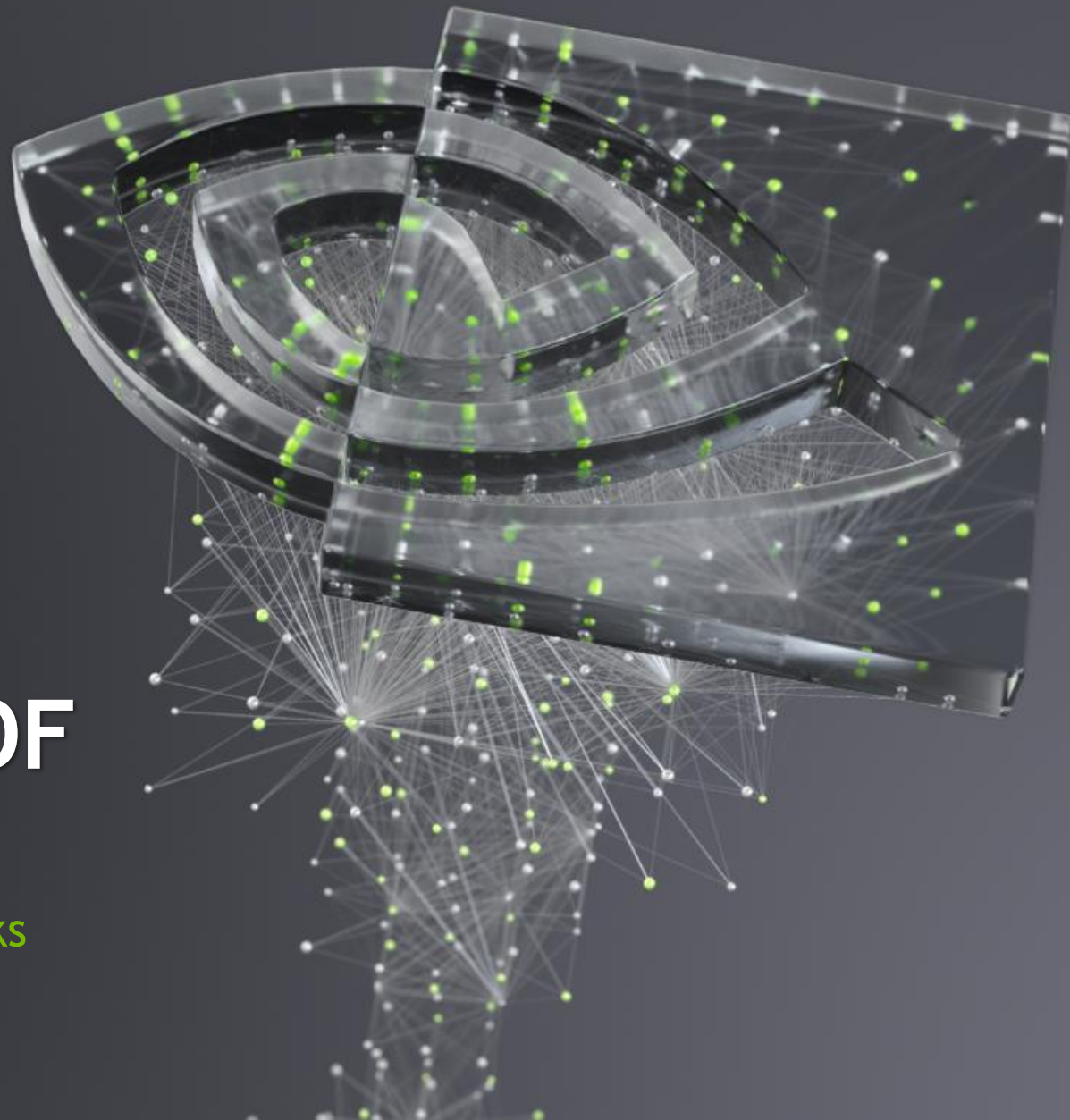




DEEP  
LEARNING  
INSTITUTE

# FUNDAMENTALS OF DEEP LEARNING

Part 3: Convolutional Neural Networks



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# AGENDA

Part 1: An Introduction to Deep Learning

Part 2: How a Neural Network Trains

Part 3: Convolutional Neural Networks

Part 4: Data Augmentation and Deployment

Part 5: Pre-trained Models

Part 6: Advanced Architectures

# AGENDA – PART 3

- Kernels and Convolution
- Kernels and Neural Networks
- Other Layers in the Model

# RECAP OF THE EXERCISE

Trained a dense neural network model



Training accuracy was high



Validation accuracy was low



Evidence of overfitting



# KERNELS AND CONVOLUTION

# KERNELS AND CONVOLUTION



Original Image



Blur



Sharpen



Brighten



Darken





# KERNELS AND CONVOLUTION

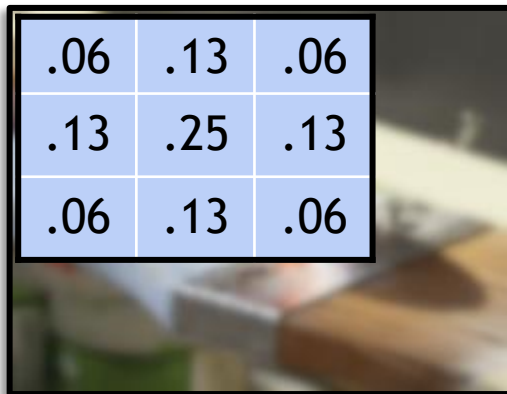


Original Image



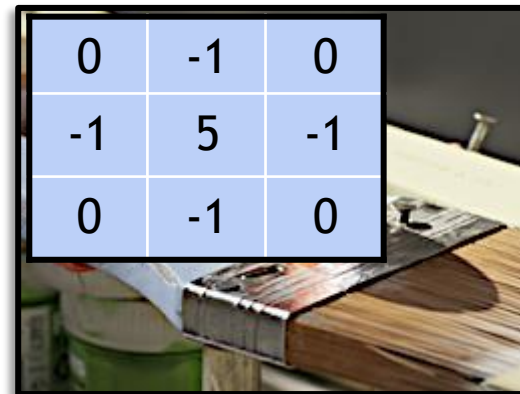
Blur

.06	.13	.06
.13	.25	.13
.06	.13	.06



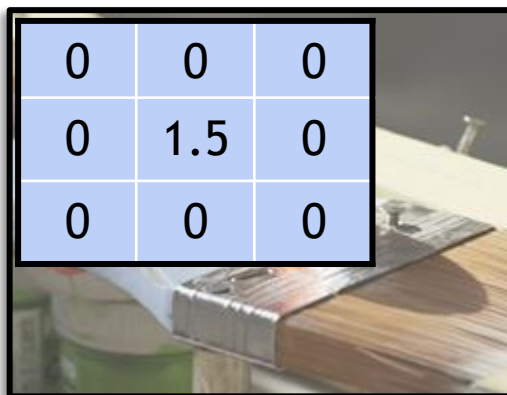
Sharpen

0	-1	0
-1	5	-1
0	-1	0



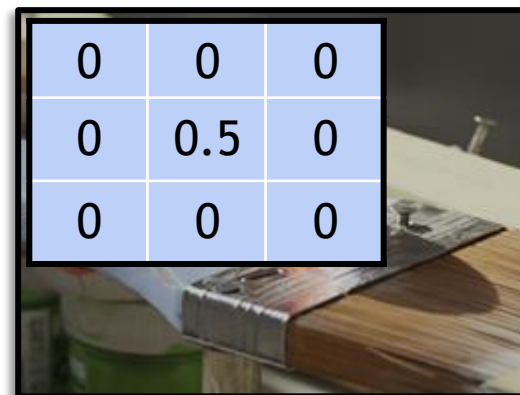
Brighten

0	0	0
0	1.5	0
0	0	0



Darken

0	0	0
0	0.5	0
0	0	0



# KERNELS AND CONVOLUTION

Blur Kernel

.06	.13	.06
.13	.25	.13
.06	.13	.06

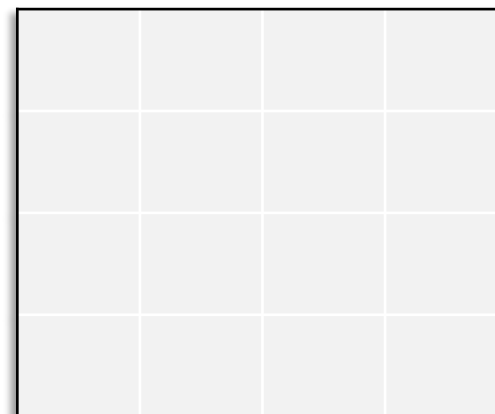
\*

Original Image

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

=

Convolved Image





# KERNELS AND CONVOLUTION

Blur Kernel

.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

Original Image

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

=

Convolved Image


# KERNELS AND CONVOLUTION



# KERNELS AND CONVOLUTION

Blur Kernel

.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

Original Image

.06	0	.06	1	0	1
0	.25	0	0	1	0
0	.13	.06	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

Total

=

Convolved Image

.56

# KERNELS AND CONVOLUTION

Blur Kernel

.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

Original Image

1	0	.13	.06	0	1
0	.13	0	0	1	0
0	.06	.13	.06	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

=

Convolved Image

.56	.57		

# KERNELS AND CONVOLUTION

Blur Kernel

.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

Original Image

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

=

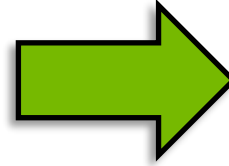
Convolved Image

.56	.57	.57	.56
.7	.82	.82	.7
.69	.95	.95	.69
.64	.69	.69	.64

# STRIDE

Stride 1

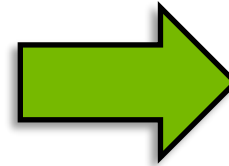
1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0



.56	.57	.57	.56
-----	-----	-----	-----

Stride 2

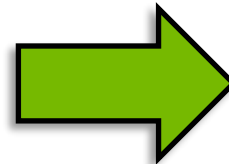
1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0



.56	.57
-----	-----

Stride 3

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0



.56	.56
-----	-----



# PADDING

Original Image

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

Zero Padding

0	0	0	0	0	0	0	0
0	1	0	1	1	0	1	0
0	0	1	0	0	1	0	0
0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
0	1	0	1	1	0	1	0
0	1	1	0	0	1	1	0
0	0	0	0	0	0	0	0

# PADDING

Original Image

1	0	1	1	0	1
0	1	0	0	1	0
0	1	1	1	1	0
0	1	1	1	1	0
1	0	1	1	0	1
1	1	0	0	1	1

Mirror Padding

1	1	0	1	1	0	1	1
1	1	0	1	1	0	1	1
0	0	1	0	0	1	0	0
0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0
1	1	0	1	1	0	1	1
1	1	1	0	0	1	1	1
1	1	1	0	0	1	1	1



# KERNELS AND NEURAL NETWORKS

# KERNELS AND NEURAL NETWORKS

Kernel

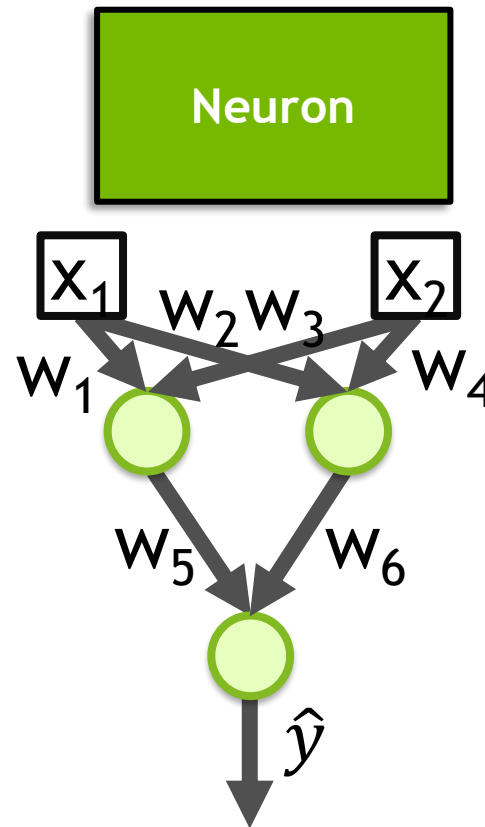
$W_1$	$W_2$	$W_3$
$W_4$	$W_5$	$W_6$
$W_7$	$W_8$	$W_9$

# KERNELS AND NEURAL NETWORKS

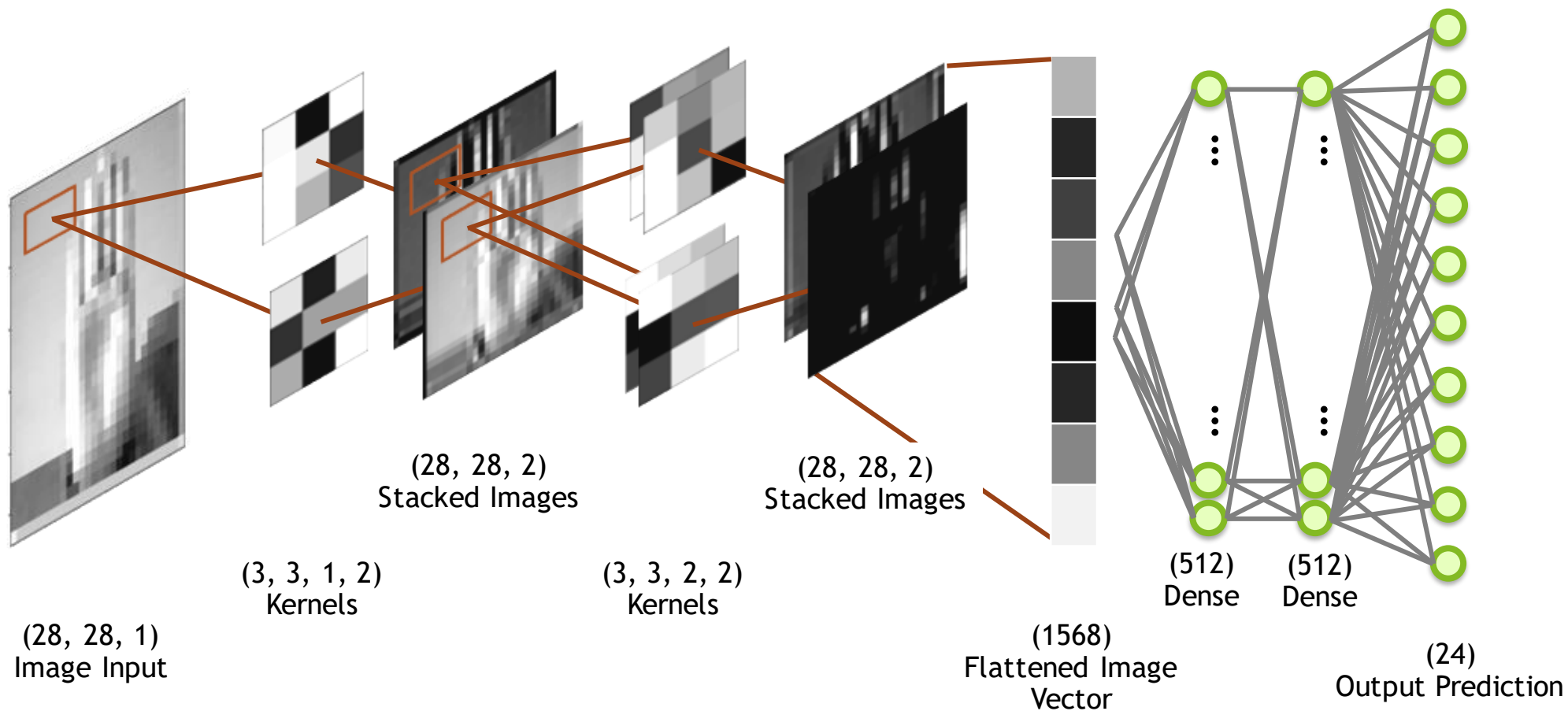
Kernel

$w_1$	$w_2$	$w_3$
$w_4$	$w_5$	$w_6$
$w_7$	$w_8$	$w_9$

Neuron



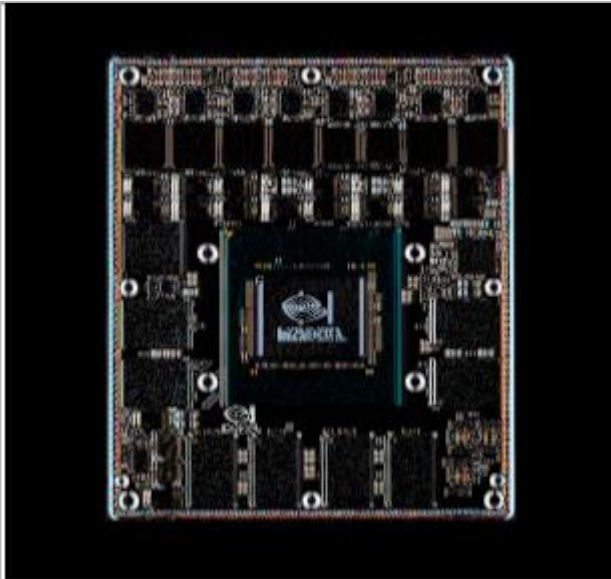
# KERNELS AND NEURAL NETWORKS





# FINDING EDGES

Vertical Edges



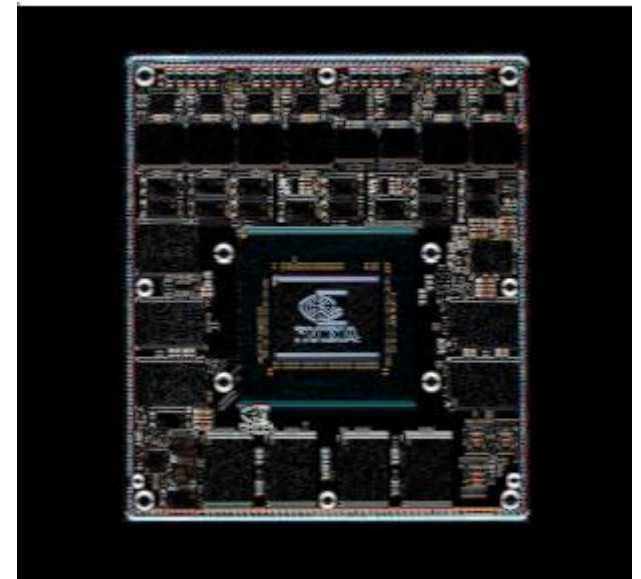
1	0	-1
2	0	-2
1	0	-1

Original Image



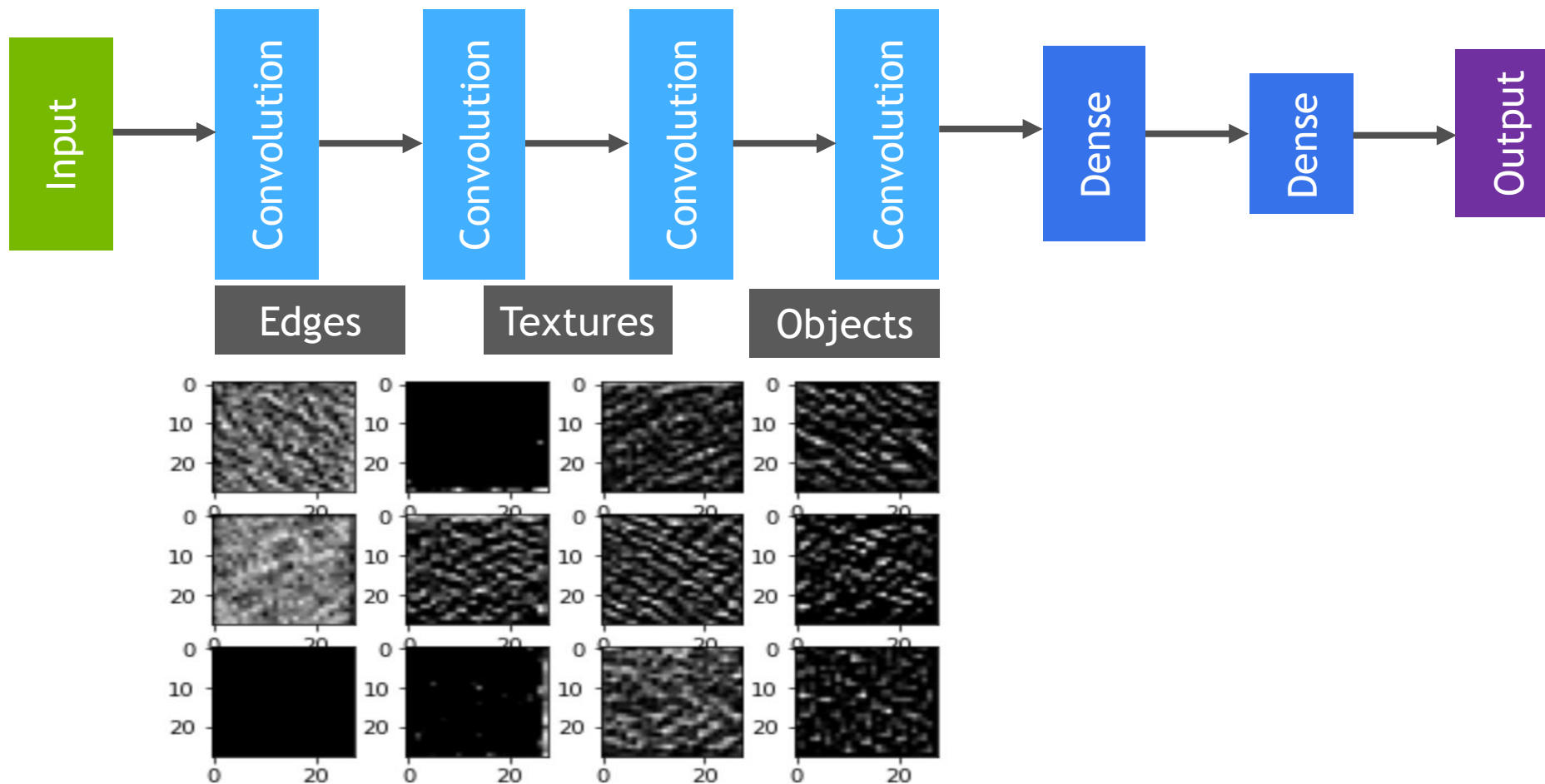
0	0	0
0	1	0
0	0	0

Horizontal Edges



1	2	1
0	0	0
-1	-2	-1

# NEURAL NETWORK PERCEPTION



# NEURAL NETWORK PERCEPTION

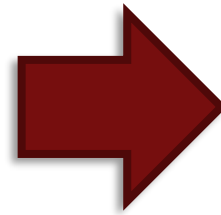




OTHER LAYERS IN THE  
MODEL

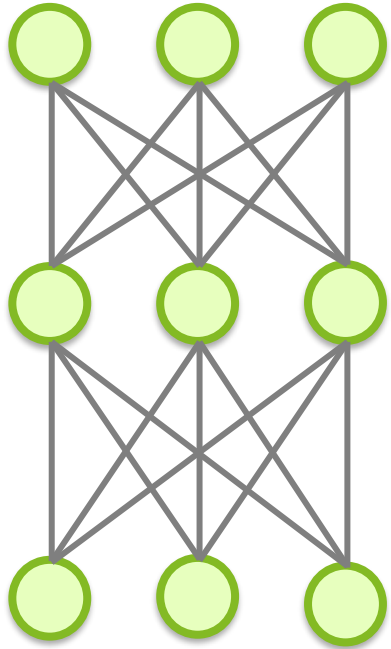
# MAX POOLING

110	256	153	67
12	89	88	43
10	15	50	55
23	9	49	23

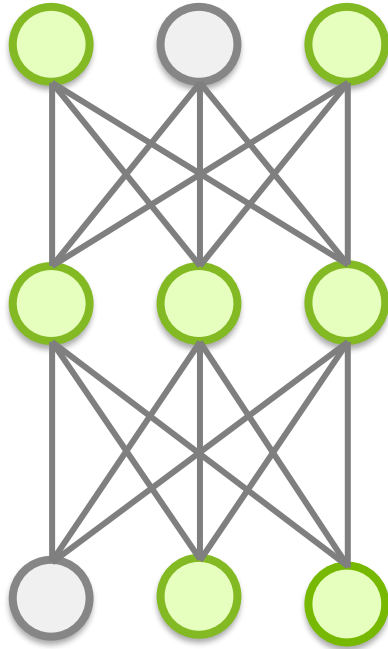


256	153
23	55

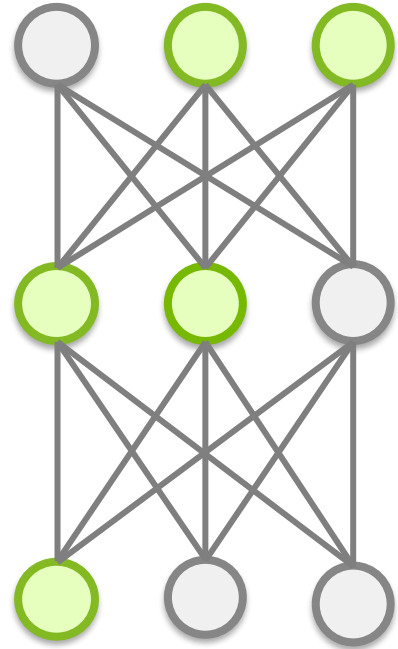
# DROPOUT



rate = 0



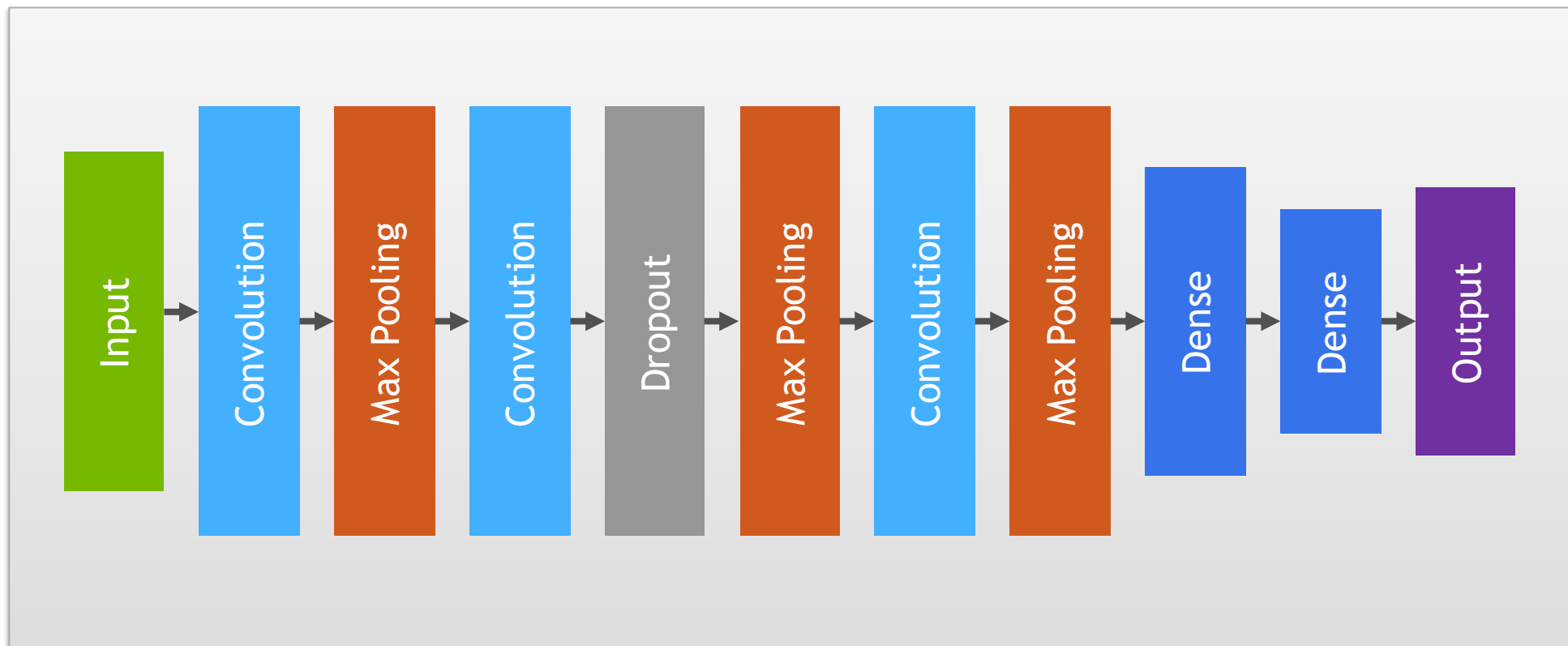
rate = .2



rate = .4



# WHOLE ARCHITECTURE





LET'S GO!



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