Deep Learning

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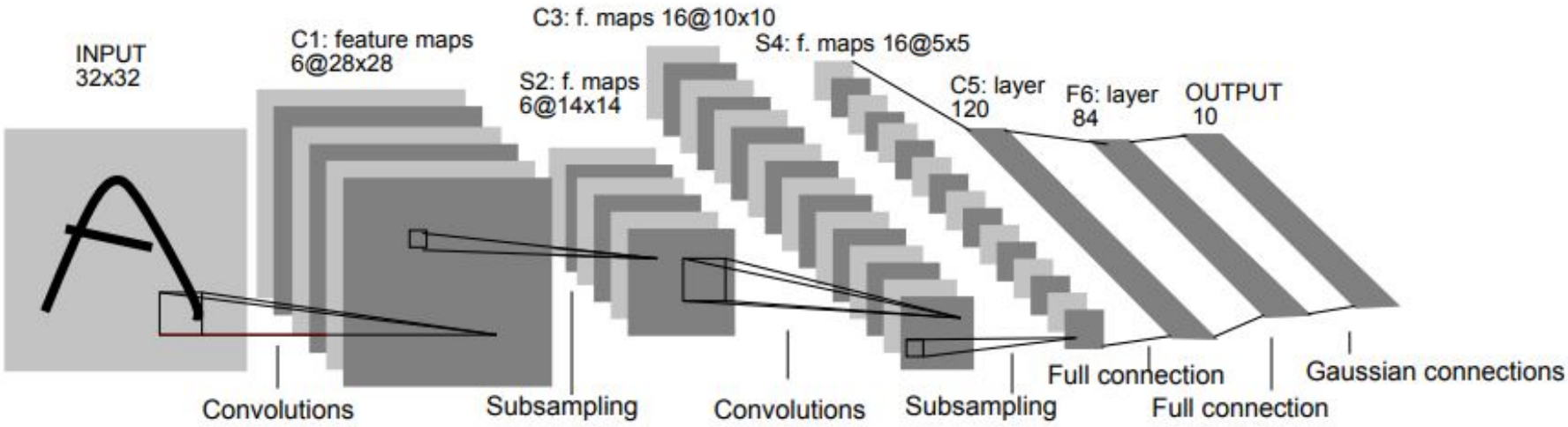
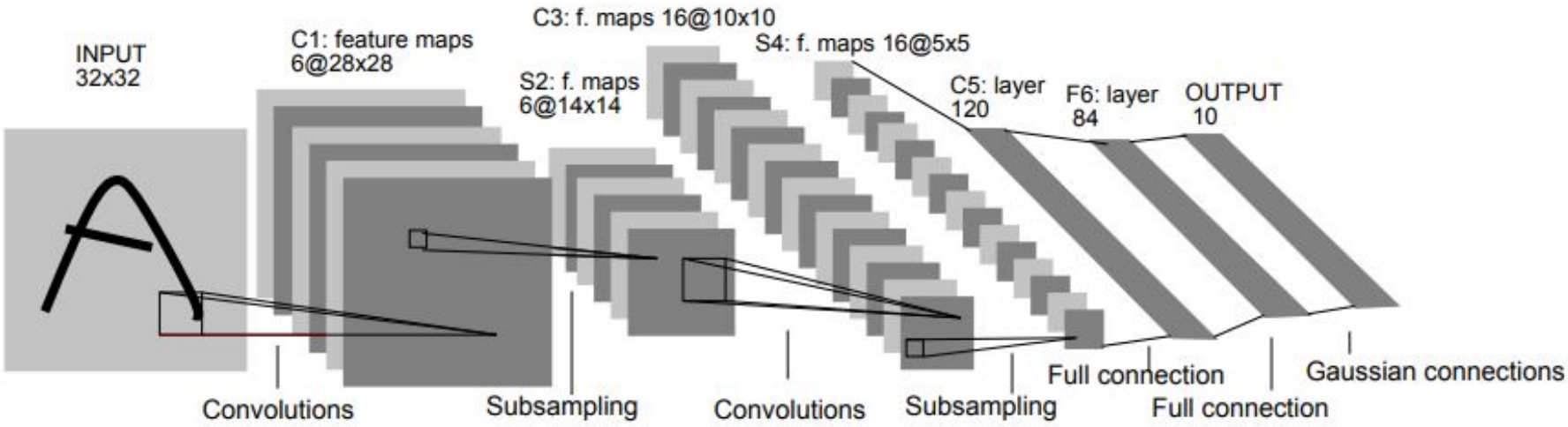
Outline

LeNet-5 (1998)

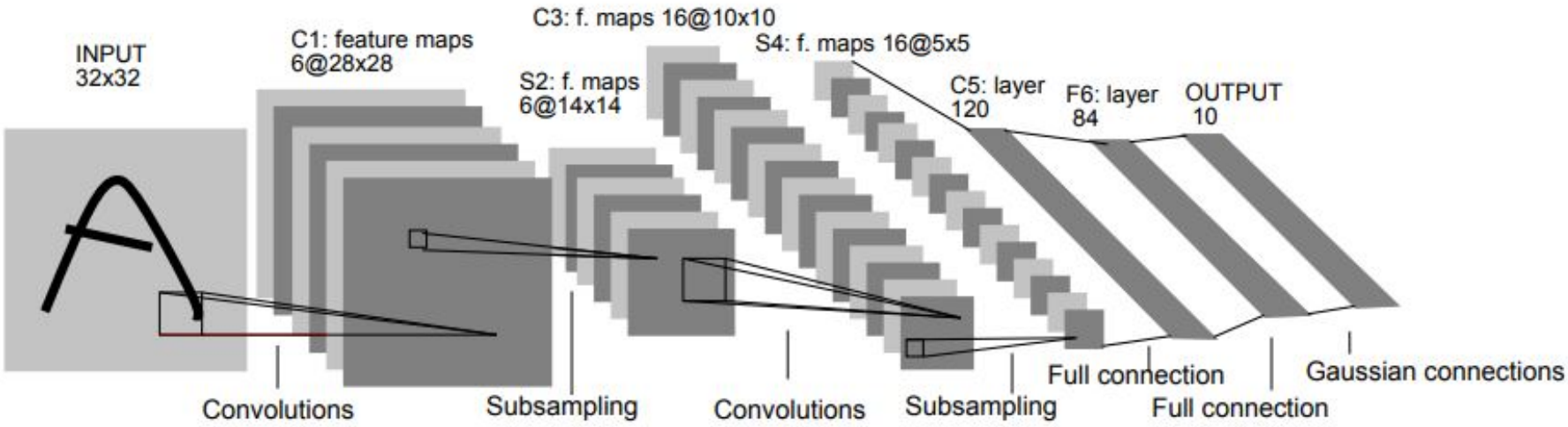

INPUT
32x32
C1: feature maps
6@28x28
S2: f. maps
6@14x14
C3: f. maps 16@10x10
S4: f. maps 16@5x5
C5: layer
120
F6: layer
84
OUTPUT
10
Convolutions
Subsampling
Convolutions
Subsampling
Full connection
Full connection
Gaussian connections

LeNet-5 (1998)



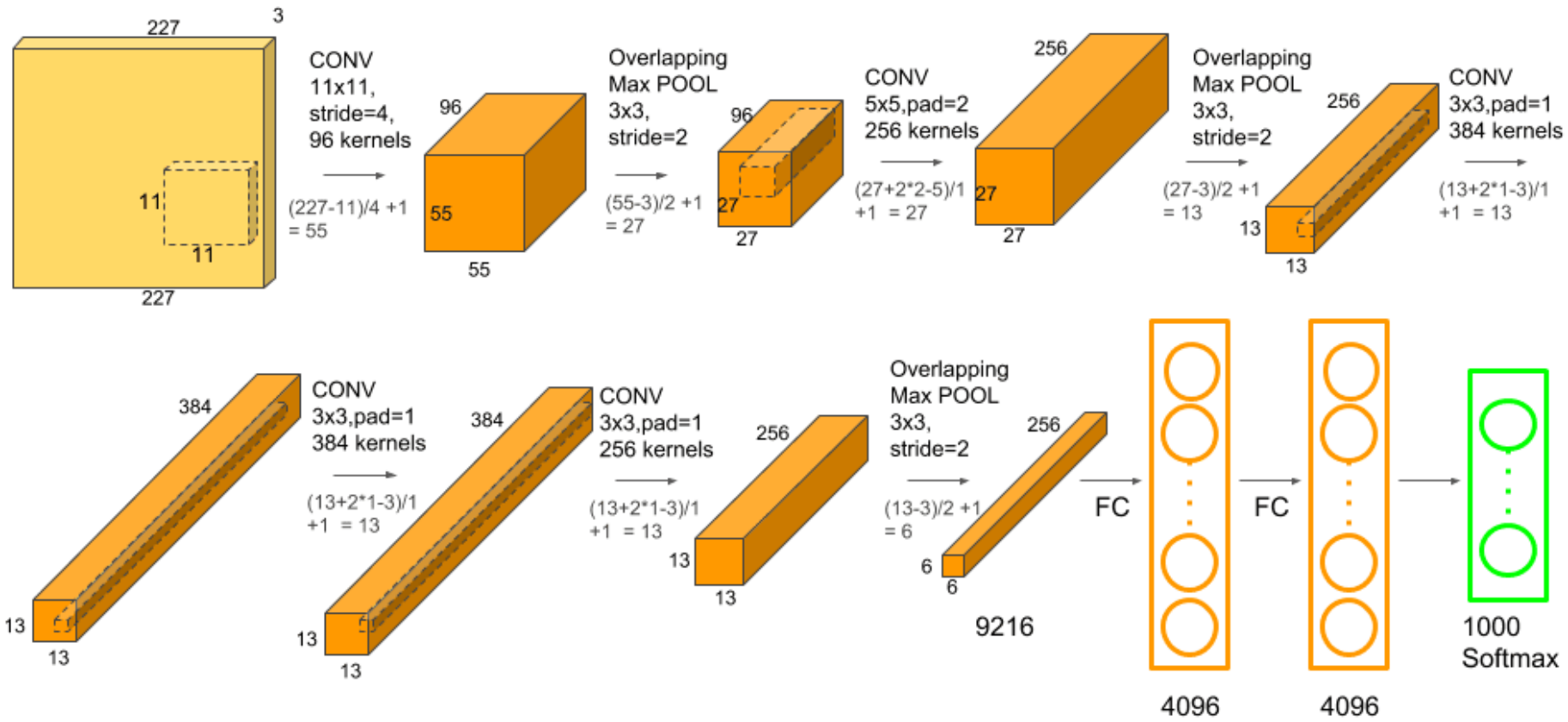
- Activation functions are sigmoids and hyperbolic tangents.

LeNet-5 (1998)



- Activation functions are sigmoids and hyperbolic tangents.
- LeNet-5 has approximately 60k parameters.

AlexNet (2012)



AlexNet (2012)

- The ReLU non-linearity is applied to the output of every convolutional and fully-connected layer.

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- Local response normalization?

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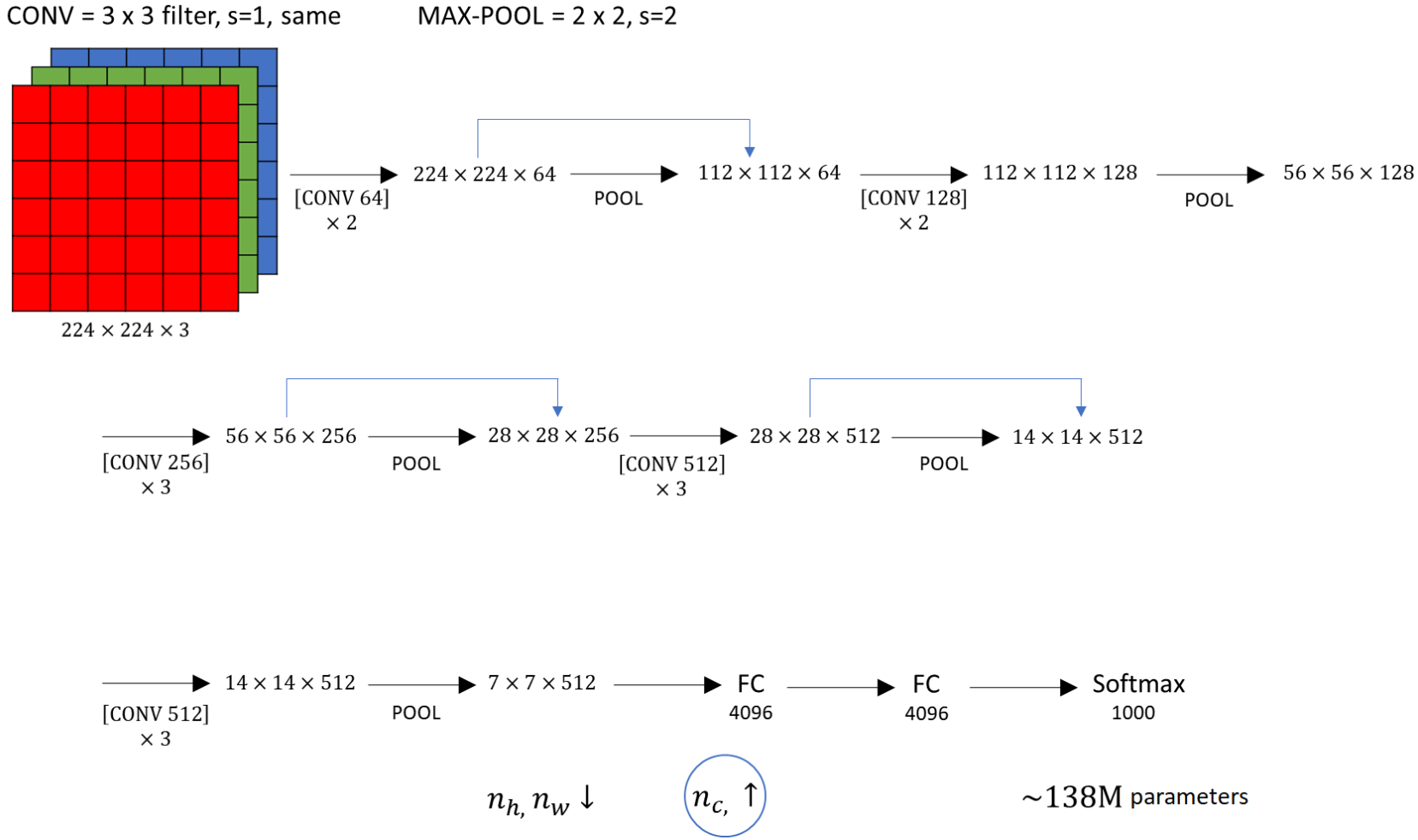
- AlexNet has approximately 60M parameters.

AlexNet (2012)

- The ReLU non-linearity is applied to the output of every convolutional and fully-connected layer.
- Local response normalization?
- AlexNet has approximately 60M parameters.
- Accuracies on ImageNet: Top1=63.3%, Top5=84.6%.

VGG-16 (2014)


CONV = 3 x 3 filter, s=1, same
MAX-POOL = 2 x 2, s=2
224 × 224 × 3
[CONV 64] × 2
224 × 224 × 64
POOL
112 × 112 × 64
[CONV 128] × 2
112 × 112 × 128
POOL
56 × 56 × 128
[CONV 256] × 3
56 × 56 × 256
POOL
28 × 28 × 256
[CONV 512] × 3
28 × 28 × 512
POOL
14 × 14 × 512
[CONV 512] × 3
14 × 14 × 512
POOL
7 × 7 × 512
FC 4096
FC 4096
Softmax 1000
$n_h, n_w \downarrow$
$n_c, \uparrow$
~138M parameters

VGG-16 (2014)

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- VGG-16 has approximately 138M parameters.
- Accuracies on ImageNet: Top1=74.4%, Top5=91.9%.

VGG-19 (2014)

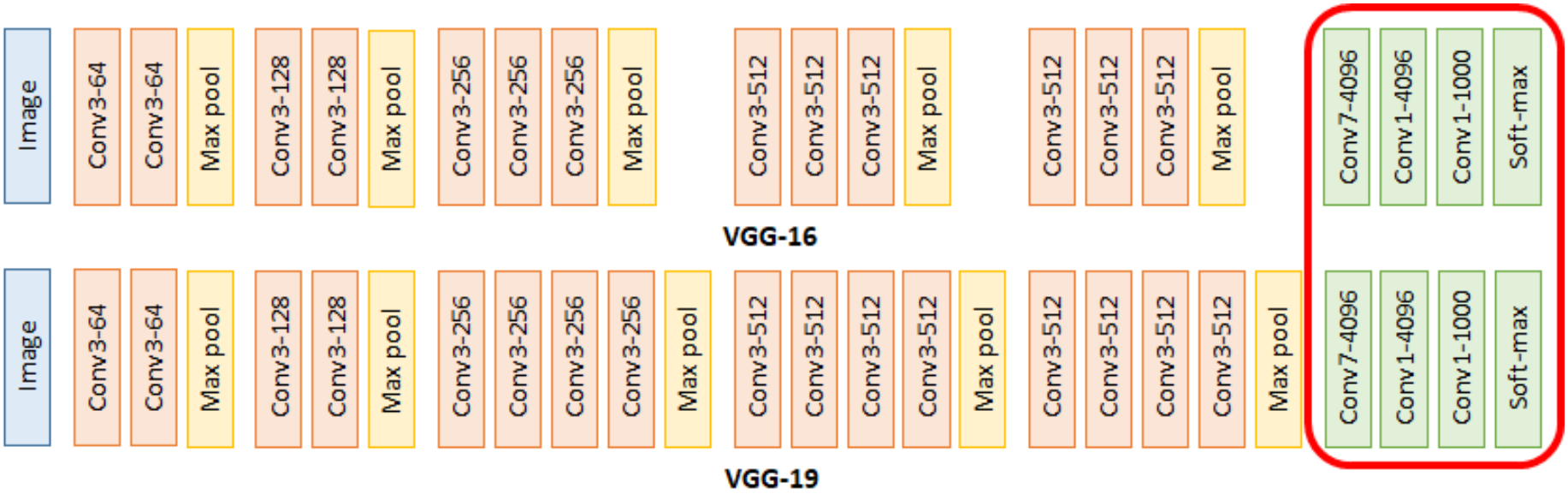
Image
Conv3-64
Conv3-64
Max pool
Conv3-128
Conv3-128
Max pool
Conv3-256
Conv3-256
Conv3-256
Max pool
Conv3-512
Conv3-512
Conv3-512
Max pool
Conv3-512
Conv3-512
Conv3-512
Max pool
Conv7-4096
Conv1-4096
Conv1-1000
Soft-max
VGG-16
Image
Conv3-64
Conv3-64
Max pool
Conv3-128
Conv3-128
Max pool
Conv3-256
Conv3-256
Conv3-256
Conv3-256
Max pool
Conv3-512
Conv3-512
Conv3-512
Conv3-512
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Conv3-512
Max pool
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Conv1-1000
Soft-max
VGG-19

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- VGG-19 has approximately 144M parameters.

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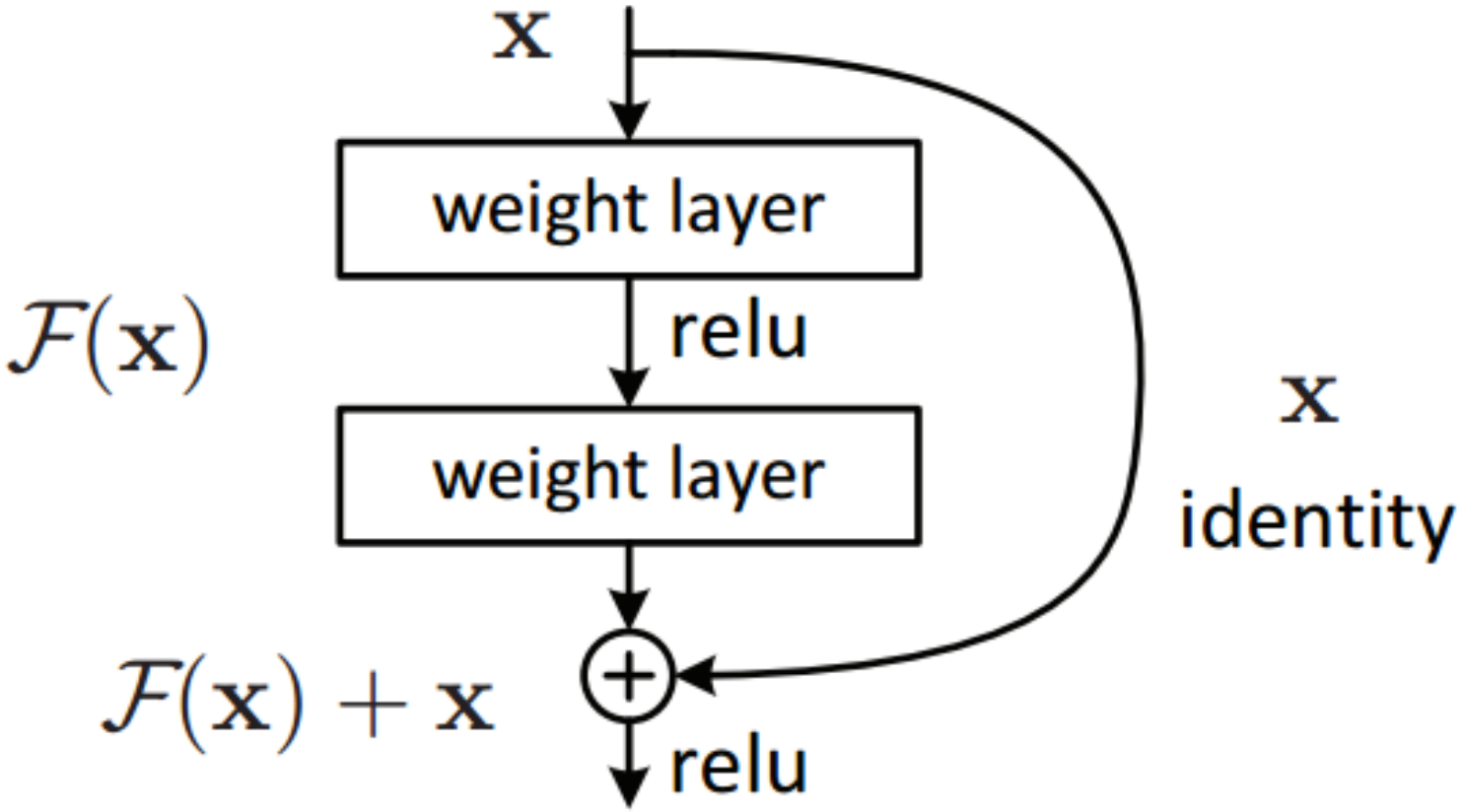
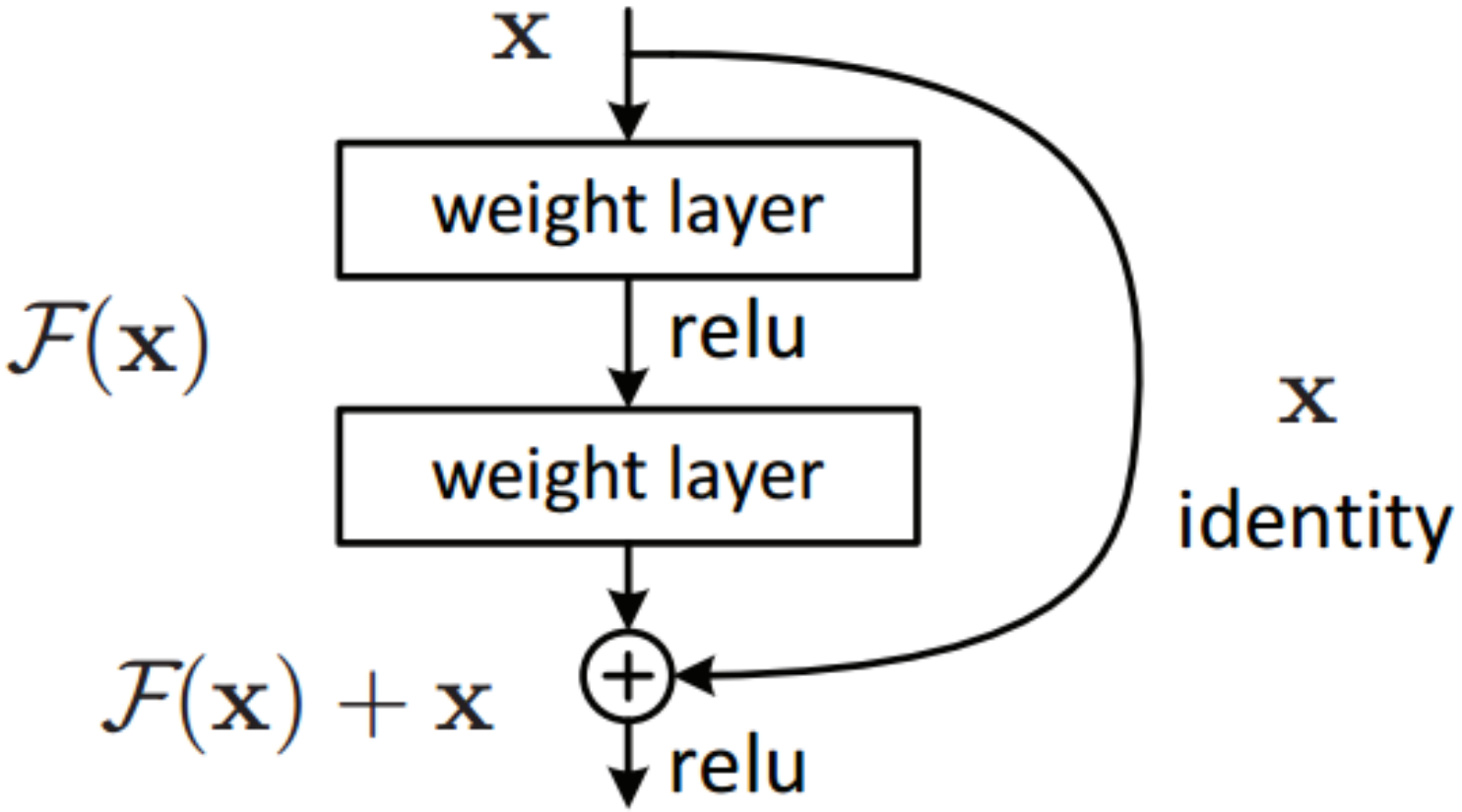
- VGG-19 has approximately 144M parameters.
- Accuracies on ImageNet: Top1=74.5%, Top5=92%.

Resnet-50 (2015)

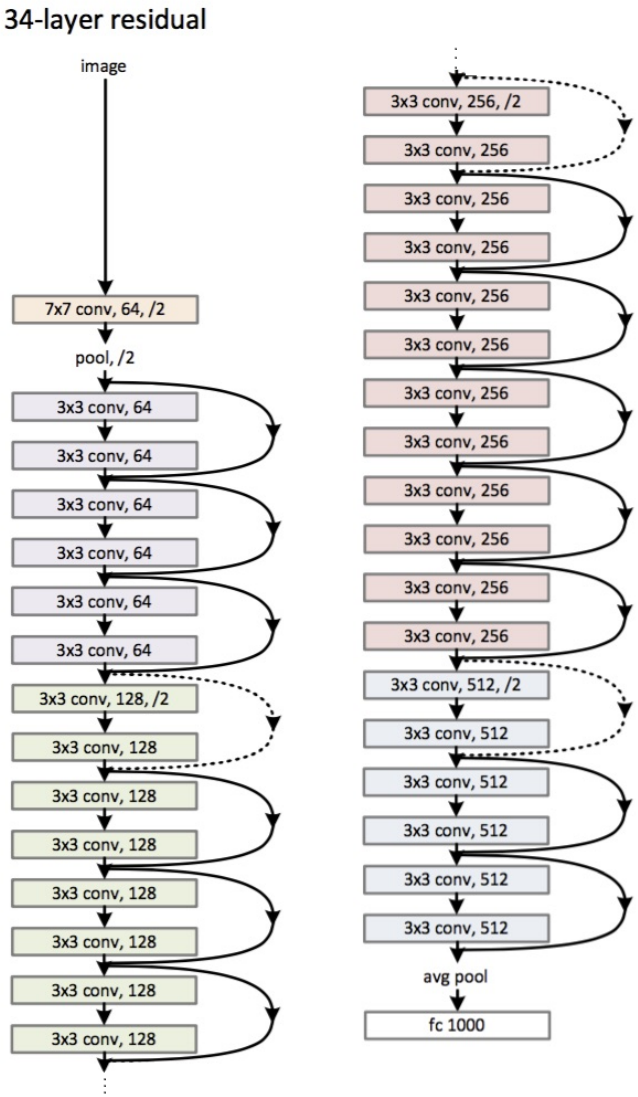


Resnet-50 (2015)



Identity function is easy to learn for residual block.

Resnet-50 (2015)



Resnet-50 (2015)

- Resnet-50 has approximately 25.6M parameters.

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- Accuracies on ImageNet: Top1=77.15%, Top5=93.29%.

GoogLeNet/Inception v1 (2014)

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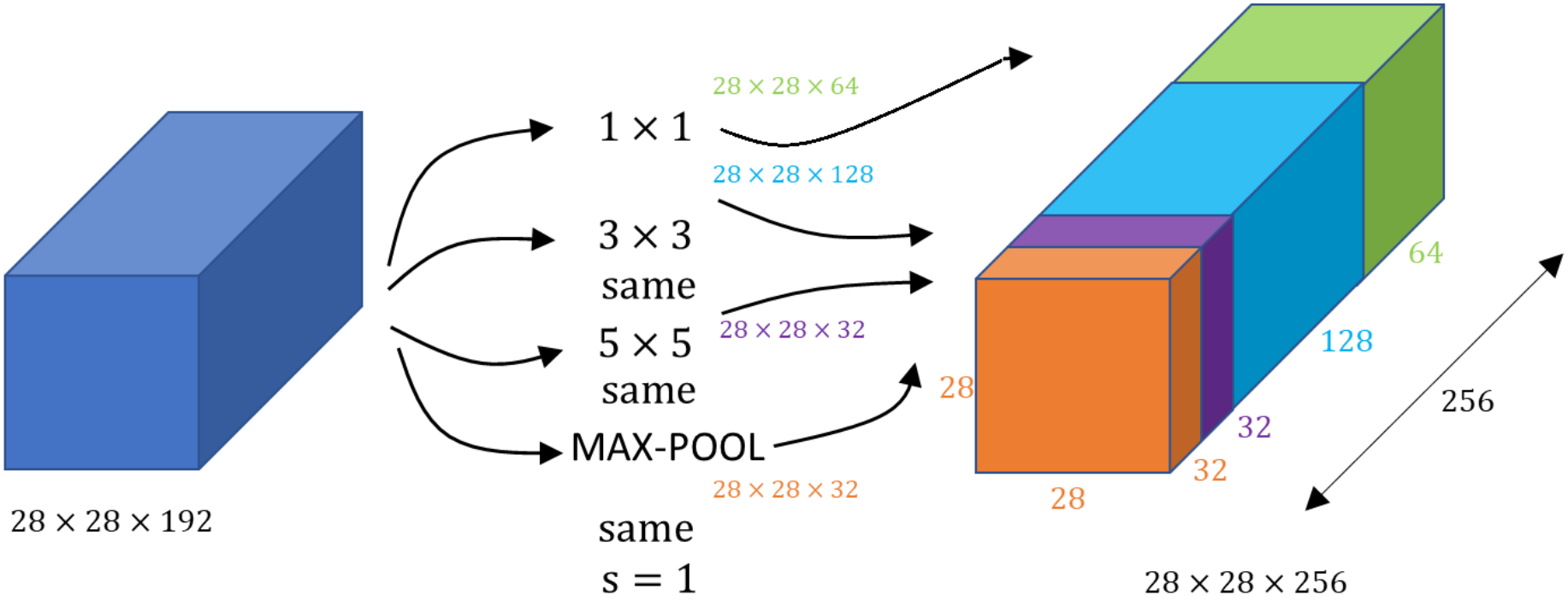
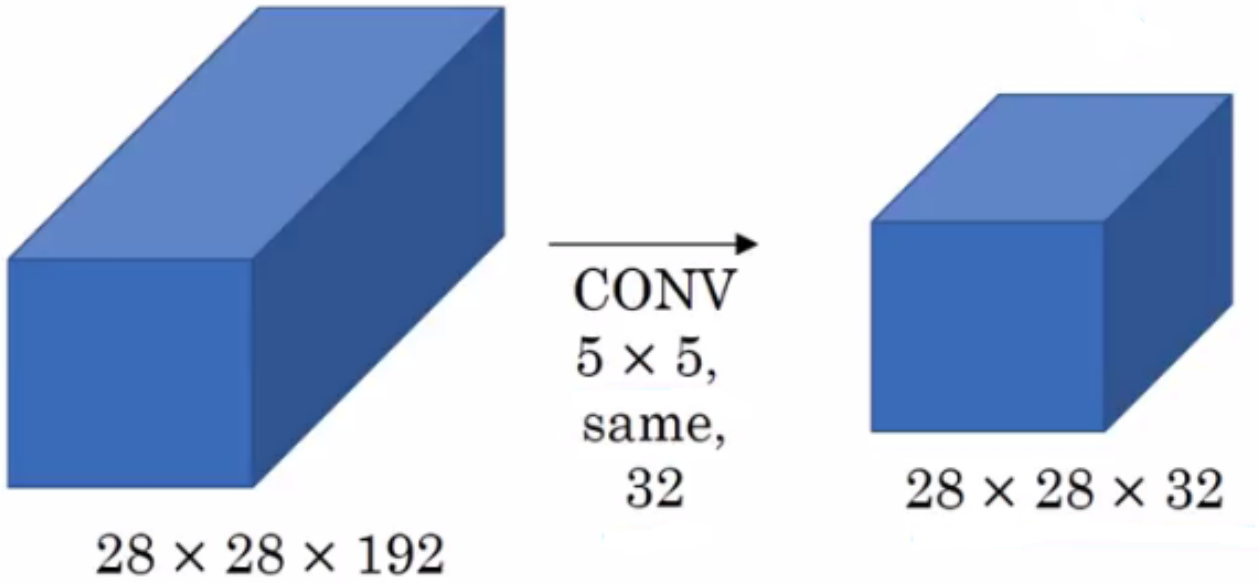


GoogLeNet/Inception v1 (2014)



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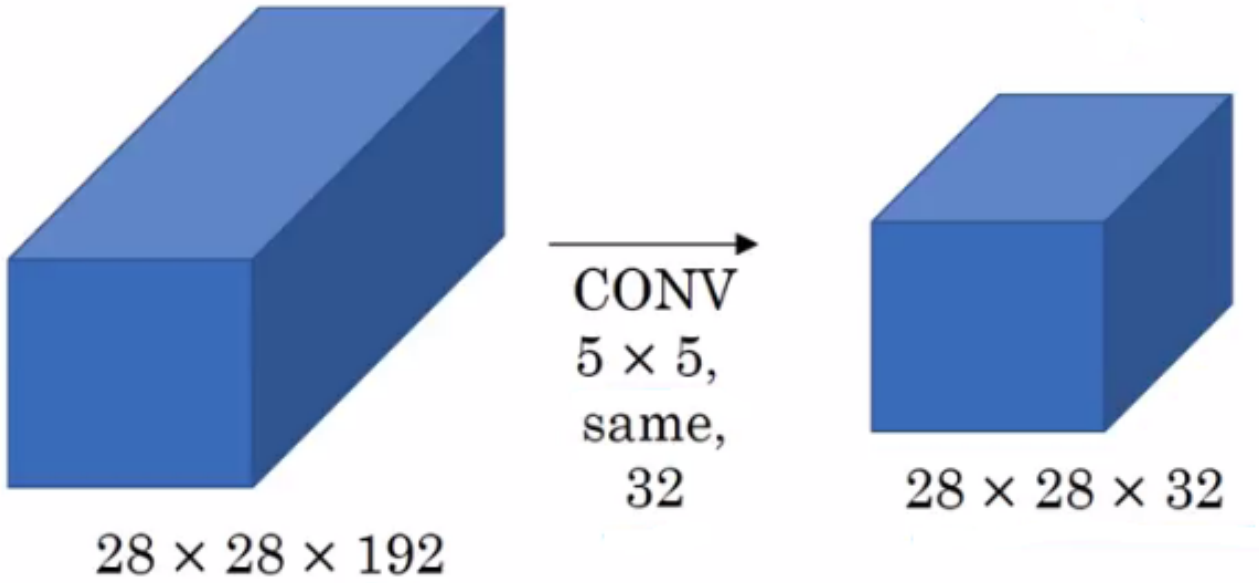

How much is the number of multiplications?

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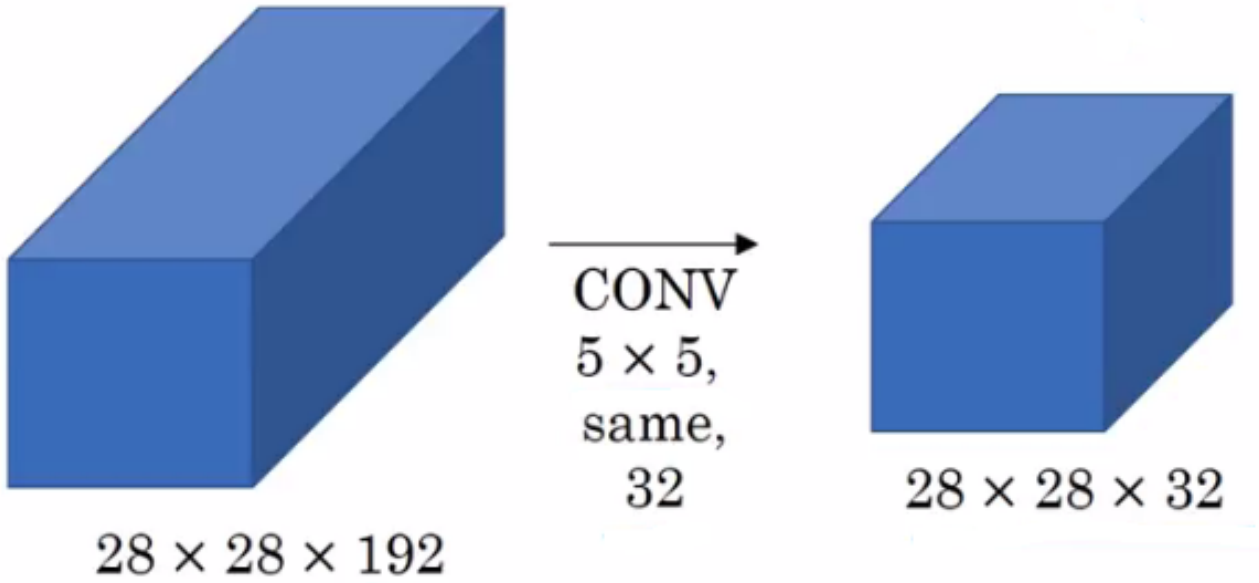
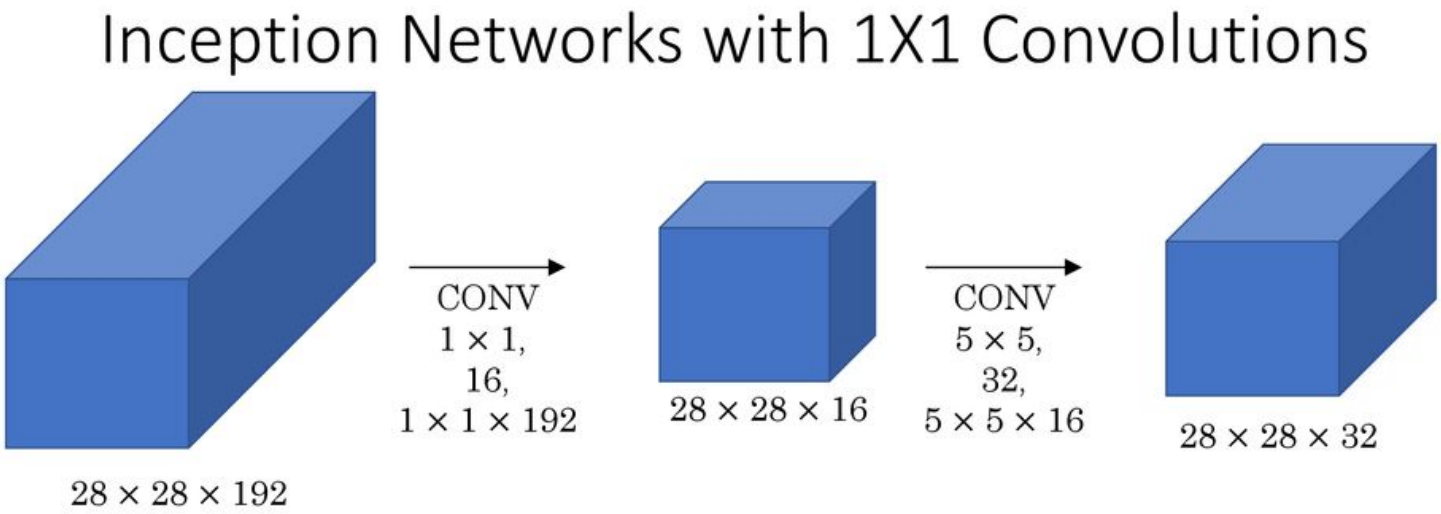


How much is the number of multiplications?

$$28 \cdot 28 \cdot 32 \cdot 5 \cdot 5 \cdot 192 \approx 120M$$

GoogLeNet/Inception v1 (2014)



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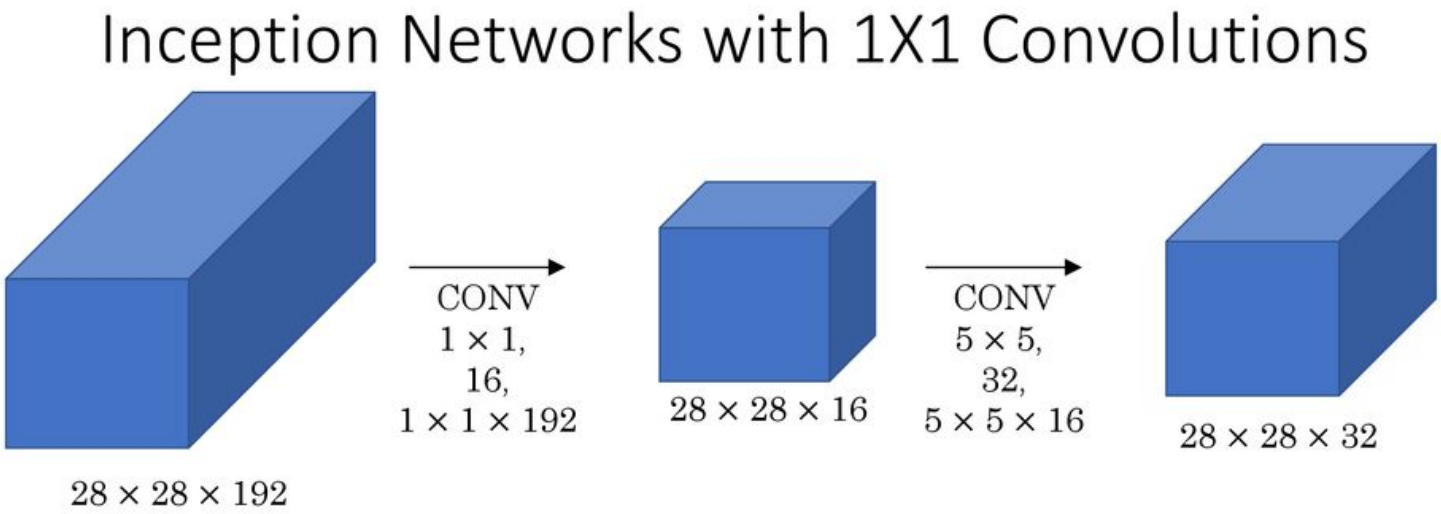

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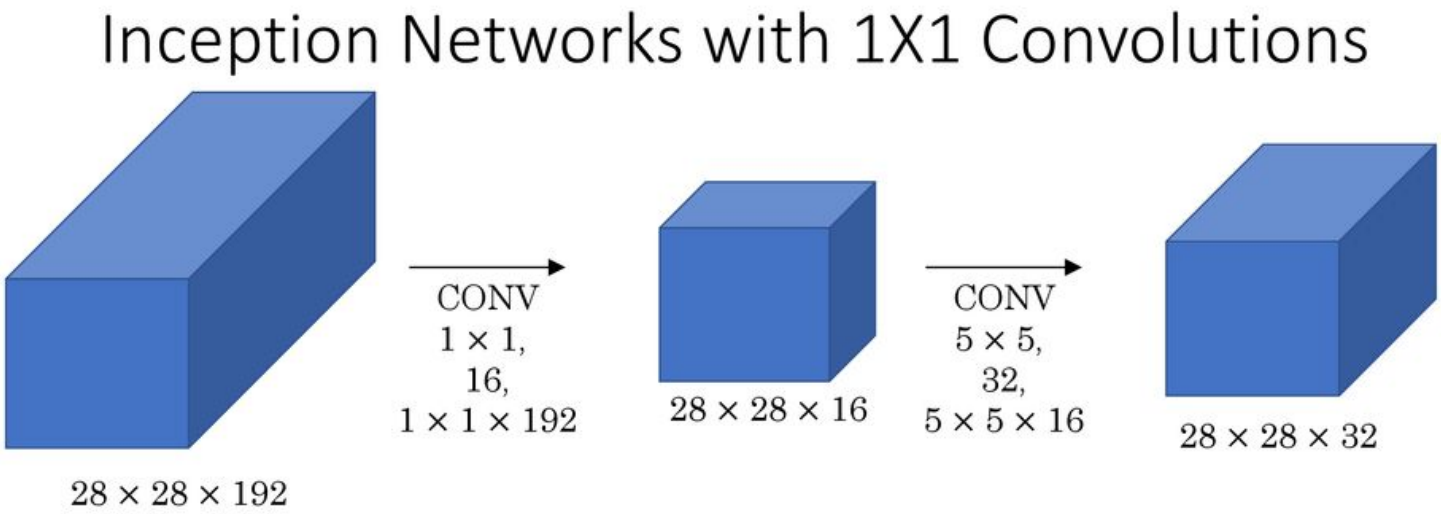
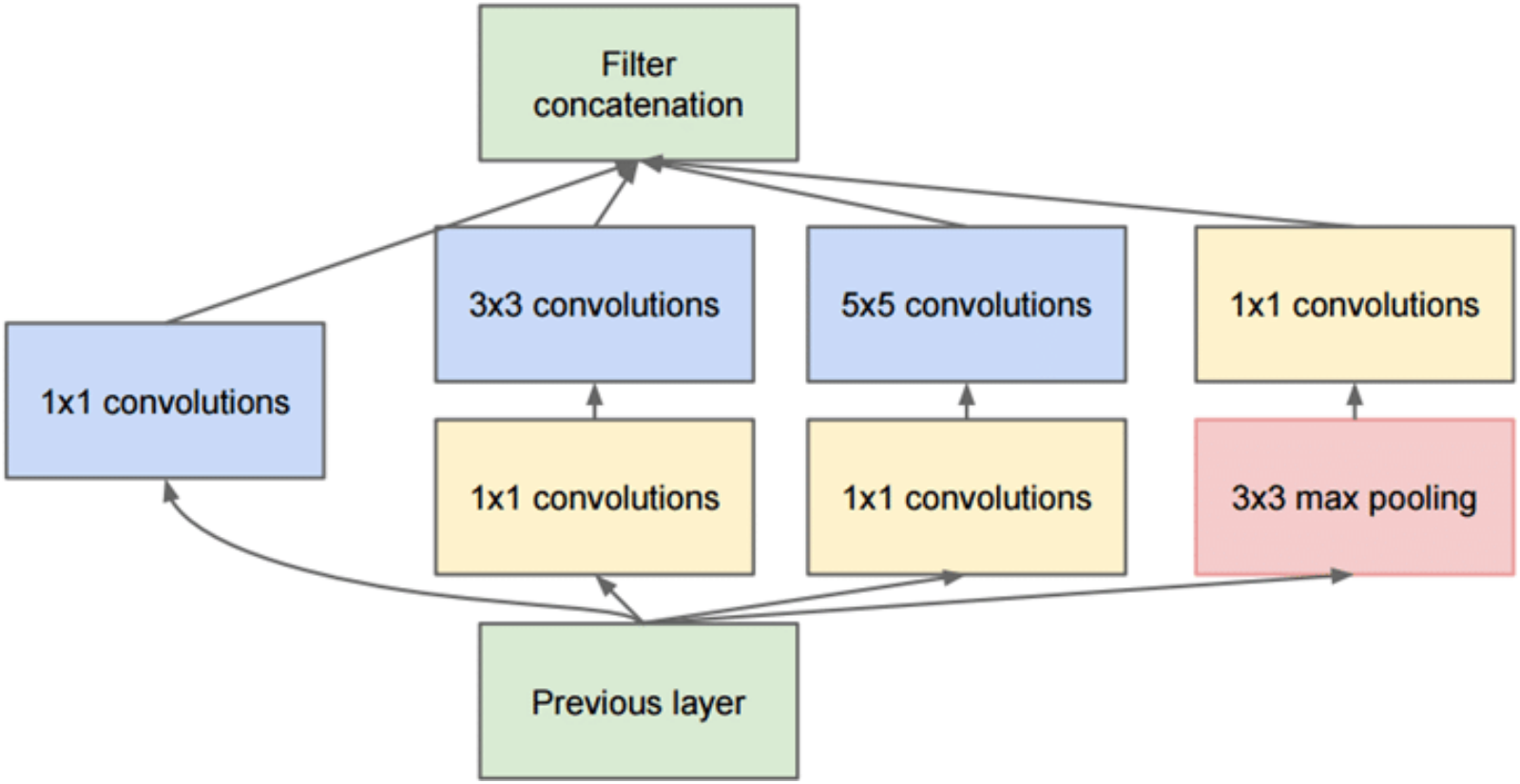


How much is the number of multiplications?

$$28 \cdot 28 \cdot 16 \cdot 1 \cdot 1 \cdot 192 + 28 \cdot 28 \cdot 32 \cdot 5 \cdot 5 \cdot 16 \approx 12.4M$$

GoogLeNet/Inception v1 (2014)



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