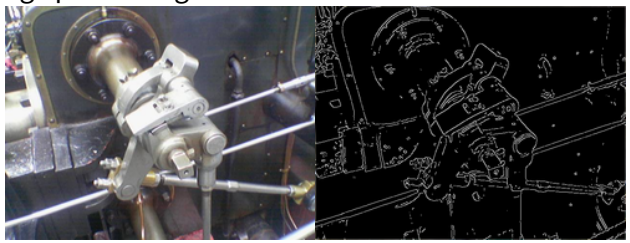
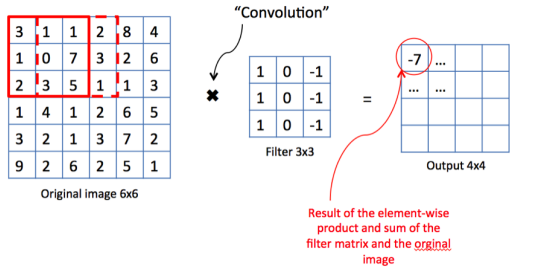
Images

Convolution

How to do image processing with a neural network?





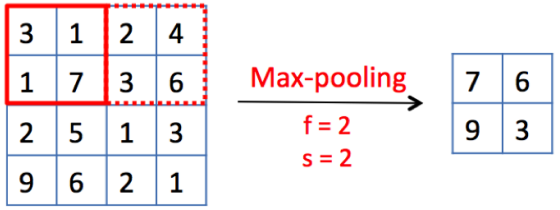
https://en.wikipedia.org/wiki/Canny_edge_detector

https://medium.com/machine-learning-bites/deeplearning-series-convolutional-neural-networks-a9c2f2ee1524

Convolution example

Mario from 3 Brown 1 Blue.
https://www.youtube.com/watch?v=8rrHTtUzyZA part of the
https://computationalthinking.mit.edu/Fall20/ course at MIT.

Pooling



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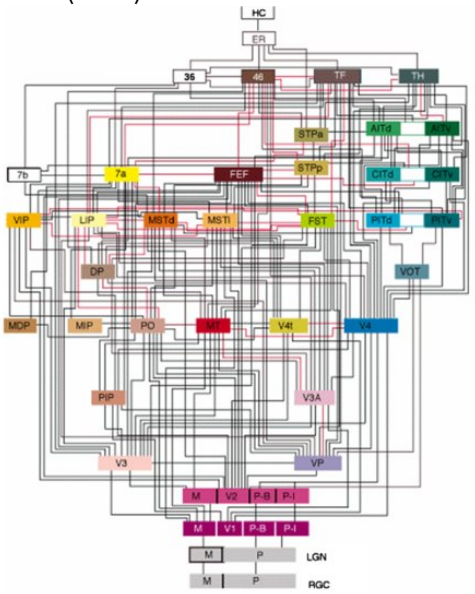
How does the brain process visual information?

Felleman and van Essen (1991).

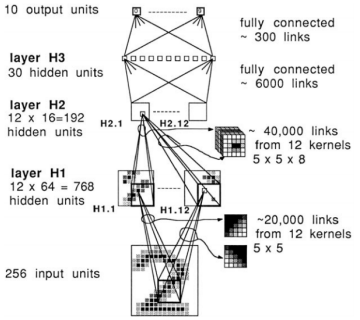


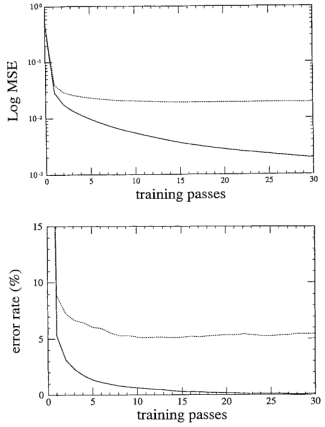
Receptive fields from the retina to the cortex

Describe retinal ganglion cell receptive fields, simple cells and complex cells.

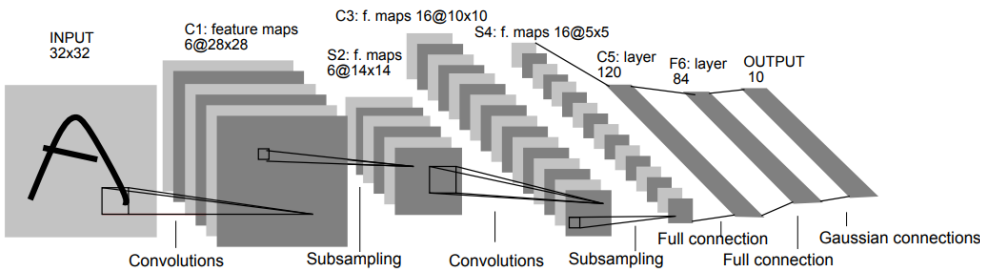
LeCun et al (1989)

LeCun Y et al (1989) Backpropagation Applied to Handwritten Zip Code Recognition. Neural Comput 1:541–551.





LeCun et al (1998)



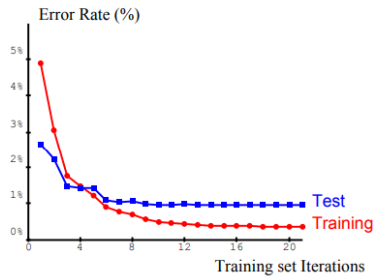
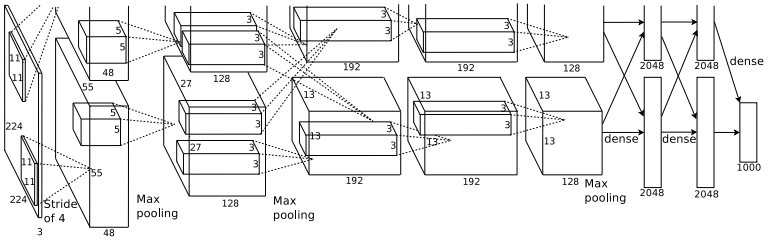


Image classification (Krizhevsky et al 2012)

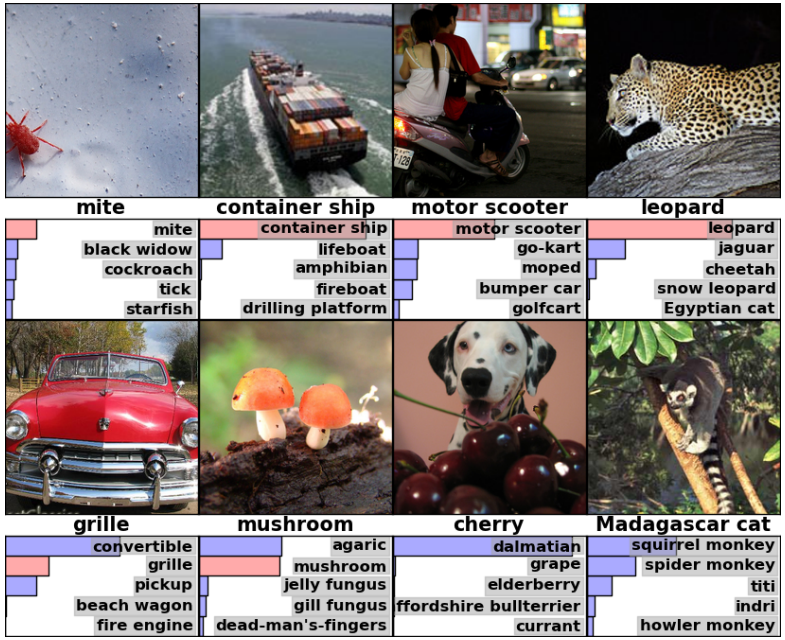
- Krizhevsky A, Sutskever I, Hinton GE (2012) ImageNet Classification with Deep Convolutional Neural Networks. In: Advances in Neural Information Processing Systems 25, Burges CJC, Bottou L, Weinberger KQ, eds), pp 1097–1105.
- Annual competition. 1,000 examples of 1,000 classes.
- Rotating/translating of training images to make 'new' samples.
- Top-1 (37.5%) and top-5 (17.0%) error rate exceed previous state of the art. Won 2012 competition with top-5 test error rate of 15%; second had error rate of 26%.

ImageNet architecture (Krizhevsky et al. 2012)

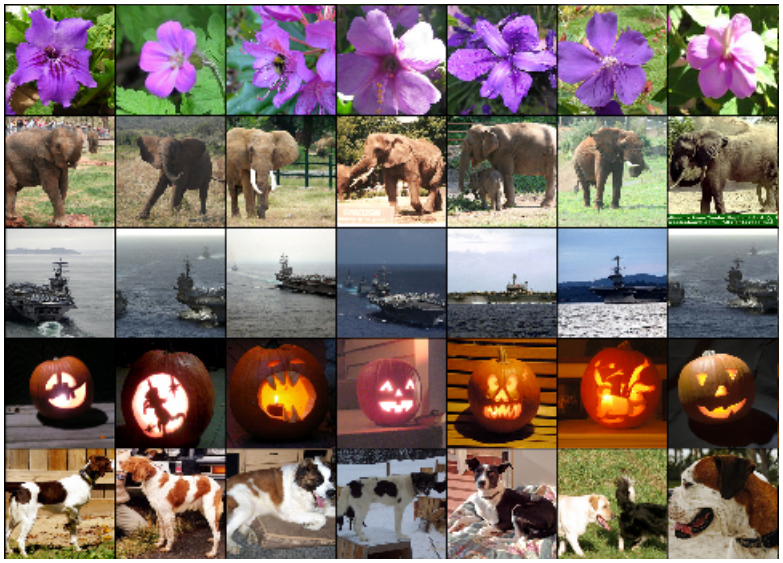


Split on 2 GPUs.
150K pixels (224 x 224 x 3) into 8 layer network:
253K-186K-65K-65K-43K-4K-4K-1K.
i.e. 650,000 neurons (excluding input), 60 million parameters.

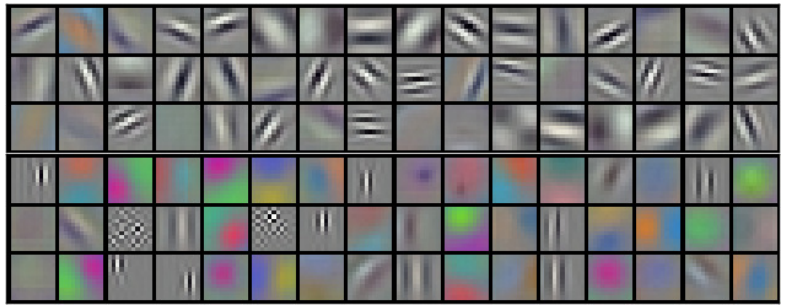
ImageNet performance



ImageNet close-matches



ImageNet RFs



"It is notable that our network's performance degrades if a single convolutional layer is removed. For example, removing any of the middle layers results in a loss of about 2% for the top-1 performance of the network. So the depth really is important for achieving our results."

Life since AlexNet

1. 2012: AlexNet (Krizhevsky et al 2012). Top-5 error of 17% (top-1 of 37%).
2. 2014: GoogLeNet / "Inception" (Szegedy et al 2014). Top-5 error of 6.67%.
3. 2015: ResNet (He et al 2015). First to beat human, top-5 error of 3.75%. 152 layers.
4. ResNet with 1001 layers (He et al 2016).

Convolutional layers not just for images

Other applications: transcription factor binding site example; 1d space = time (see later).

Transfer learning

Transfer learning using these networks to provide features: freeze main network and learn layers on top.
Allows you to focus on just the bits that you care about in the later layers.
TL "can improve machine learning model performance for data-disadvantaged ethnic groups, and thus provides an effective approach to reduce health care disparities arising from data inequality among ethnic groups.". (Gao and Cui 2020).