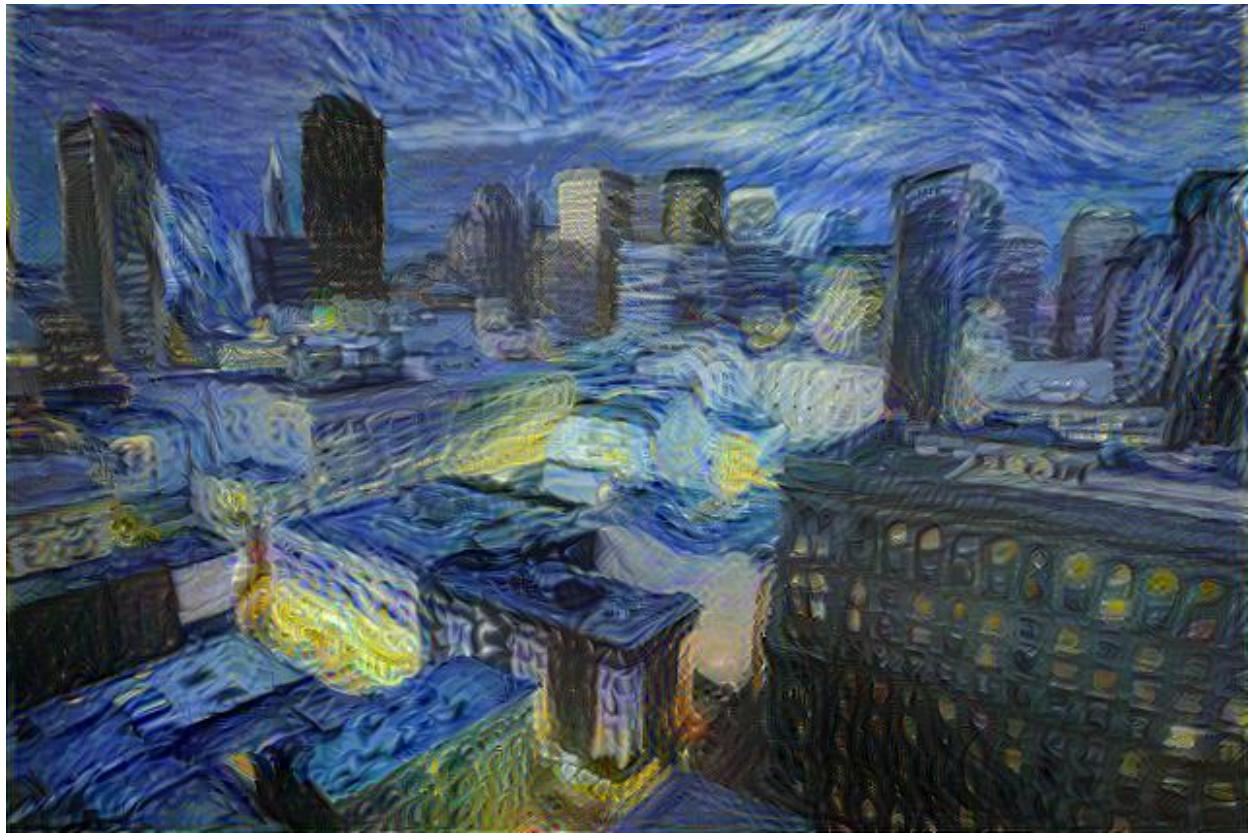
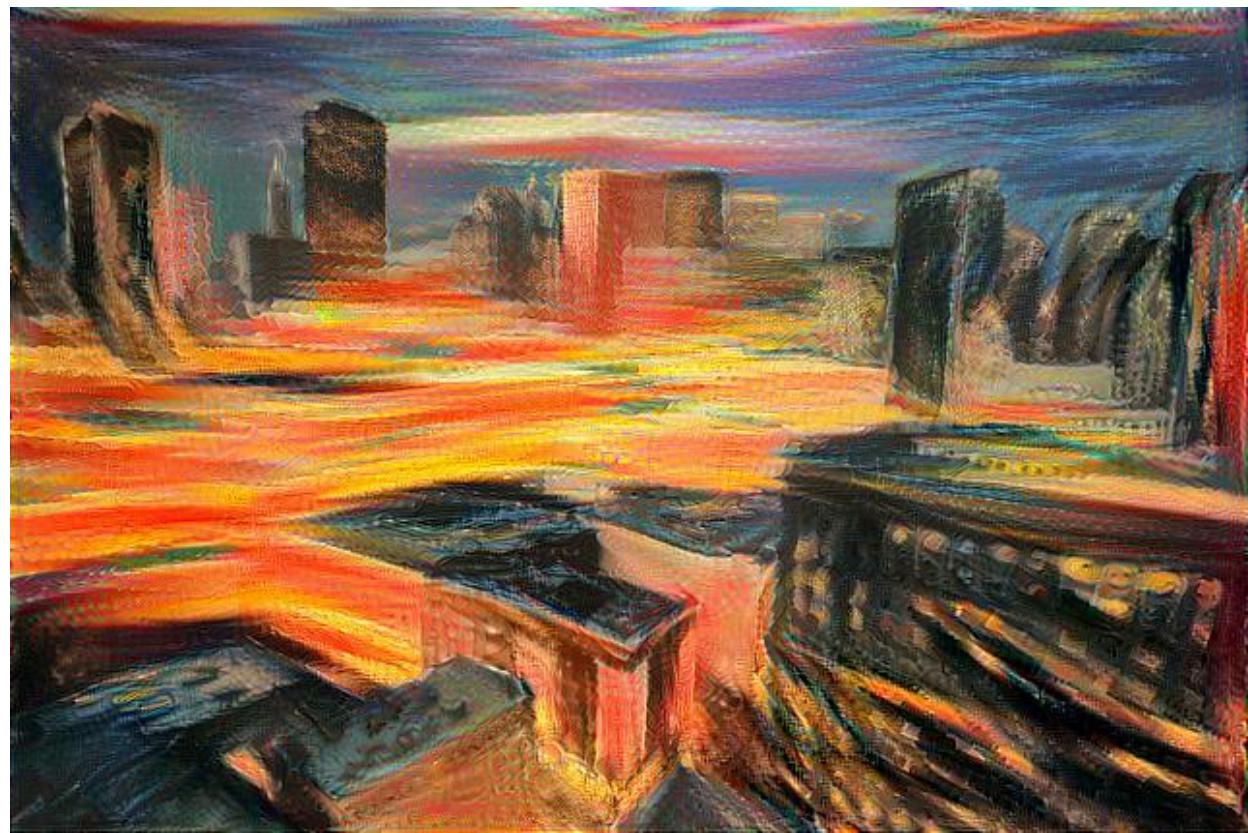
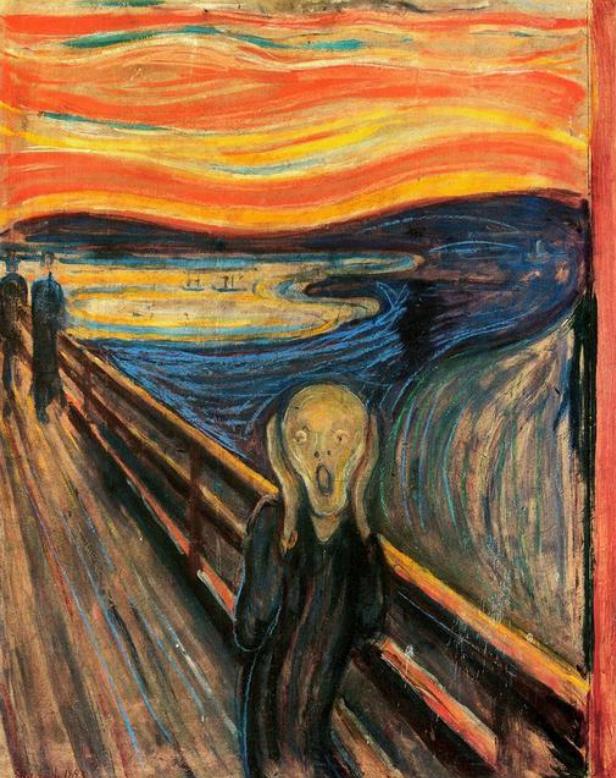


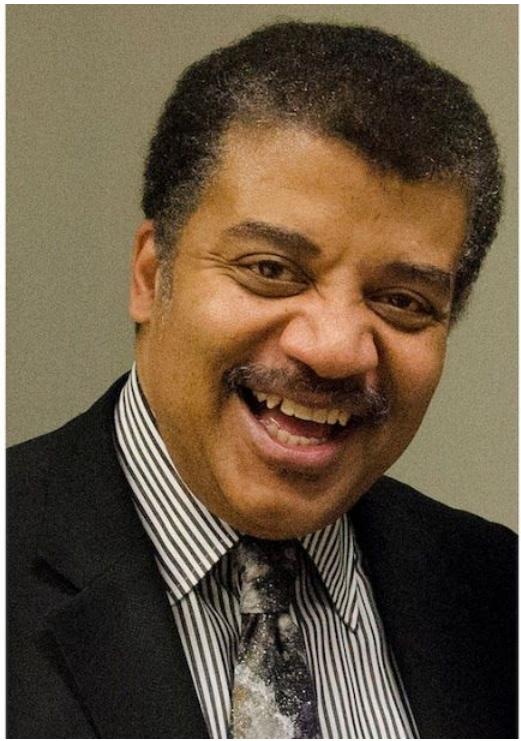
# Convolutional Neural Networks and Artistic Style Transfer











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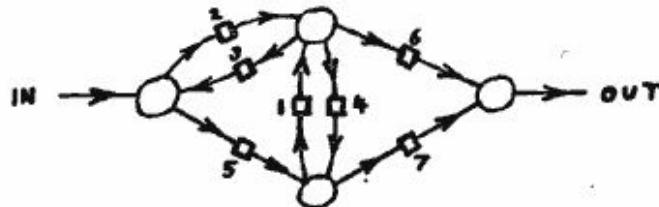
# Overview

1. What is a **Neural Network**?
2. What is a ***Convolutional* Neural Network**?
3. How does it allow for the transferring of **Artistic Style**?

# What is a Neural Network?

## 4. Organising unorganised machinery.

Many unorganised machines have configurations such that if once that configuration is reached, and if the interference thereafter is appropriately restricted, the machine behaves as one organised for some definite purpose. For instance the B-type machine shown below was chosen at random.



If the connections numbered 1, 3, 6, 4, are in condition ii) initially and connections 2, 5, 7 are in condition i), then the machine may be considered to be one for the purpose of passing on signals with a delay of 4 moments. This is a particular case of a very general property of B-type machines (and many other types) viz that with suitable initial conditions they will do any required job, given sufficient time and provided the number of units is sufficient. In particular with a B-type unorganised machine with sufficient units one can find initial conditions which will make it into a universal machine with a given storage capacity. (A formal proof to this effect might be of some interest, or even a demonstration of it starting with a particular unorganised B-type machine, but I am not giving it as it lies rather too far outside the main argument).

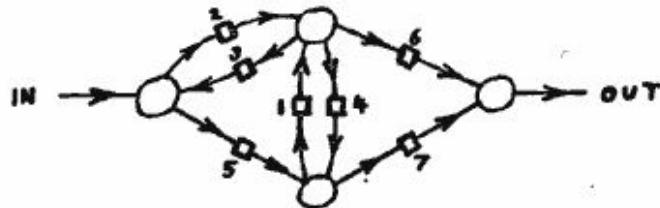


Alan Turing (1912-1954)

# What is a Neural Network?

## 4. Organising unorganised machinery.

Many unorganised machines have configurations such that if once that configuration is reached, and if the interference thereafter is appropriately restricted, the machine behaves as one organised for some definite purpose. For instance the I-type machine shown below was chosen at random



Various state-of-the-art neural network architectures today differ in:

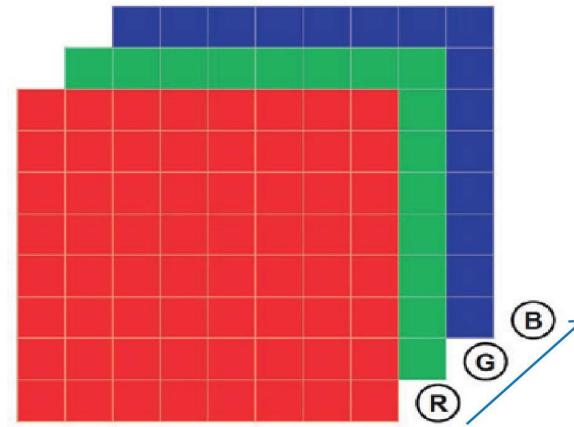
- Pre-imposed structure
- Operations done at the nodes



Alan Turing (1912-1954)

# What is a *Convolutional* Neural Network?

Operations at the nodes are carried out by **convolutional filters**

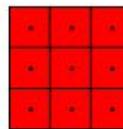


$$T = \begin{bmatrix} X_{11N} & X_{12N} & X_{13N} & \dots & X_{1NN} \\ X_{112} & X_{122} & X_{132} & \dots & X_{1N2} \\ X_{111} & X_{121} & X_{131} & \dots & X_{1N1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ X_{N11} & X_{N21} & X_{N31} & \dots & X_{NN1} \end{bmatrix}$$

# Convolutional Filters

Input Image

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Filter

Output  
Image

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Original Image



Box-filtered image

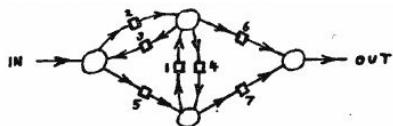
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1



Gaussian-filtered image

0	0	0	5	0	0	0
0	5	18	32	18	5	0
0	18	64	100	64	18	0
5	32	100	100	100	32	5
0	18	64	100	64	18	0
0	5	18	32	18	5	0
0	0	0	5	0	0	0

# What is a *Convolutional* Neural Network?

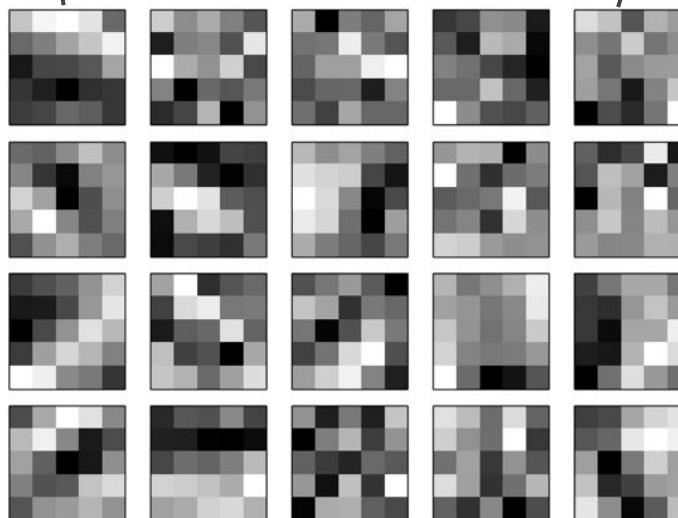


Input Image



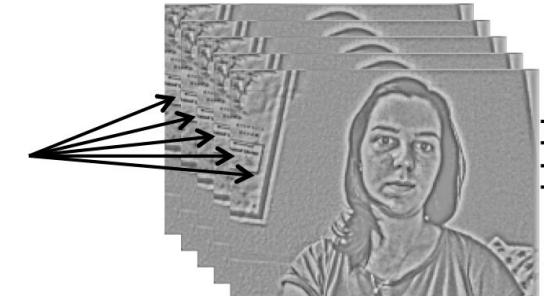
17	24	1	8	15
23	5	7	14	16
4	6	13	20	22
10	12	19	21	3
11	18	25	2	9

Filter Bank (initially random)



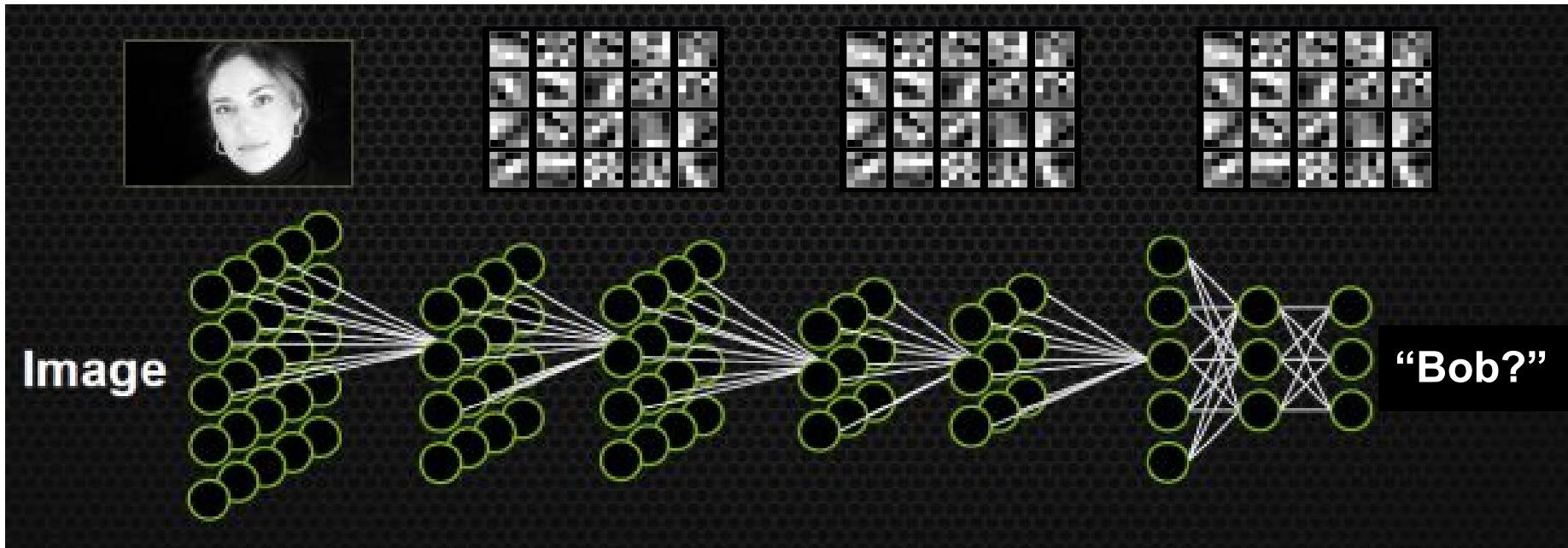
7	2	3	5	3
9	2	2	4	3
1	5	6	3	5
1	5	6	2	6
2	6	3	6	3

Output Images



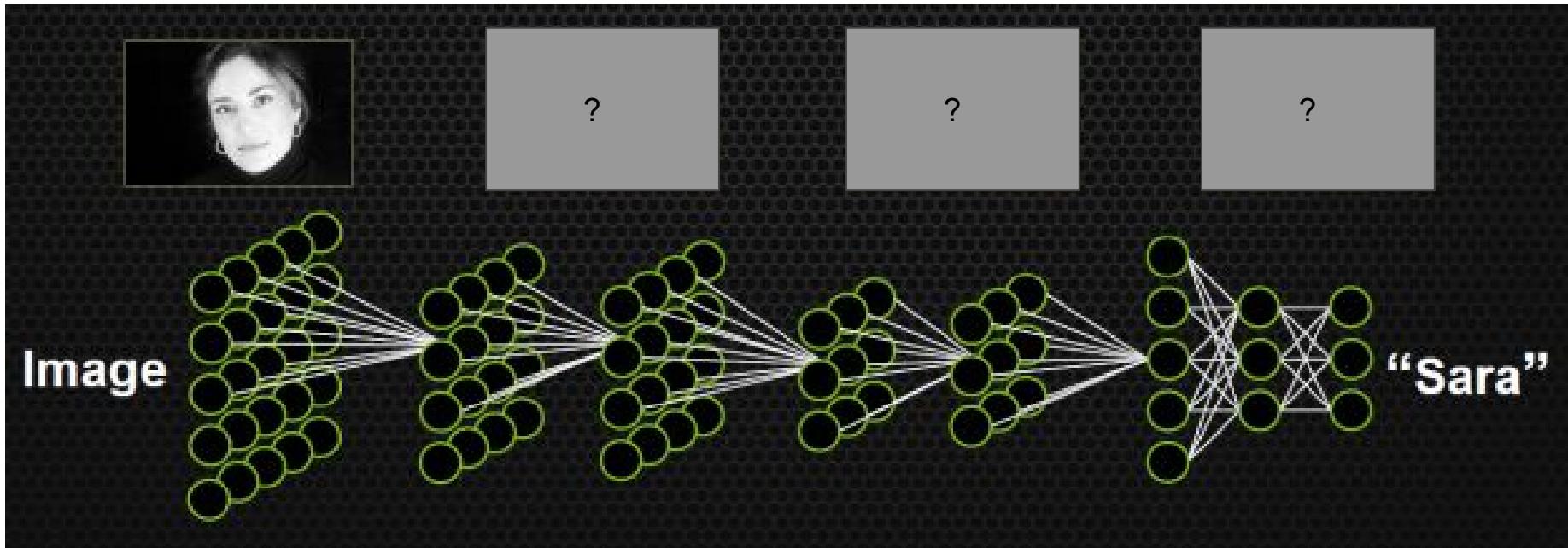
# What is a *Convolutional* Neural Network?

Layers of Filter Banks (before training)



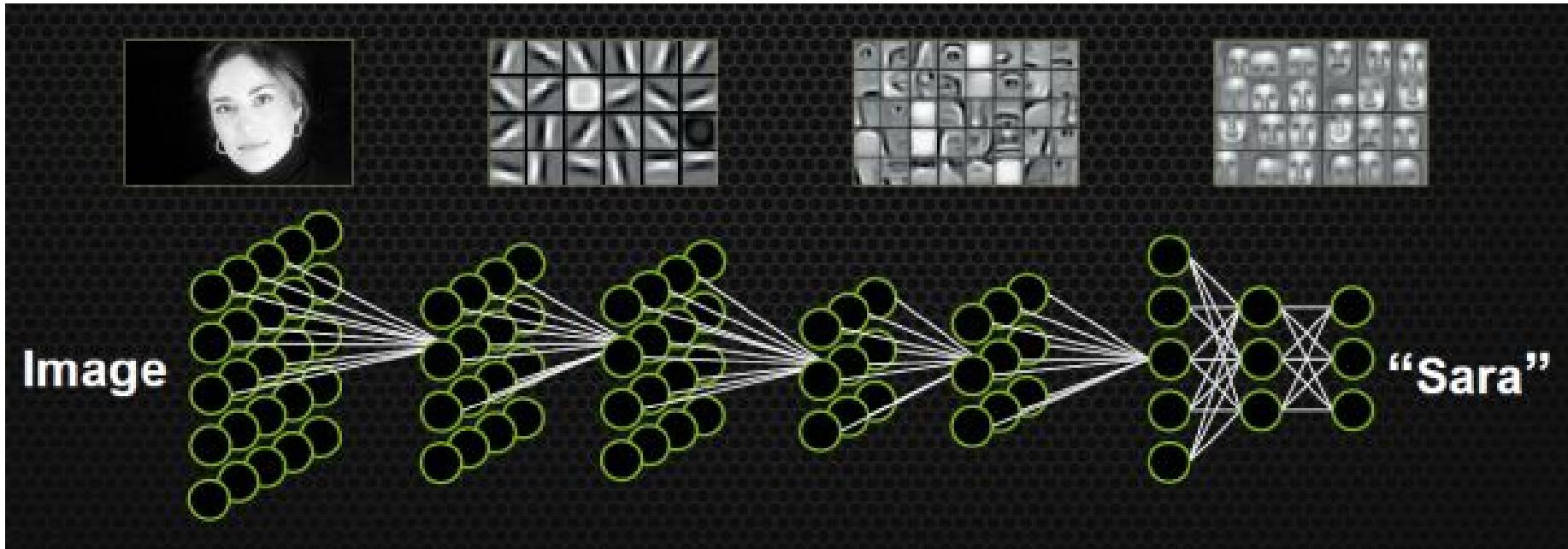
# What is a *Convolutional* Neural Network?

Layers of Filter Banks (after training)



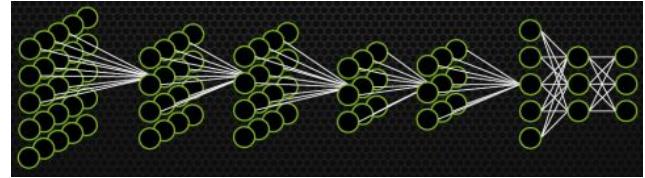
# What is a *Convolutional* Neural Network?

Layers of Filter Banks (after training)



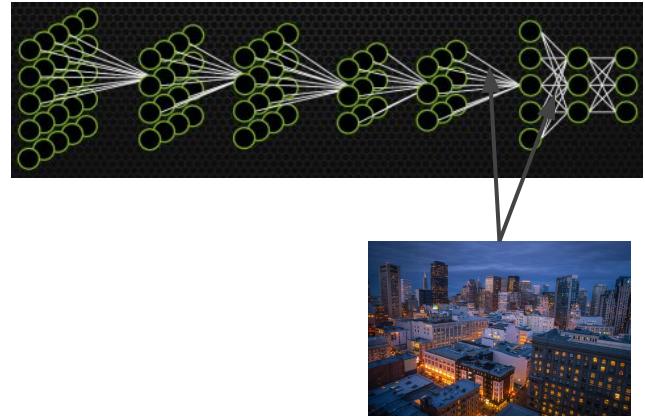
# Artistic Style Transfer in 4 Easy Steps:

1. Train a large neural network to classify a wide array of images



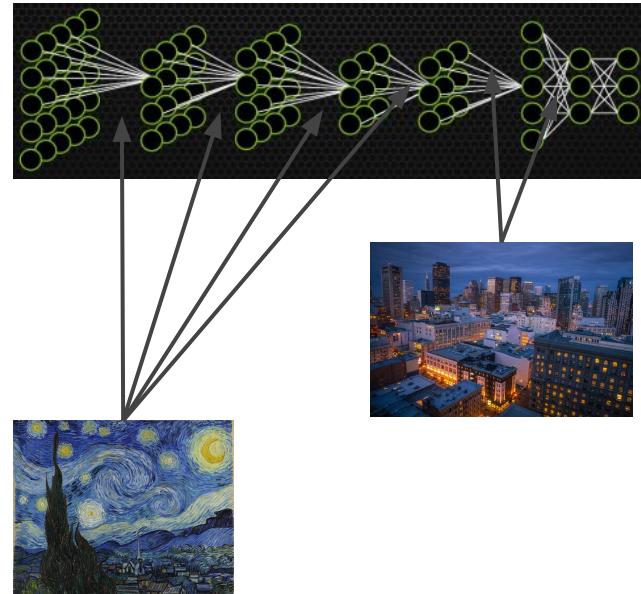
# Artistic Style Transfer in 4 Easy Steps:

1. Train a large neural network to classify a wide array of images
2. Pass the **content** image through the network, save the filter response of the later layers (contains **contextual** information)



# Artistic Style Transfer in 4 Easy Steps:

1. Train a large neural network to classify a wide array of images
2. Pass the **content** image through the network, save the filter response of the later layers (contains **contextual** information)
3. Pass the **style** image through the network, save the filter response of the earlier layers (contain **textual** information)

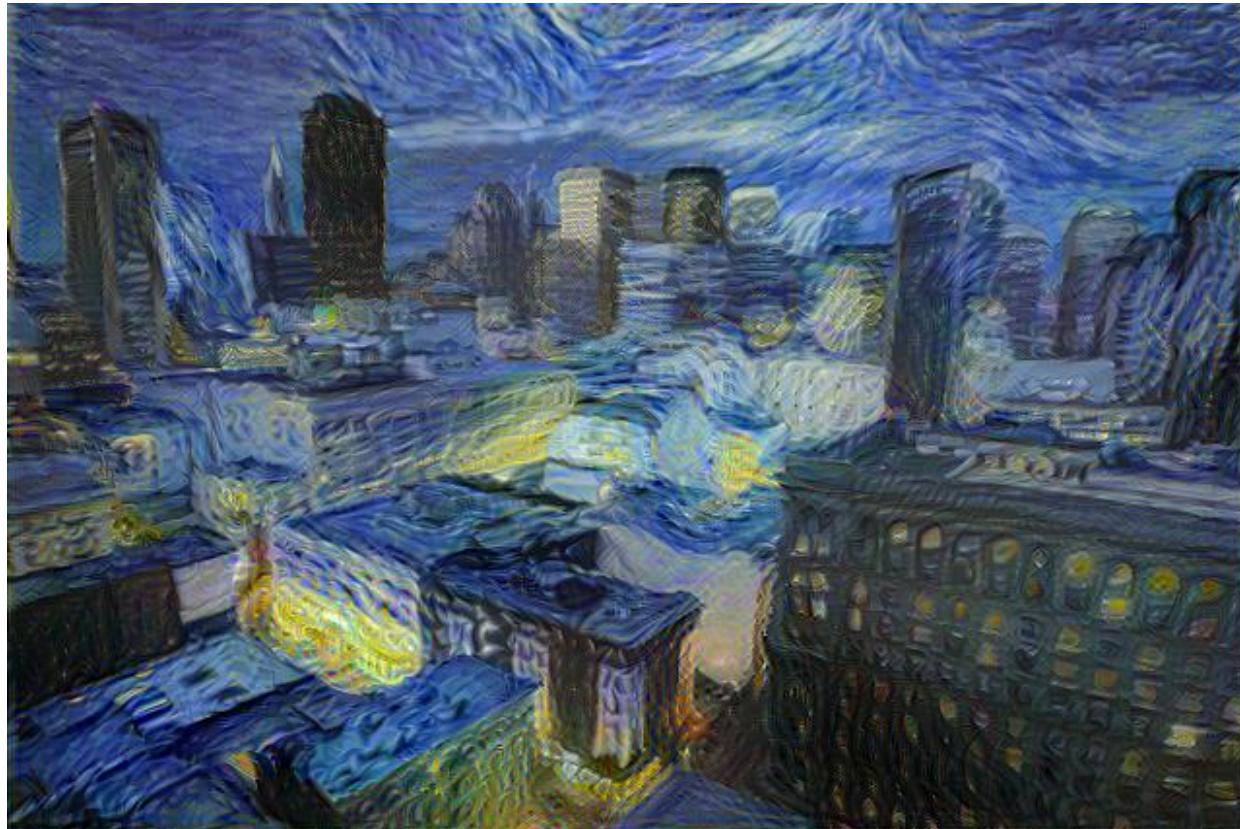


# Artistic Style Transfer in 4 Easy Steps:

1. Train a large neural network to classify a wide array of images
2. Pass the **content** image through the network, save the filter response of the later layers (contains **contextual** information)
3. Pass the **style** image through the network, save the filter response of the earlier layers (contain **textual** information)
4. Pass a **random noise** image through the network over-and-over again, adjust it (with gradient descent) until the filter responses of the network match the saved filter responses of the previous two images



Done!



# Neural Doodle!

