

Convolutional Neural Networks

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Example: MNIST

Famous data set in machine learning community

- ▶ <http://yann.lecun.com/exdb/mnist/>

Kaggle competition

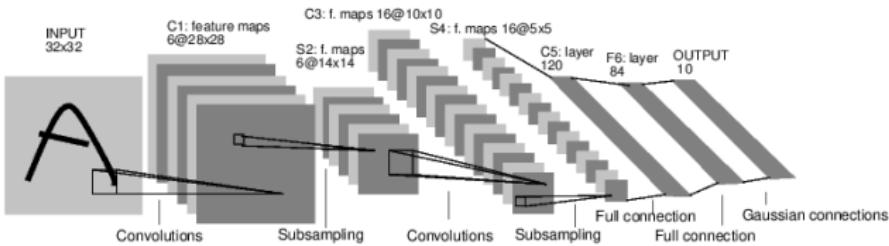
- ▶ <https://www.kaggle.com/c/digit-recognizer>

Online demo

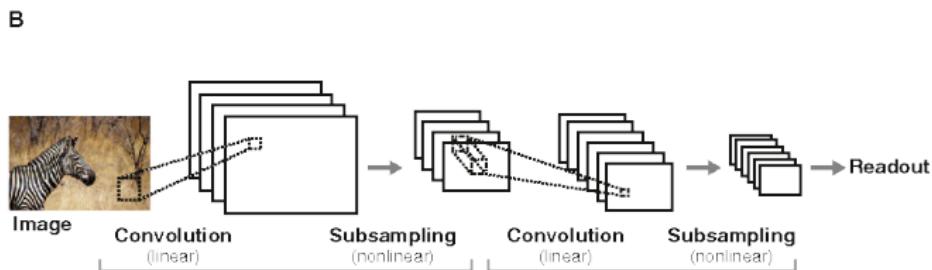
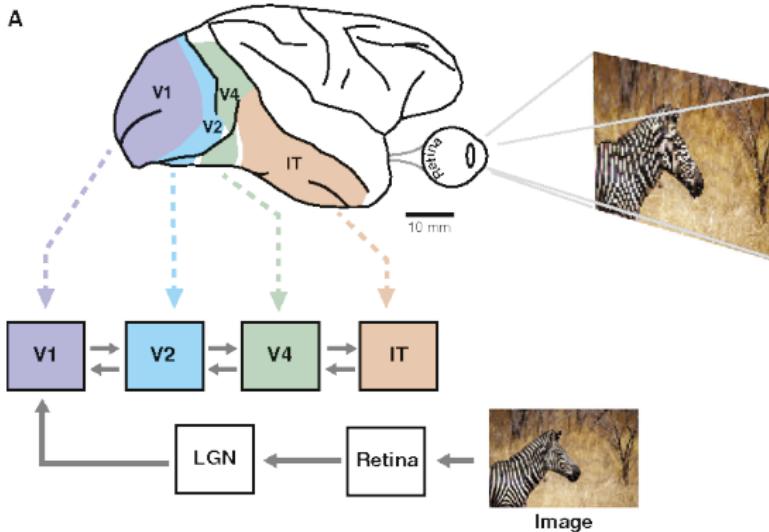
- ▶ <http://cs.stanford.edu/people/karpathy/convnetjs/demo/mnist.html>

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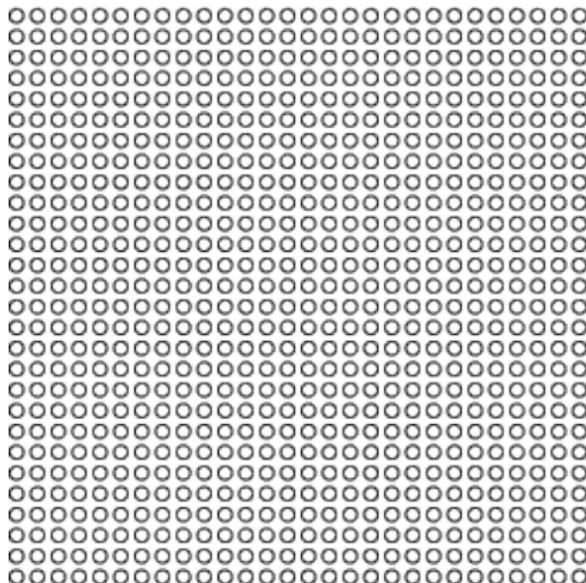
LeNet5: convolutional neural network



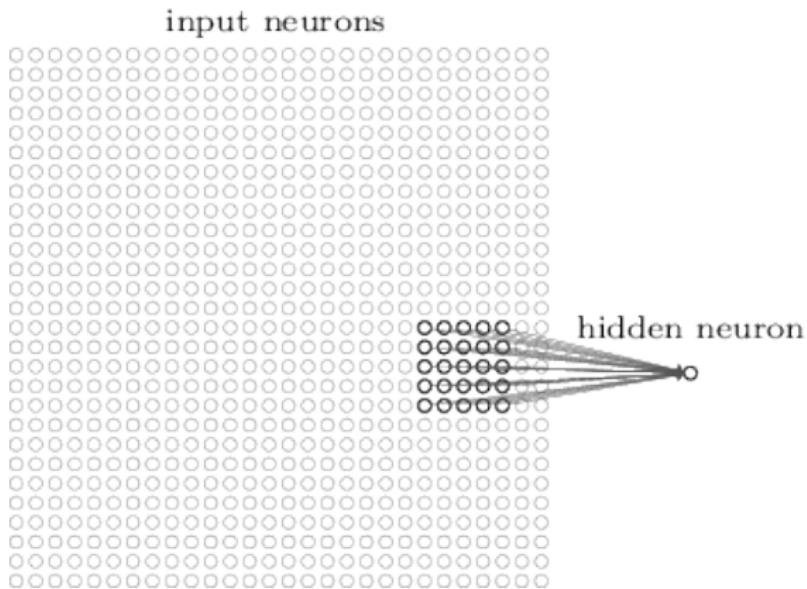
See <http://yann.lecun.com/exdb/lenet/>



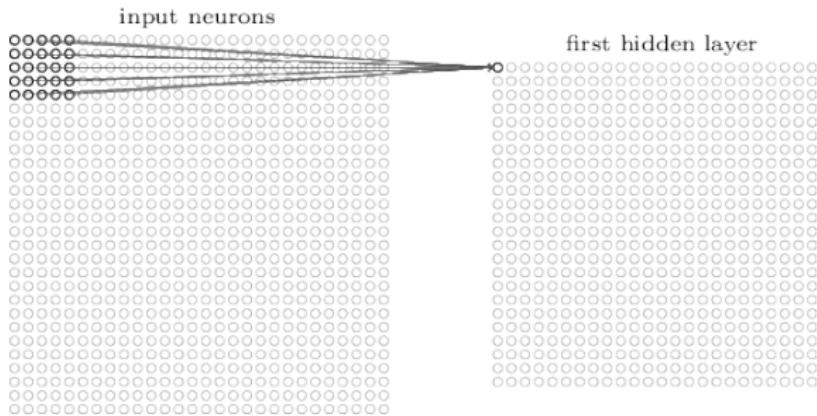
input neurons



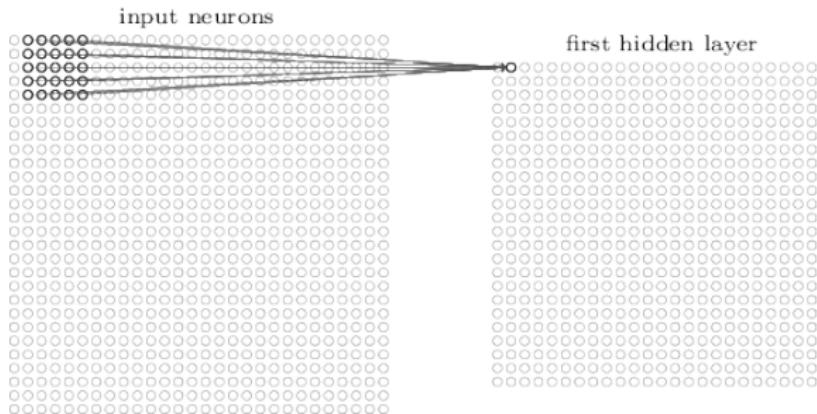
From: <http://neuralnetworksanddeeplearning.com/chap6.html>



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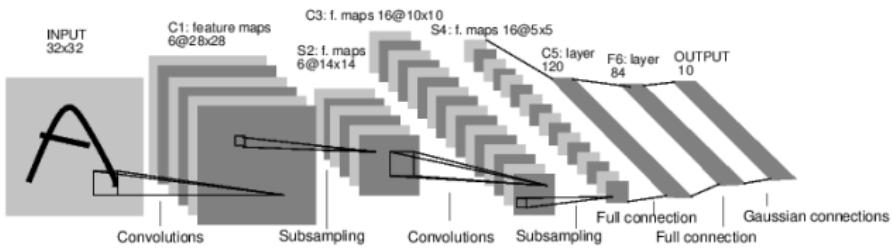


From: <http://neuralnetworksanddeeplearning.com/chap6.html>

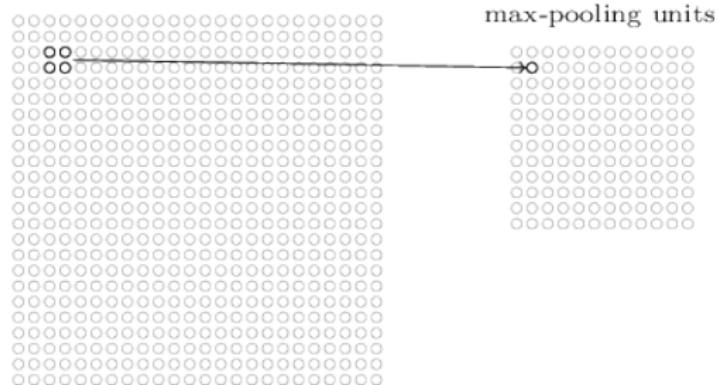
Convolutional demo

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

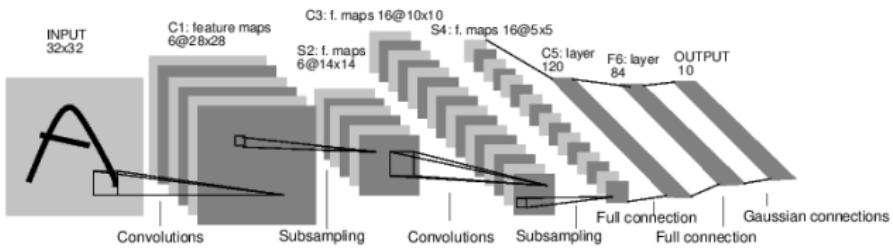
- ▶ we are looking at an example of convolution
- ▶ many additional information can be found here



hidden neurons (output from feature map)



From: <http://neuralnetworksanddeeplearning.com/chap6.html>



Mistakes made by LeNet5



Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. Gradient-based learning applied to document recognition. Proceedings of the IEEE, November 1998.

Practical consideration

Standard trick — expand the set of examples

- ▶ small distortions, scaling, rotation, ...
- ▶ <http://yann.lecun.com/exdb/lenet/index.html>

What else needs to be done to make system useful?

MNIST online demo

Train a convolutional neural network in your browser

<http://cs.stanford.edu/people/karpathy/convnetjs/demo/mnist.html>

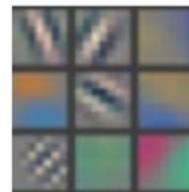
What do Neurons Learn?

drawNet

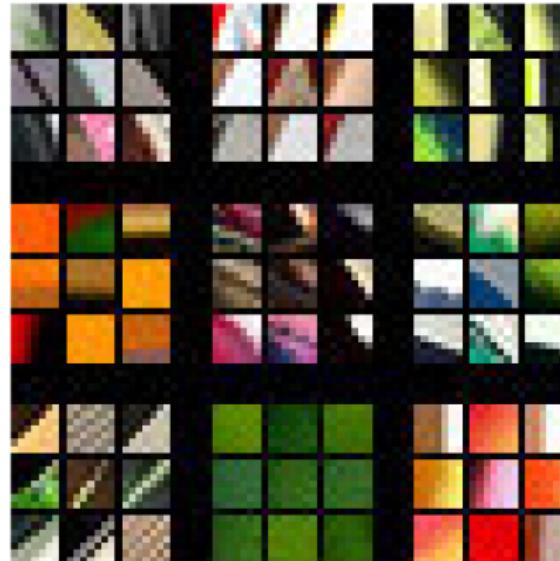
- ▶ [http://people.csail.mit.edu/torralba/research/drawCNN/
drawNet.html?path=imagenetCNN](http://people.csail.mit.edu/torralba/research/drawCNN/drawNet.html?path=imagenetCNN)

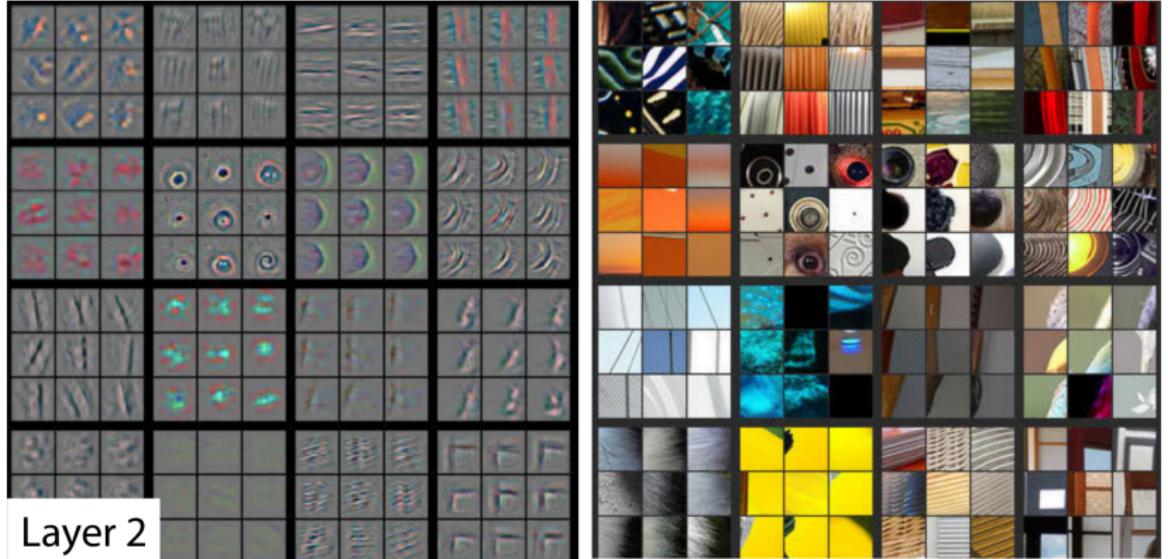
Visualizing and Understanding Convolutional Networks

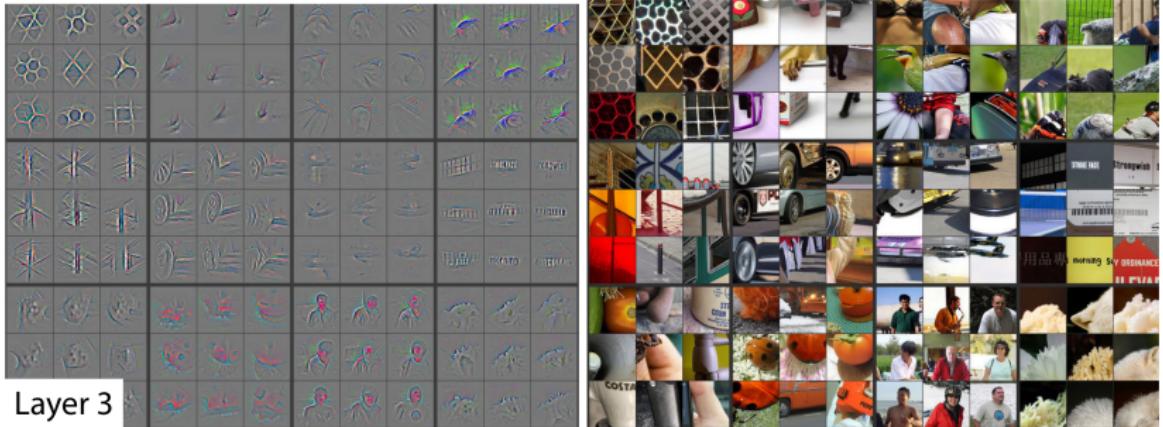
- ▶ by Zeiler and Fergus
- ▶ <https://arxiv.org/pdf/1311.2901.pdf>

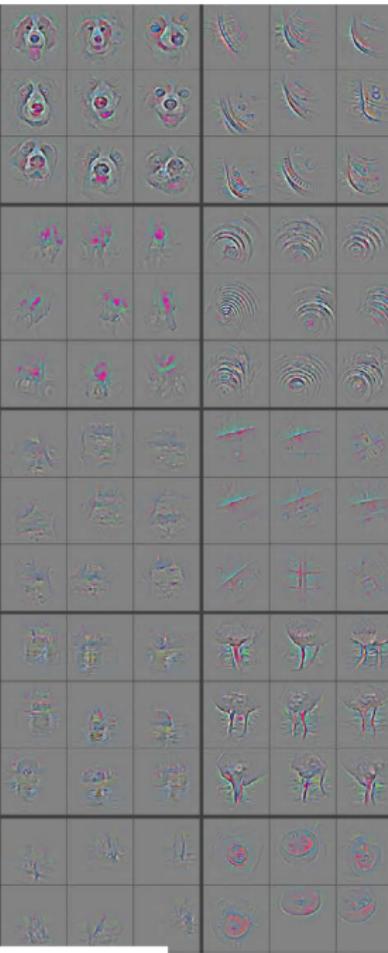


Layer 1



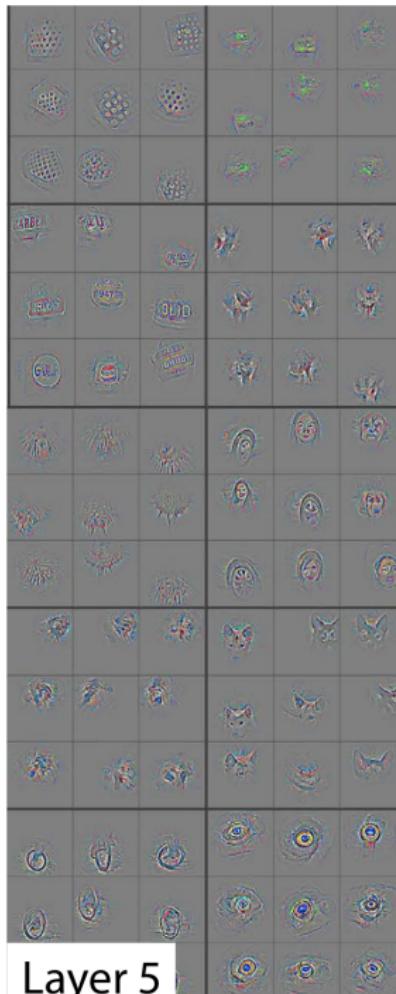






Layer 4

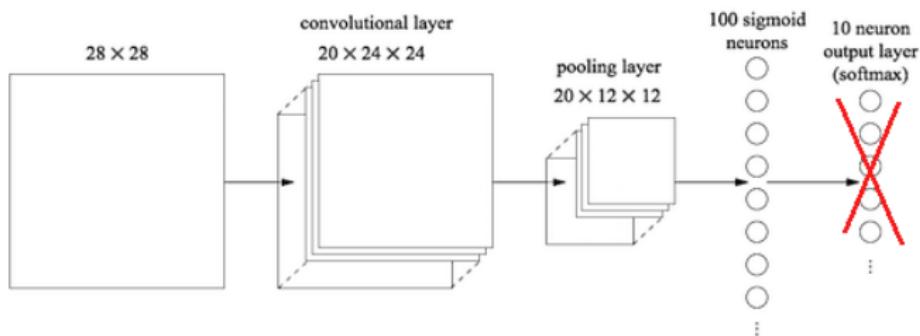




Layer 5



Learning representation



Use the output of the last layer as a representation of your data.
Fit a model with this representation.

Advantages and disadvantages

Pros:

- ▶ Tolerance to noise
- ▶ Able to capture complex signals
- ▶ In some applications lead to the state-of-the-art performance
- ▶ Fast at test time

Cons:

- ▶ Very hard/impossible to interpret (black box method)
- ▶ Can easily overfit
- ▶ Need a large amount of data to train
- ▶ Slow to train