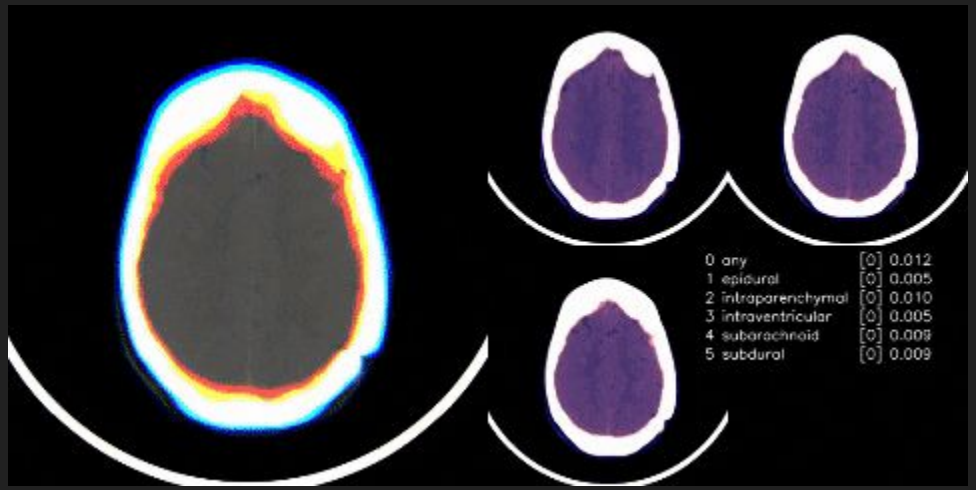
Convolutional Neural Networks

Cool things you can do with CNNs

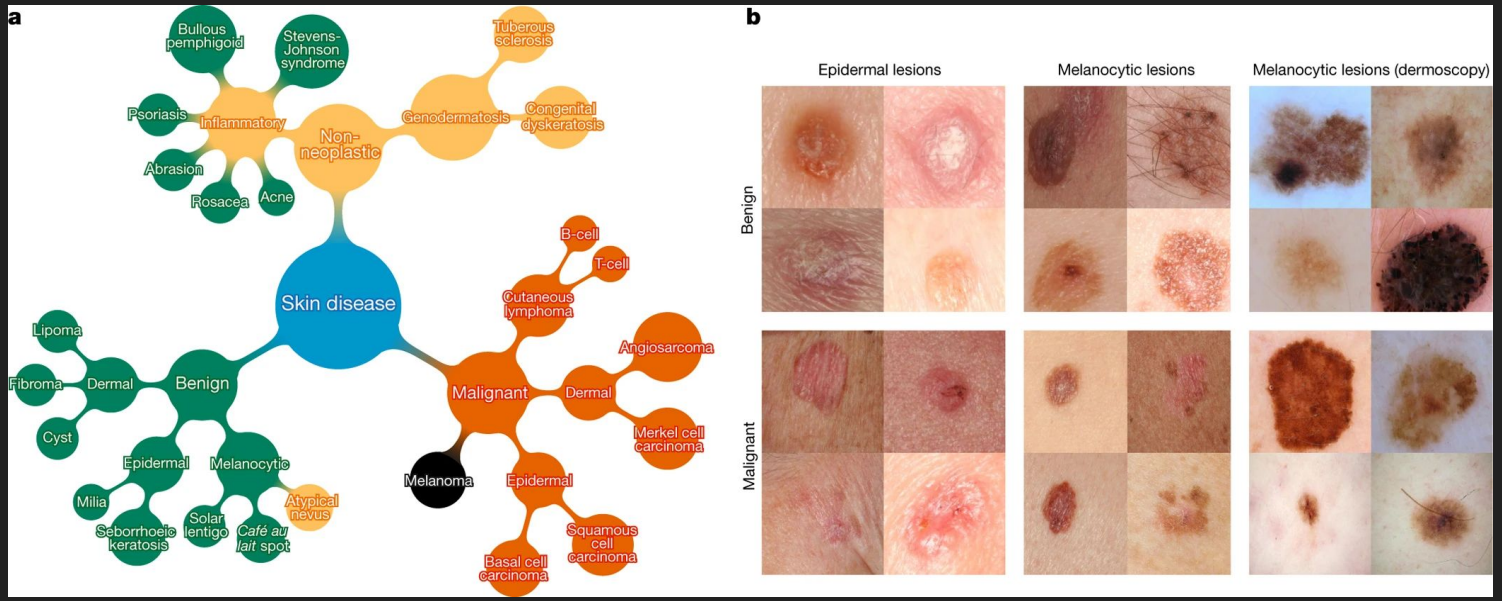
Classify hemorrhages inside the skull



https://github.com/darraghdog/rsna

Cool things you can do with CNNs

Determine whether moles are malignant



https://www.nature.com/articles/nature21056

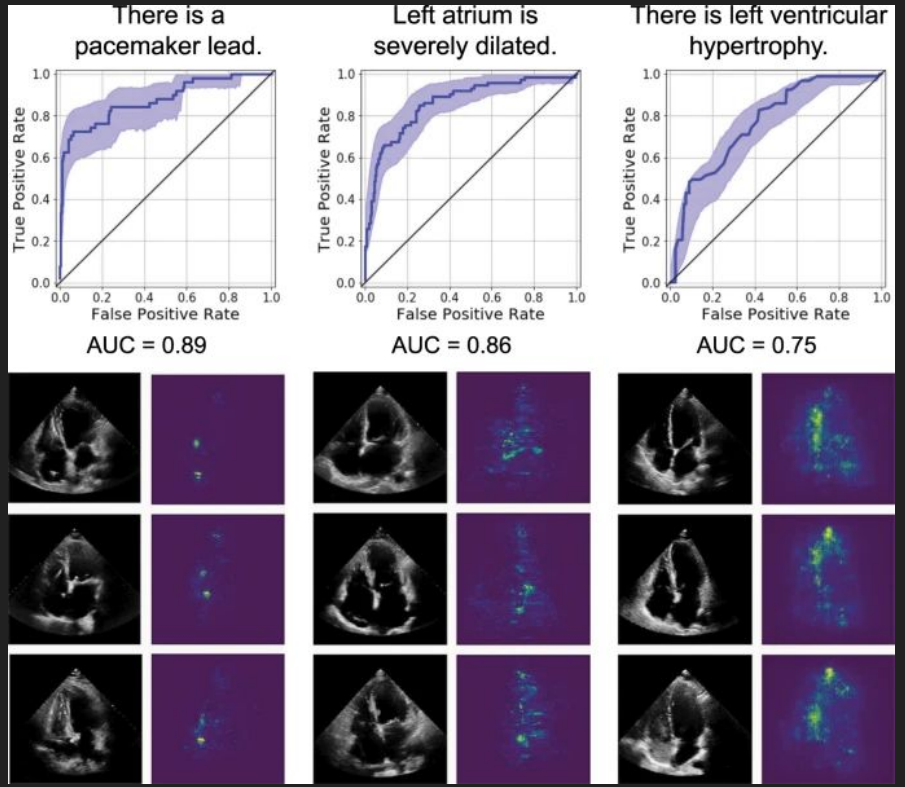
Cool things you can do with CNNs

Label objects in images

https://github.com/facebookresearch/detectron2

Cool things you can do with CNNs

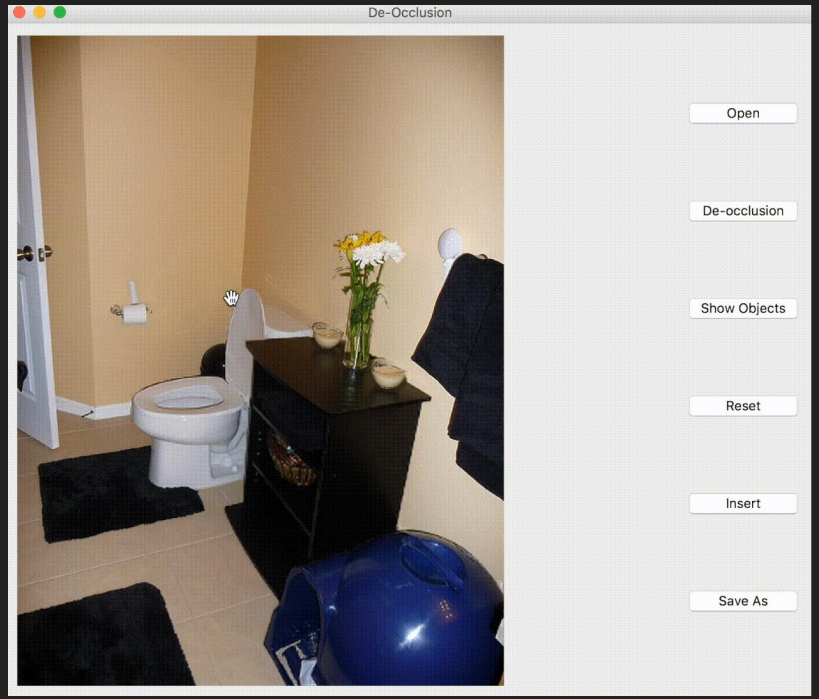
Analyze echocardiograms



https://www.nature.com/articles/s41746-019-0216-8

Cool things you can do with CNNs

Scene deocclusion



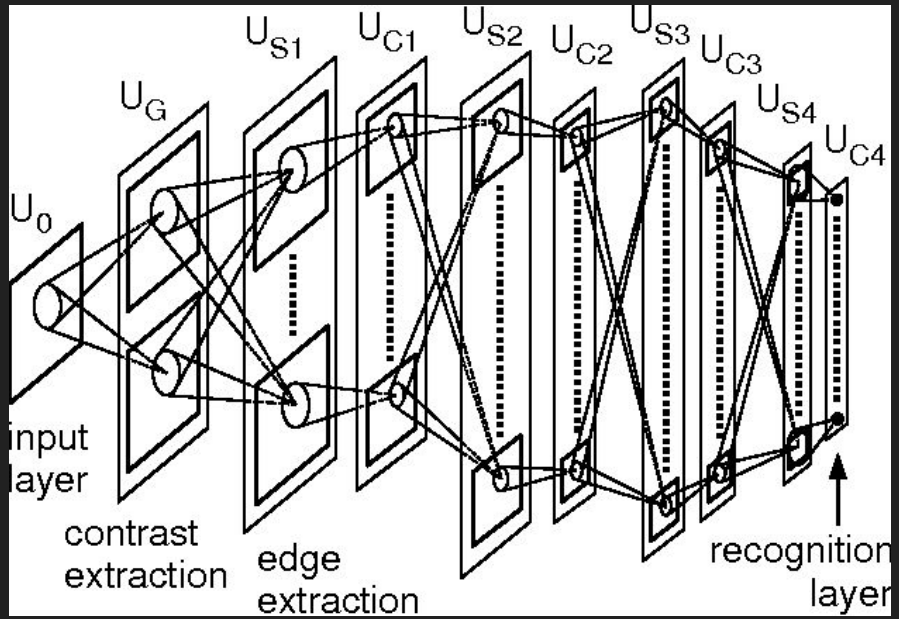
https://github.com/XiaohangZhan/deocclusion

Cool things you can do with CNNs

Usually a couple things a year that seem like magic

History

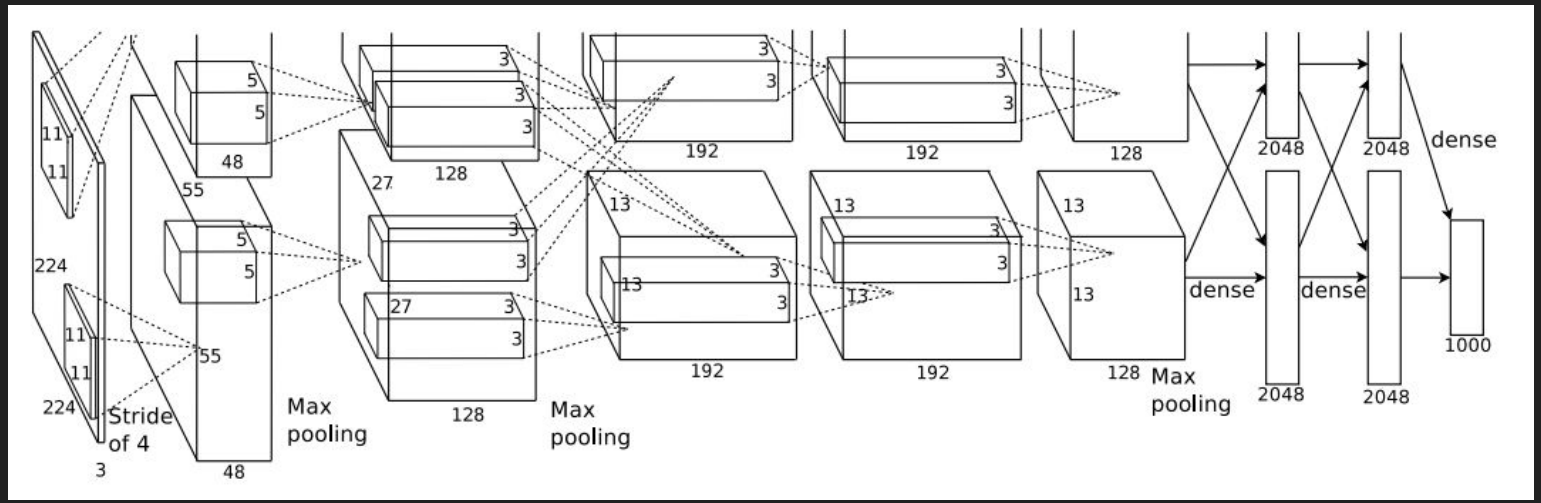
The neocognitron (1980)



https://link.springer.com/article/10.1007/BF00344251

(Recent) History

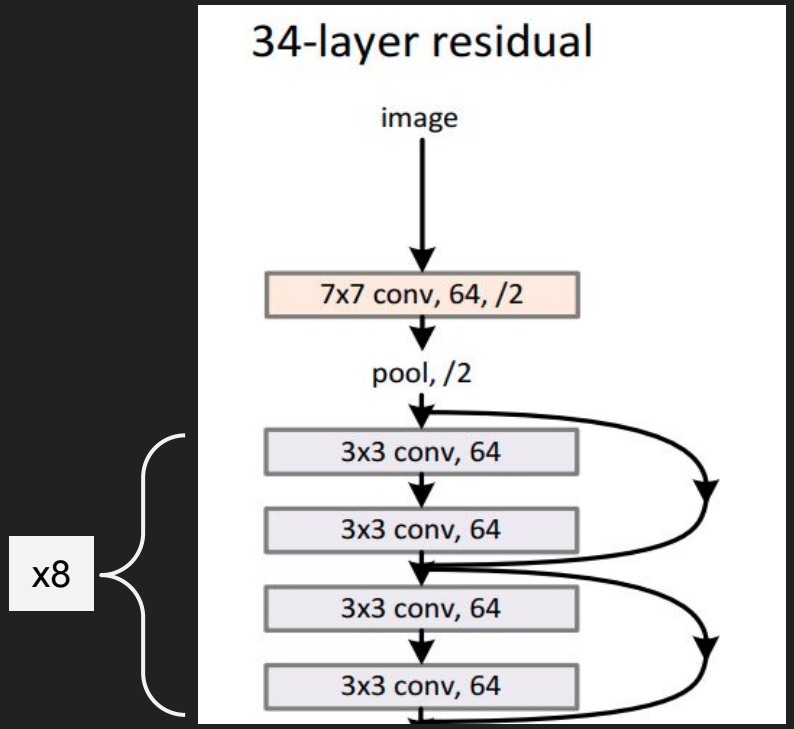
AlexNet (2012)



http://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf

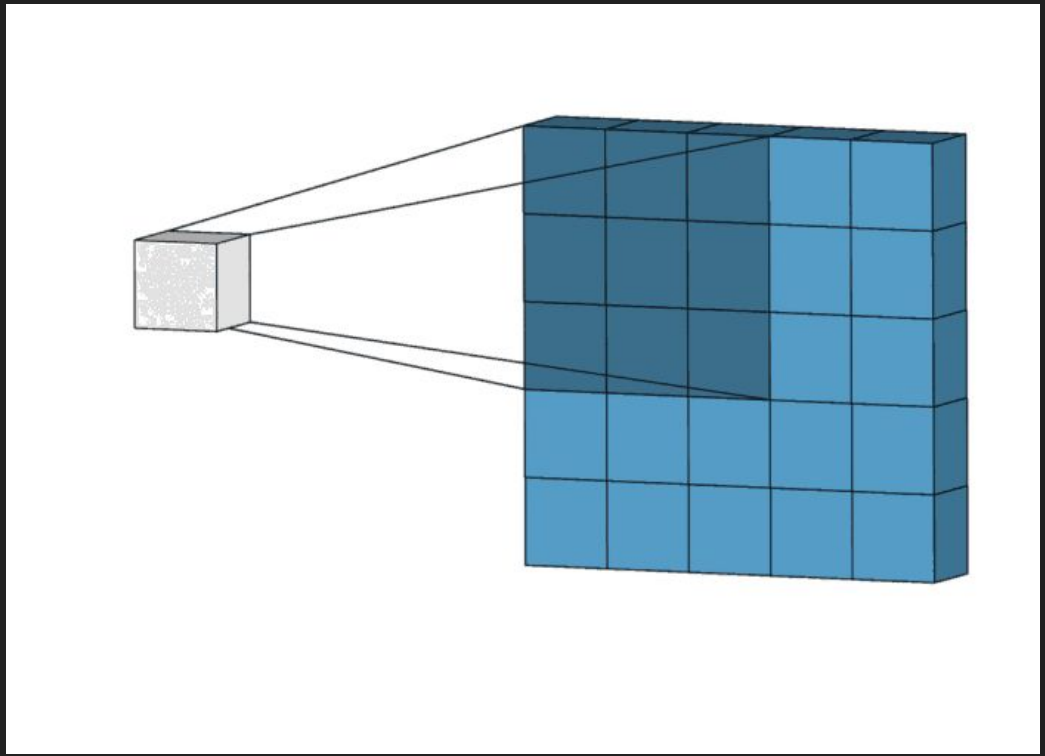
(More Recent) History

- Deeper network
- Skip layers
- The core is the same: convolution and pooling layers



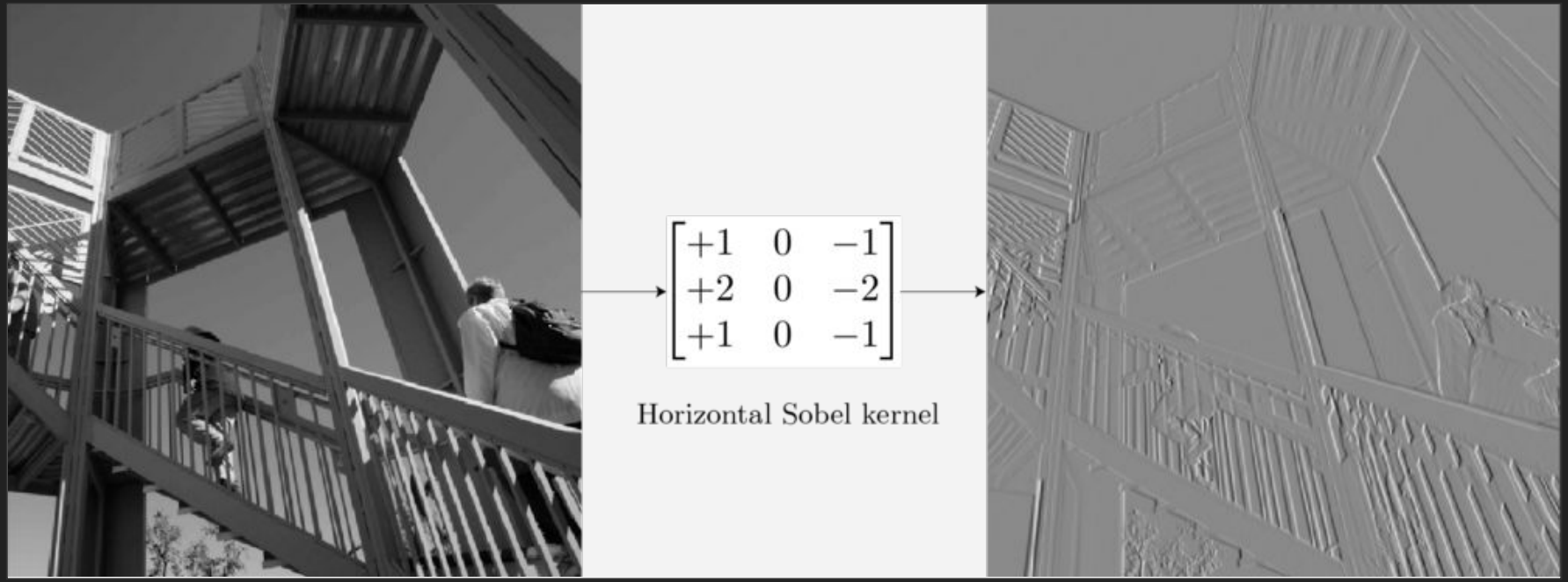
https://arxiv.org/pdf/1512.03385.pdf

What is convolution?



https://towardsdatascience.com/intuitively-understanding-convolutions-for-deep-learning-1f6f42faee1

What is convolution?



https://towardsdatascience.com/intuitively-understanding-convolutions-for-deep-learning-1f6f42faee1

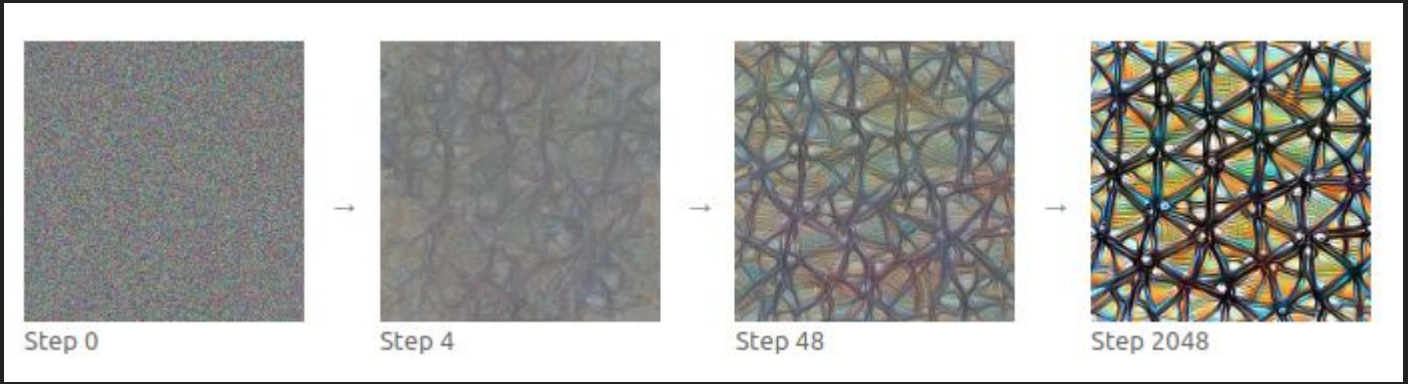
Top CNN layers learn parameters like Sobel filters

Why do we need deep learning then?

http://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf

Why do we need deep learning then?

But deeper layers compose different features to look for patterns

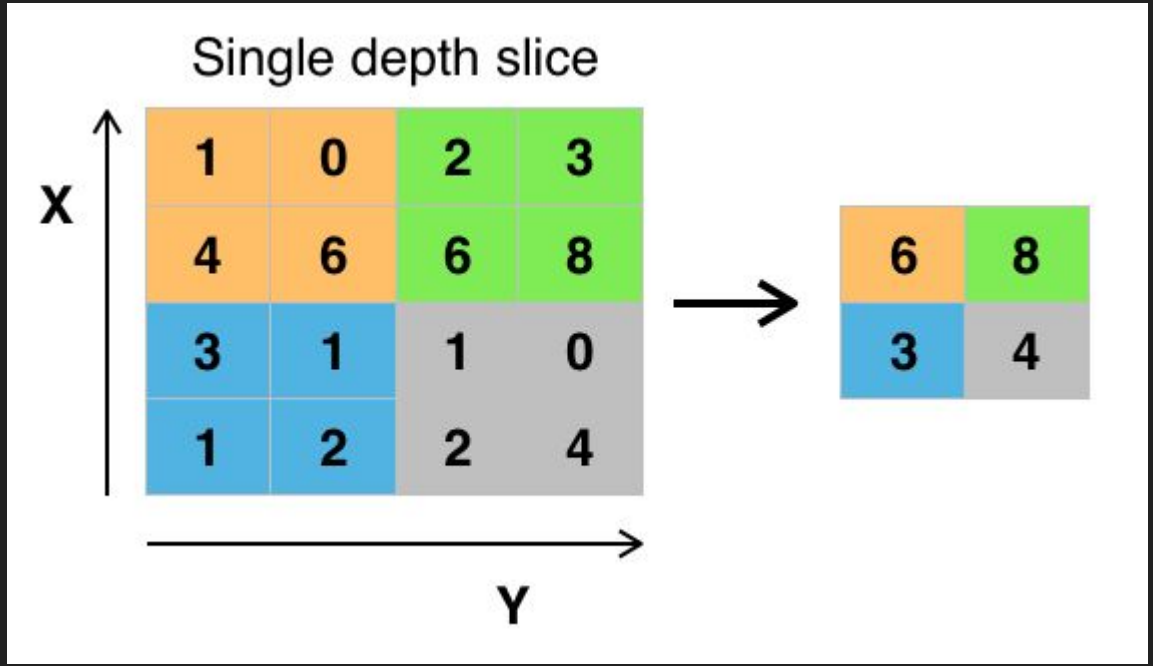


https://distill.pub/2017/feature-visualization/

Why use a convolutional layer?

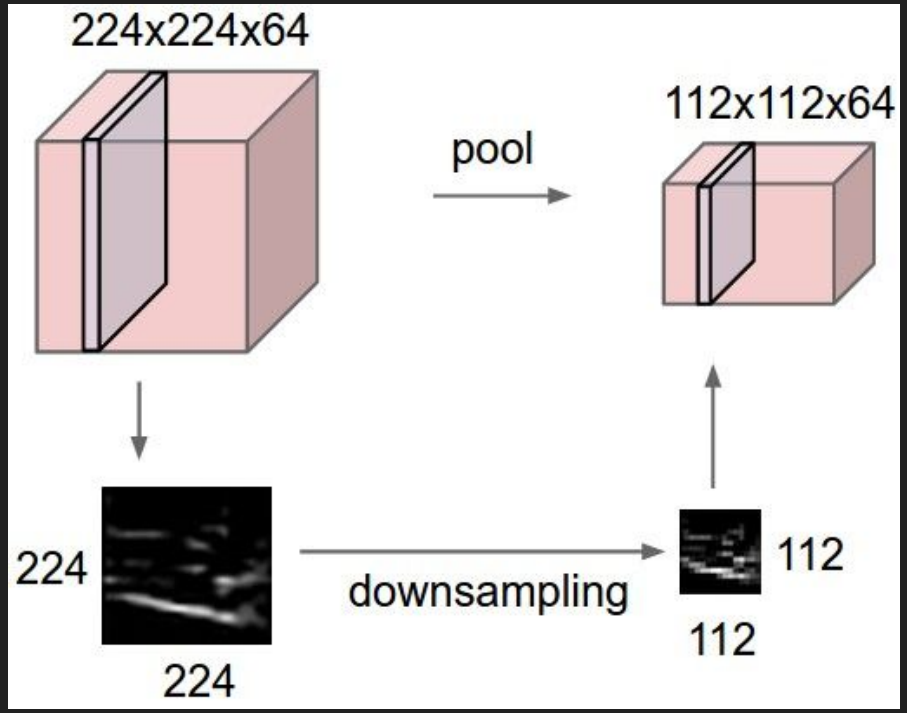
- Image processing is (was?) a hard problem
- Phone cameras take photos with ~ 10 million pixels
- 10 million pixels * 4 bytes * the size of your first fully connected layer = more GPU memory than you have
- As shown previously, you can solve interesting problems with image data

What is pooling?



Wikimedia Commons

What is pooling?

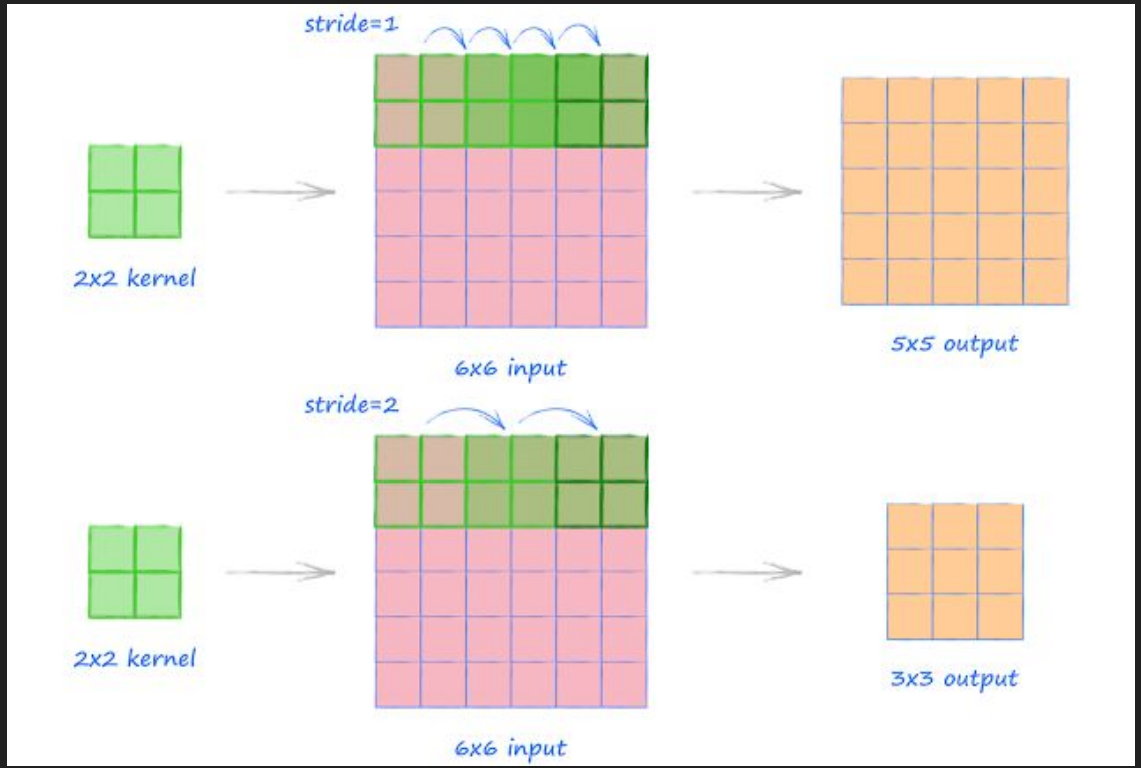


https://cs231n.github.io/convolutional-networks/#pool

Why use pooling?

- Conv layers use few parameters, but they don’t (usually) reduce the size of the result much
- You still have to use a fully connected layer to classify the output

What is the stride of a convolution/pooling layer?

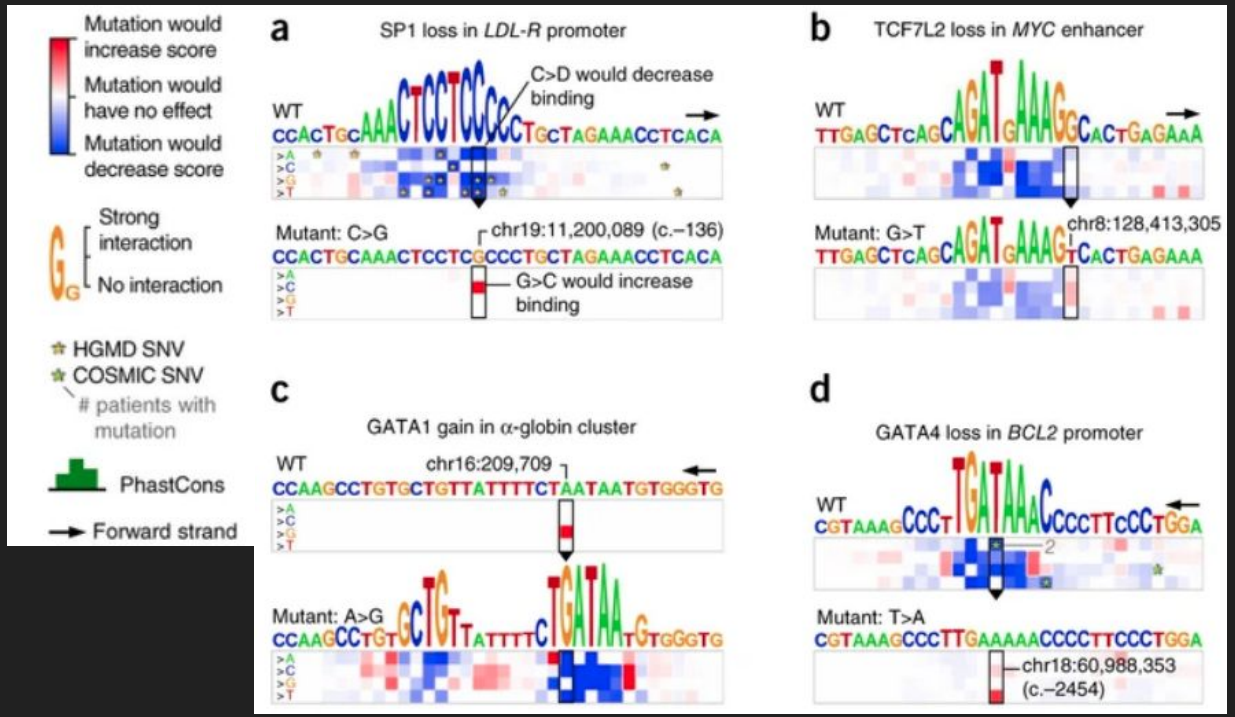


http://makeyourownneuralnetwork.blogspot.com/

Are CNNs only useful for images?

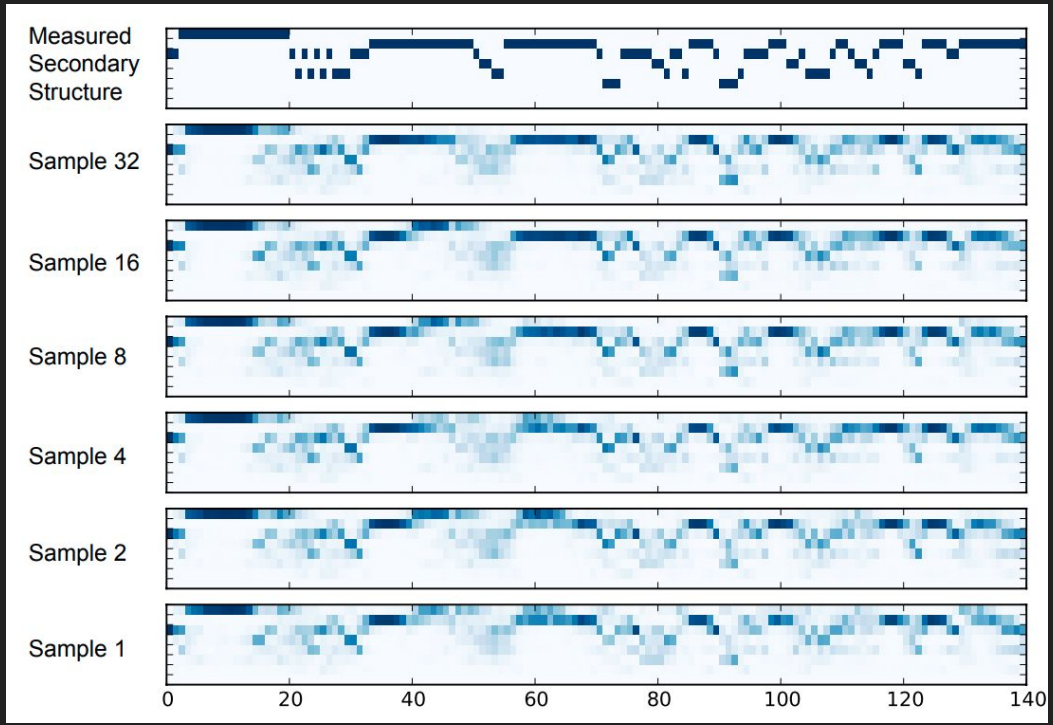
No

Predicting protein binding sites



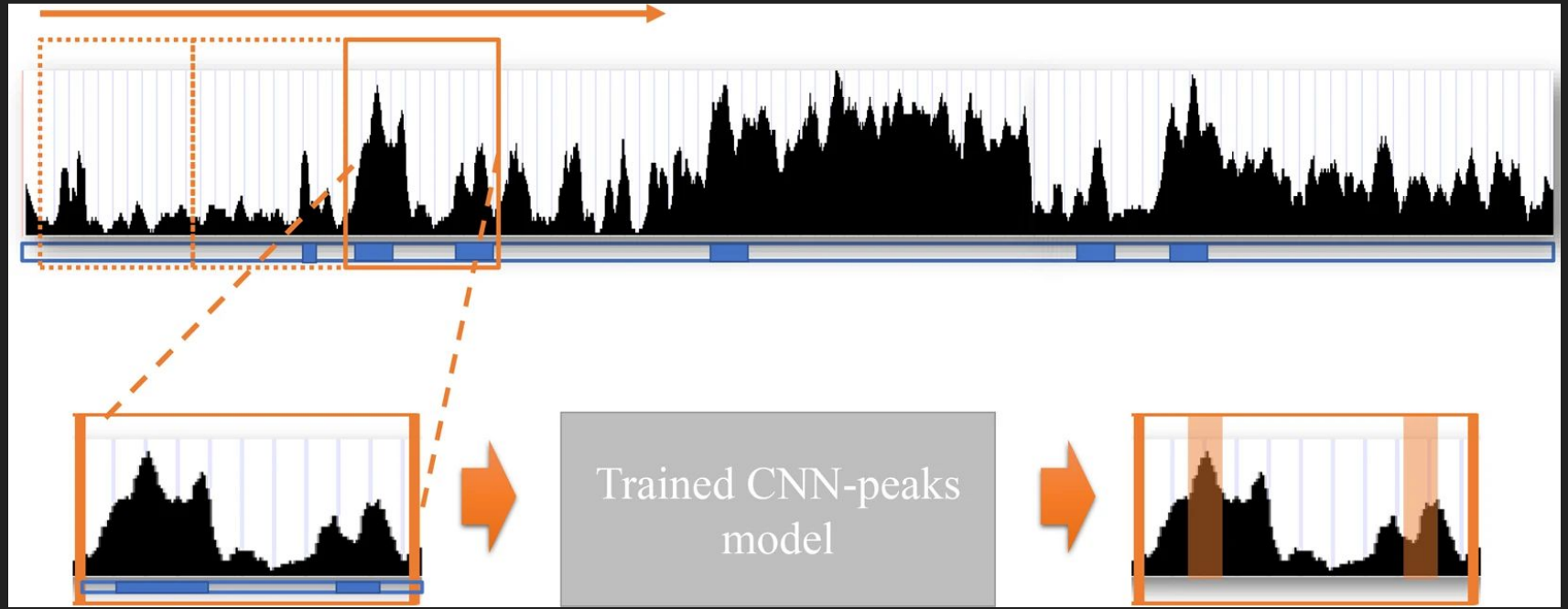
https://www.nature.com/articles/nbt.3300

Predicting protein secondary structure



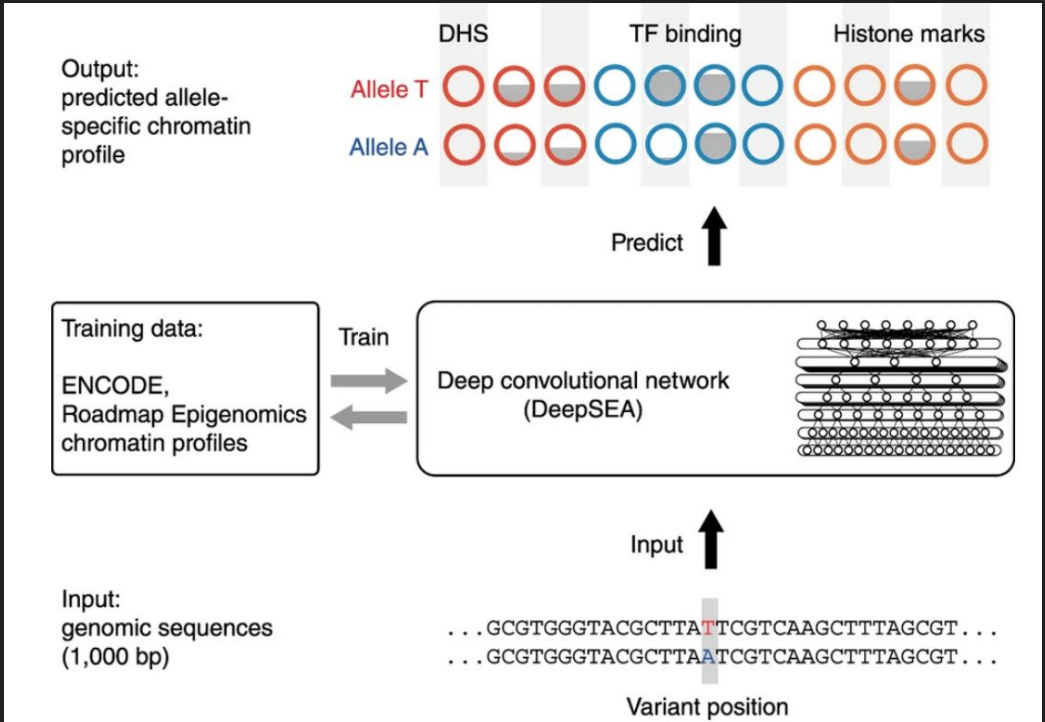
http://proceedings.mlr.press/v32/zhou14.pdf

Calling ChIP-Seq peaks



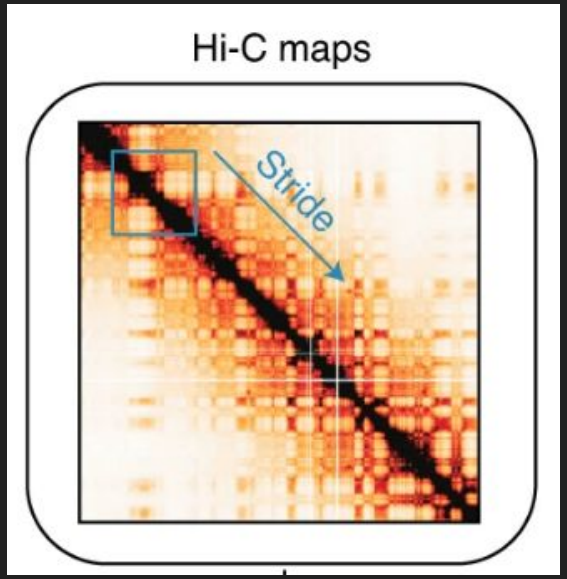
https://www.nature.com/articles/s41598-020-64655-4

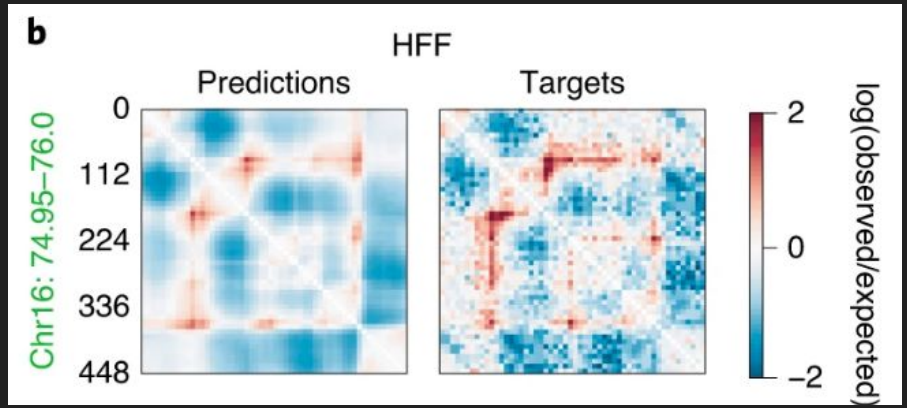
Predicting epigenetic features



https://www.nature.com/articles/nmeth.3547

Predicting genome folding





https://www.nature.com/articles/s41592-020-0958-x

Misuses in bio

- Using a CNN when you should use an RNN
- Assuming microarrays are images

Takeaways

- CNNs are great when only local features matter
- CNNs aren’t just for images
- Many previously labor intensive problems can now be solved with CNNs

Questions?