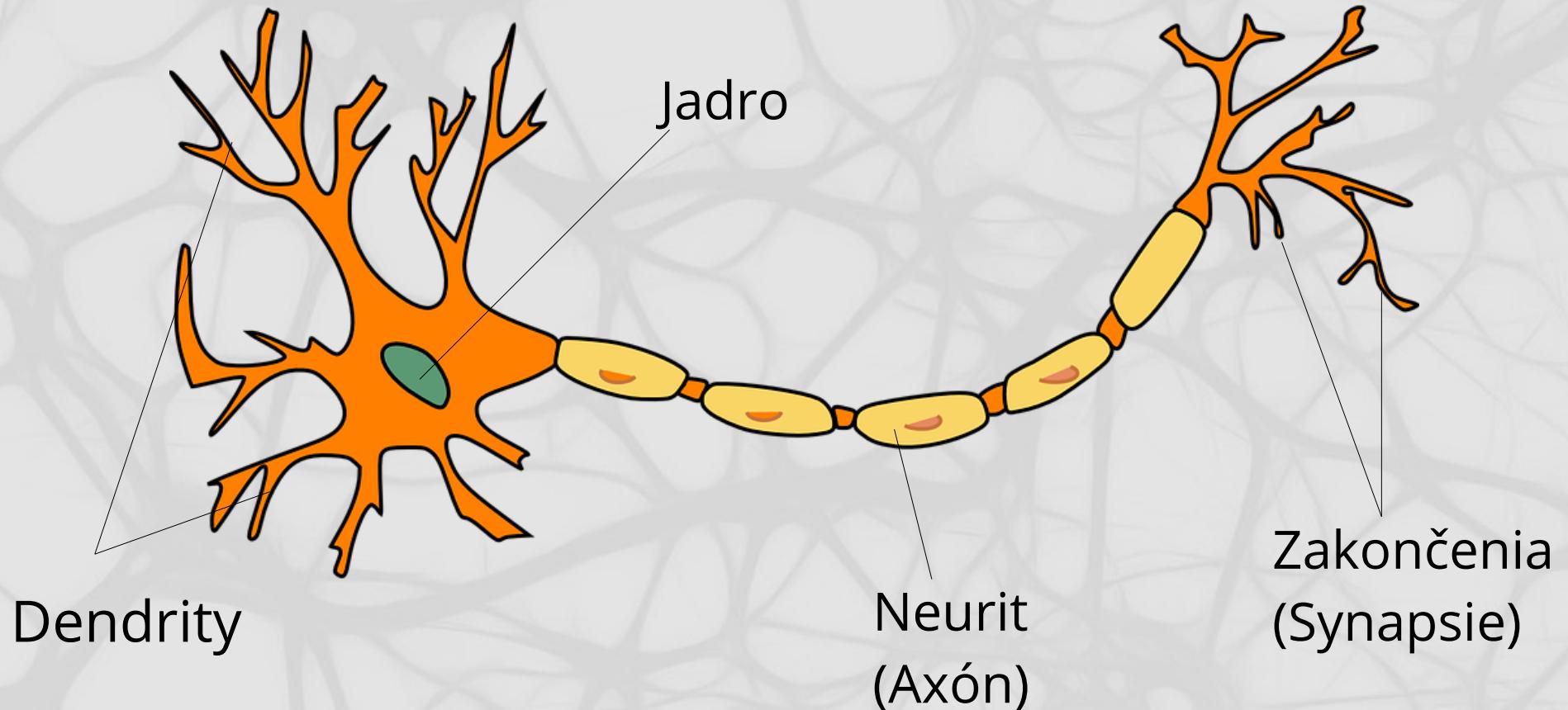


# Schopnosť kategorizovať

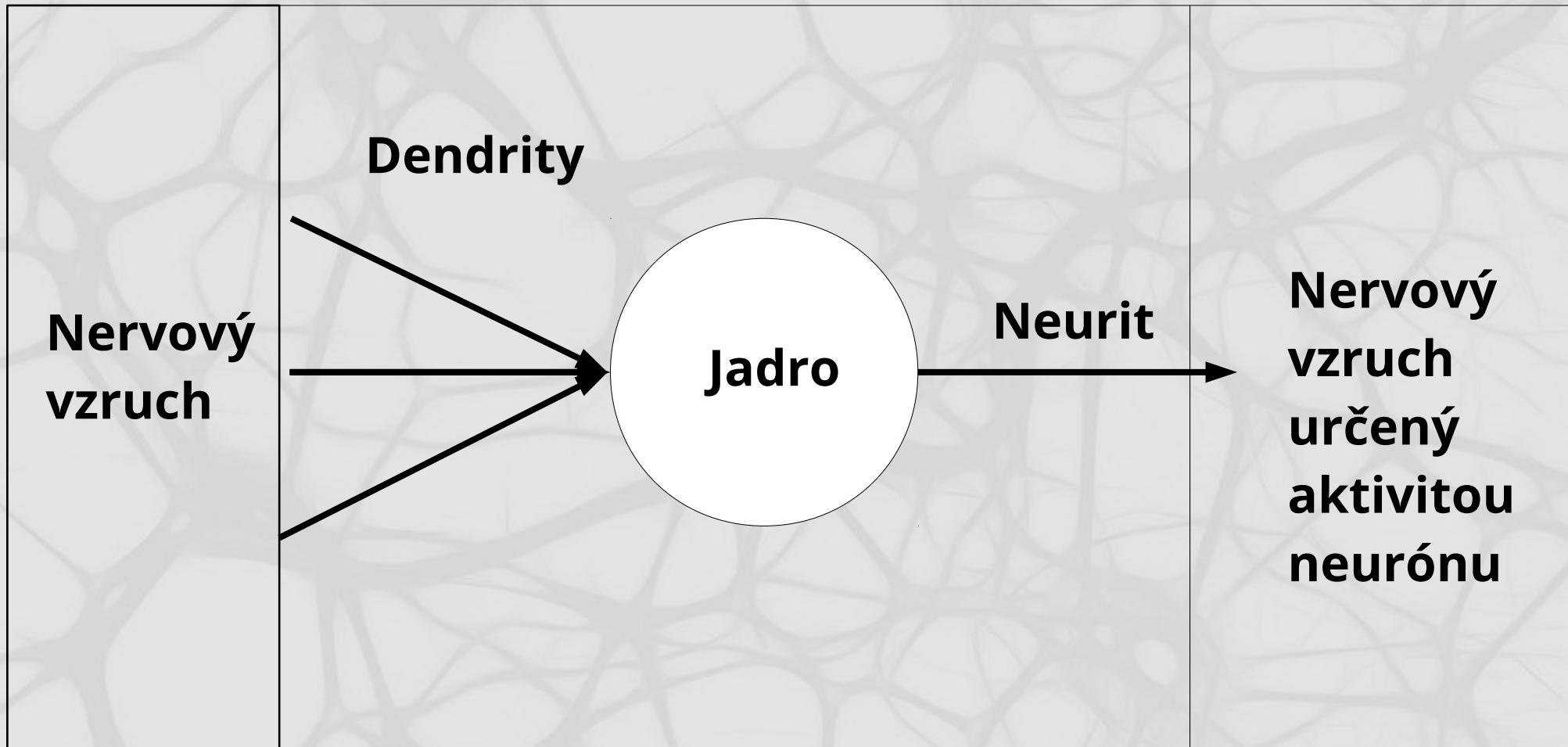
# MNIST databáza rukopisov čísel



# Biologický neurón



# Schéma fungovania neurónu



Vstup

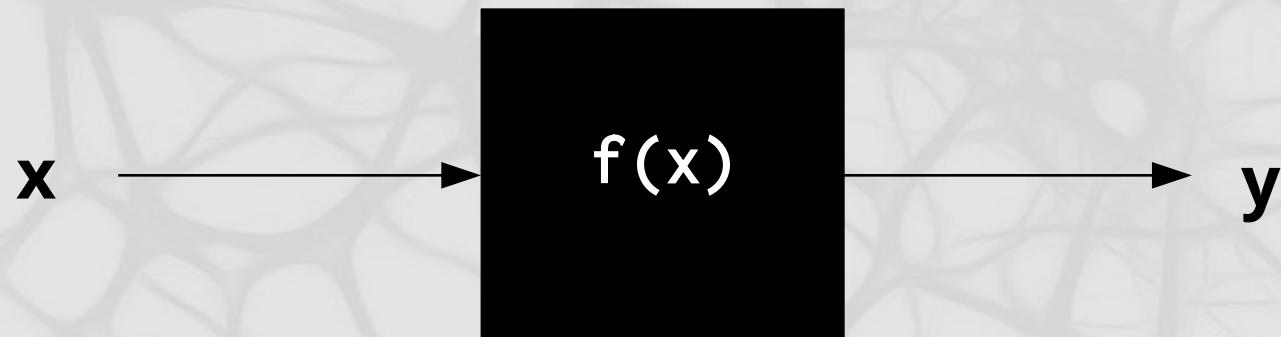
Výpočet (Algoritmus)

Výstup

# Schéma programu



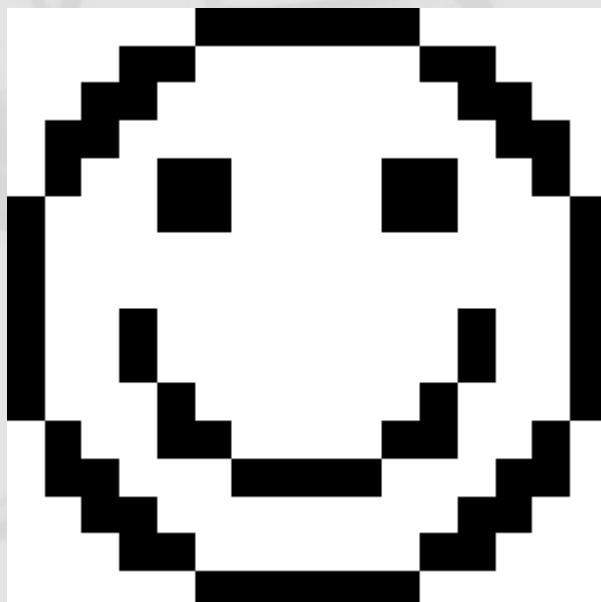
# Matematická funkcia



# Ako simulovaloť náš mozog?

- Algoritmy – deterministický model – presný postup
- Umelý neurón – stochastický model – učenie sa

Napr. Rozoznávanie obrázkov



```
00000111110000  
0001100000011000  
001100000001100  
011000000000110  
010011000110010  
100011000110001  
100011000110001  
100000000000001  
100000000000001  
100100000001001  
100100000001001  
100010000010001  
010011000110010  
0110001111000110  
001100000001100  
0001100000011000  
000001111100000
```

# **Čo sa s tým dá ešte robiť?**

- Rozoznávanie vzorov – tvári, znakov (OCR)
- Predpovedanie budúcich javov – počasie, burza
- Ovládanie – roboty, samoriadiace autá
- Senzory – vytvorenie nadhľadu z množstva dát
- Detekcia anomálii – doprava, spánková rutina pacienta
- Určenie diagnózy (v budúcnosti)

## THE PERCEPTRON: A PROBABILISTIC MODEL FOR INFORMATION STORAGE AND ORGANIZATION IN THE BRAIN<sup>1</sup>

F. ROSENBLATT

*Cornell Aeronautical Laboratory*

If we are eventually to understand the capability of higher organisms for perceptual recognition, generalization, recall, and thinking, we must first have answers to three fundamental questions:

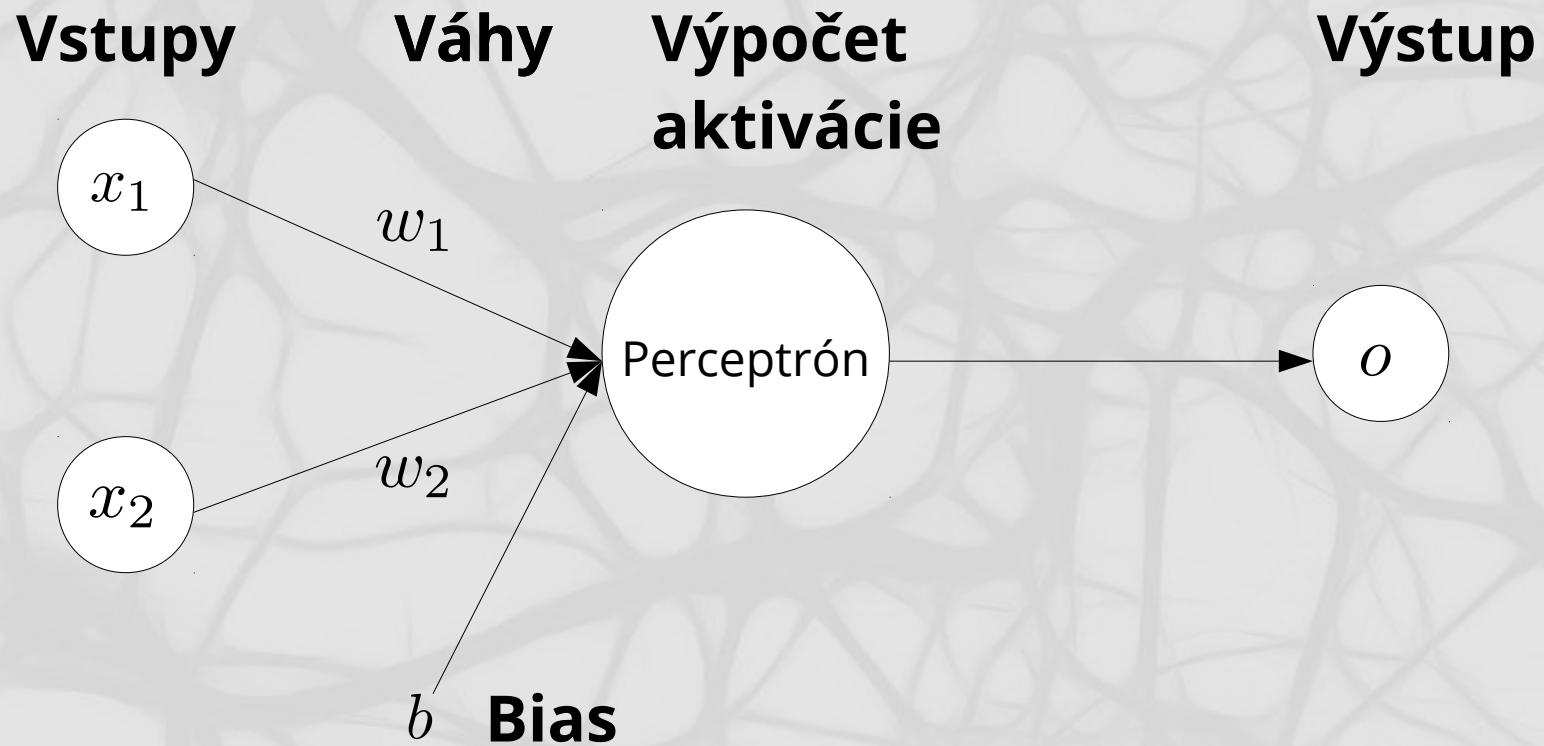
1. How is information about the physical world sensed, or detected, by the biological system?
2. In what form is information stored, or remembered?
3. How does information contained in storage, or in memory, influence recognition and behavior?

The first of these questions is in the province of sensory physiology, and is the only one for which appreciable understanding has been achieved. This article will be concerned primarily with the second and third questions, which are still subject to a vast amount of speculation, and where the few relevant facts currently supplied by neurophysiology have not yet been integrated into an acceptable theory.

With regard to the second question, two alternative positions have been maintained. The first suggests that storage of sensory information is in the form of coded representations or images, with some sort of one-to-one

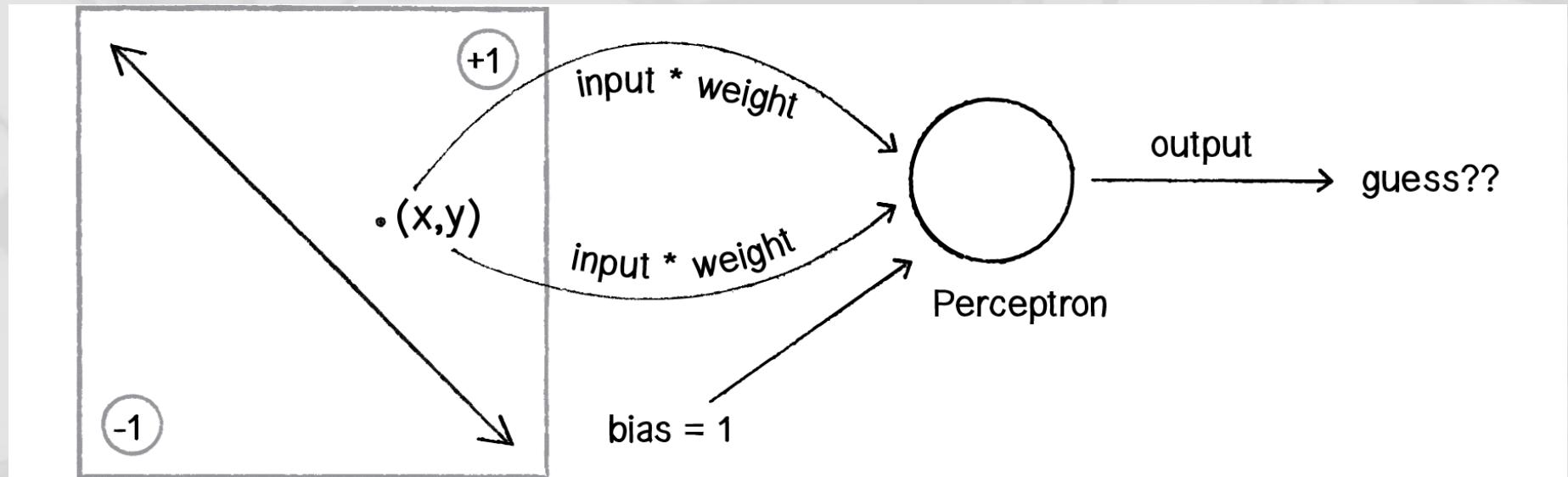
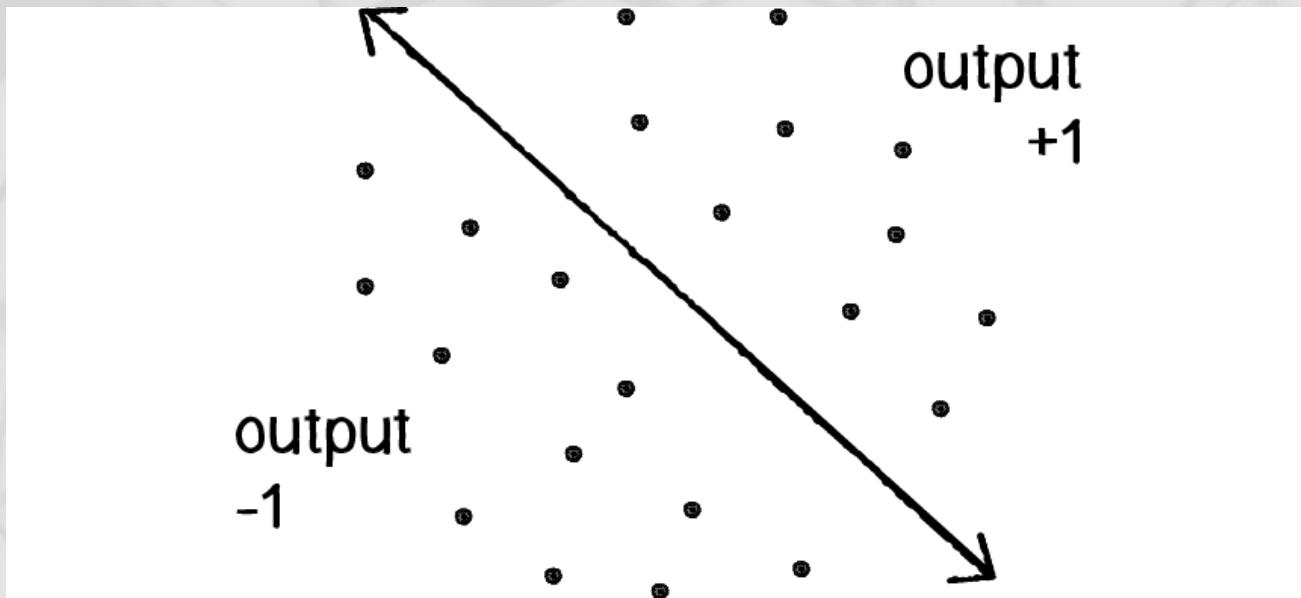
and the stored pattern. According to this hypothesis, if one understood the code or "wiring diagram" of the nervous system, one should, in principle, be able to discover exactly what an organism remembers by reconstructing the original sensory patterns from the "memory traces" which they have left, much as we might develop a photographic negative, or translate the pattern of electrical charges in the "memory" of a digital computer. This hypothesis is appealing in its simplicity and ready intelligibility, and a large family of theoretical brain models has been developed around the idea of a coded, representational memory (2, 3, 9, 14). The alternative approach, which stems from the tradition of British empiricism, hazards the guess that the images of stimuli may never really be recorded at all, and that the central nervous system simply acts as an intricate switching network, where retention takes the form of new connections, or pathways, between centers of activity. In many of the more recent developments of this position (Hebb's "cell assembly," and Hull's "cortical anticipatory goal response," for example) the "responses" which are associated to stimuli may be entirely contained within the CNS itself. In this case

# Perceptrón

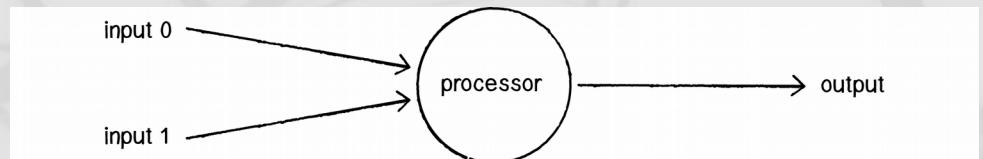


Aktivácia umelého neurónu  
$$o = (x_1 \cdot w_1 + x_2 \cdot w_2) + b$$

# Príklad - lineárny klasifikátor



# Popis činnosti



**1. Prijatie vstupov**  $x = 24$   
 $y = 5$

## 2. Pridaj váhy

- na začiatku sú náhodne na konci optimálne pre riešenie problému

$$x \cdot w_x \Rightarrow 24 \cdot 0.5 = 12$$

$$y \cdot w_y \Rightarrow 5 \cdot (-1) = -5$$

## 3. Sčítaj vstupy

$$Sum = 12 + (-5) = 7$$

## 4. Vytvor výstup pomocou aktivačnej funkcie

$$\text{znamienko}(x) : x > 0 \Rightarrow +1 \\ x < 0 \Rightarrow -1$$

# Typy strojového učenia

- **Učenie s učiteľom** (Supervised)
- **Učenie bez učiteľa** (Unsupervised)
- **Učenie so spätnou väzbou** (Reinforcement)

# Učenie s učiteľom v našom príklade

## Použijeme učenie s učiteľom

- Vytvoríme testovaciu sadu bodov

- Upravíme váhy postupne

**chyba** = (**žiadany** výstup) - (**tip** perceptróna)

**nová váha** = (**váha teraz**) + (**zmena váhy**)

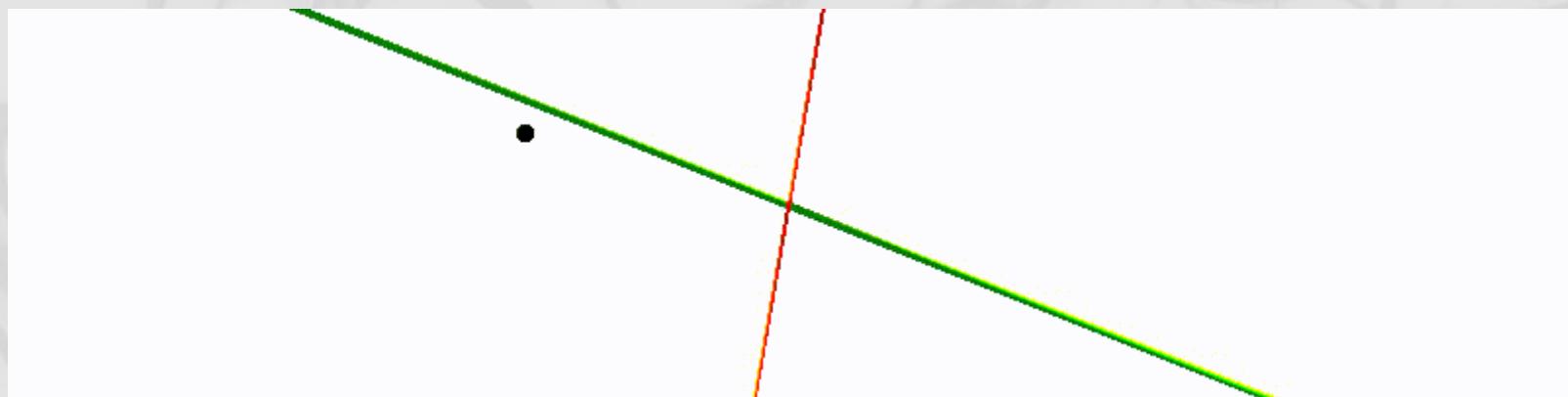
**zmena váhy** = chyba \* vstup

**NOVÁ VÁHA = VÁHA + CHYBA \* VSTUP \* RÝCHLOSŤ UČENIA**

# Ako to vyzerá?

„Univerzálny funkčný aproximátor“

Rýchlosť učenia: 0.00001



Rýchlosť učenia: 0.0001



# Kód alebo ako je to v praxi

```
import random

class Perceptron:
    def __init__(self, n, c):                      # 1. Načítaj náhodné váhy
        self.weights = [random.uniform(-1, 1) for i in range(n)]
        self.learn_rate = c

    def activate(self, suma):                      # znamienko
        if suma >= 0:
            return 1
        else:
            return -1

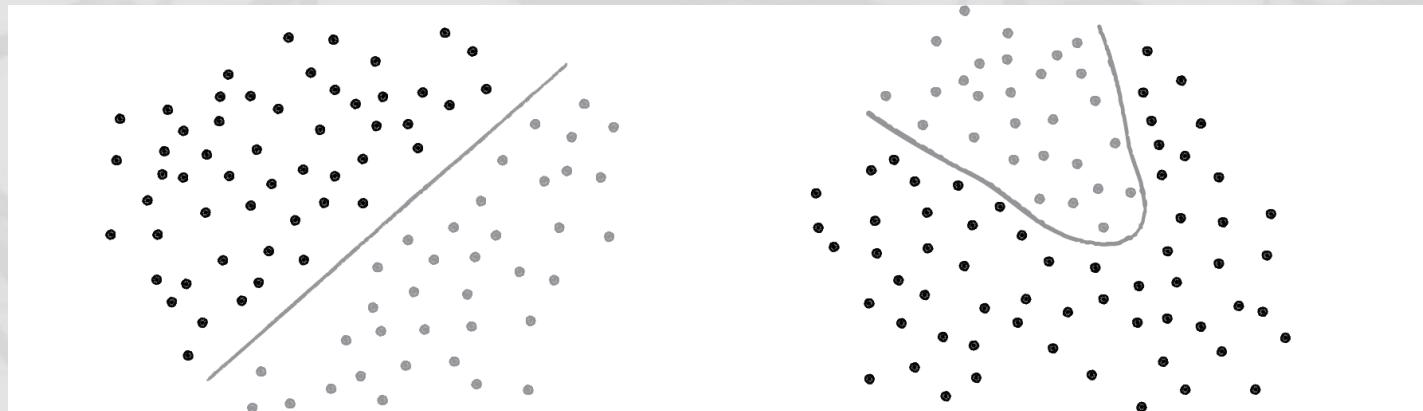
    def feedforward(self, inputs):
        suma = 0
        for i in range(len(self.weights)):
            suma += inputs[i] * self.weights[i]      # 2. Vážený súčet
        return self.activate(suma)                  # 3. Aktivačná funkcia

    def train(self, inputs, desired):
        guess = self.feedforward(inputs)
        error = desired - guess
        for i in range(len(self.weights)):          # 4. Uprav váhy
            self.weights[i] += error * inputs[i] * self.learn_rate
```

# Kedy perceptrón nestačí?

- Rieši len lineárne rozdeliteľné skupiny (1 priamka)
- XOR je neriešiteľné!

**Marvin Minsky, Seymour Papert; Perceptrons (1969)**



AND

	T	F
T	T	F
F	F	F

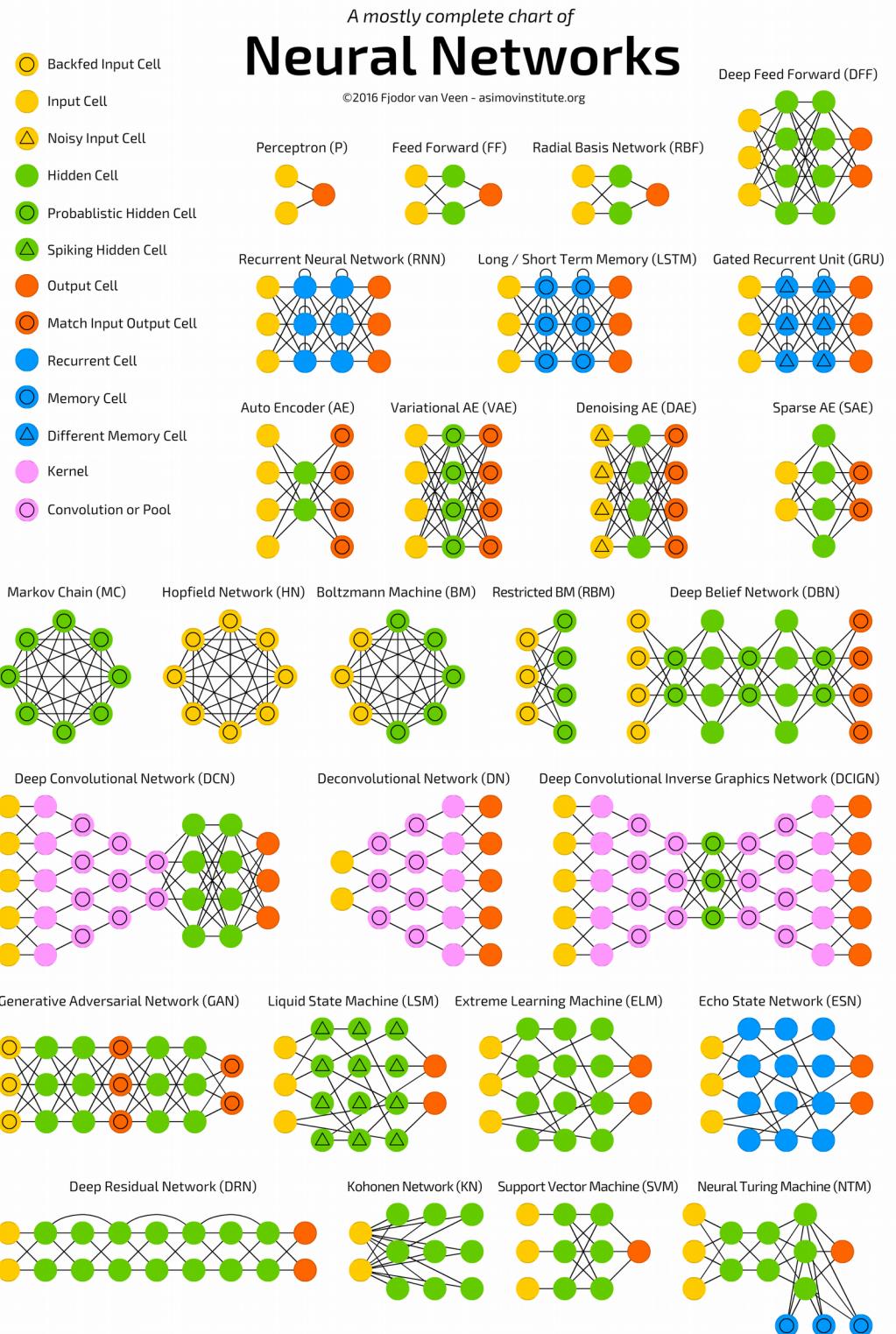
OR

	T	F
T	T	T
F	T	F

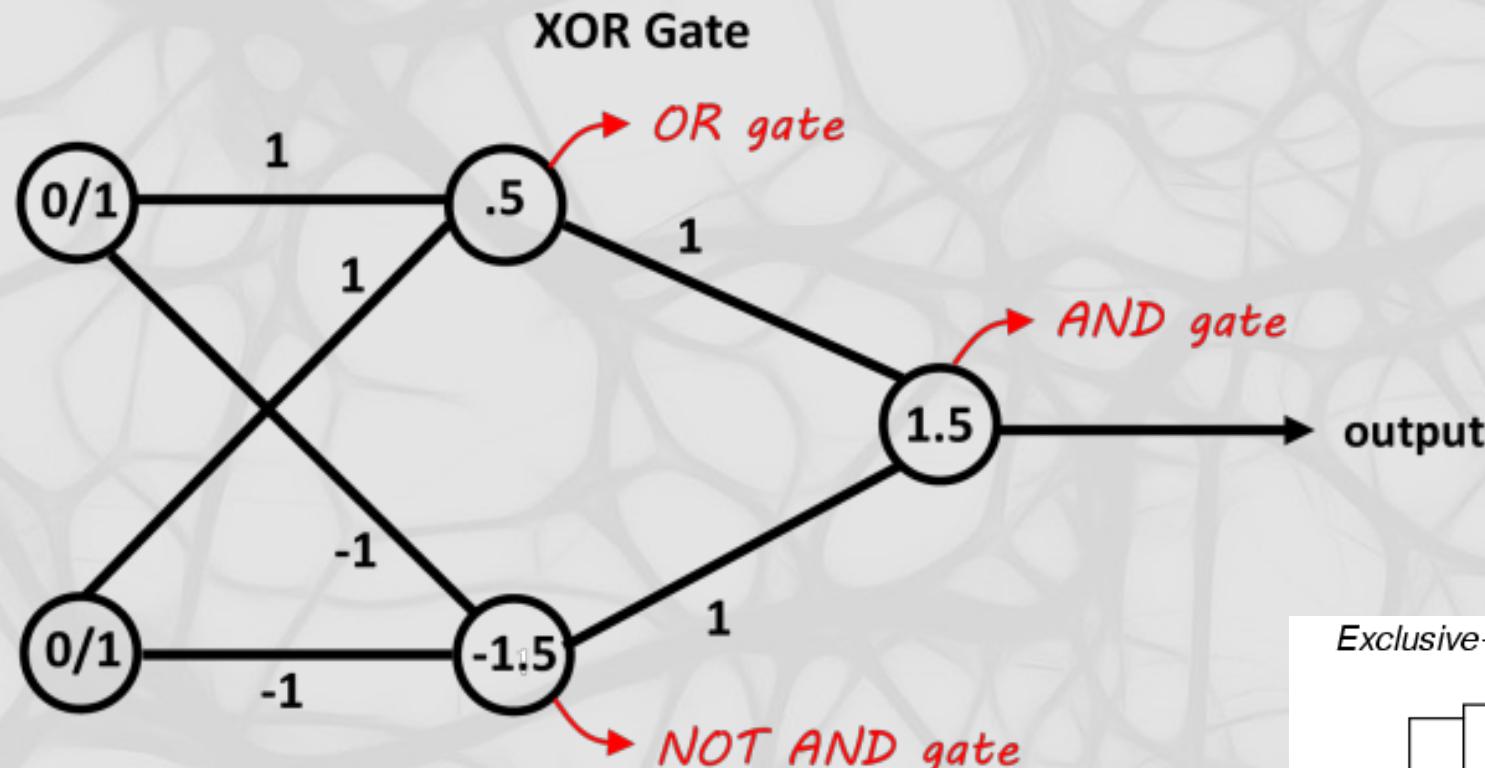
XOR

	T	F
T	F	T
F	T	F

# Spájanie do neurónových sietí



# Riešenie problému XOR

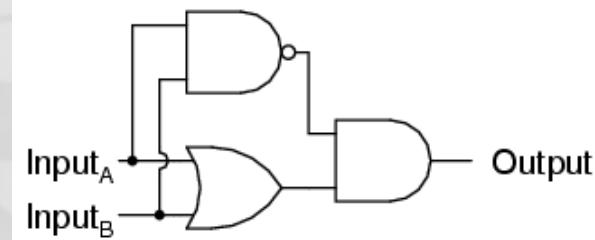


Vstupná  
vrstva

Skrytá  
vrstva

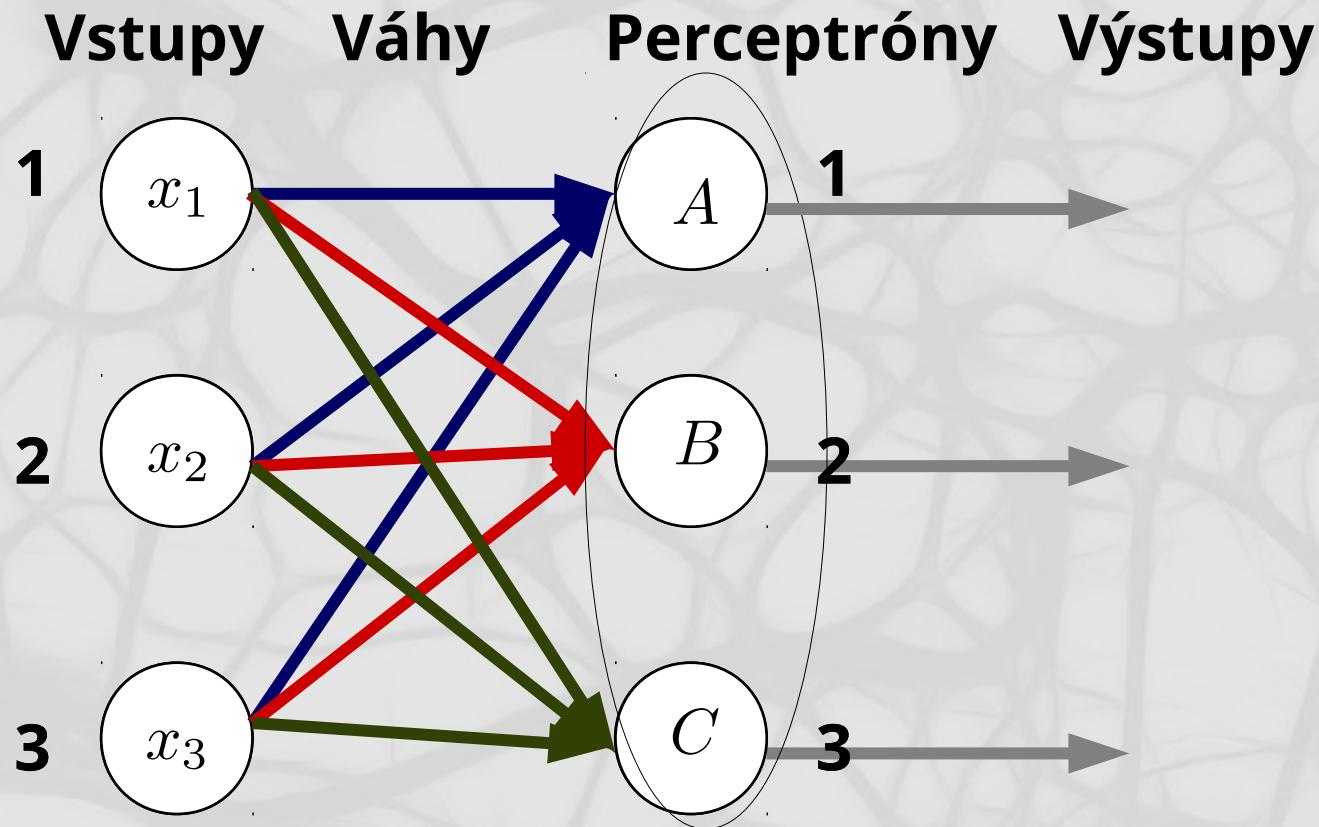
Výstupná  
vrstva

Exclusive-OR equivalent circuit



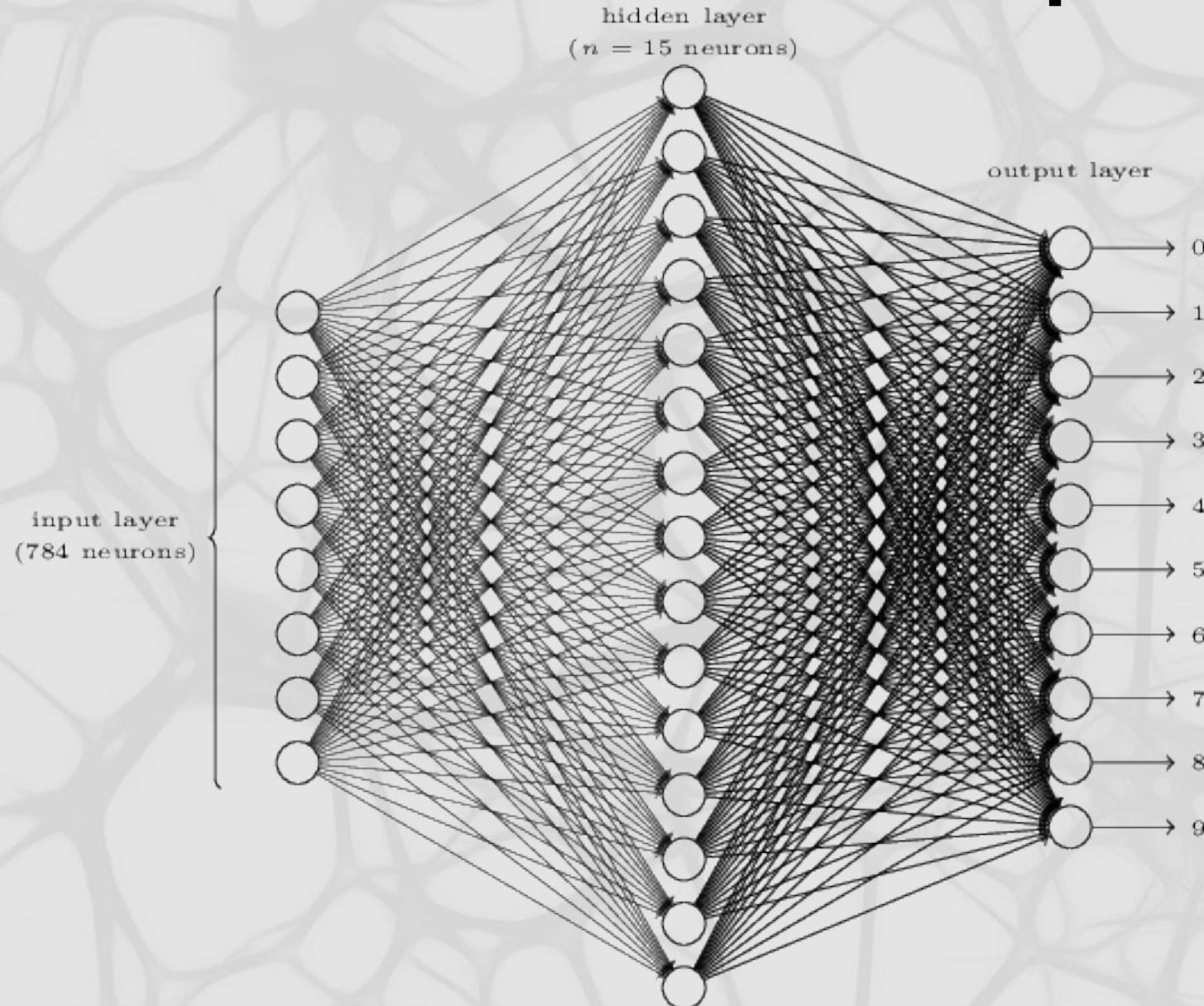
A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

# Spojenia medzi vrstvami



$$\vec{y} = \sigma \left( \begin{matrix} w_{1,1} & w_{1,2} & w_{1,3} \\ w_{2,1} & w_{2,2} & w_{2,3} \\ w_{3,1} & w_{3,2} & w_{3,3} \end{matrix} \right) \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$$

# Klasifikácia čísel z rukopisu

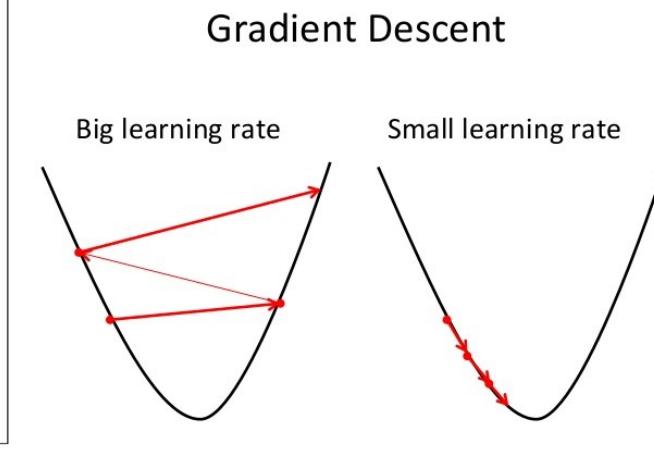
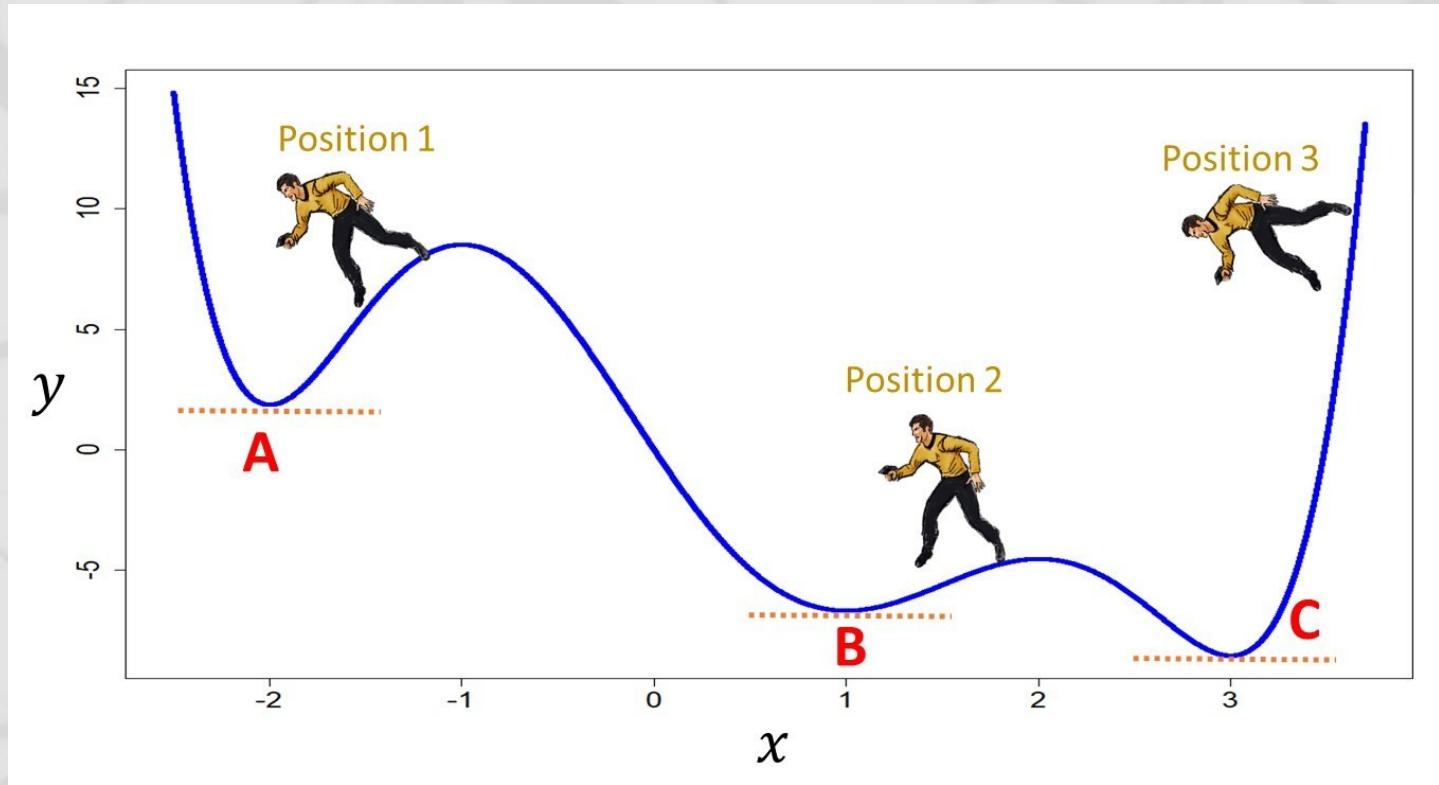


MNIST Samples									
6	1	9	4	2	5				
7	8	7	1	3	0				
0	7	2	4	8	0				
8	4	5	3	8	7				
1	9	8	4	5	8				
7	7	3	6	8	2				

- Databáza MNIST:
- $28 \times 28 = 764$  vektor
- Ako funkcia:
- **Vstupy:** 784 pixelov
  - **Prepojenia:** 11925 váh a biasov
  - **Výstup:** 10 pravdepodobností (0.0 – 1.0)

# Učenie neurónových sietí

- Gradient descent a Backpropagation
- Optimalizácia – hľadanie najlepšieho lokálneho minima funkcie



$$\frac{dC}{dx}(w) = 0$$

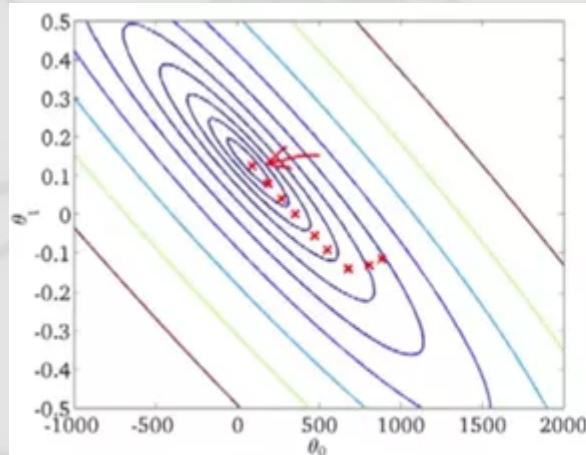
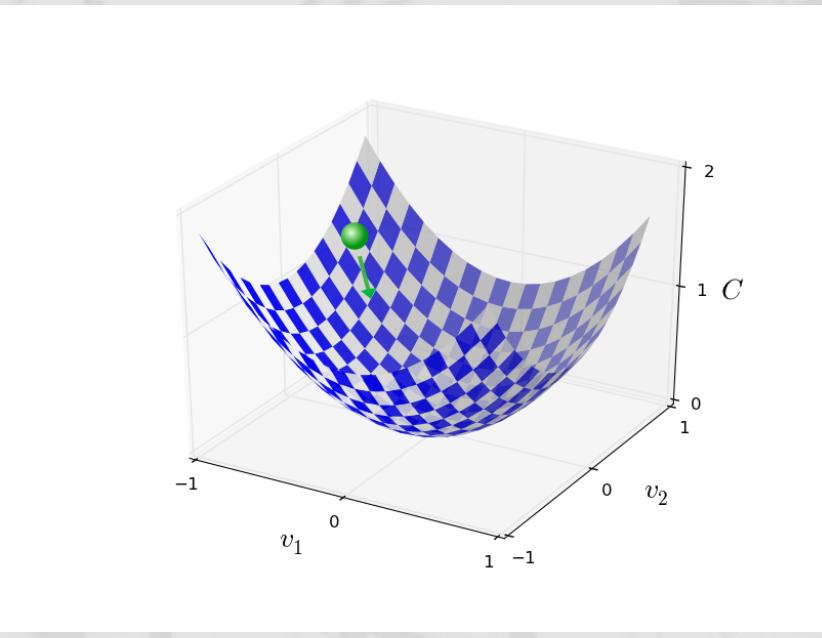
# Hľadanie v n-rozmernom priestore

$$C(w, b) \equiv \frac{1}{2n} \sum_x \|y(x) - a\|^2$$

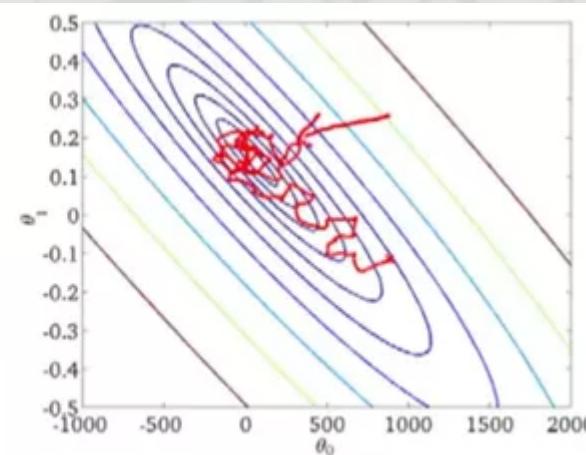
$$\nabla C \equiv \left( \frac{\partial C}{\partial v_1}, \dots, \frac{\partial C}{\partial v_m} \right)^T \quad \Delta C \approx \nabla C \cdot \Delta v$$

$$\nabla C \approx \frac{1}{m} \sum_{j=1}^m \nabla C_{X_j},$$

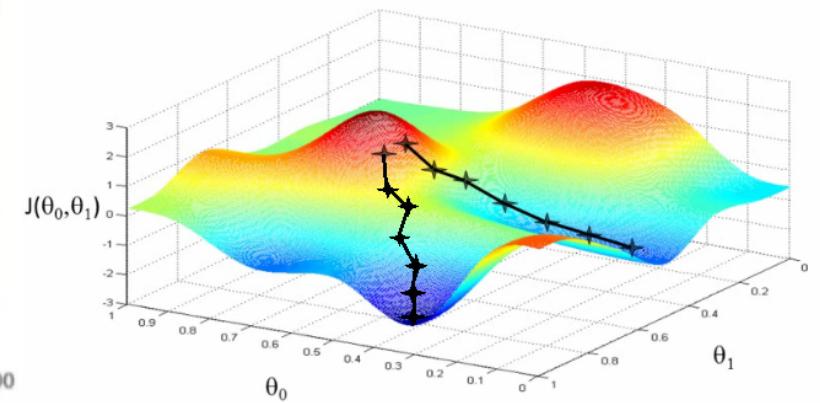
$$w_k \rightarrow w'_k = w_k - \frac{\eta}{m} \sum_j \frac{\partial C_{X_j}}{\partial w_k}$$



**Batch Gradient Descent**



**Stochastic Gradient Descent**



# But wait, there is more ...

THE NATURE OF CODE  
DANIEL SHIFFMAN

WELCOME  
ACKNOWLEDGMENTS  
DEDICATION  
PREFACE  
INTRODUCTION  
1. VECTORS  
2. FORCES  
3. OSCILLATION  
4. PARTICLE SYSTEMS  
5. PHYSICS LIBRARIES  
6. AUTONOMOUS AGENTS  
7. CELLULAR AUTOMATA  
8. FRACTALS  
9. THE EVOLUTION OF CODE  
10. NEURAL NETWORKS  
FURTHER READING  
INDEX

## Chapter 10. Neural Networks

"You can't process me with a normal brain."  
— Charlie Sheen

We're at the end of our story. This is the last official chapter of this book (though I envision additional supplemental material for the website and perhaps new chapters in the future). We began with inanimate objects living in a world of forces and gave those objects desires, autonomy, and the ability to take action according to a system of rules. Next, we allowed those objects to live in a population and evolve over time. Now we ask: What is each object's decision-making process? How can it adjust its choices by learning over time? Can a computational entity process its environment and generate a decision?

The human brain can be described as a biological neural network—an interconnected web of neurons transmitting elaborate patterns of electrical signals. Dendrites receive input signals and, based on those inputs, fire an output signal via an axon. Or something like that. How the human brain actually works is an elaborate and complex mystery, one that we certainly are not going to attempt to tackle in rigorous detail in this chapter.

root:~\$ Siraj Raval  
Artificial Intelligence Education  
New Video Every Week!

Siraj Raval 268 472 zhlédnutí 268 TIS. ODBER AKTÍVNY

DOMOV VIDEÁ ZOZNAMY VIDEÍ KOMUNITA INFORMÁCIE

Nahrané videá PREHRAT VŠETKO

Unity AI - Unity 3D Artificial Intelligence 29 ts. zhlédnutí • Pred 3 dnami

Numenta Explained 22 ts. zhlédnutí • Pred 5 dnami

Keras Explained 25 ts. zhlédnutí • Pred 5 dnami

How Does Cardano Work? 30 ts. zhlédnutí • Pred 1 týždňom

Artificial Intelligence for Kids 18 ts. zhlédnutí • Pred 2 týždňmi

Thierry

But what \*is\* a Neural Network? | Chapter 10: Neural Networks 3Blue1Brown 19:13

How machines learn 3Blue1Brown 21:01

What is backpropagation really doing? | Chapter 10: Neural Networks 3Blue1Brown 13:54

Backpropagation calculus | Appendix to Chapter 10: Neural Networks 3Blue1Brown 10:18

PREHRAT VŠETKO

### Neural networks

4 videá • 78 100 zhlédnutí • Naposledy aktualizované 3. 11. 2017

3Blue1Brown ODBER AKTÍVNY 644 TIS.

This screenshot shows the 'Neural Networks' chapter from the 'The Nature of Code' website. It includes a sidebar with navigation links and a main content area with text, a quote, and a detailed description of neural networks. Below this is a video player for a video titled 'But what \*is\* a Neural Network? | Chapter 10: Neural Networks' by 3Blue1Brown. At the bottom, there's a section for 'Neural networks' with a list of four videos and a summary.

## Online knihy

<http://neuralnetworksanddeeplearning.com/>  
<http://www.deeplearningbook.org/>

## MAKE YOUR OWN NEURAL NETWORK



*A gentle journey through the mathematics of neural networks, and making your own using the Python computer language.*

TARIQ RASHID



### 10: Neural Networks - The Nature of Code

11 videá • 52 233 zhlédnutí • Aktualizované pred 3 dniami

PREHRAT VŠETKO

The Coding Train ODBER AKTÍVNY 393 TIS.

This playlist accompanies Chapter 10 of The Nature of Code book.  
<http://natureofcode.com/book/chapter-10-neural-networks/>



### 10.1: Introduction to Neural Networks - The Nature of Code

The Coding Train



### 10.2: Neural Networks: Perceptron Part 1 - The Nature of Code

The Coding Train



### 10.3: Neural Networks: Perceptron Part 2 - The Nature of Code

The Coding Train



### 10.4: Neural Networks: Multilayer Perceptron Part 1 - The Nature of Code

The Coding Train



### 10.5: Neural Networks: Multilayer Perceptron Part 2 - The Nature of Code

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### 10.6: Neural Networks: Matrix Math Part 1 - The Nature of Code

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### 10.7: Neural Networks: Matrix Math Part 2 - The Nature of Code

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### 10.8: Neural Networks: Updating Code to ES6 - The Nature of Code

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### 10.9: Neural Networks: Matrix Math Part 3 - The Nature of Code

The Coding Train



### 10.10: Neural Networks: Matrix Math Part 4 - The Nature of Code

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