Fundamentals of Deep Learning

Part 3: Convolutional Neural Networks

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

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Recap of the exercise

Trained a dense neural network model

Training accuracy was high

Validation accuracy was low

Evidence of overfitting

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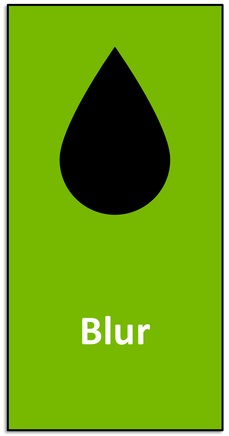
Kernels and Convolution

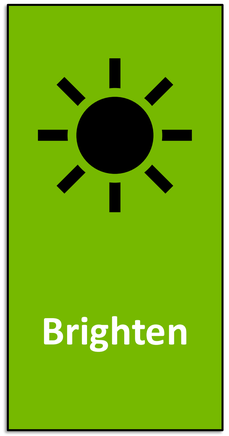
Kernels and Convolution

Original Image



Blur

Sharpen



Brighten

Darken

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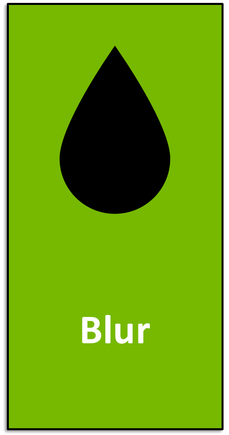
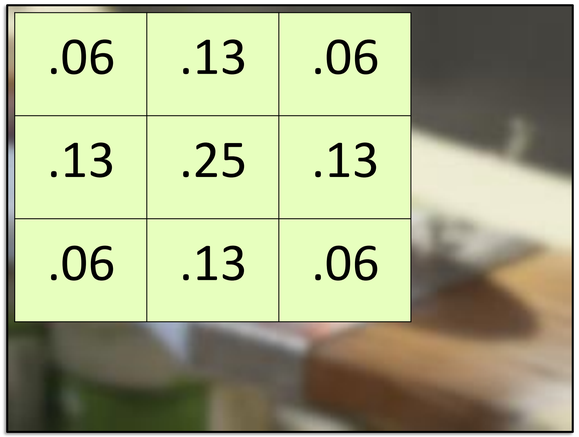
Kernels and Convolution

Original Image



Blur

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



Sharpen

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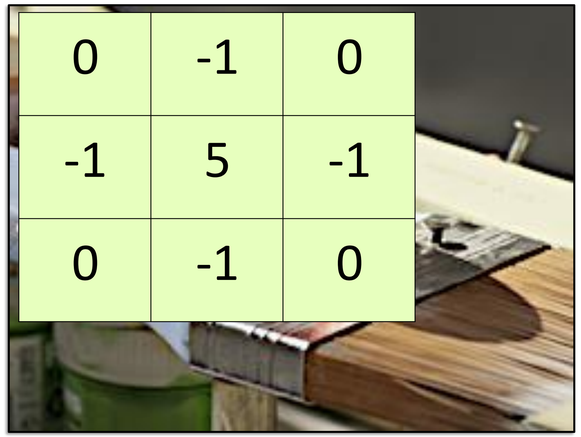
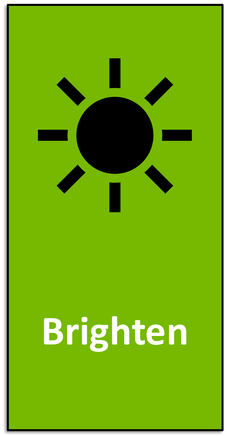
-1	5	-1
0	-1	0





Brighten

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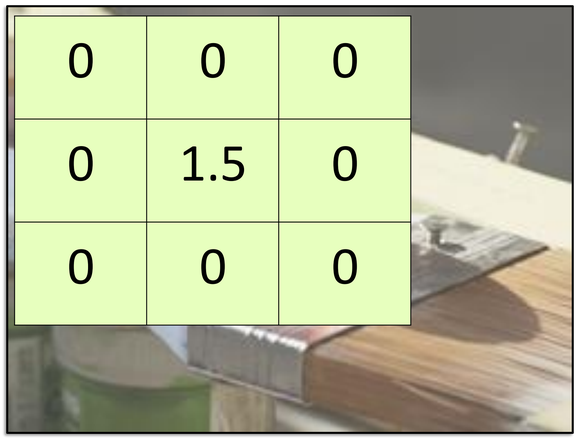
0	1.5	0
0	0	0



Darken

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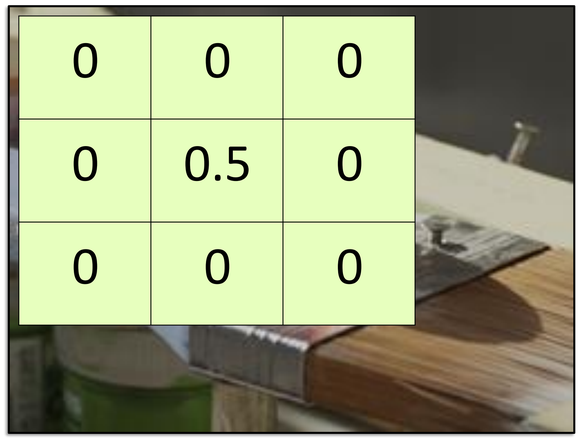

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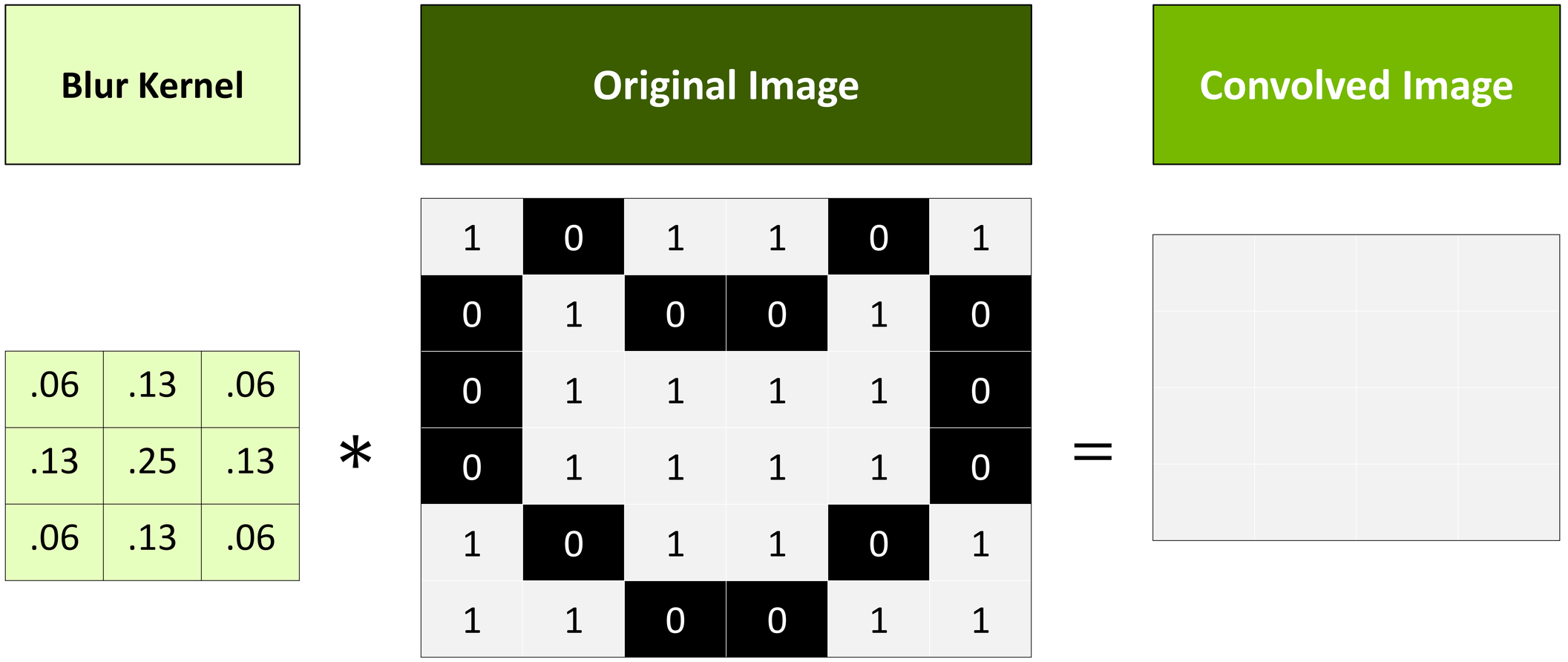
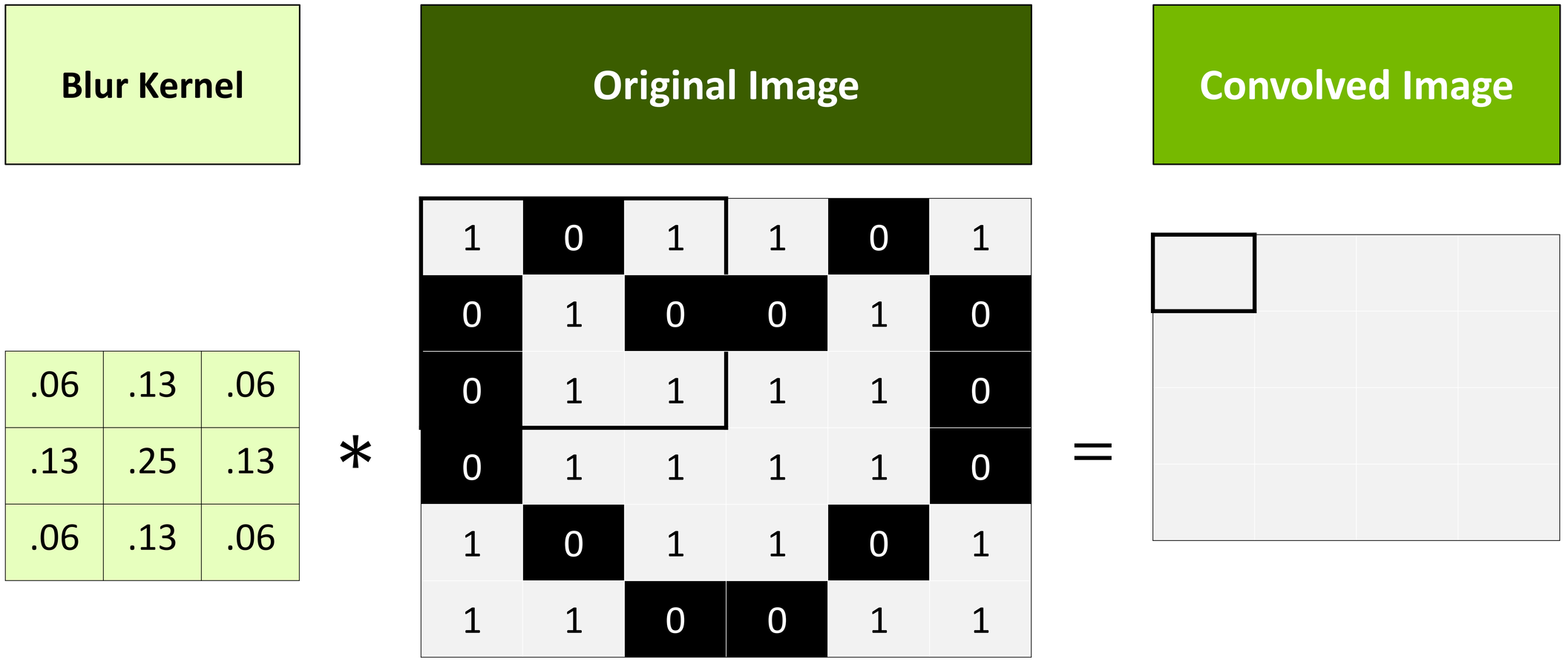
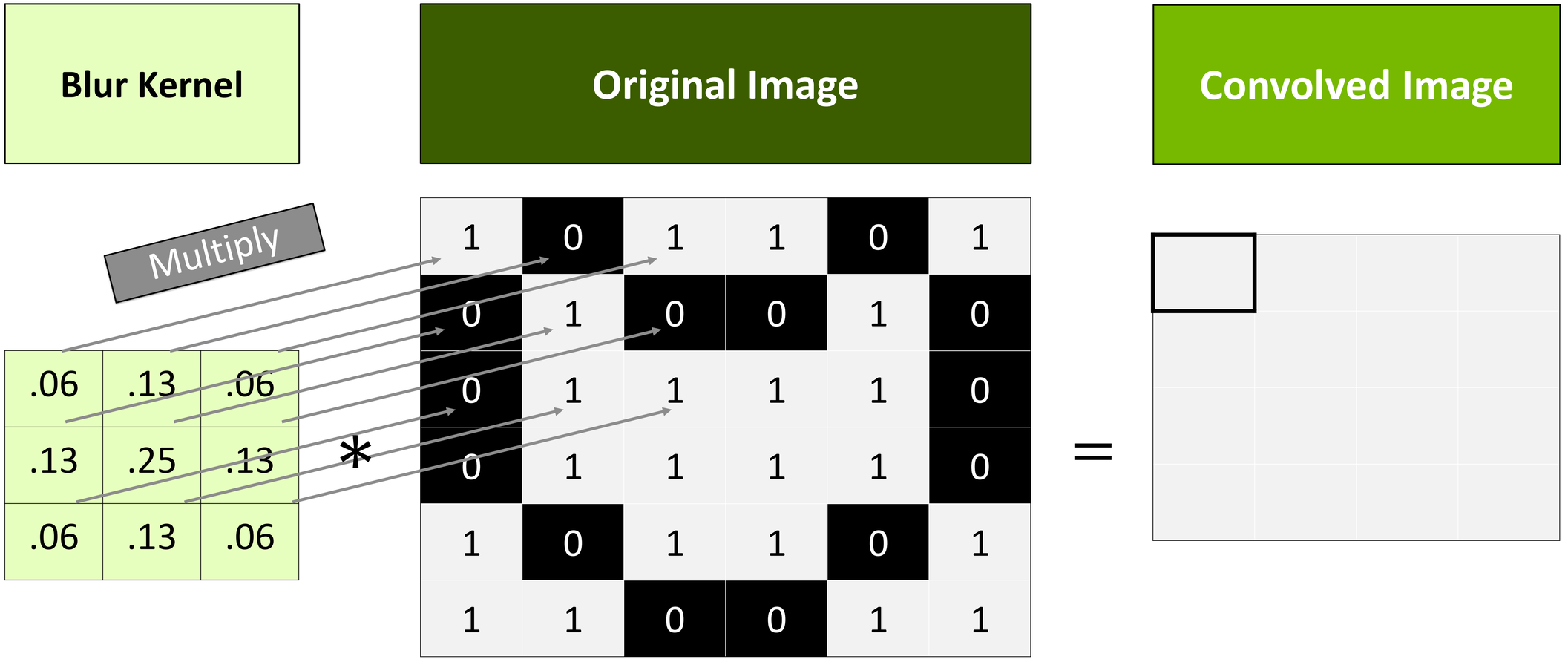
Kernels and Convolution



Kernels and Convolution



Kernels and Convolution



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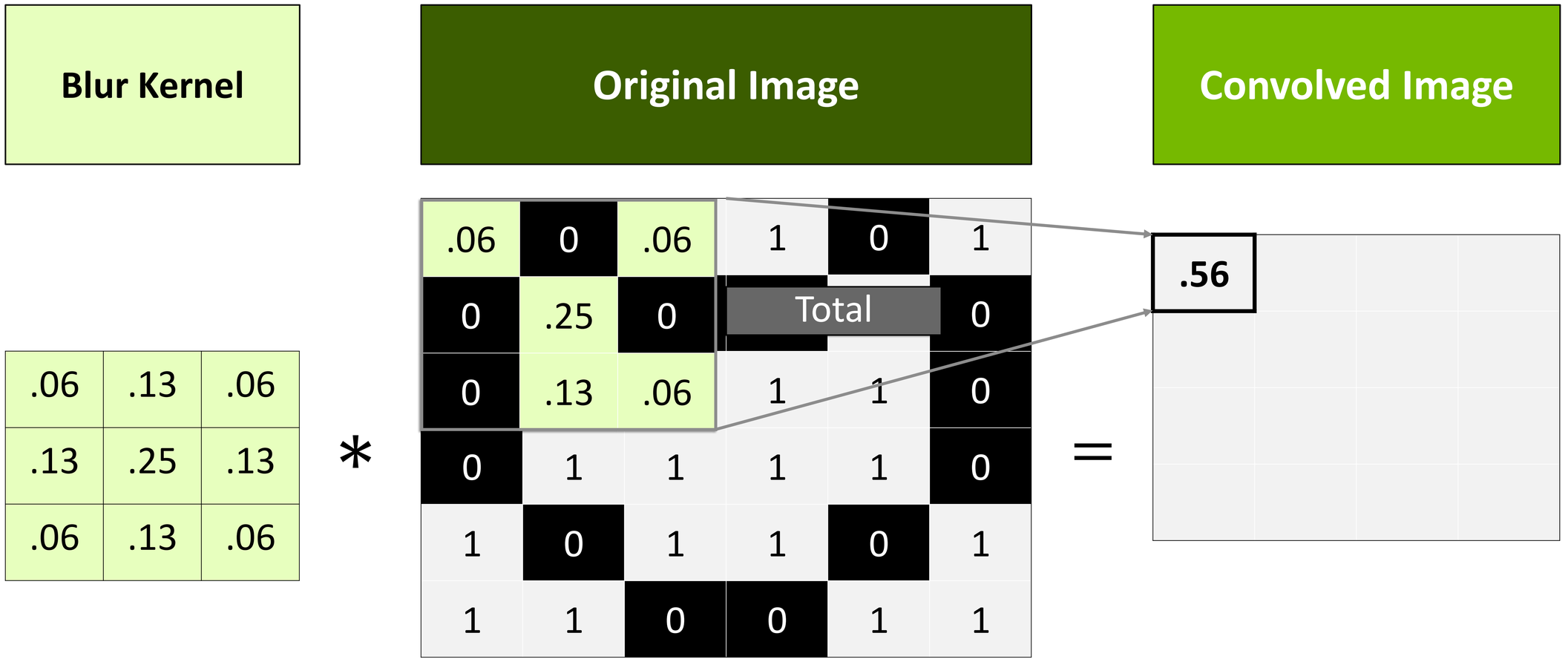
Kernels and Convolution



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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**		

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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

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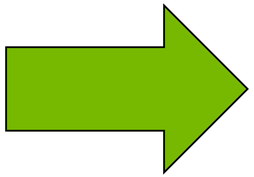
Stride

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

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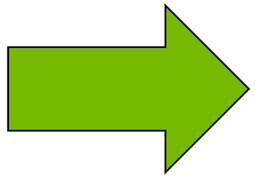
0	1	1	1	1	0



.56	.57

Stride 3

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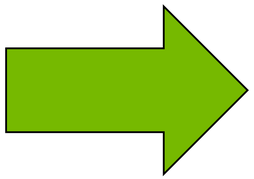
0	1	1	1	1	0



.56	.56

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Padding

Original Image

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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

NVIDIA.

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

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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

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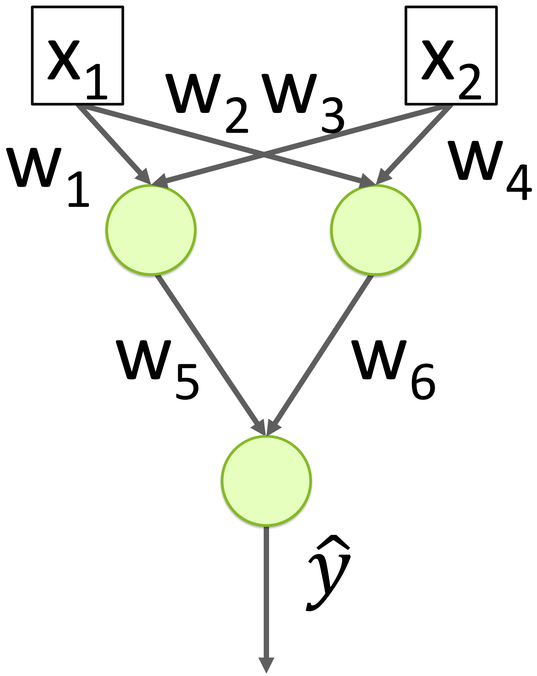
Kernels and Neural Networks

Kernel

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

Neuron



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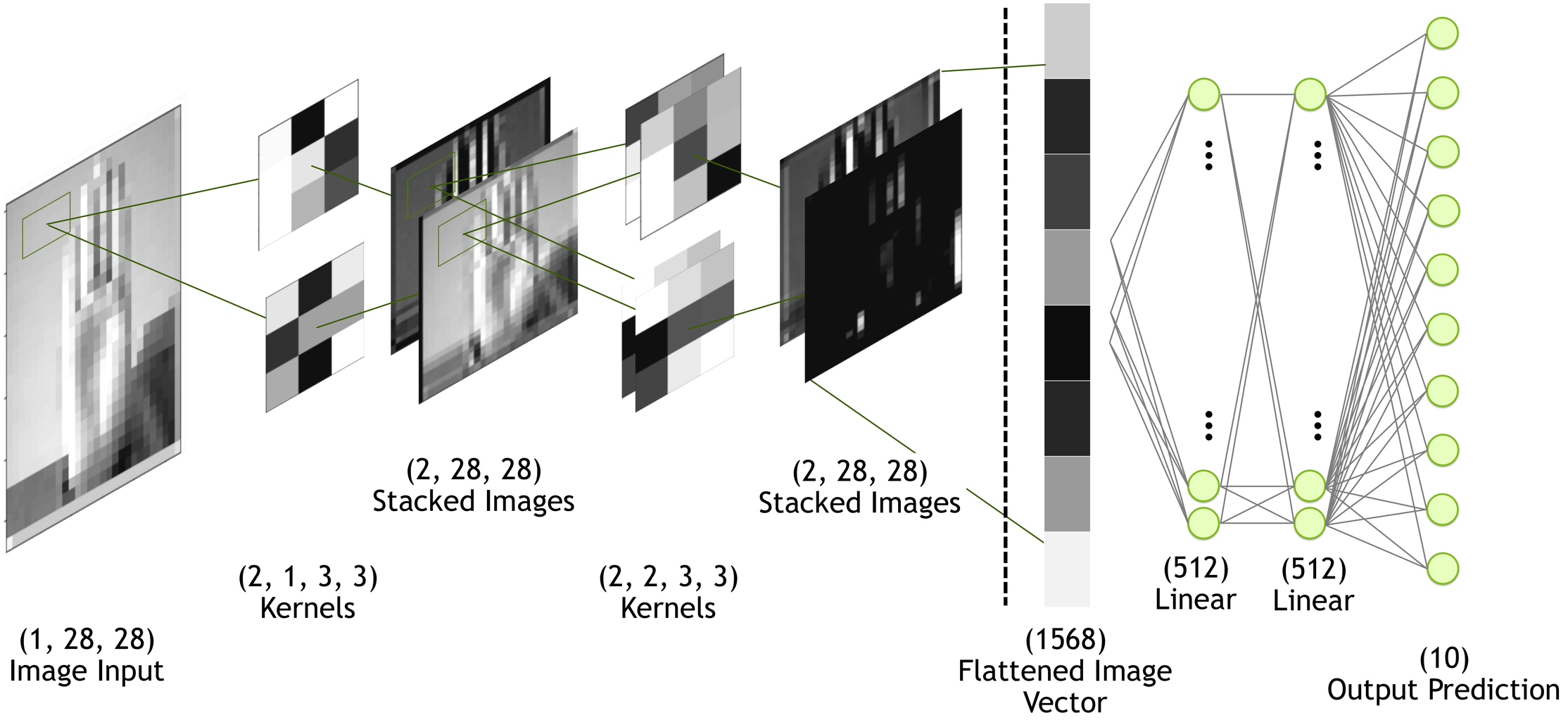
Kernels and Neural Networks



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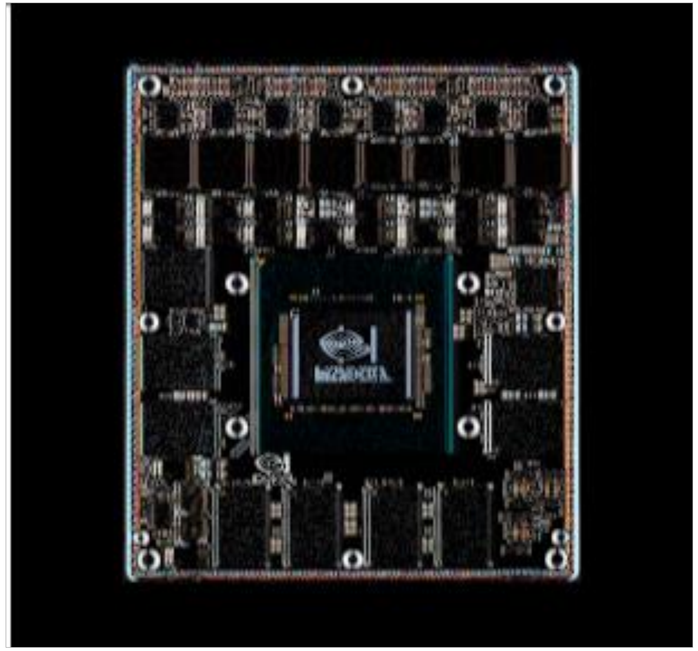
Finding Edges

Vertical Edges

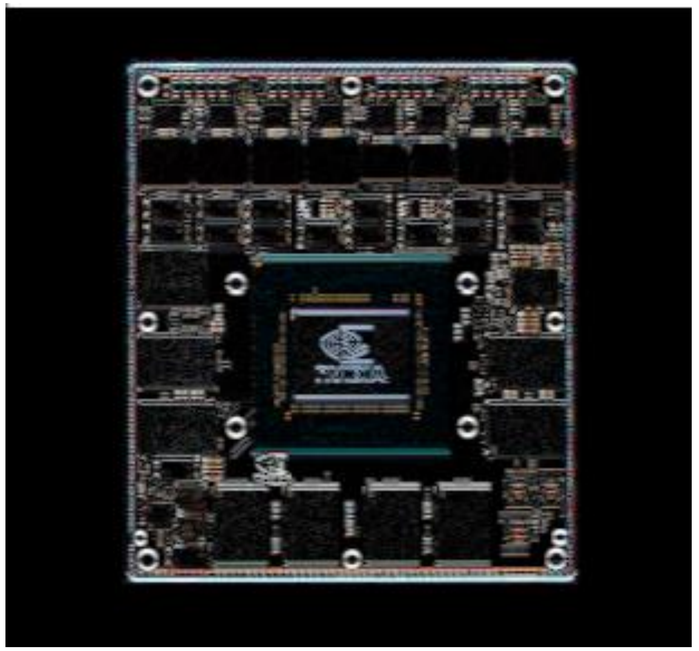


1	0	-1
2	0	-2
1	0	-1

Original Image

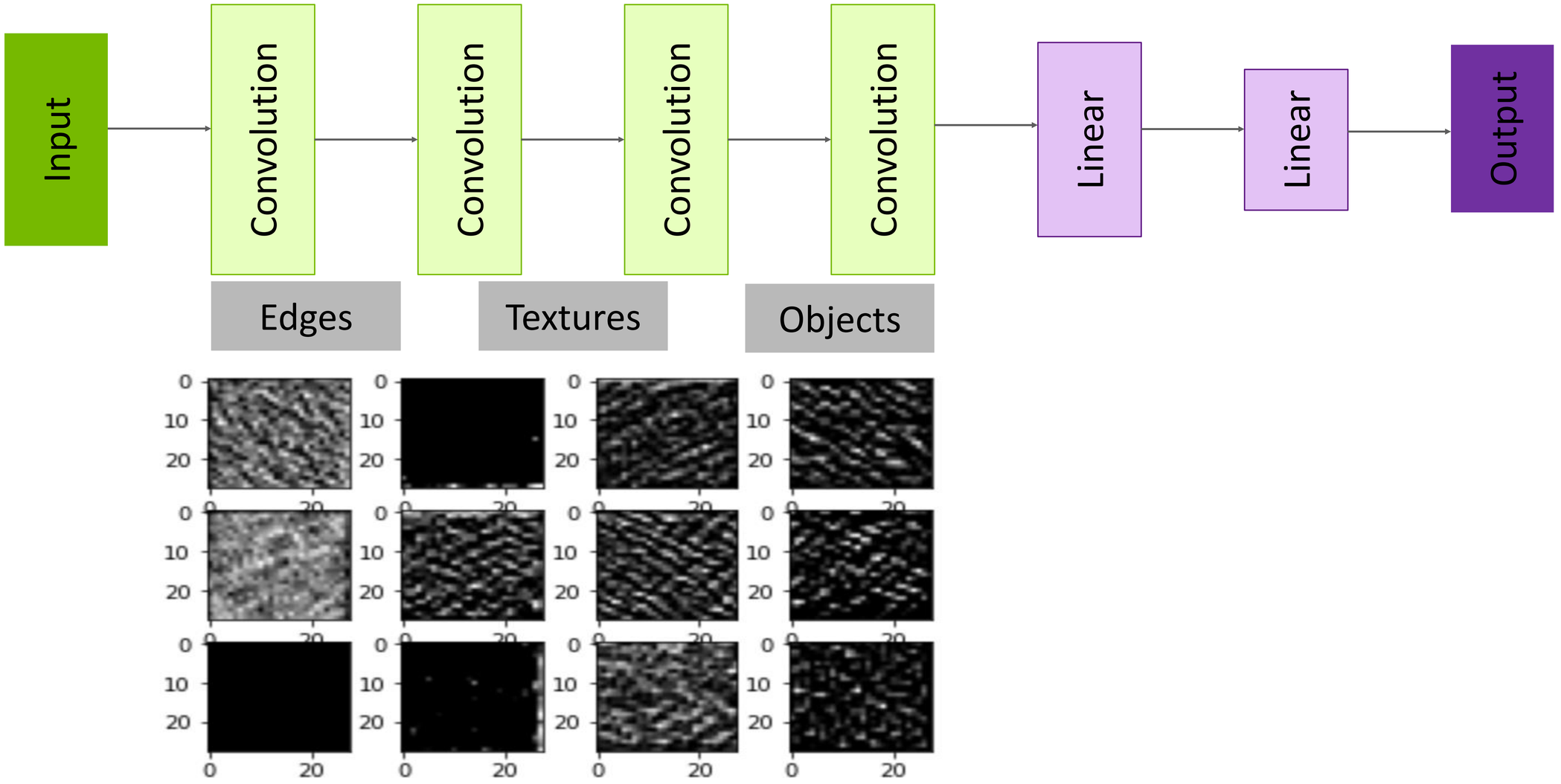
0	0	0
0	1	0
0	0	0

Horizontal Edges



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

Neural Network Perception

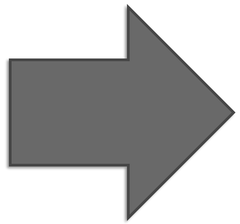


Neural Network Perception

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

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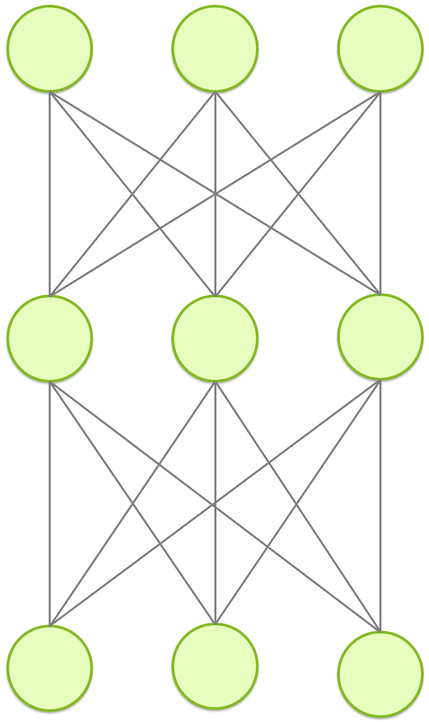
Dropout



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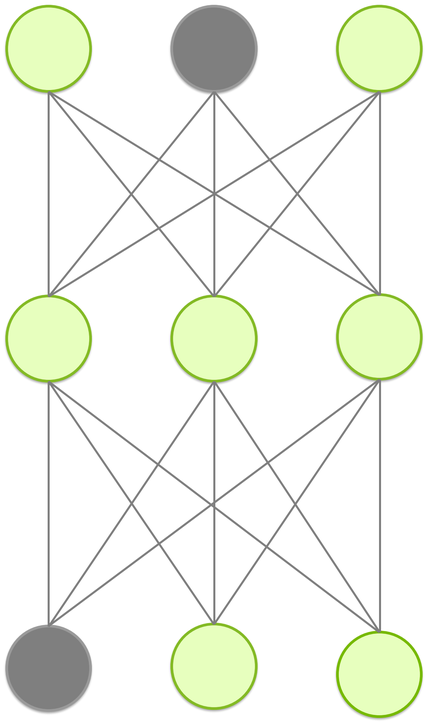

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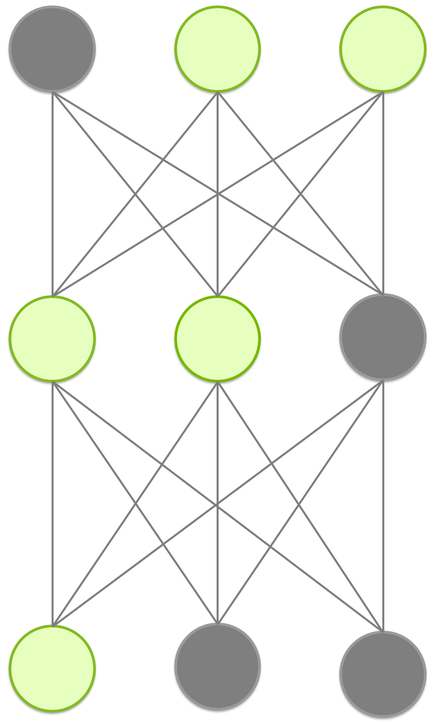

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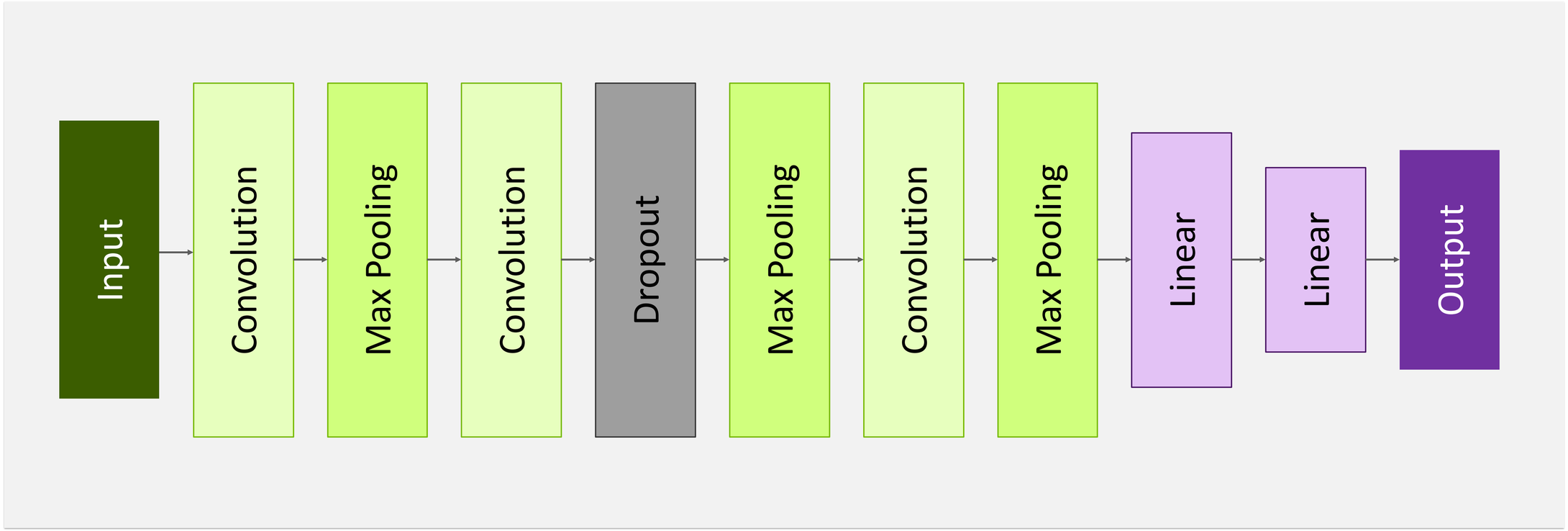
Whole Architecture



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Let’s go!