

SGN-13000/SGN-13006 Introduction to Pattern Recognition and Machine Learning (5 cr)

Black Box Models in Machine Learning

Joni-Kristian Kämäräinen

September 2018

Department of Signal Processing
Tampere University of Technology

- Lecturer's notes
- T.M. Mitchell. *Machine Learning*. McGraw-Hill, 1997: Chapter 4
- A.R. Webb and K.D. Copsey. *Statistical Pattern Recognition*. 3rd. Wiley, 2011: Sections 5.4 and 6.3
- Computer examples

Black boxes

Neural networks

- Physiological background

- Convolutional Neural Networks (CNNs)

Support vector machines

Black boxes

Black box methods

S. B. Kotsiantis. “Supervised Machine Learning: A Review of Classification Techniques”. In: *Informatica* 31 (2007), pp. 249–268

	Decision Trees	Neural Networks	Naïve Bayes	kNN	SVM	Rule-learners
Accuracy in general	**	***	*	**	****	**
Speed of learning with respect to number of attributes and the number of instances	***	*	****	****	*	**
Speed of classification	****	****	****	*	****	****
Tolerance to missing values	***	*	****	*	**	**
Tolerance to irrelevant attributes	***	*	**	**	****	**
Tolerance to redundant attributes	**	**	*	**	***	**
Tolerance to highly interdependent attributes (e.g. parity problems)	**	***	*	*	***	**
Dealing with discrete/binary/continuous attributes	****	*** (not discrete)	*** (not continuous)	*** (not directly discrete)	** (not discrete)	*** (not directly continuous)
Tolerance to noise	**	**	***	*	**	*
Dealing with danger of overfitting	**	*	***	***	**	**
Attempts for incremental learning	**	***	****	****	**	*
Explanation ability/transparency of knowledge/classifications	****	*	****	**	*	****
Model parameter handling	***	*	****	***	*	***

Table 4. Comparing learning algorithms (**** stars represent the best and * star the worst performance)

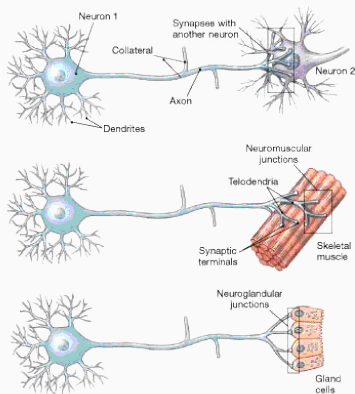
Neural networks

Neural networks

Physiological background

Brain is a neural network

- Neuron is the smallest computational unit in the brains
- Single neuron provides simple processing, but their huge interconnected network establishes human cognition



Neural network (Multi-layer perceptron, MLP)

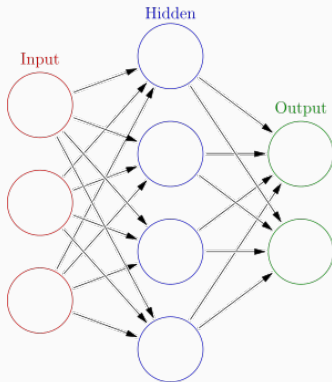


Figure 1: Neural network <http://en.wikipedia.org> .

Neural networks

Convolutional Neural Networks (CNNs)

Deep Convolutional Neural Networks

- Neural networks dominated machine learning and pattern recognition in 80's and 90's, but were subsided by support vector machine (SVM) learning in late 90's.

Deep Convolutional Neural Networks

- Neural networks dominated machine learning and pattern recognition in 80's and 90's, but were subsided by support vector machine (SVM) learning in late 90's.
- Thanks to a small but active community led by Geoffrey Hinton, Yann LeCun (@y1ecun) and Yoshua Bengio, NNs continued developing and since 2012 they again dominate



Figure 2: Y. Lecun, Y. Bengio, and G.E. Hinton. “Deep Learning”. In: *Nature* 521 (2015), pp. 436–444

The old NN workflow for image classification

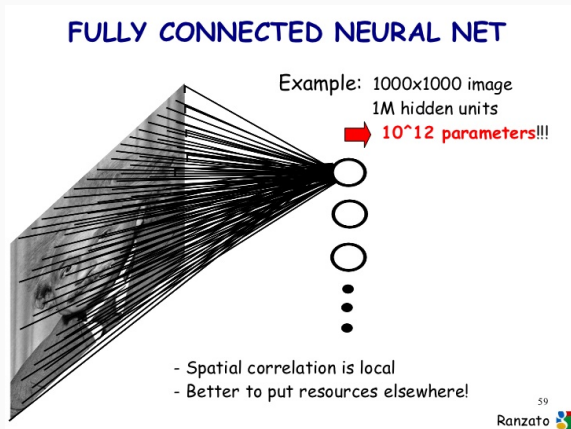


Figure 3: M. Ranzato tutorial

Improved NN workflow for image classification

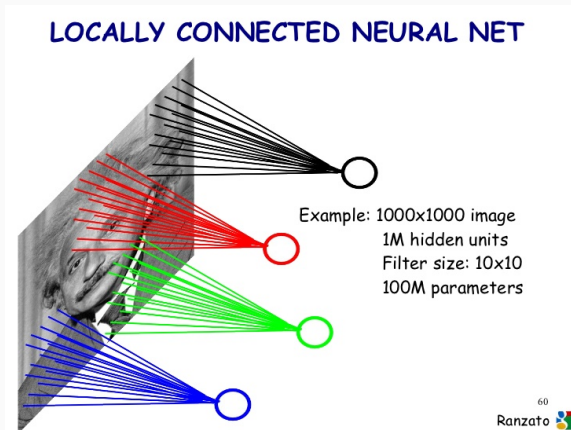


Figure 4: M. Ranzato tutorial

Convolutional Neural Network (CNN)

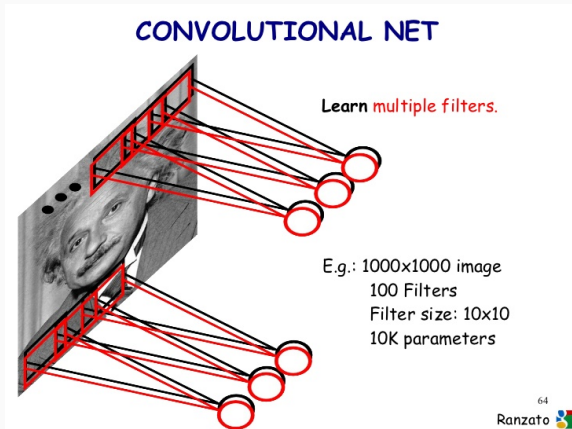


Figure 5: M. Ranzato tutorial

Deep CNN architecture

A. Krizhevsky, I. Sutskever, and G.E. Hinton. "ImageNet Classification with Deep Convolutional Neural Networks". In: *NIPS*. 2012

