Convolutional Neural Network

Hung-yi Lee

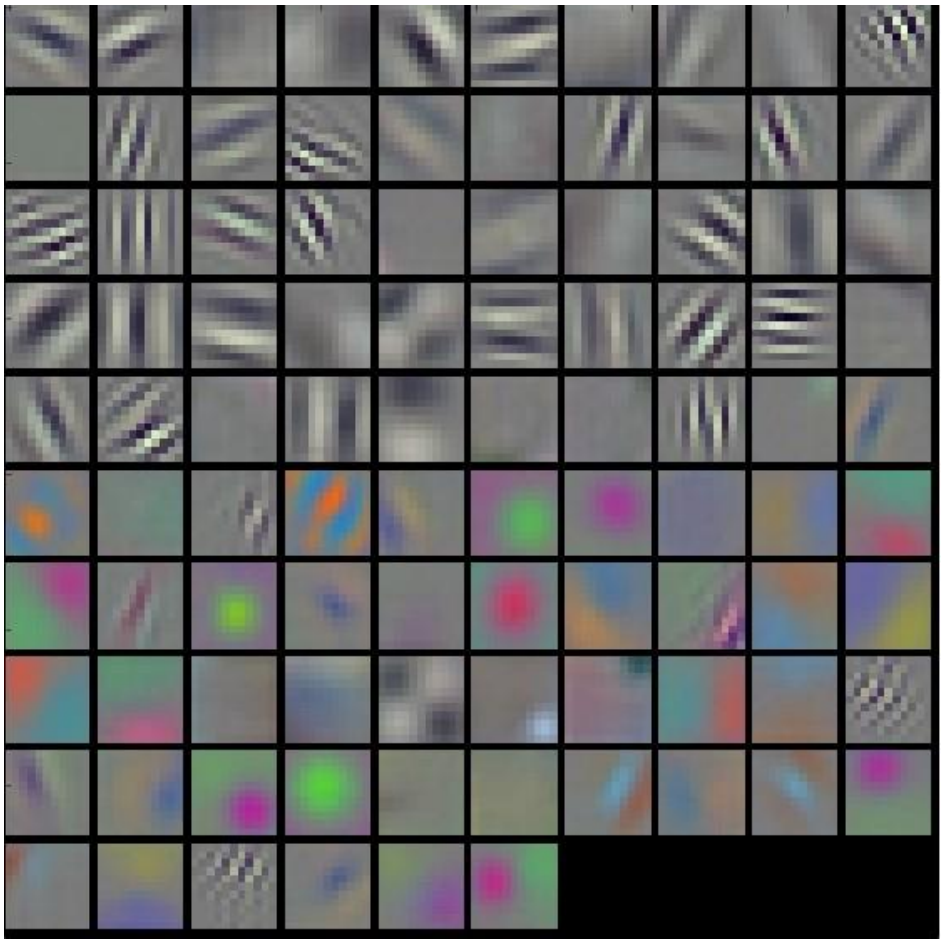
Can the network be simplified by considering the properties of images?

What does machine learn?

http://newsneakernews.wpengine.netdna-cdn.com/wp-content/uploads/2016/11/rihanna-puma-creeper-velvet-release-date-02.jpg

First Convolution Layer

- Typical-looking filters on the trained first layer

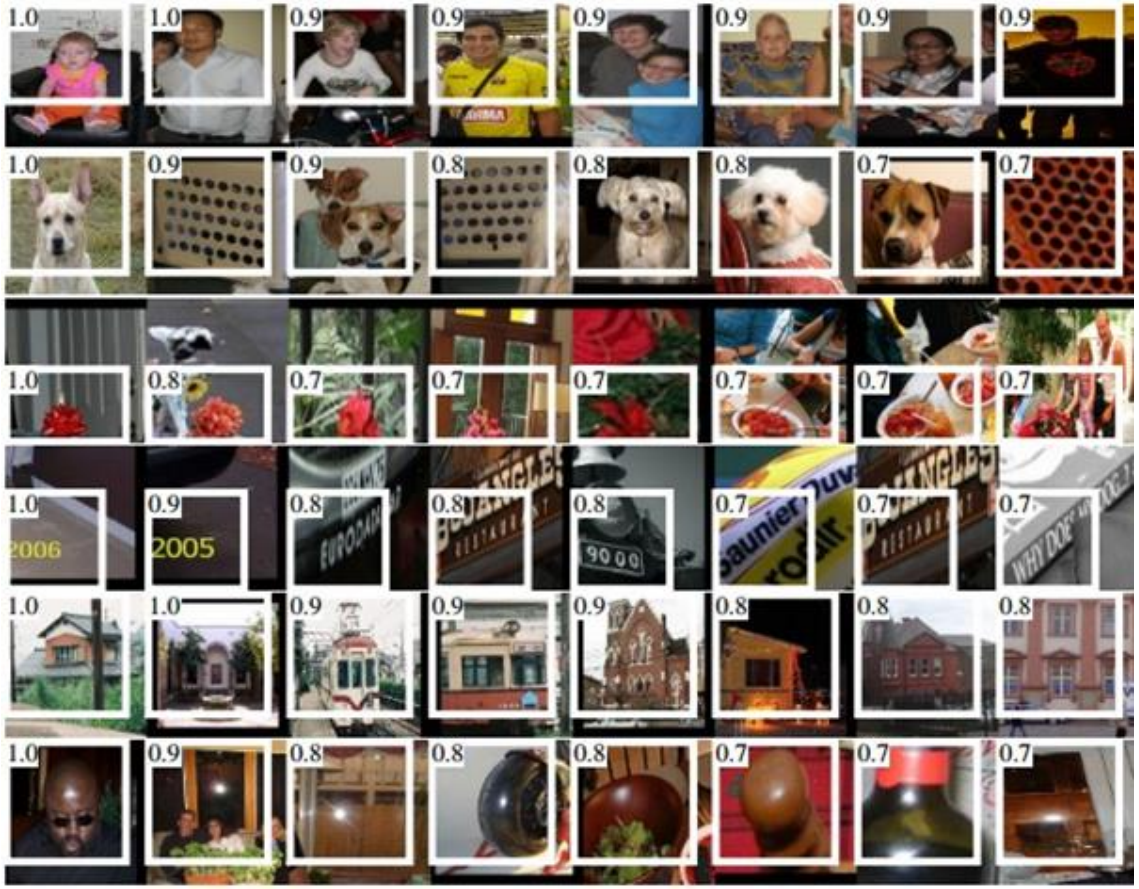


11 x 11
(AlexNet)

http://cs231n.github.io/understanding-cnn/

How about higher layers?

- Which images make a specific neuron activate



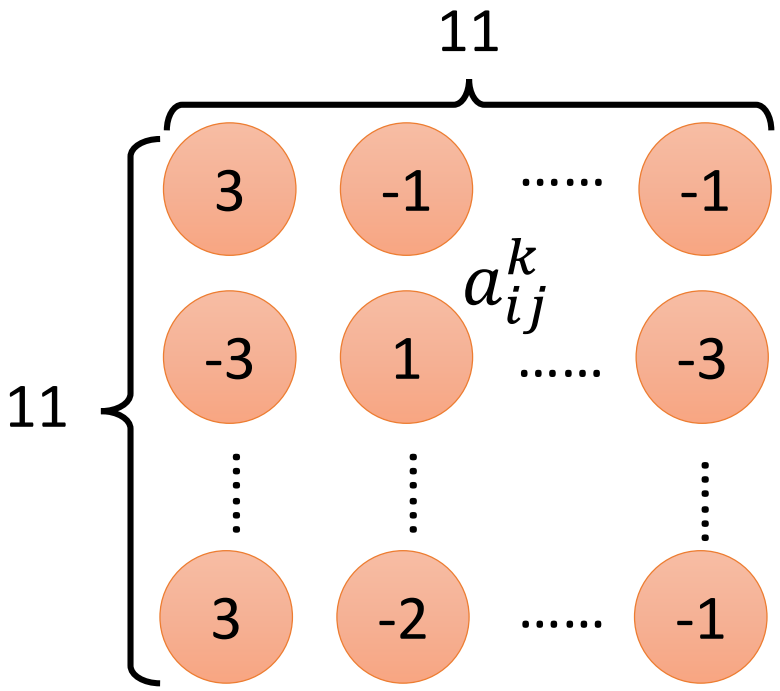
Ross Girshick, Jeff Donahue, Trevor Darrell, Jitendra Malik, “Rich feature hierarchies for accurate object detection and semantic segmentation”, CVPR, 2014

What does CNN learn?

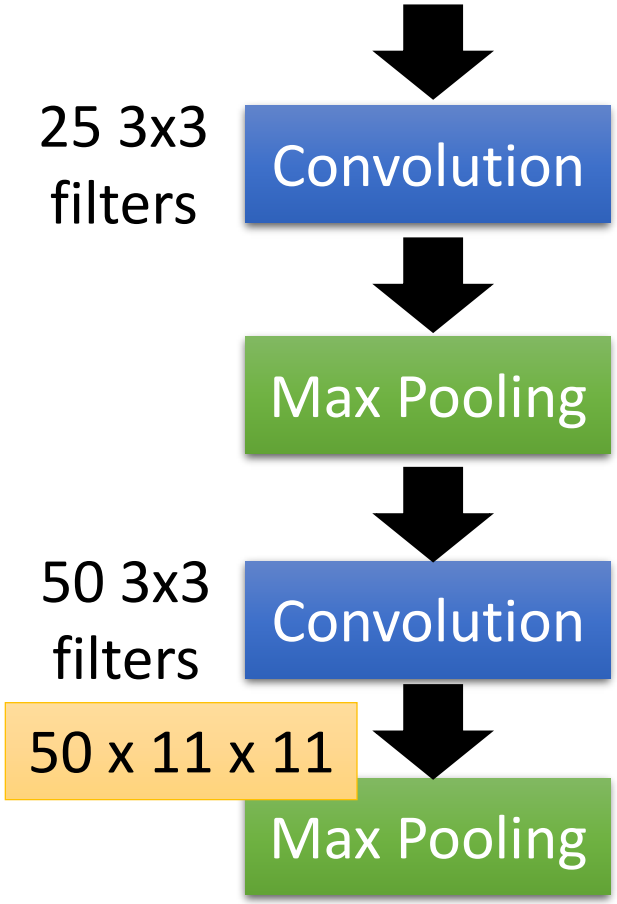
The output of the k-th filter is a 11 x 11 matrix.

Degree of the activation of the k-th filter: $a^k = \sum_{i=1}^{11} \sum_{j=1}^{11} a_{ij}^k$

$x^* = arg \max_x a^k$ (gradient ascent)



$\frac{\partial a^k}{\partial x_{ij}}$ x input

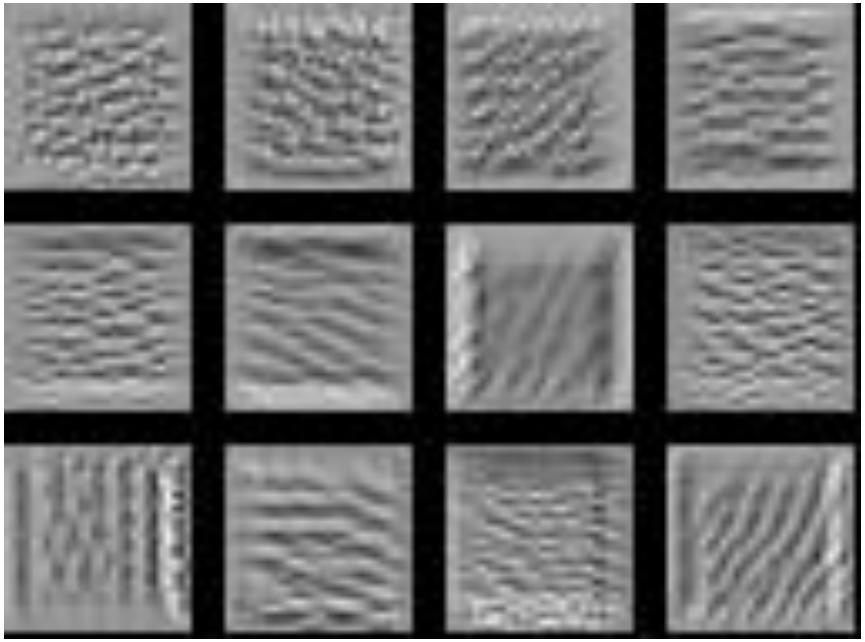


What does CNN learn?

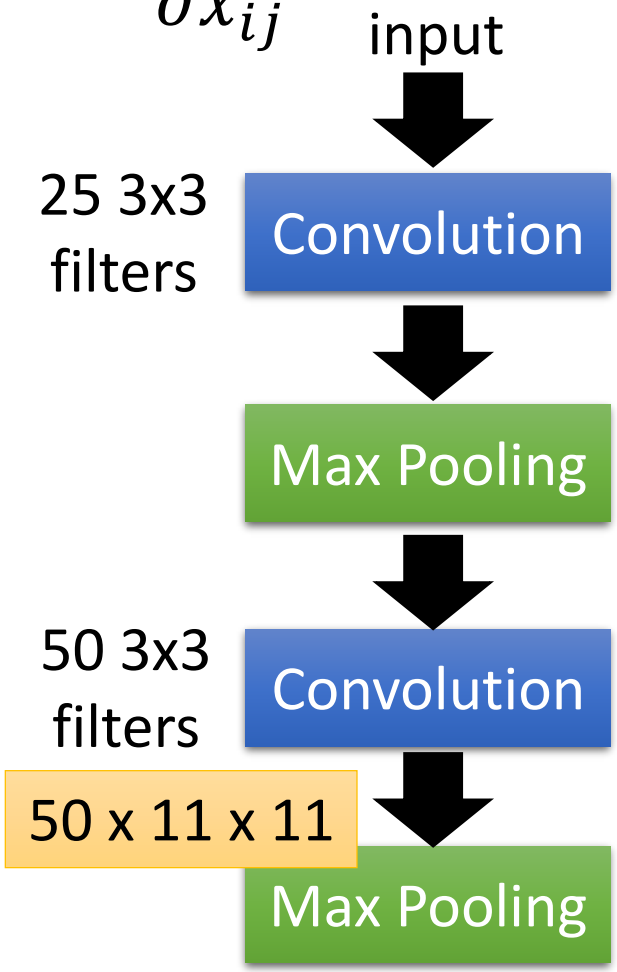
The output of the k-th filter is a 11 x 11 matrix.

Degree of the activation of the k-th filter: $a^k = \sum_{i=1}^{11} \sum_{j=1}^{11} a_{ij}^k$

$x^* = arg \max_x a^k$ (gradient ascent)



$\frac{\partial a^k}{\partial x_{ij}}$

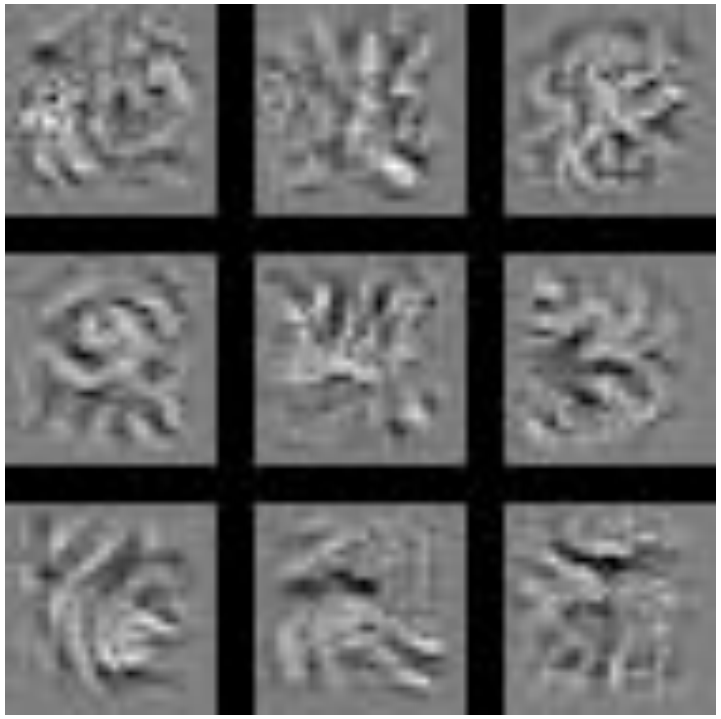


For each filter

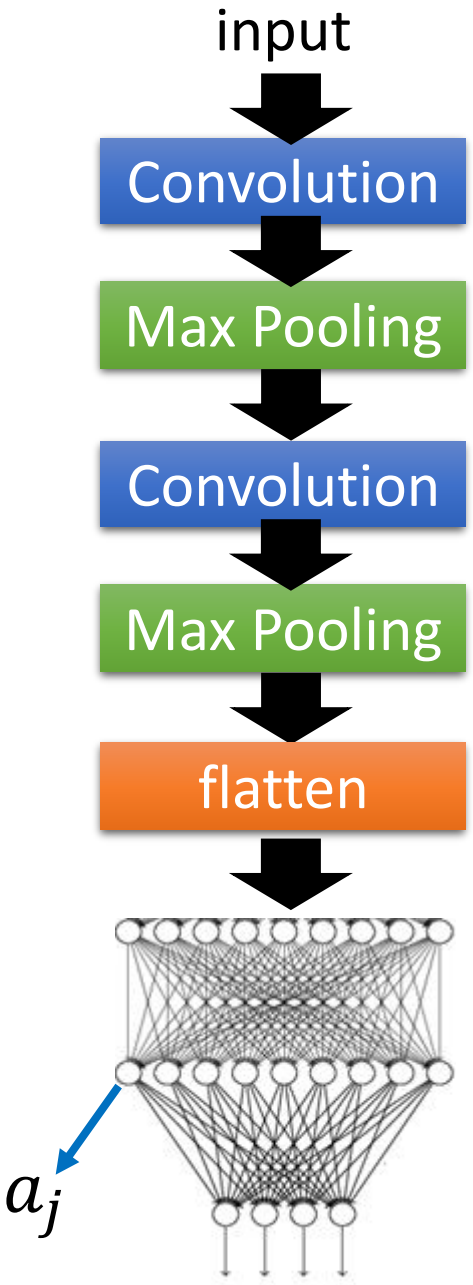
What does CNN learn?

Find an image maximizing the output of neuron:

$$x^* = arg \max_x a^j$$



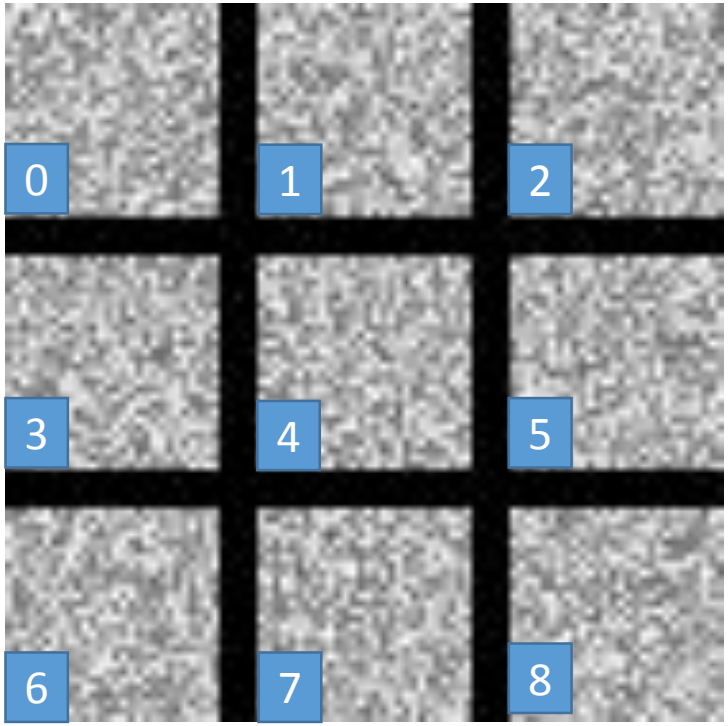
Each figure corresponds to a neuron



What does CNN learn?

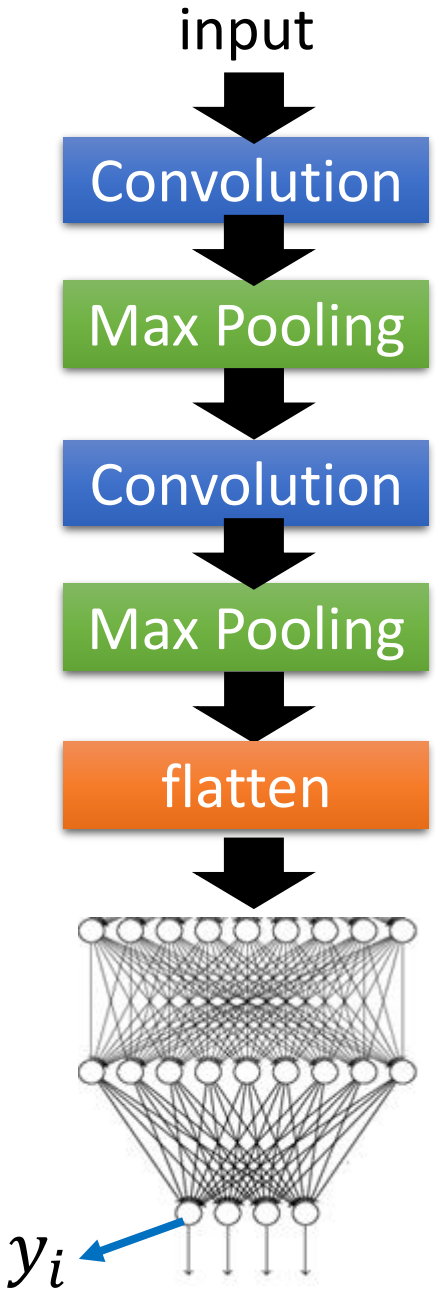
$$x^* = arg\max_x y^i$$

Can we see digits?



Deep Neural Networks are Easily Fooled

https://www.youtube.com/watch?v=M2IebCN9Ht4

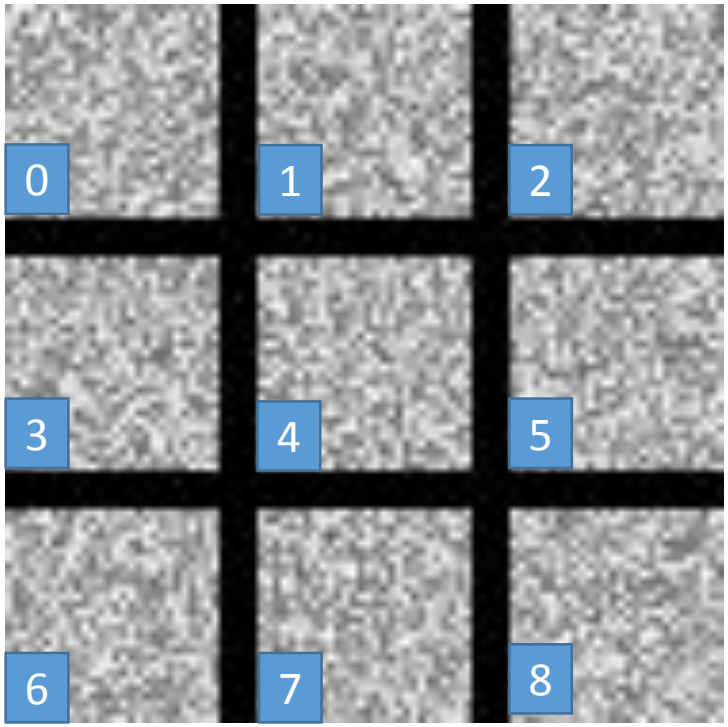


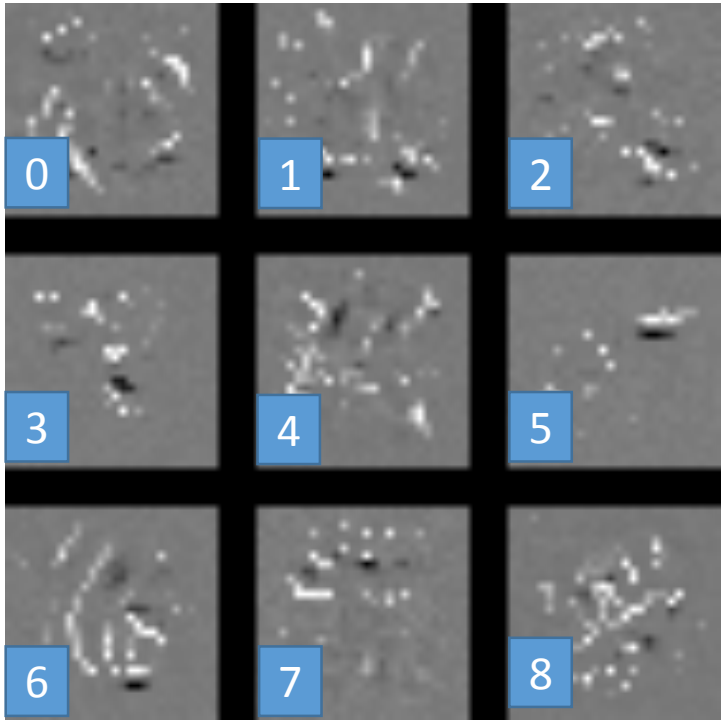
What does CNN learn?

$$x^* = arg\max_x y^i$$

Over all pixel values

$$x^* = arg\max_x \left(y^i - \sum_{i,j} |x_{ij}| \right)$$





Karen Simonyan, Andrea Vedaldi, Andrew Zisserman, “Deep Inside Convolutional Networks: Visualising Image Classification Models and Saliency Maps”, ICLR, 2014

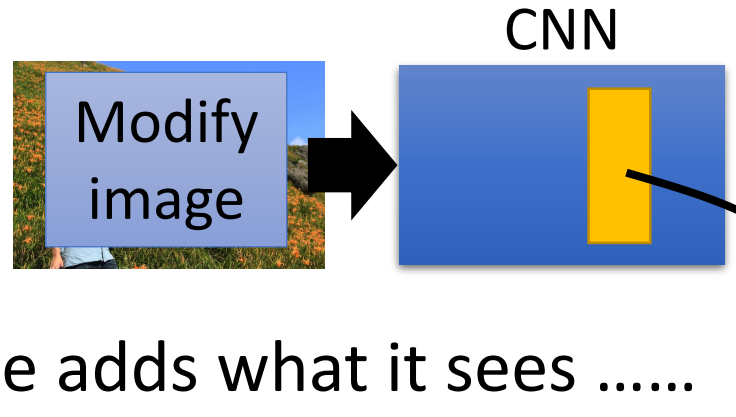
$$\left|\frac{\partial y_k}{\partial x_{ij}}\right|$$

y_k: the predicted class of the model

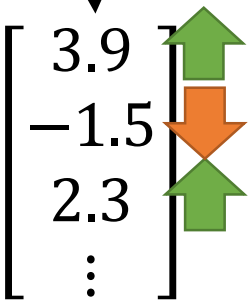
Karen Simonyan, Andrea Vedaldi, Andrew Zisserman, "Deep Inside Convolutional Networks: Visualising Image Classification Models and Saliency Maps", ICLR, 2014

Reference: Zeiler, M. D., & Fergus, R. (2014). Visualizing and understanding convolutional networks. In *Computer Vision–ECCV 2014* (pp. 818-833)

Deep Dream



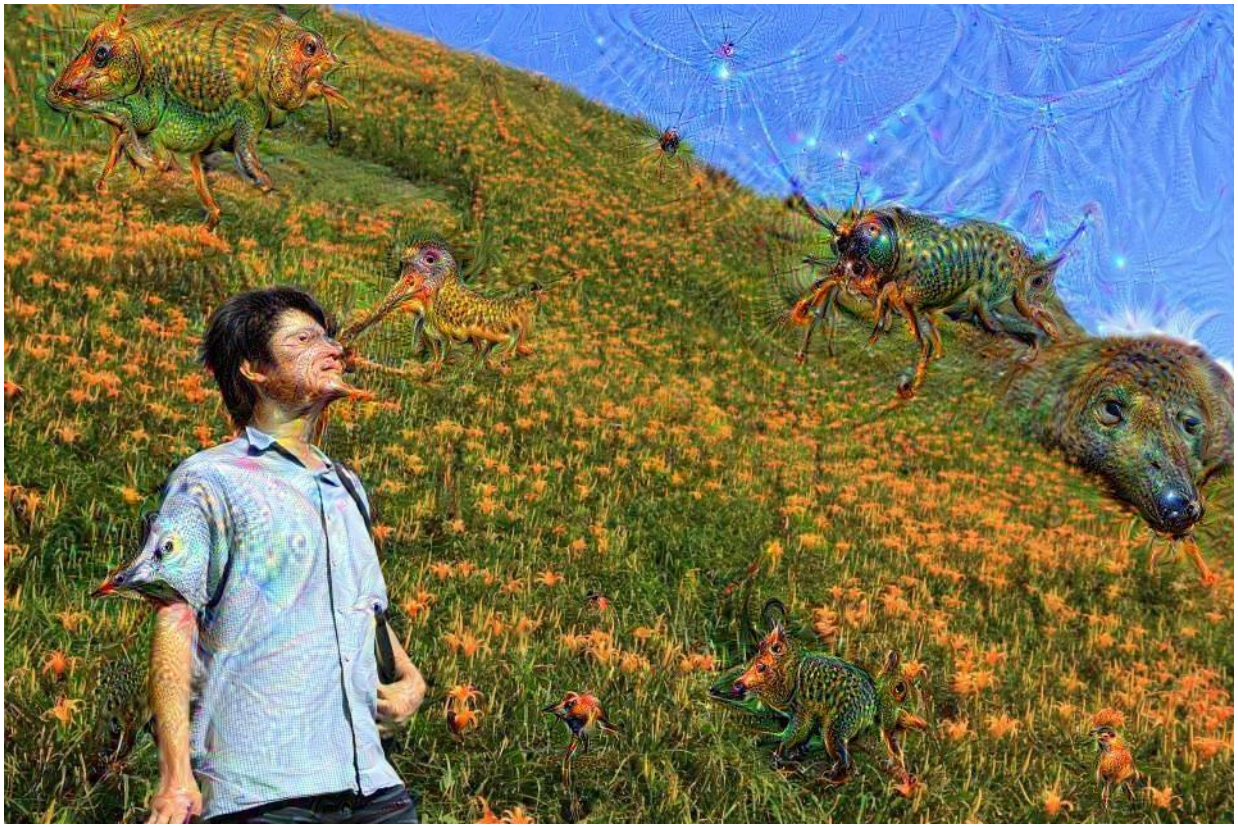
- Given a photo, machine adds what it sees ……



http://deepdreamgenerator.com/

Deep Dream

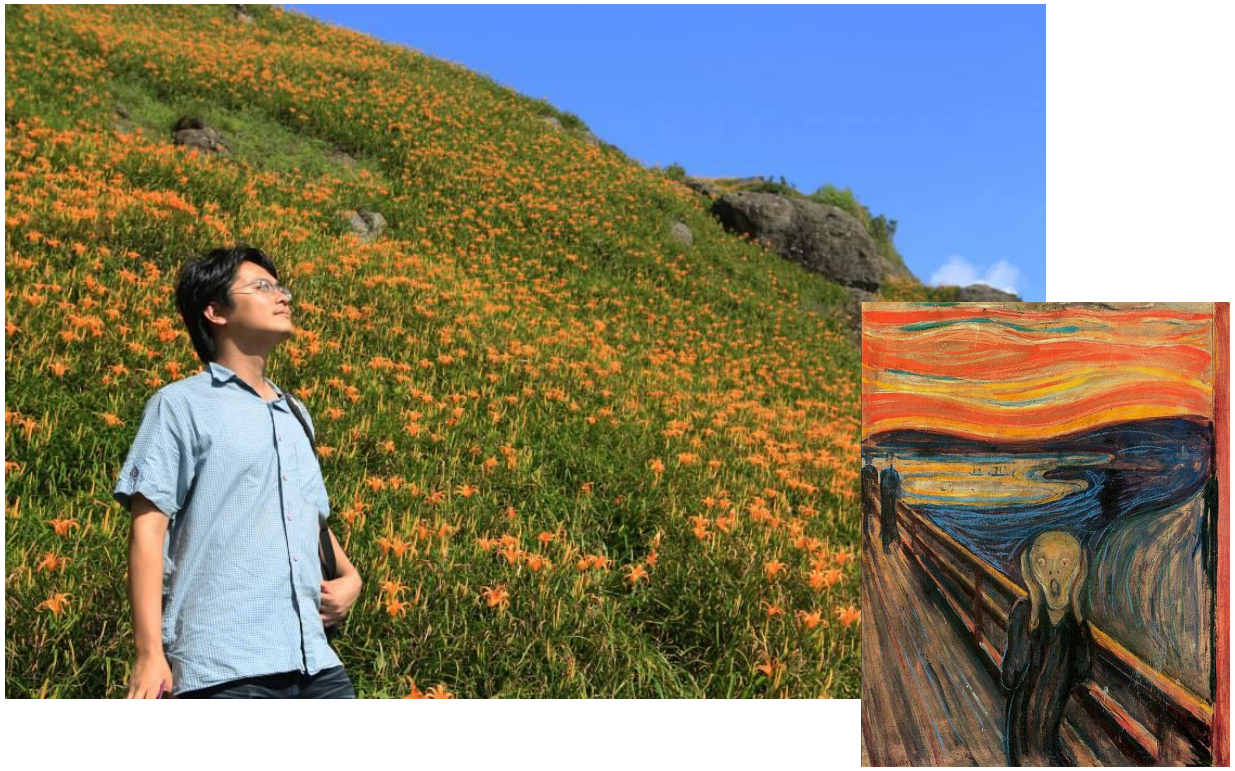
- Given a photo, machine adds what it sees ……



http://deepdreamgenerator.com/

Deep Style

- Given a photo, make its style like famous paintings



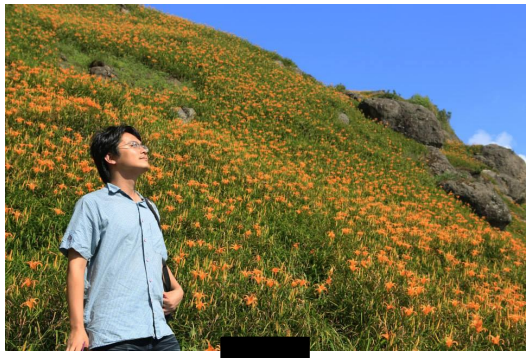
https://dreamscopeapp.com/

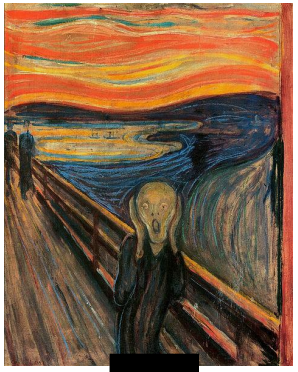
Deep Style

- Given a photo, make its style like famous paintings

https://dreamscopeapp.com/

Deep Style





CNN

CNN

content

style

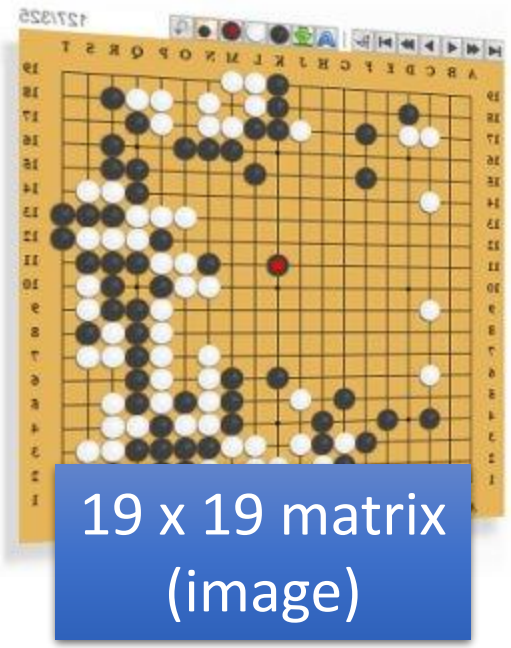
CNN

?

A Neural Algorithm of Artistic Style

https://arxiv.org/abs/1508.06576

More Application: Playing Go



19 x 19 matrix (image)

Network

Next move (19 x 19 positions)

19 x 19 vector

Black: 1

white: -1

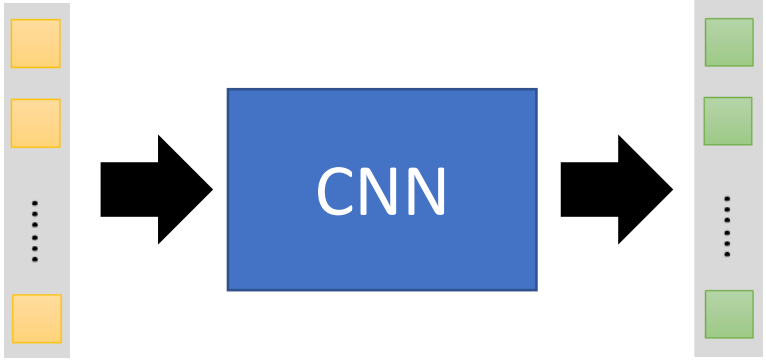
none: 0

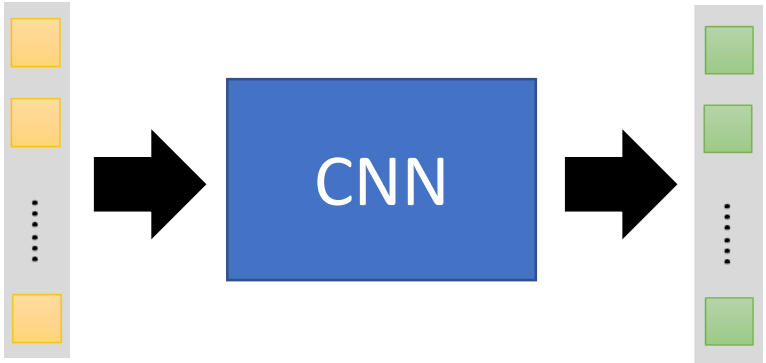
Fully-connected feedforward network can be used

But CNN performs much better.

More Application: Playing Go

Training: record of previous plays 黑: 5之五 → 白: 天元 → 黑: 五之5 …





Target:
“天元” = 1
else = 0

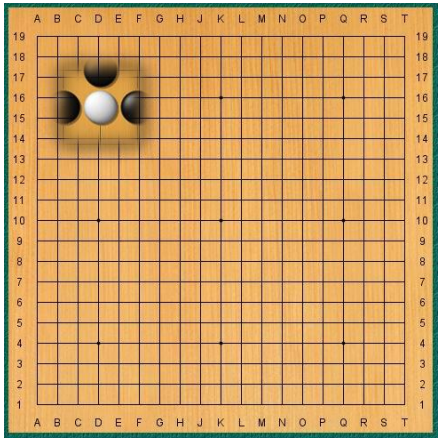
Target:
“五之 5” = 1
else = 0

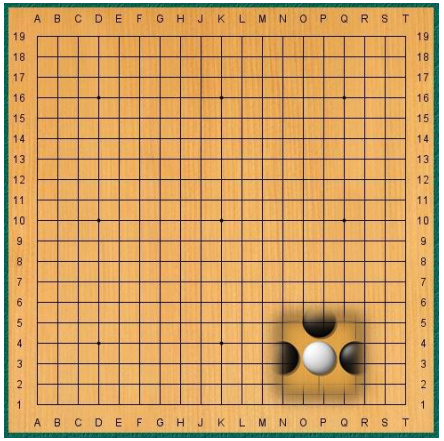
Why CNN for playing Go?

- Some patterns are much smaller than the whole image

  Alpha Go uses 5 x 5 for first layer

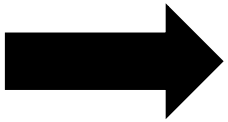
- The same patterns appear in different regions.





Why CNN for playing Go?

- Subsampling the pixels will not change the object



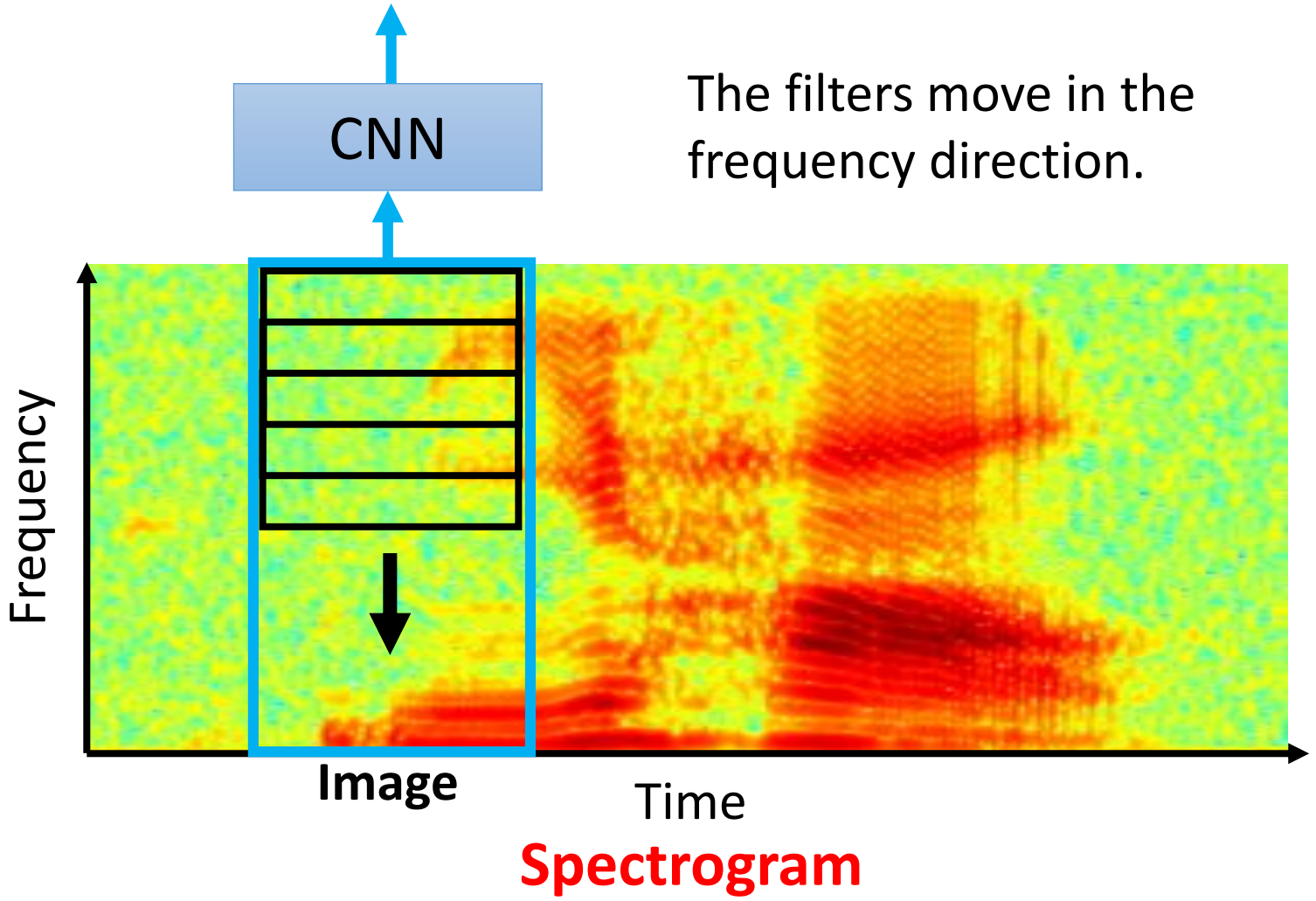
Max Pooling

How to explain this???

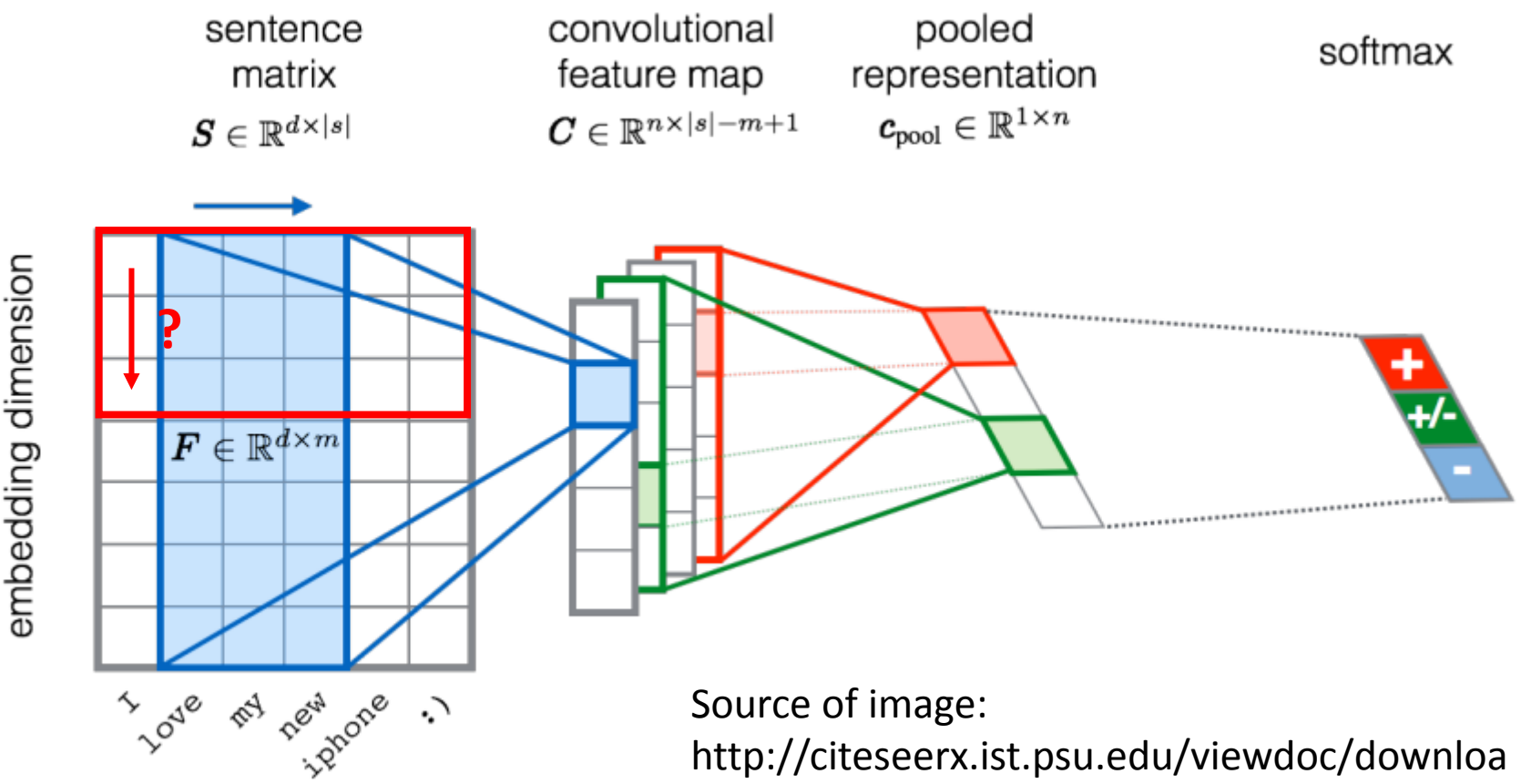
Neural network architecture. The input to the policy network is a $19 \times 19 \times 48$ image stack consisting of 48 feature planes. The first hidden layer zero pads the input into a 23×23 image, then convolves k filters of kernel size 5×5 with stride 1 with the input image and applies a rectifier nonlinearity. Each of the subsequent hidden layers 2 to 12 zero pads the respective previous hidden layer into a 21×21 image, then convolves k filters of kernel size 3×3 with stride 1, again followed by a rectifier nonlinearity. The final layer convolves 1 filter of kernel size 1×1 with stride 1, with a different bias for each position, and applies a softmax function. The Extended Data Table 3 additionally show the results of training with $k = 128$, 256 and 384 filters.

Alpha Go does not use Max Pooling ……

More Application: Speech



More Application: Text



Source of image: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.703.6858&rep=rep1&type=pdf

Acknowledgment

- 感謝 Guobiao Mo 發現投影片上的打字錯誤