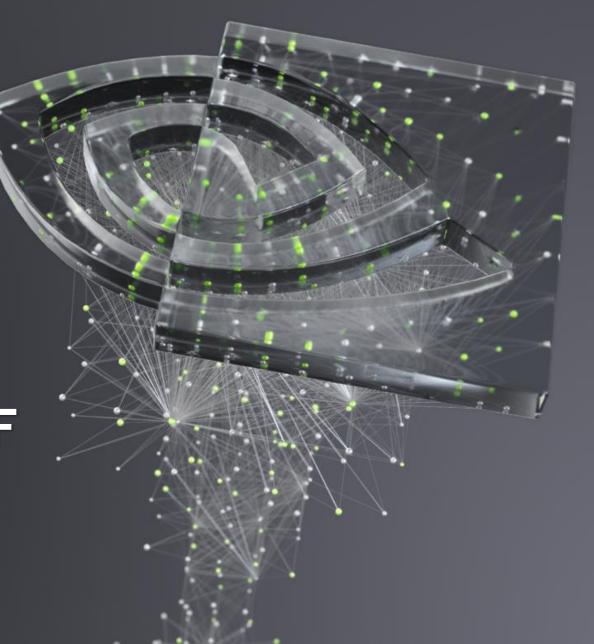


# FUNDAMENTALS OF DEEP LEARNING

Part 3: Convolutional Neural Networks



#### AGENDA

Part I: 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













Original Image







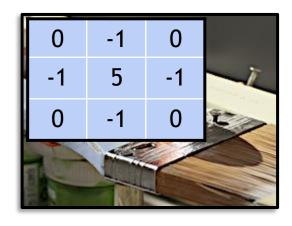






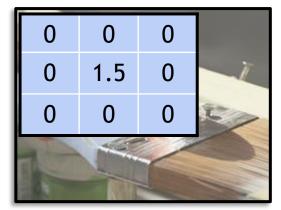




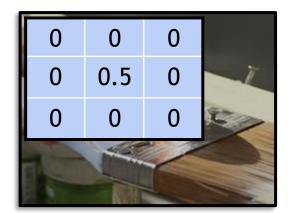


Original Image









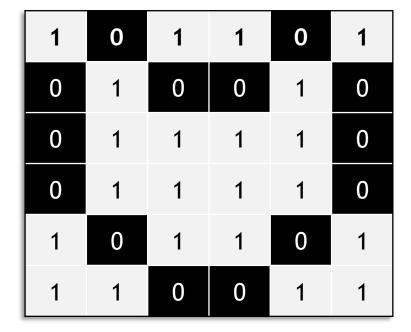
**Blur Kernel** 

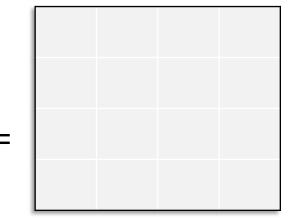
Original Image

**Convolved Image** 

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

\*





**Blur Kernel** 

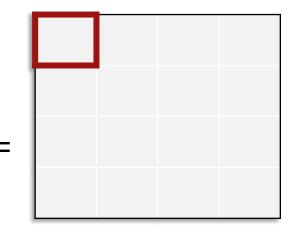
.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

**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** 







Blur Kernel

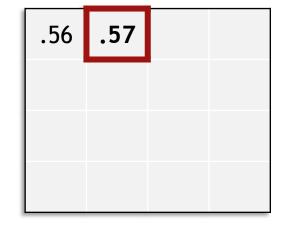
.06	.13	.06
.13	.25	.13
.06	.13	.06

\*

**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** 



Blur Kernel

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

\*

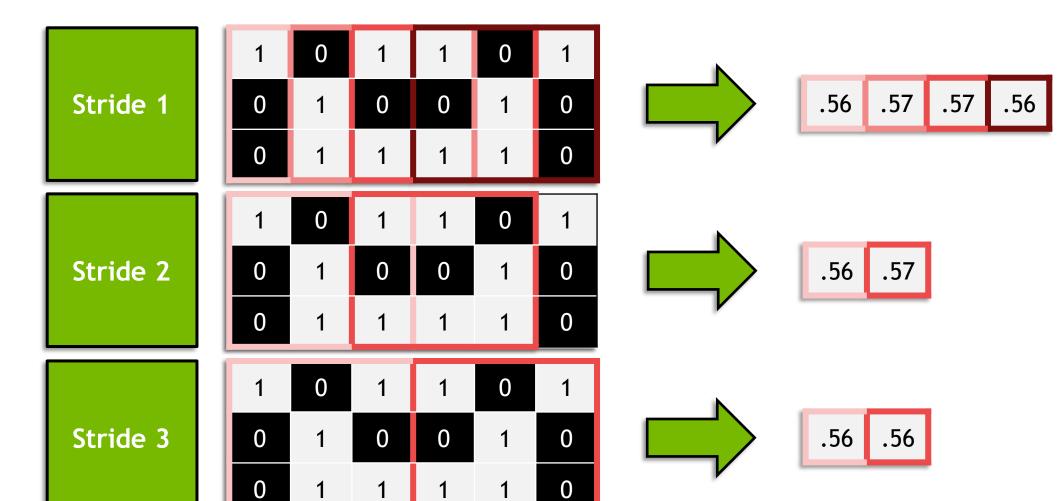
Original Image

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**





# **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**

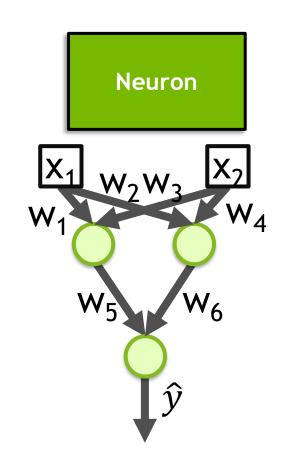
Kernel

W <sub>1</sub>	W <sub>2</sub>	$W_3$	
W <sub>4</sub>	$W_5$	$W_6$	
W <sub>7</sub>	W <sub>8</sub>	W <sub>9</sub>	

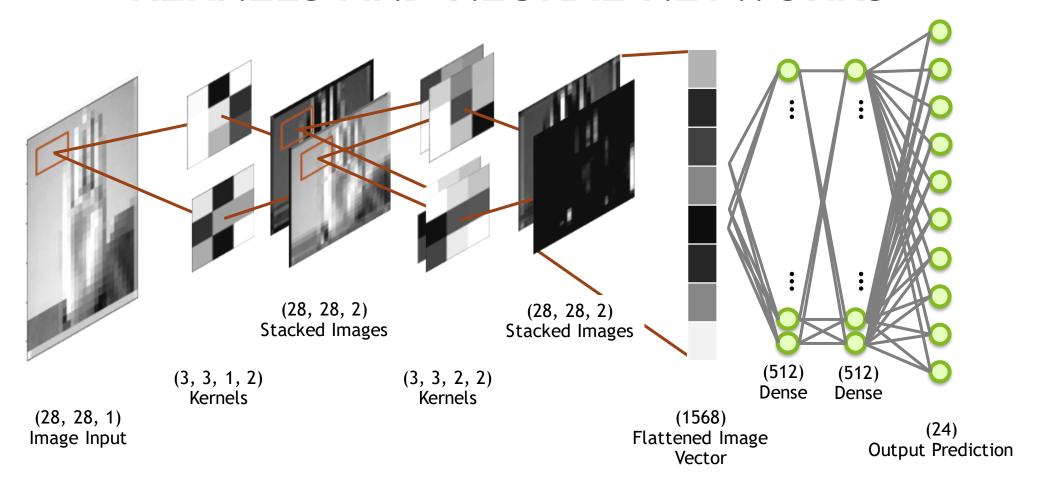
## **KERNELS AND NEURAL NETWORKS**

Kernel

W <sub>1</sub>	W <sub>2</sub>	$W_3$	
W <sub>4</sub>	$W_5$	$W_6$	
W <sub>7</sub>	W <sub>8</sub>	W <sub>9</sub>	



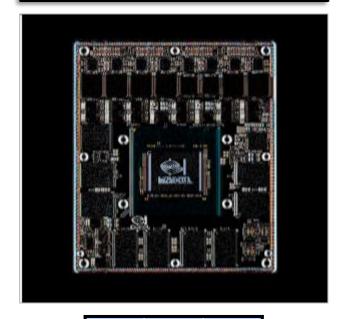
## KERNELS AND NEURAL NETWORKS





## FINDING EDGES

#### **Vertical Edges**



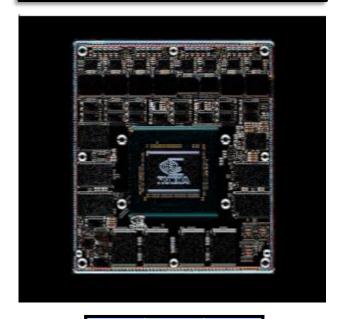
1	0	-1
2	0	-2
1	0	-1

#### Original Image



0	0	0
0	1	0
0	0	0

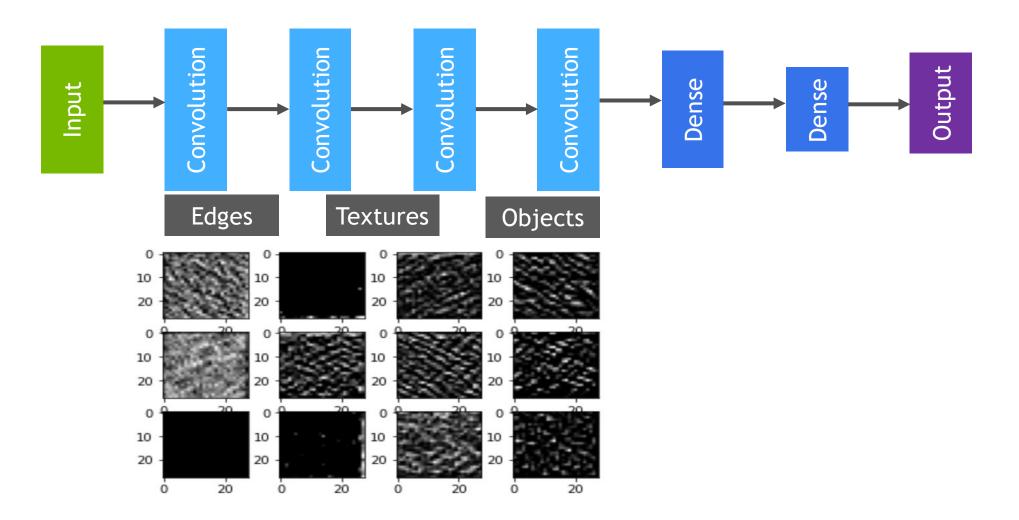
#### **Horizontal Edges**



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



## **NEURAL NETWORK PERCEPTION**





## **NEURAL NETWORK PERCEPTION**





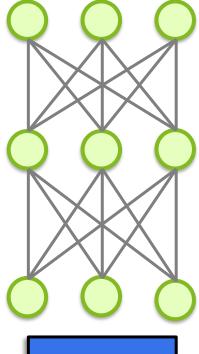




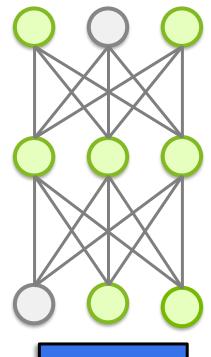
## **MAX POOLING**

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

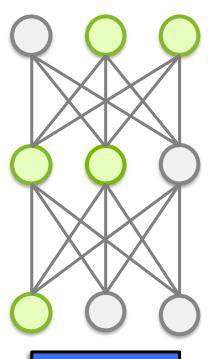
# **DROPOUT**













## WHOLE ARCHITECTURE

