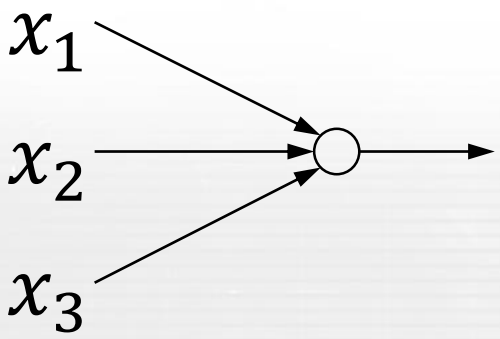
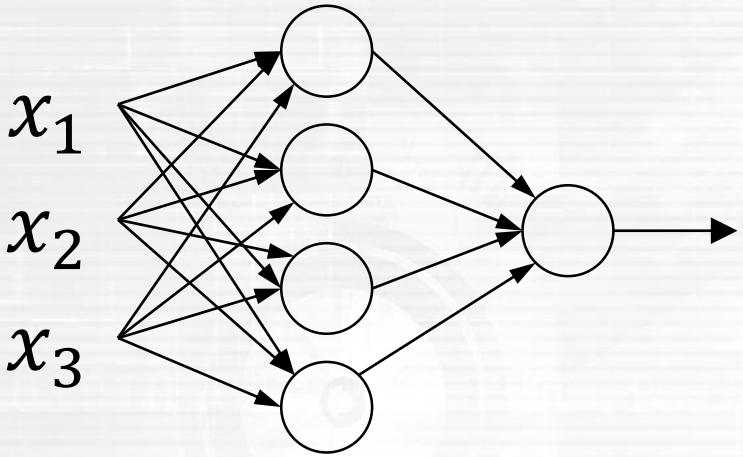
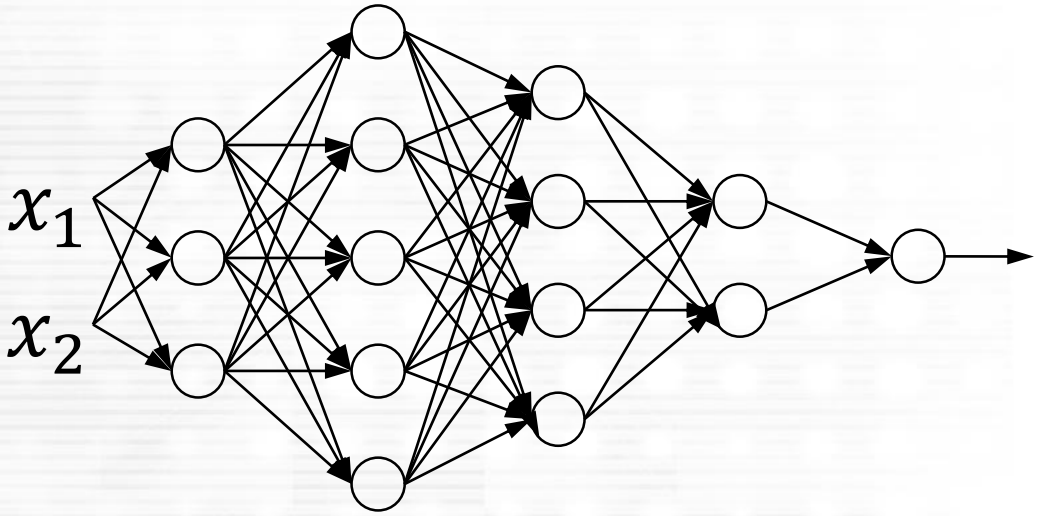
Classification

	Conventional methods	Deep Learning methods
Classification	Logistic regression Neural network Support vector machine Random forest	Deep neural network Convolutional neural network

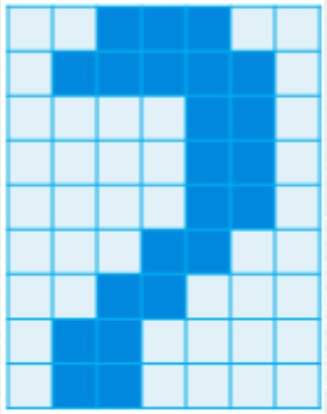
Neural Network

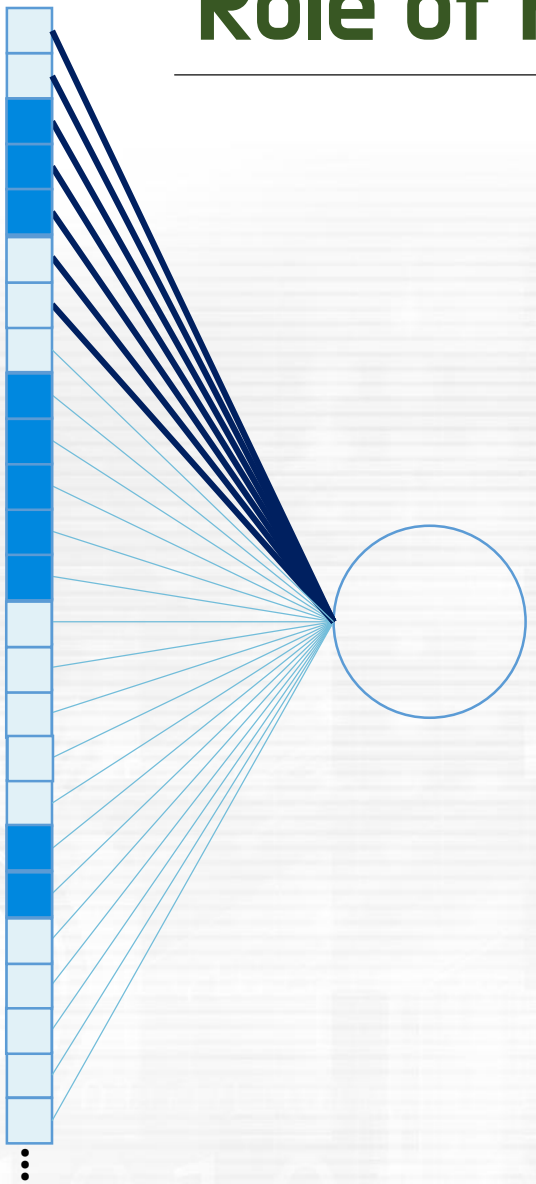




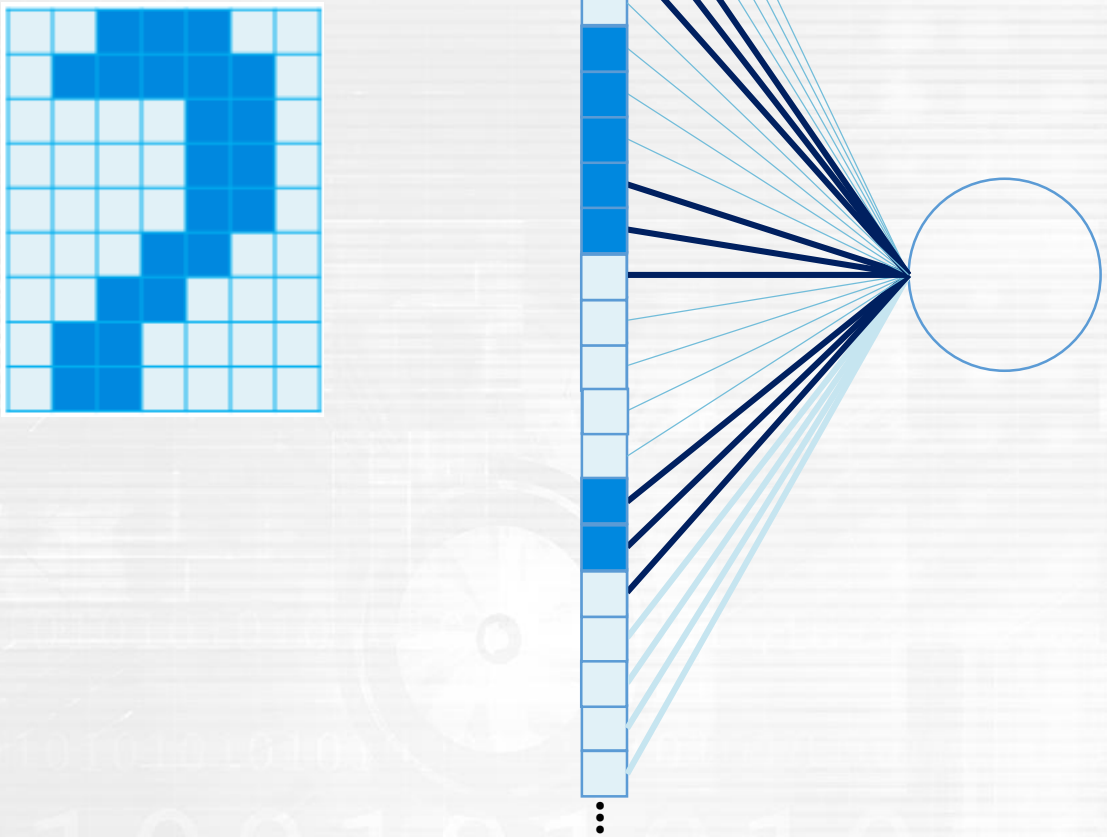


Role of Hidden Layer

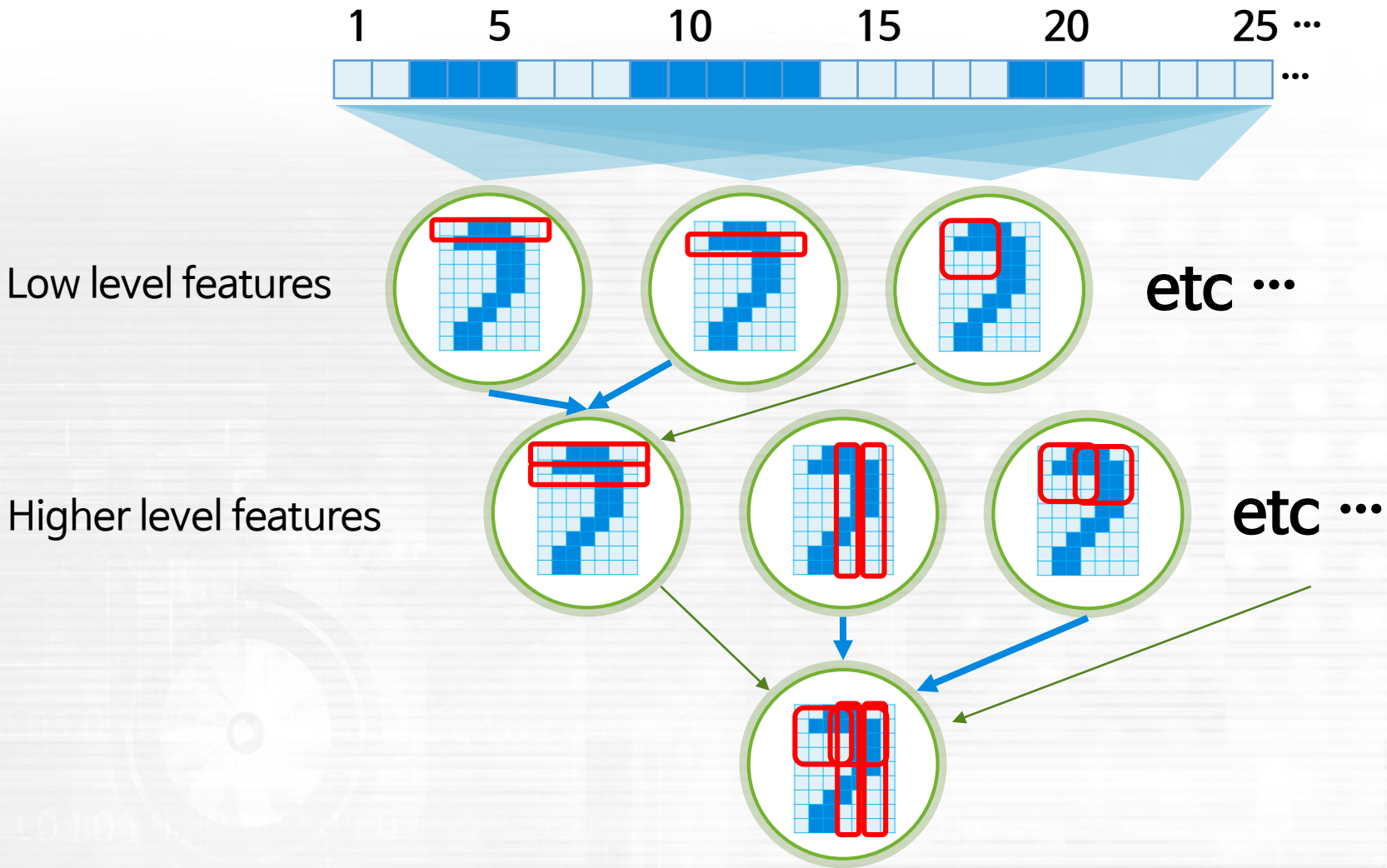




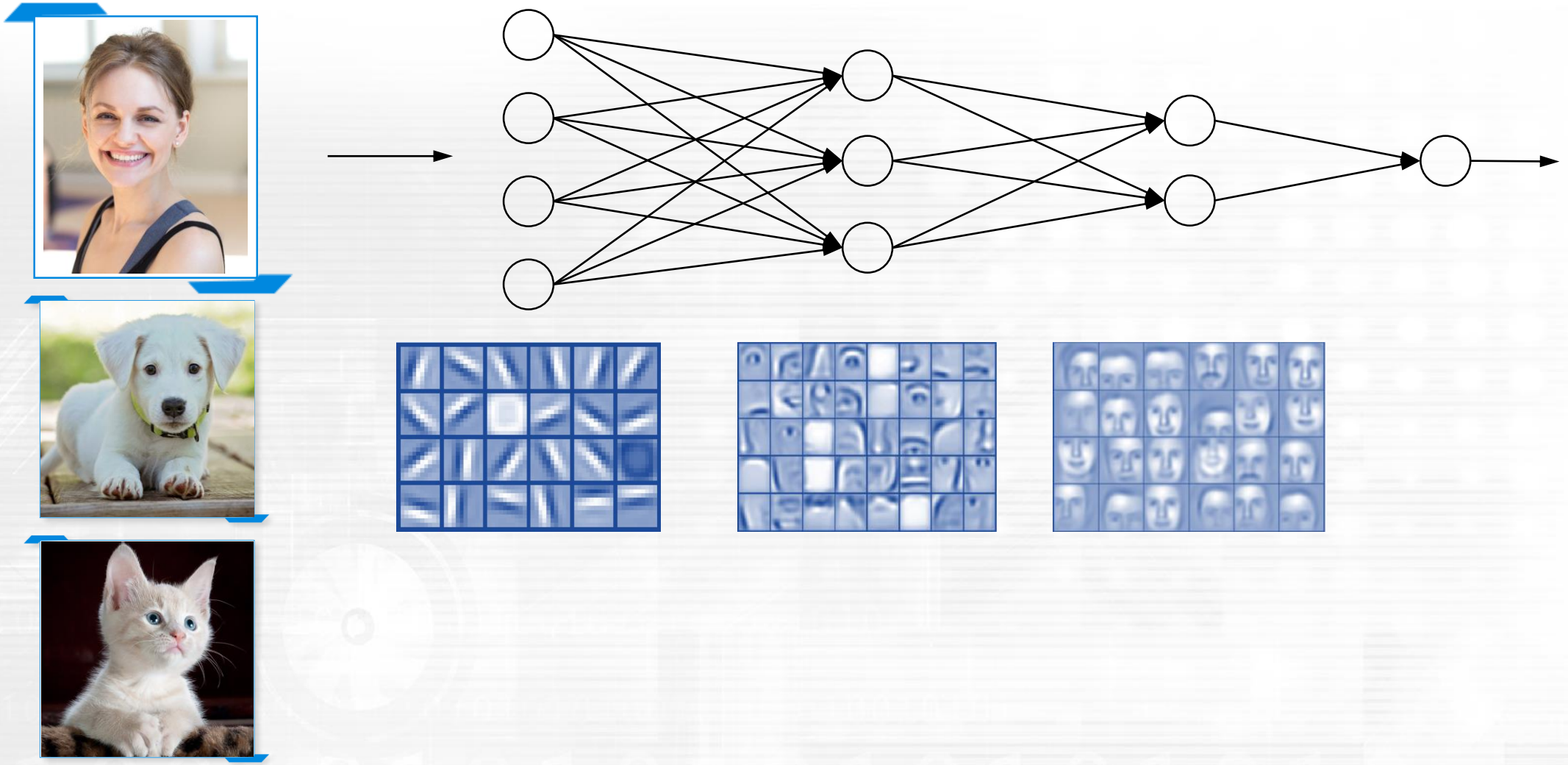
Role of Hidden Layer



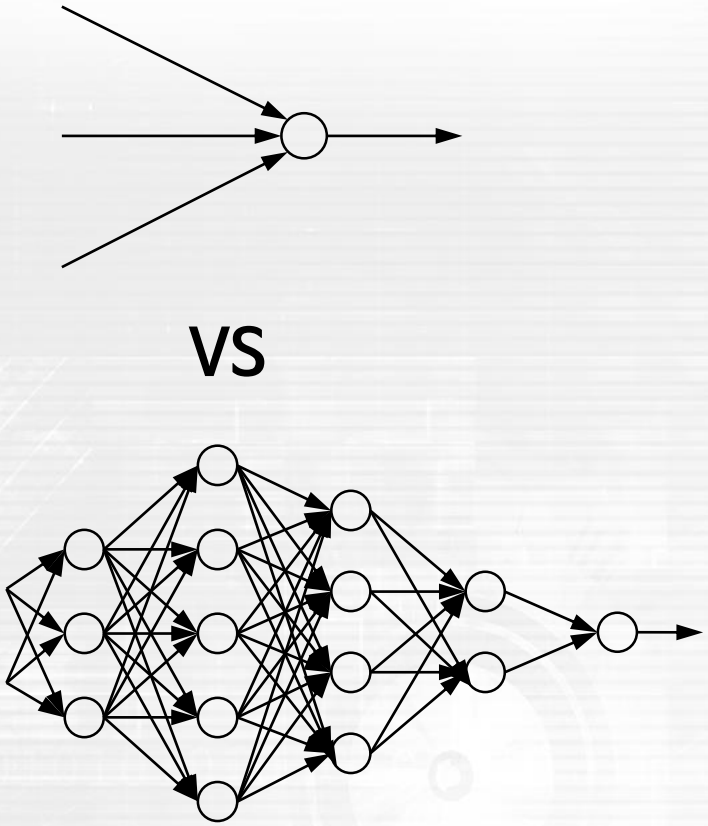
Role of Deep Hidden Layers

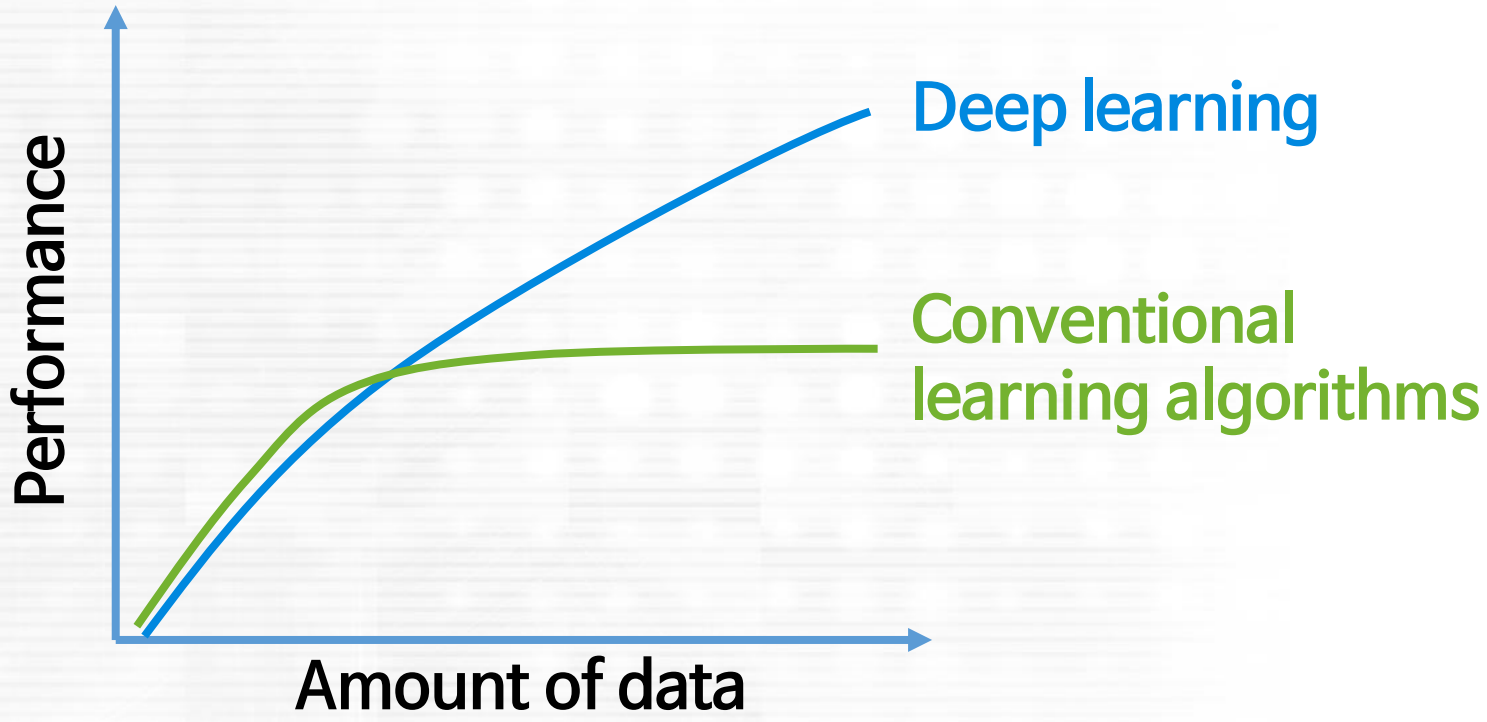


Deep Neural Network



Performance Change depending on Data Size





Limitation of Deep Neural Network

Convolution

9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0

$*$

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

$=$

9	6	3	0
9	6	3	0
9	6	3	0
9	6	3	0

Convolution

9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0
9	9	9	0	0	0

$*$

-1/9	-1/9	-1/9
-1/9	17/9	-1/9
-1/9	-1/9	-1/9

$=$

9	12	-3	0
9	12	-3	0
9	12	-3	0
9	12	-3	0

Convolution

Original

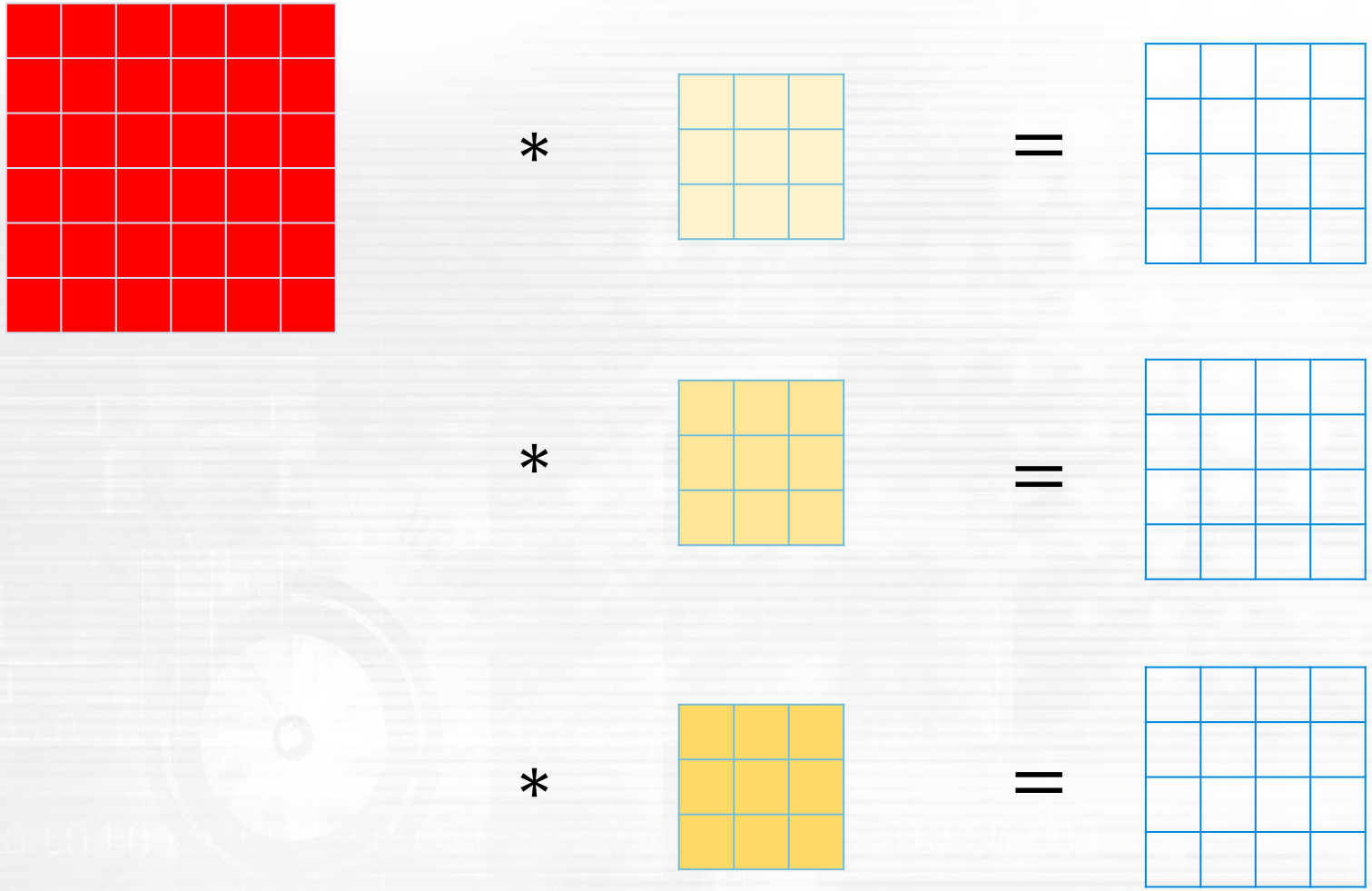
1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

0	1	0
1	−4	1
0	1	0

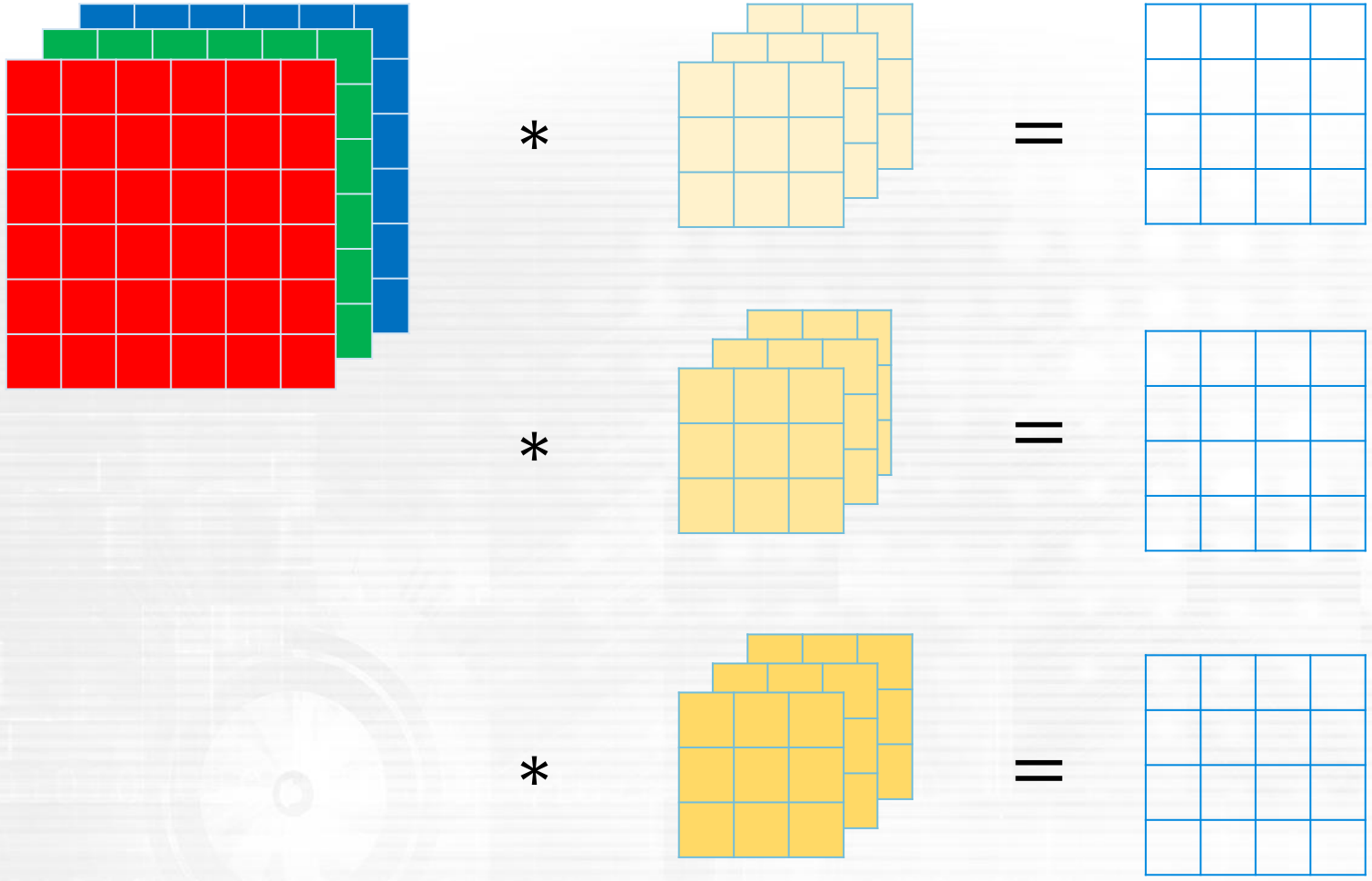
−1/9	−1/9	−1/9
−1/9	17/9	−1/9
−1/9	−1/9	−1/9



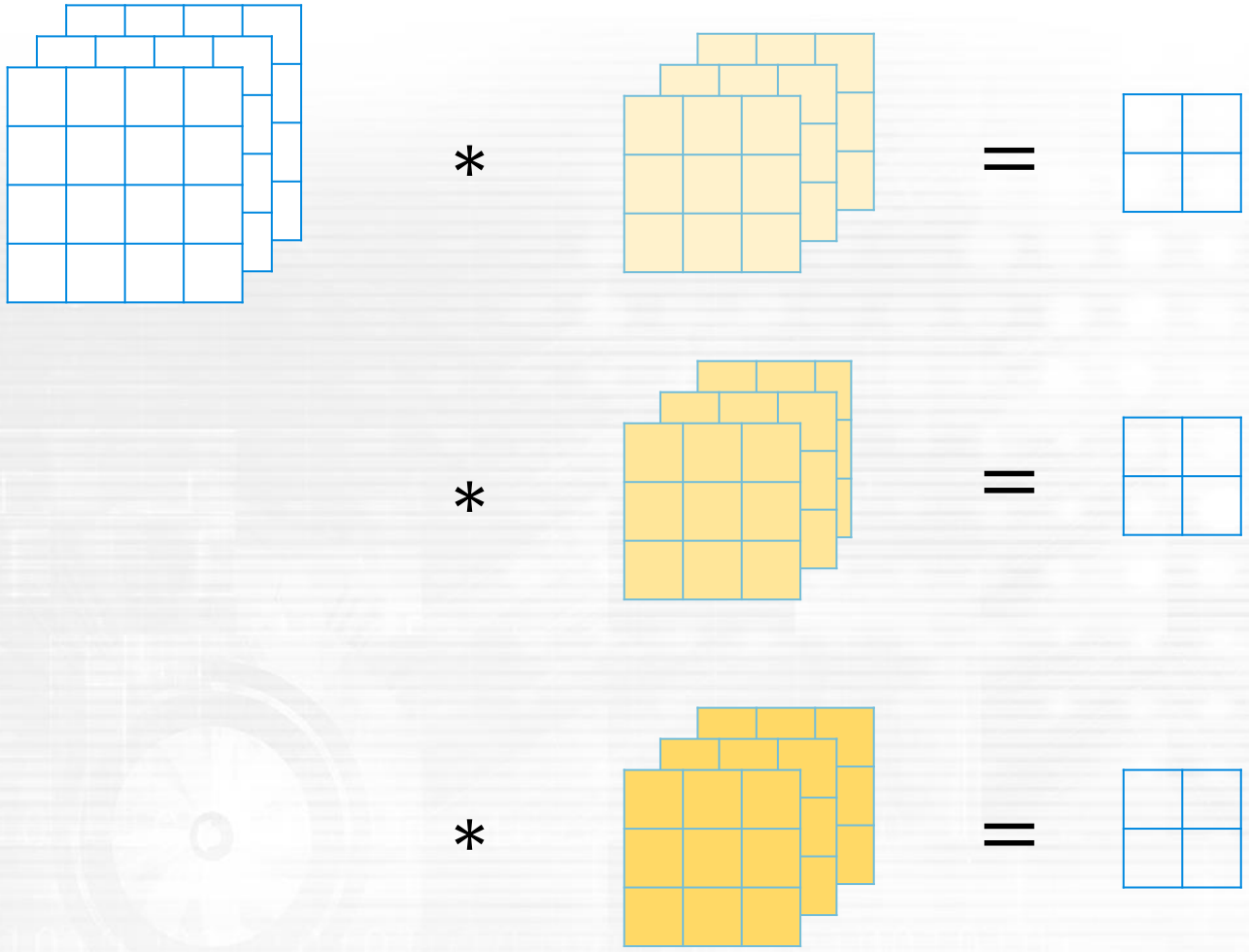

Convolutional Layer



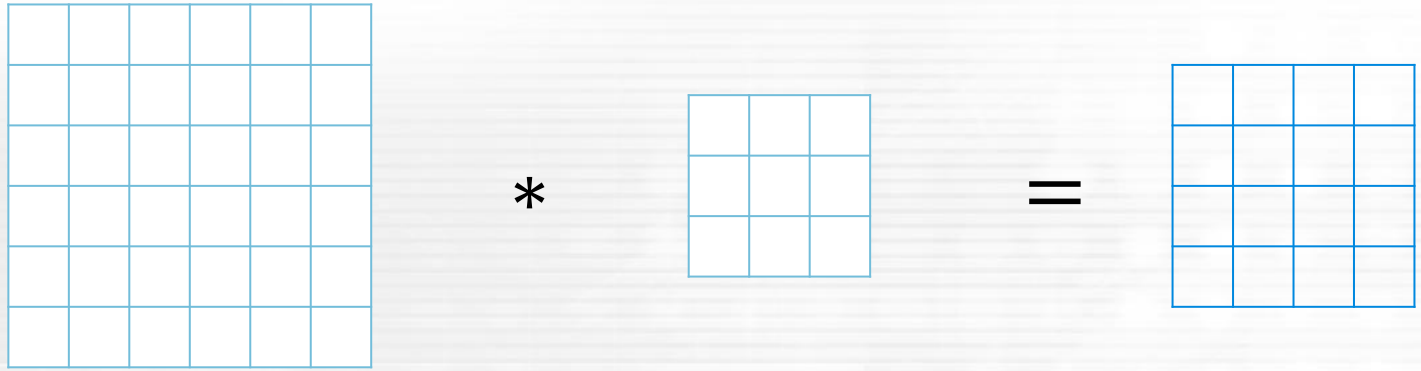
Convolutional Layer

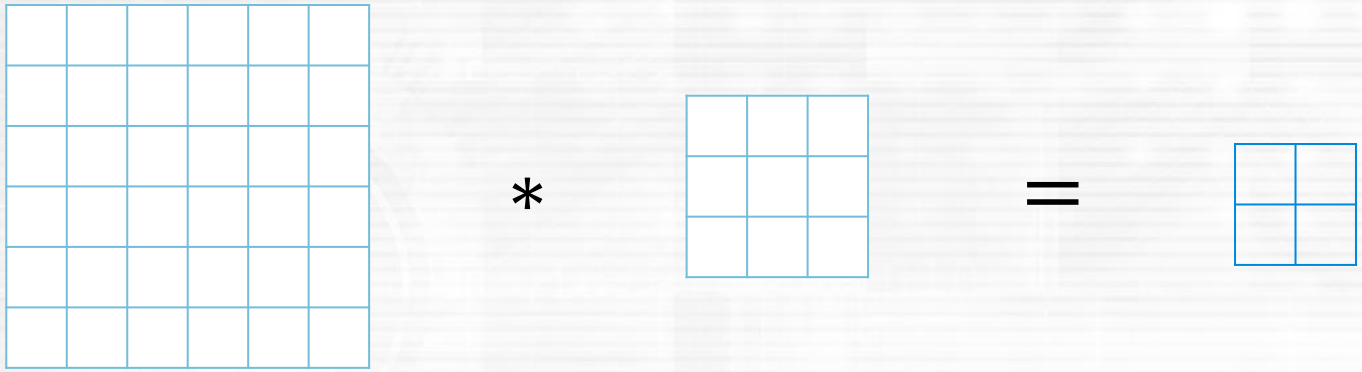


Convolutional Layer

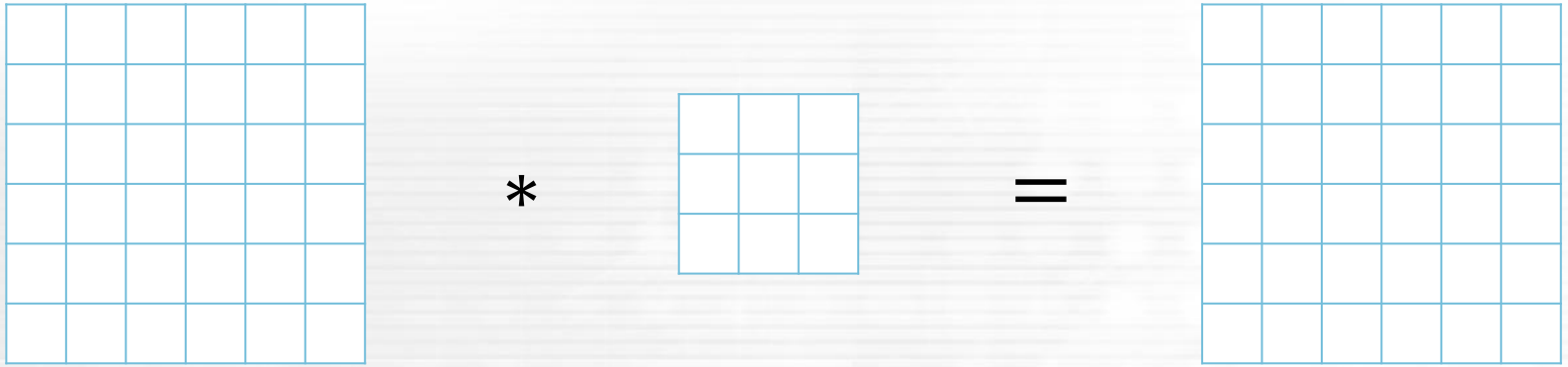


Strided Convolution





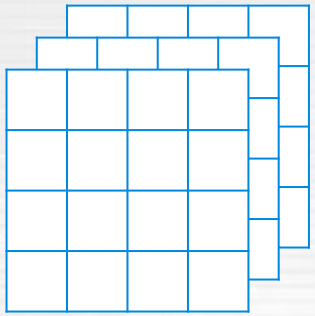
Padding

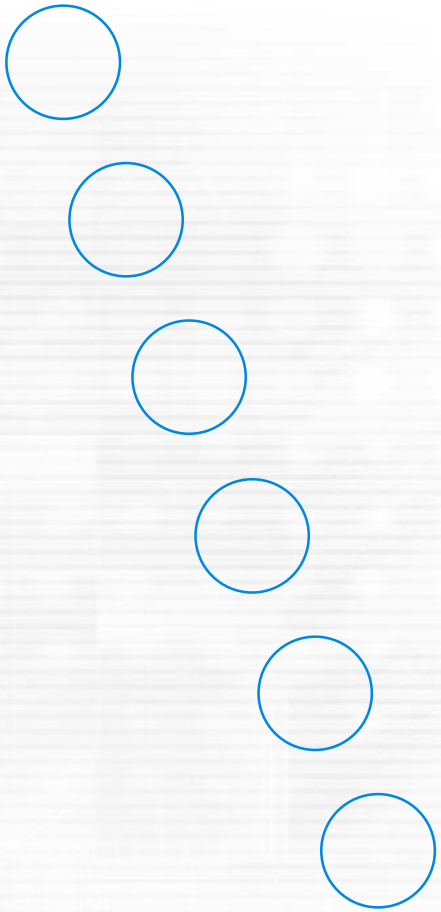


Pooling Layer

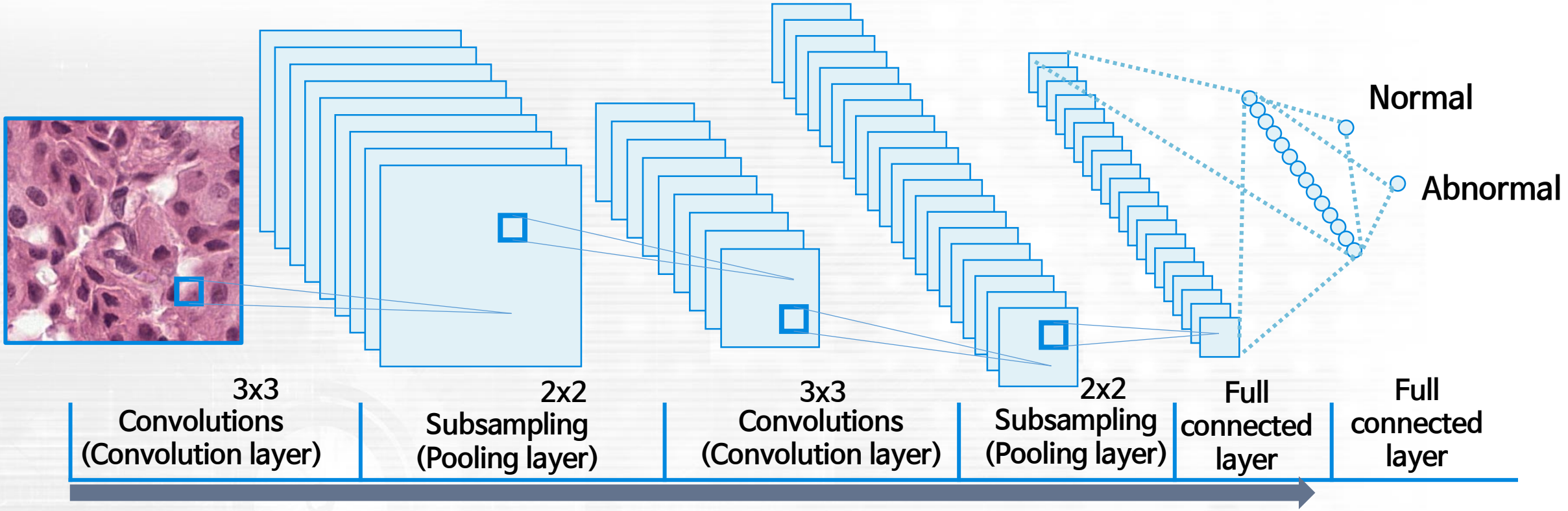
1	2	4	4
2	3	8	4
1	3	1	3
2	6	9	3

Fully Connected Layer





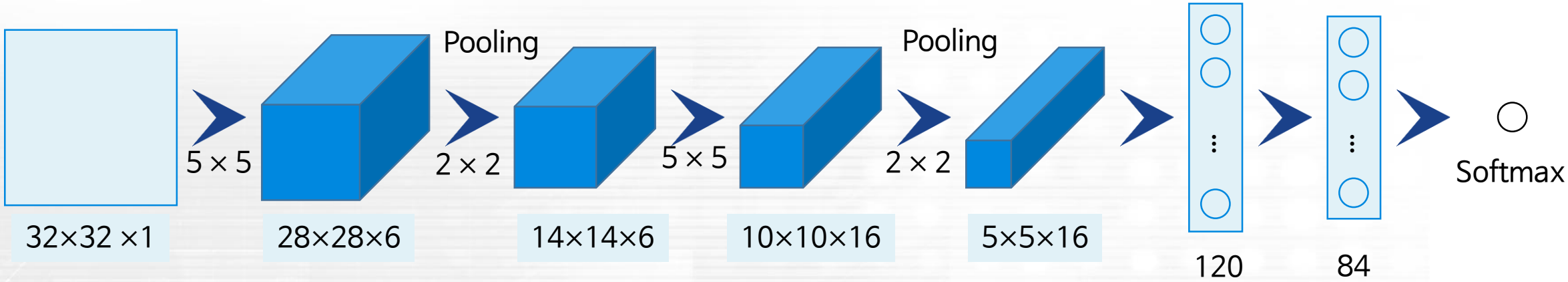
Convolutional Neural Network



Convolutional Neural Networks

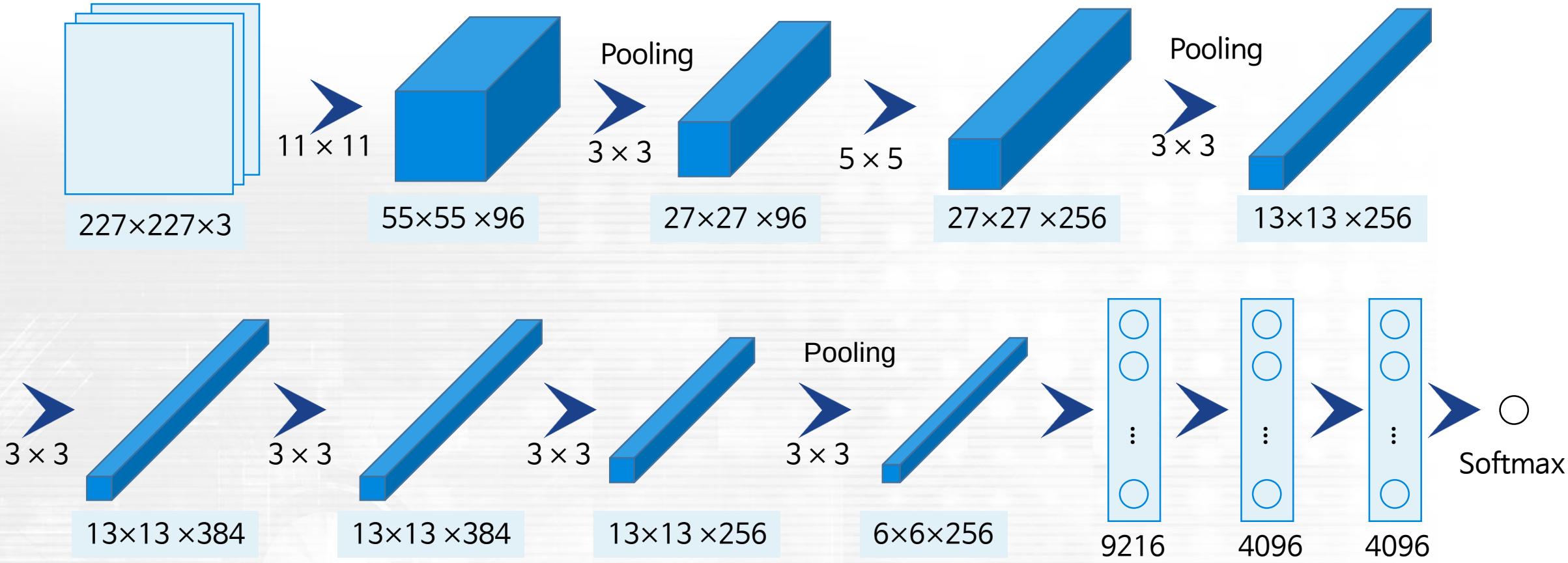
- LeNet-5
- AlexNet
- VGG
- ResNet
- Inception
- DenseNet

LeNet - 5



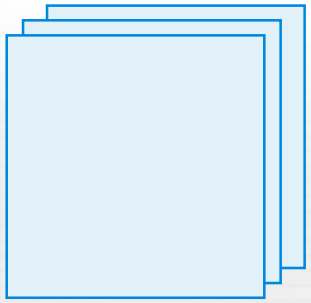
출처 LeCun et al., 1998. Gradient-based learning applied to document recognition

AlexNet



출처 Krizhevsky et al., 2012. ImageNet classification with deep convolutional neural networks

VGG - 16



224×224×3

3 × 3 twice

224×224×64

Pooling

112×112 ×64

3 × 3 twice

112×112 ×128

Pooling

56×56 ×128

3 × 3 twice

56×56 ×256

Pooling

28×28 ×256

3 × 3 twice

28×28 ×512

Pooling

14×14×512

3 × 3 twice

14×14 ×512

Pooling

7×7×512

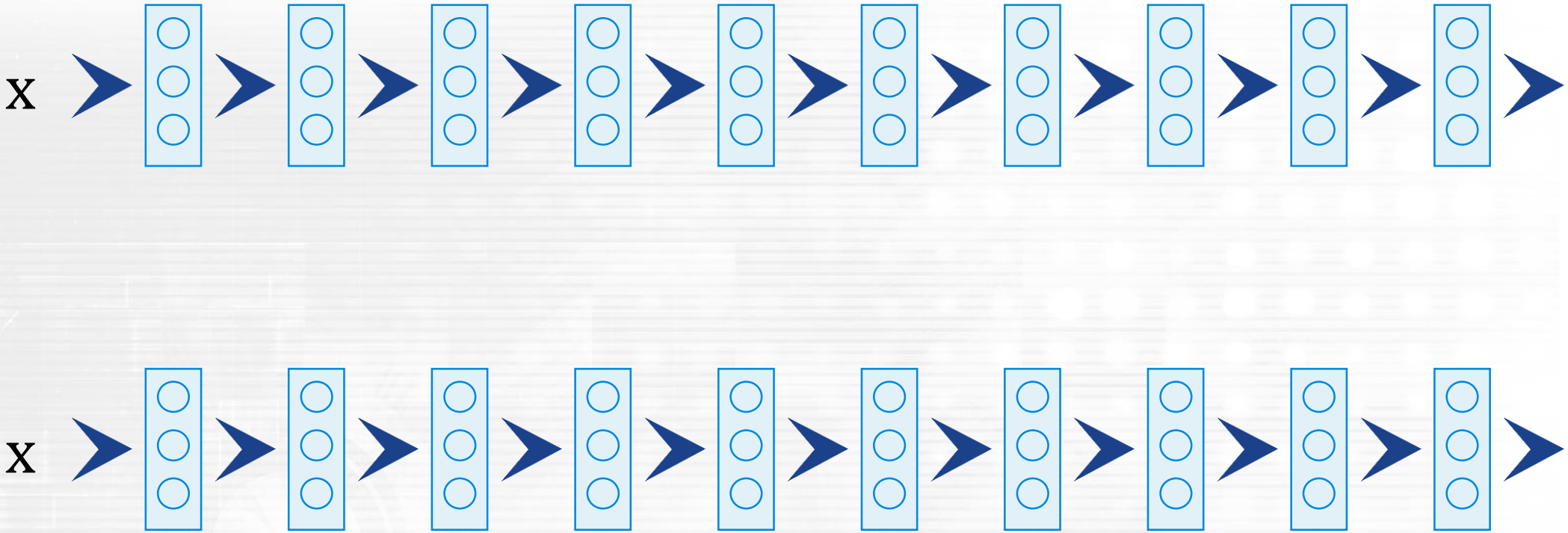
FC 4096

FC 4096

Softmax

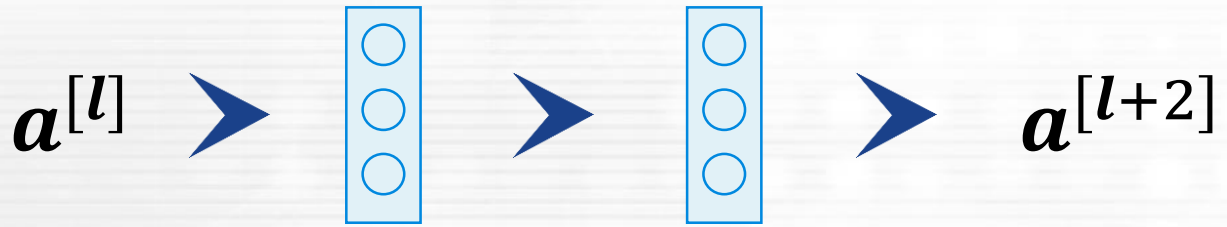
출처 Simonyan & Zisserman 2015. Very deep convolutional networks for large-scale image recognition

Residual Network



출처 He et al., 2015. Deep residual networks for image recognition

Residual Block



$$z^{[l+1]} = W^{[l+1]}\, a^{[l]} + b^{[l+1]}$$

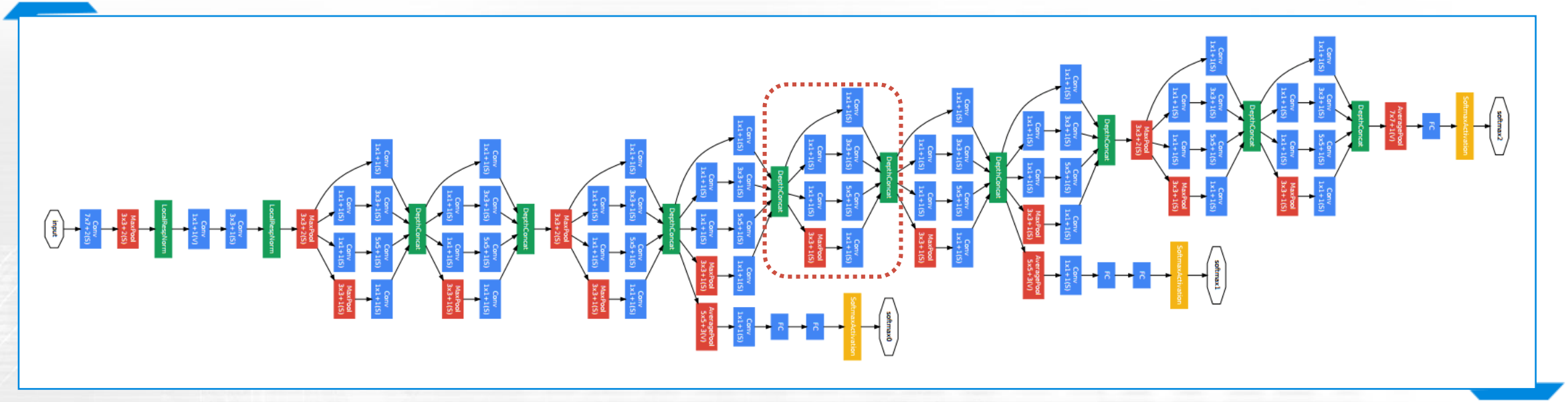
$$a^{[l+1]} = g(z^{[l+1]})$$

$$z^{[l+2]} = W^{[l+2]} a^{[l+1]} + b^{[l+2]}$$

$$a^{[l+2]} = g(z^{[l+2]} + a^{[l]})$$

출처 He et al., 2015. Deep residual networks for image recognition

Inception Network



출처 Szegedy et al., 2014, Going Deeper with Convolutions

Inception Module

28×28×192

Previous Activation

1 × 1 CONV

1 × 1 CONV

3 × 3 CONV

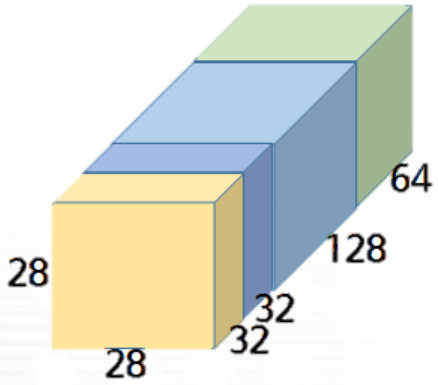
1 × 1 CONV

5 × 5 CONV

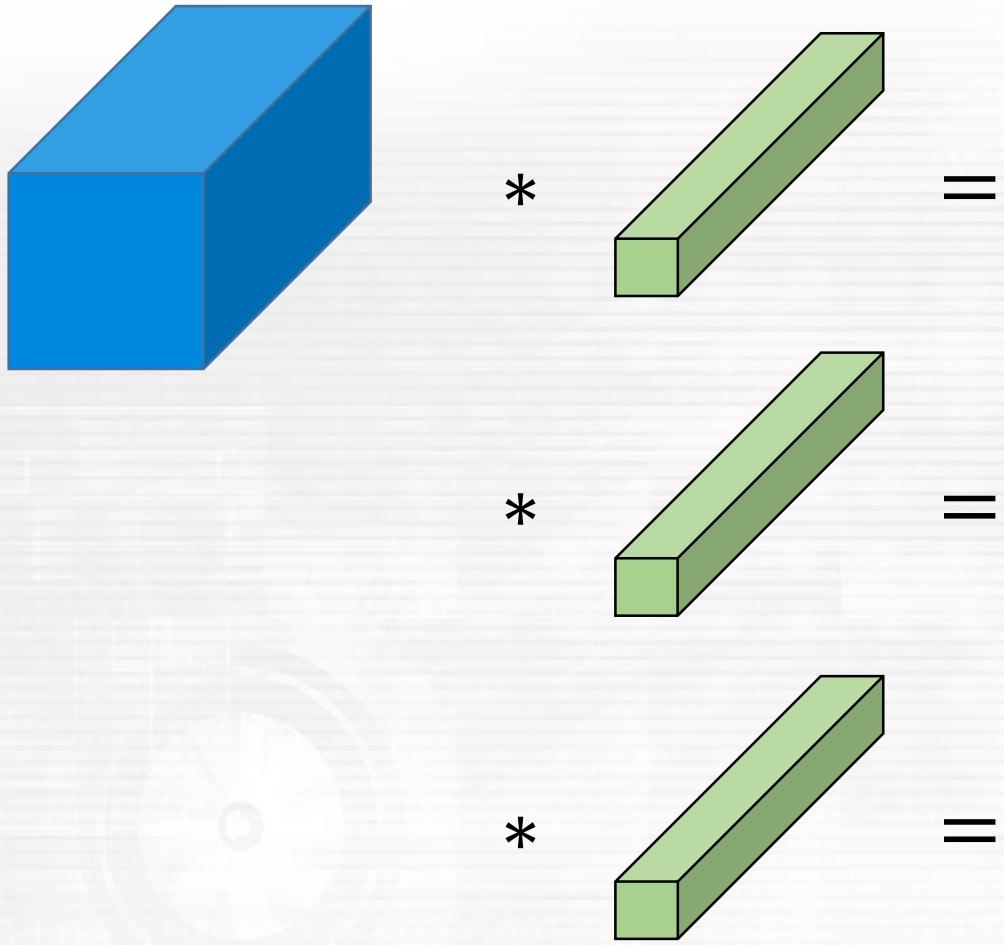
MAXPOOL 3 × 3,s = 1 same

1 × 1 CONV

Channel Concat

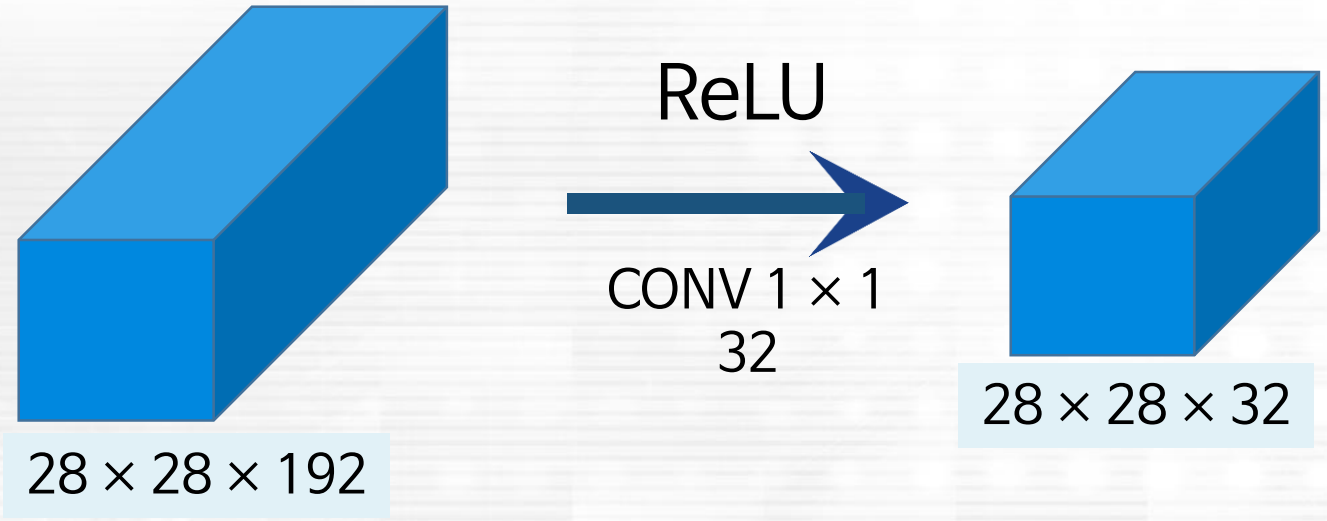


1 X 1 convolution



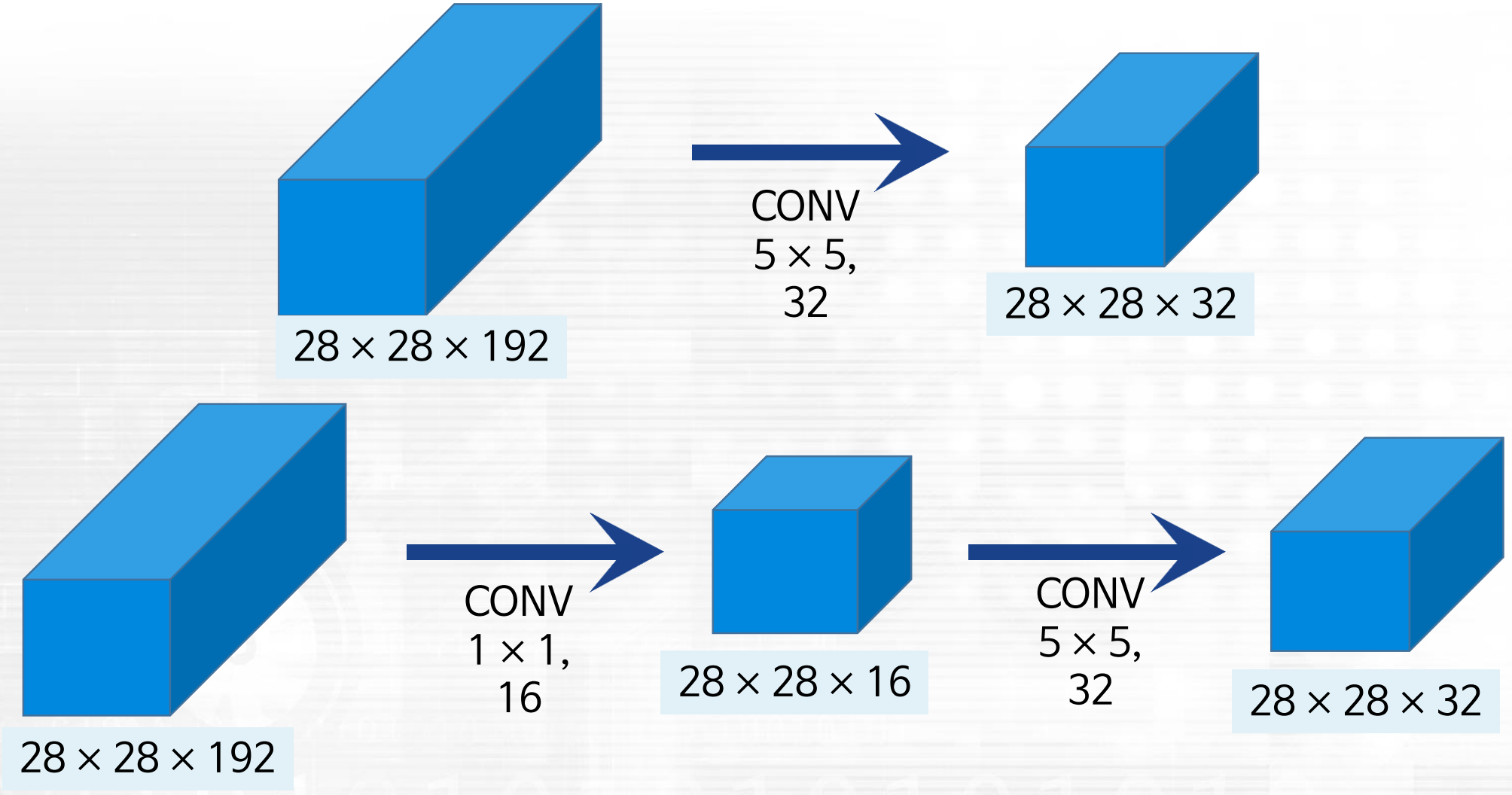
출처 Lin et al., 2013. Network in network

1 X 1 convolution

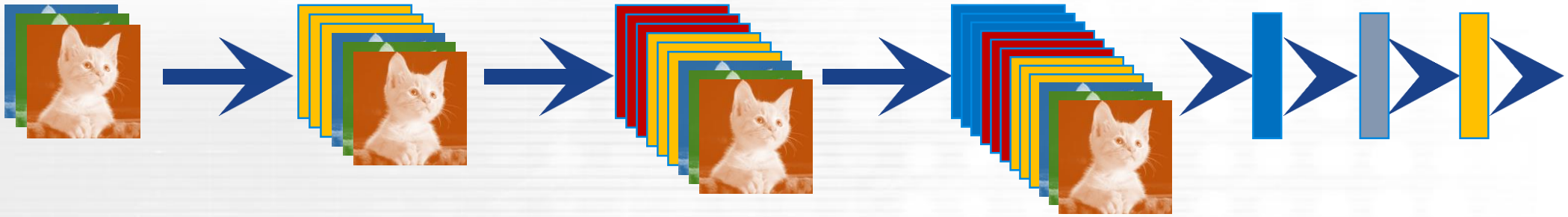


출처 Lin et al., 2013. Network in network

1 X 1 convolution

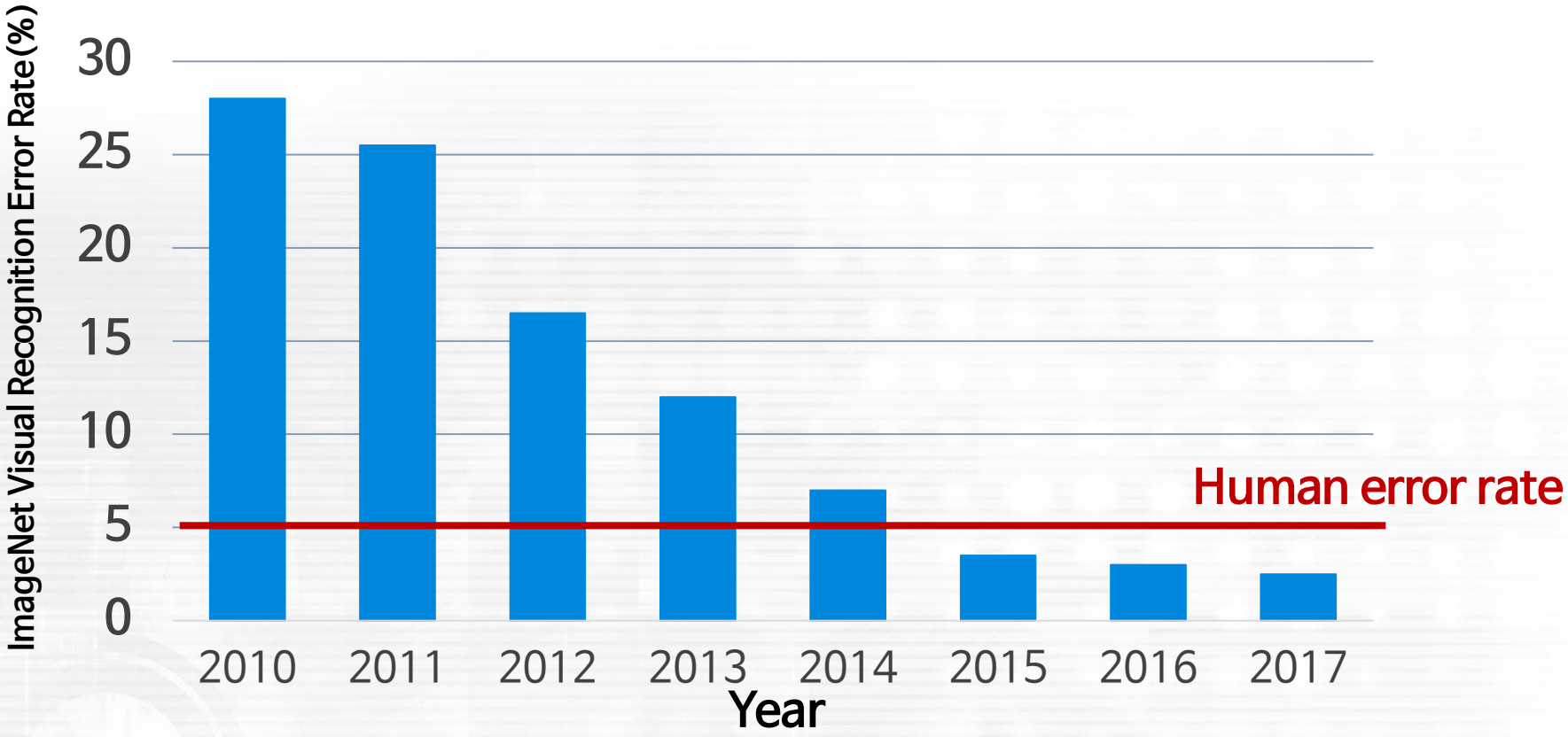


Dense Network



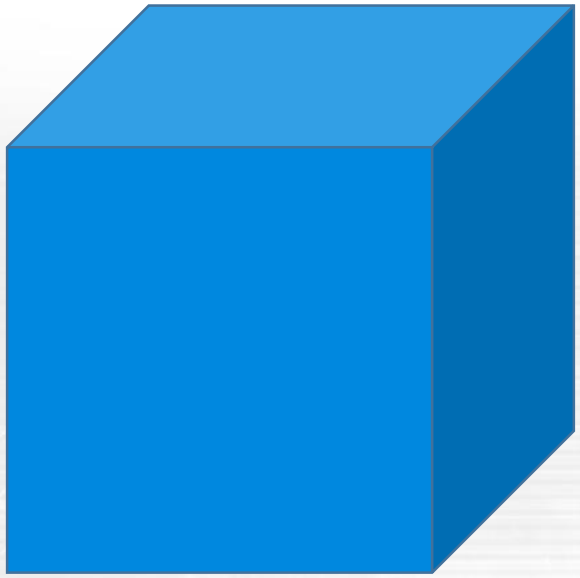
출처 Huang, Gao, et al., 2017, Densely connected convolutional networks

Performance Changes



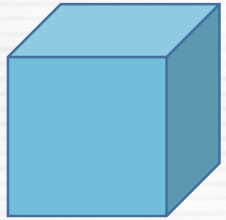
Error rates on the ImageNet Large-Scale Visual Recognition Challenge. Accuracy dramatically improved with the introduction of deep learning in 2012 and continued to improve thereafter. Human perform with an error rate of approximately 5%

Convolutions in 3D



3D volume

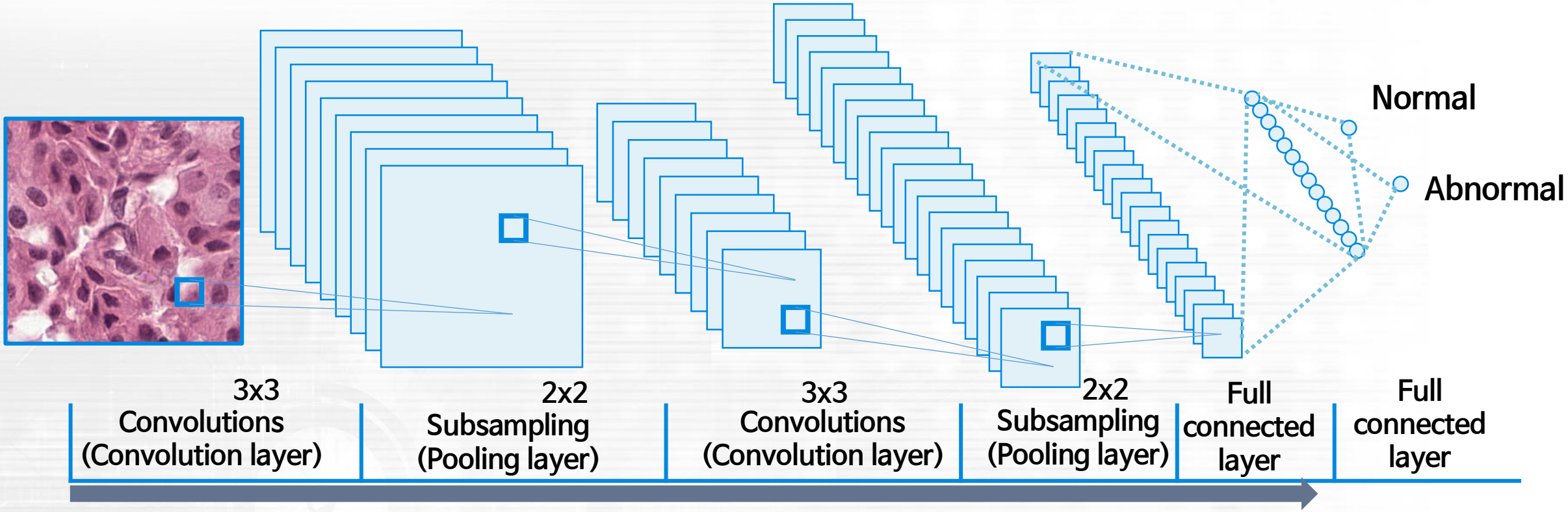
*



3D filter

3D CNN with Demographic Scores

End to End Learning



CNN with Preprocessing