From boolean algebra to convolutional neural networks

Tom Krajník

Artificial Intelligence Centre, Czechia

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What is intelligence

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What is intelligence

Intelligence is a provable ability to

- plan and reason,
- solve complex problems,
- make decisions under uncertainty,
- undestand the world,
- and to learn and adapt.

What is (machine) learning

Measurable change of behaviour acquired through

- instruction - supervised learning,
-
-

Simplifications:

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What is (machine) learning

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- experience - unsupervised learning,
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What is (machine) learning

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- instruction - supervised learning,
- experience - unsupervised learning,
- study - semi-supervised learning.

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Simplifications:

- behaviour: obtain a set of observable features X and perform a decision Y.
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What is (machine) learning

Measurable change of behaviour acquired through

- instruction - supervised learning,
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Simplifications:

- behaviour: obtain a set of observable features X and perform a decision Y.
- given the knowledge of probability distributions p(F|S), p(S)
- and the reward function R(Y,S).

Example:

Early retirement contract:

- Y: propose a retirement contract
-
-
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Example:

Early retirement contract:

- Y: propose a retirement contract
- X: features of the person
-
-

Example:

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How many neurons are needed for such a decision?

Bio-inspired computational model:

McCulloh, Pritts: A Logical Calculus of Ideas Immanent in Nervous Activity. (1943)

1. The activity of the neuron is an all-or-none process.
2. A certain fixed number of synapses must be excited within the period of latent addition in order to excite a neuron at any time, and this number is independent of previous activity and position on the neuron.
3. The only significant delay within the nervous sytem is synaptic delay.
4. The activity of any inhibitory synapse absolutely prevents excitation of the neuron at that time.
5. The structure of the net does not change with time.

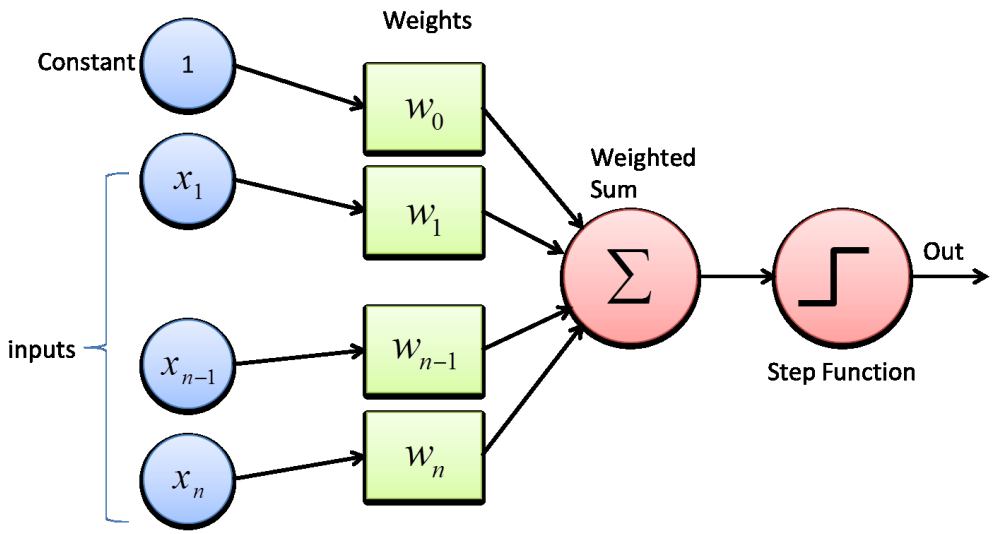
Towards learning of neurons

Ronald Hebb: The Organization of Behavior. (1949)

When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased.

Perceptron

Rosenblatt: Principles of Neurodynamics. American Journal of Psychology (1969)



Perceptron training

while err do
    err = false
    foreach $\mathbf{x}$ in positive samples:
        if ($\mathbf{w}^\mathbf{T}\,\mathbf{x} < 0$) $\mathbf{w} = \mathbf{w} + \mathbf{x}$
        err = true
    foreach $\mathbf{x}$ in negative samples:
        if ($\mathbf{w}^\mathbf{T}\,\mathbf{x} > 0$) $\mathbf{w} = \mathbf{w} - \mathbf{x}$
        err = true

Perceptron limitations

Papert, Minski: Perceptrons: An Introduction to Computational Geometry. (1967): *Perceptron cannot do XOR, NXOR .... the research based on perceptron is doomed computational infeasibility to train large networks*

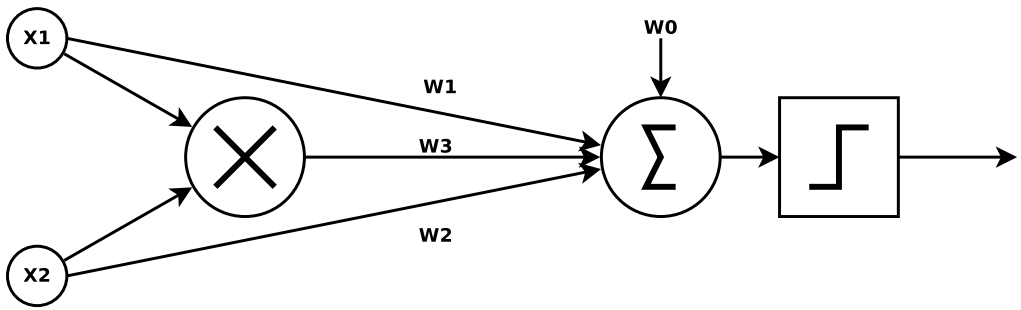
- Little research done until 1980 (?).

- Solutions ?

Perceptron and XOR problem

Perceptron cannot do XOR, NXOR

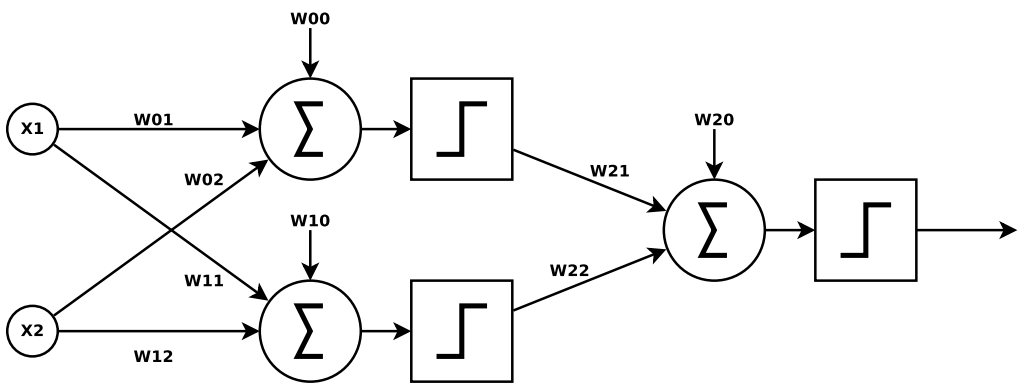
- projection into a higher-dimensional space
- additional feature $x_3 = x_1\, x_2$



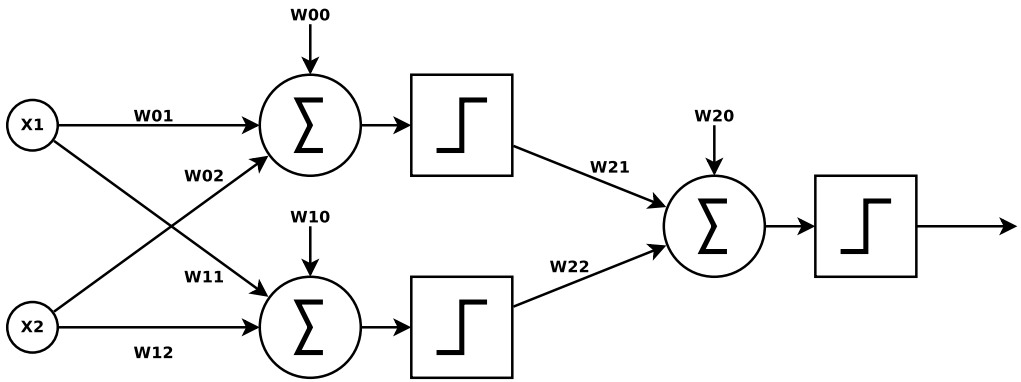
Perceptron and XOR problem

Perceptron cannot do XOR, NXOR

- multiple layers



How to train a multi-layered NN

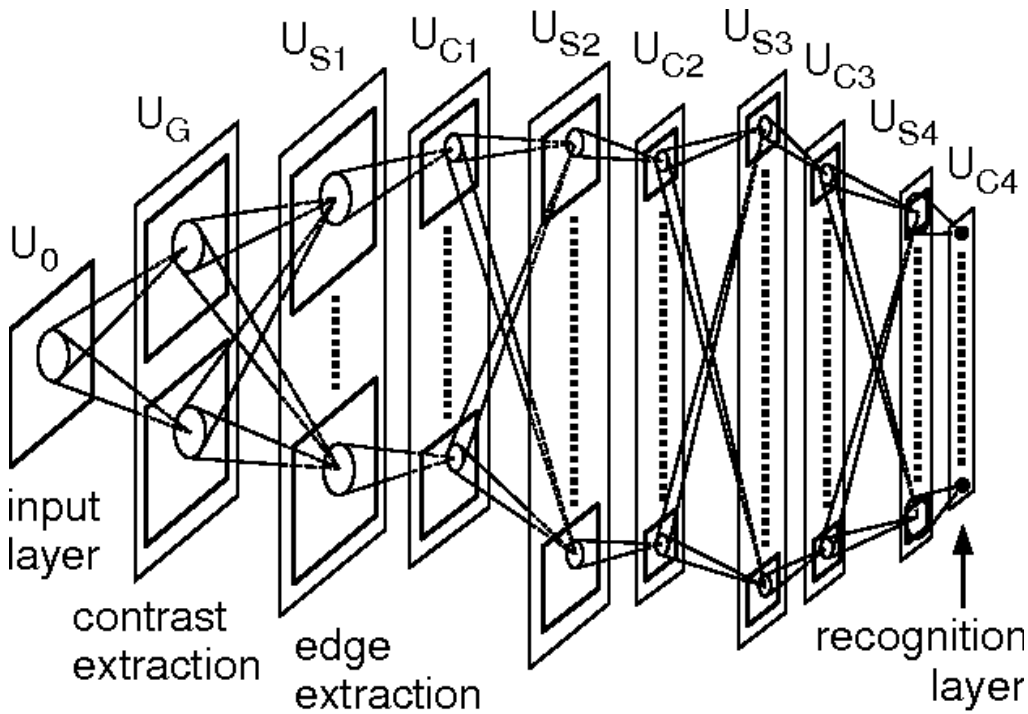


Backpropagation

- same idea as perceptron training, but by layers (last to first)

(Neo)cognitron

- Fukushima 1975: Cognitron: layered NN (unsupervised learning)
- Fukushima 1980: Neocognitron: layered NN (unsupervised learning) for text recognition



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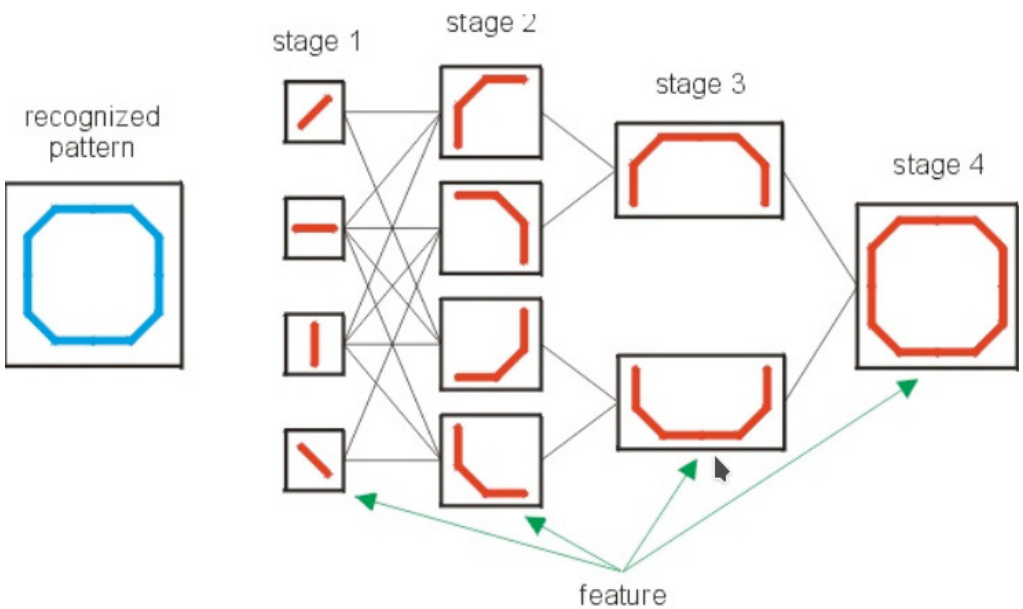
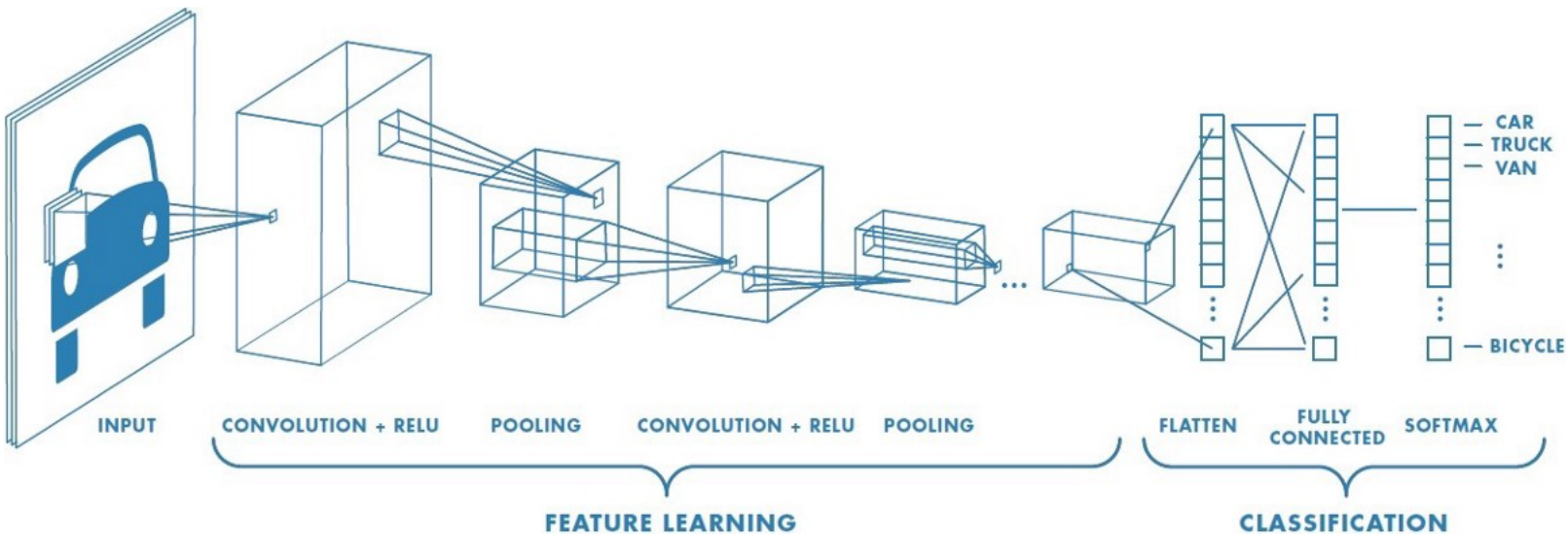


Convolutional neural networks



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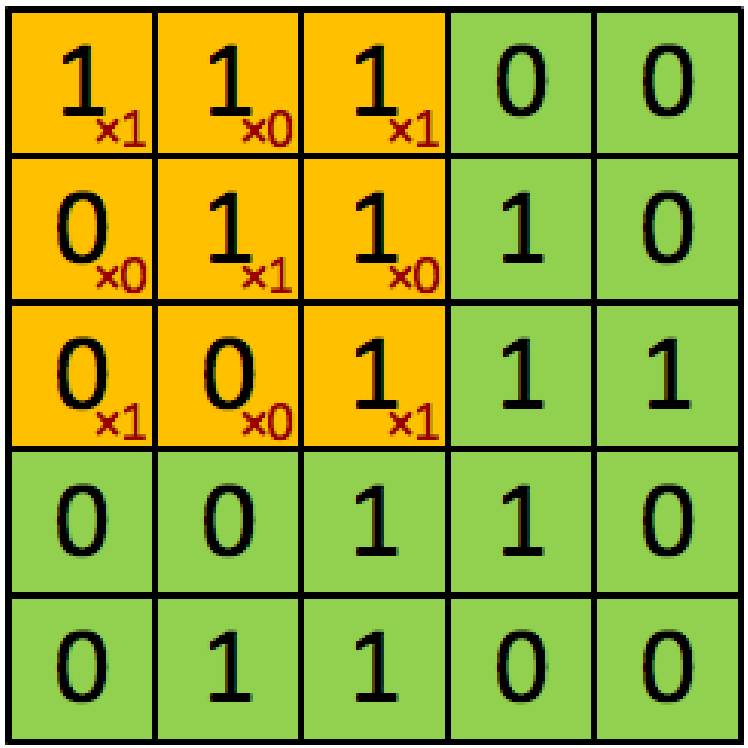
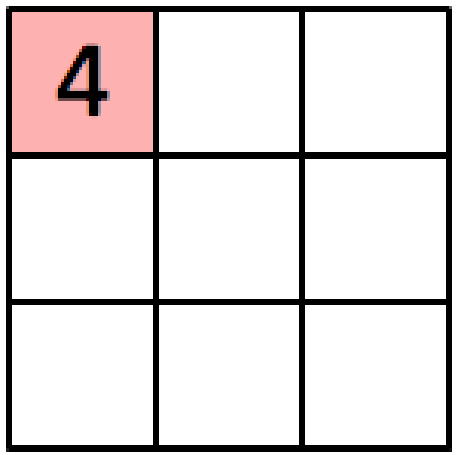


Image



Convolved Feature

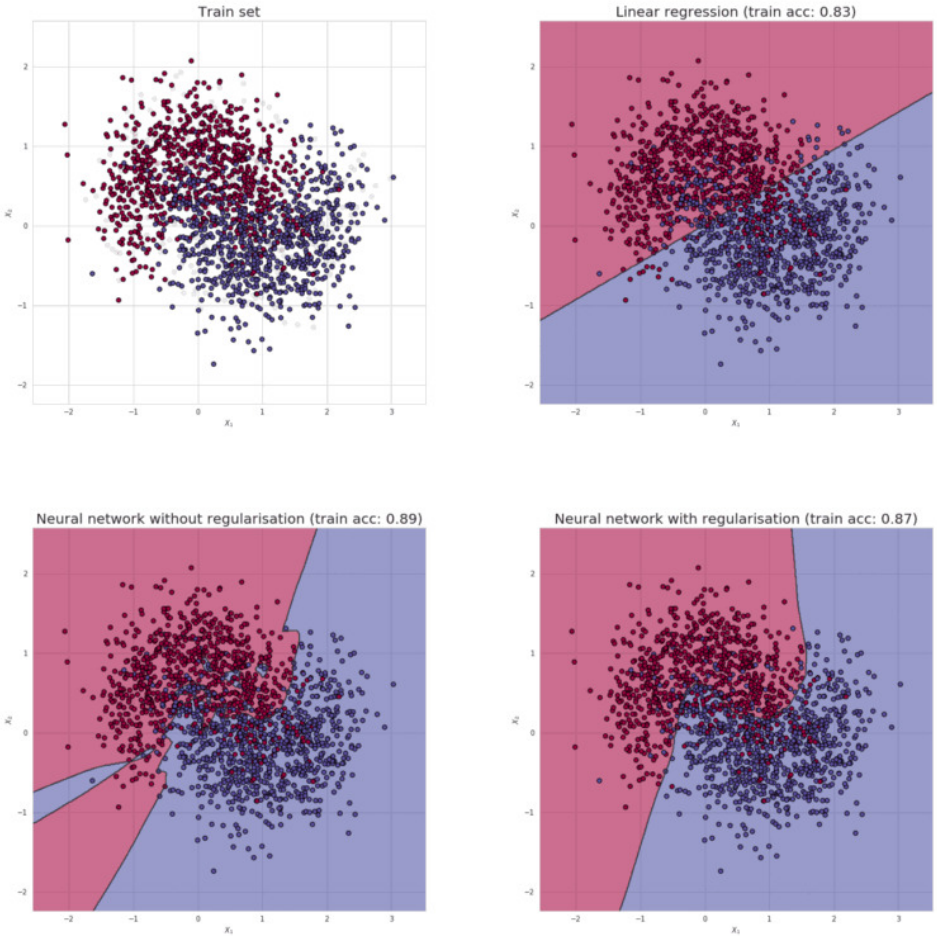
The problem of good data

Data bias:
- google images for "person"
- why is that?

Dataset size:
- number of annotated data needed to teach a NN vs number of NN weights?

Overfitting vs. accurracy:
- How well will my model work on non-trained data?

What is overfitting and how to prevent it?



Public perception

What does convetional programmer do?
- Programming complex systems is overwhelmingly boring.
- ML gets us rid of programming, it works out of the box!

So what does AI specialist do instead of programming?

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So what does AI specialist do instead of programming?

- Dataset annotation
- Parameter tuning
- Trial-and-error testing

Sources

Geoffrey Hinton materials:

`http://www.cs.toronto.edu/~hinton/coursera_lectures.html`

Introduction to deep learning:

`https://www.youtube.com/playlist?list=PLZHQObOWTQDNU6R1_67000Dx_ZCJB-3pi`

Next lecture?

Chronorobotics vs. AI in robotics

Vote here `https://doodle.com/poll/bubn6dfa772t7h8x`