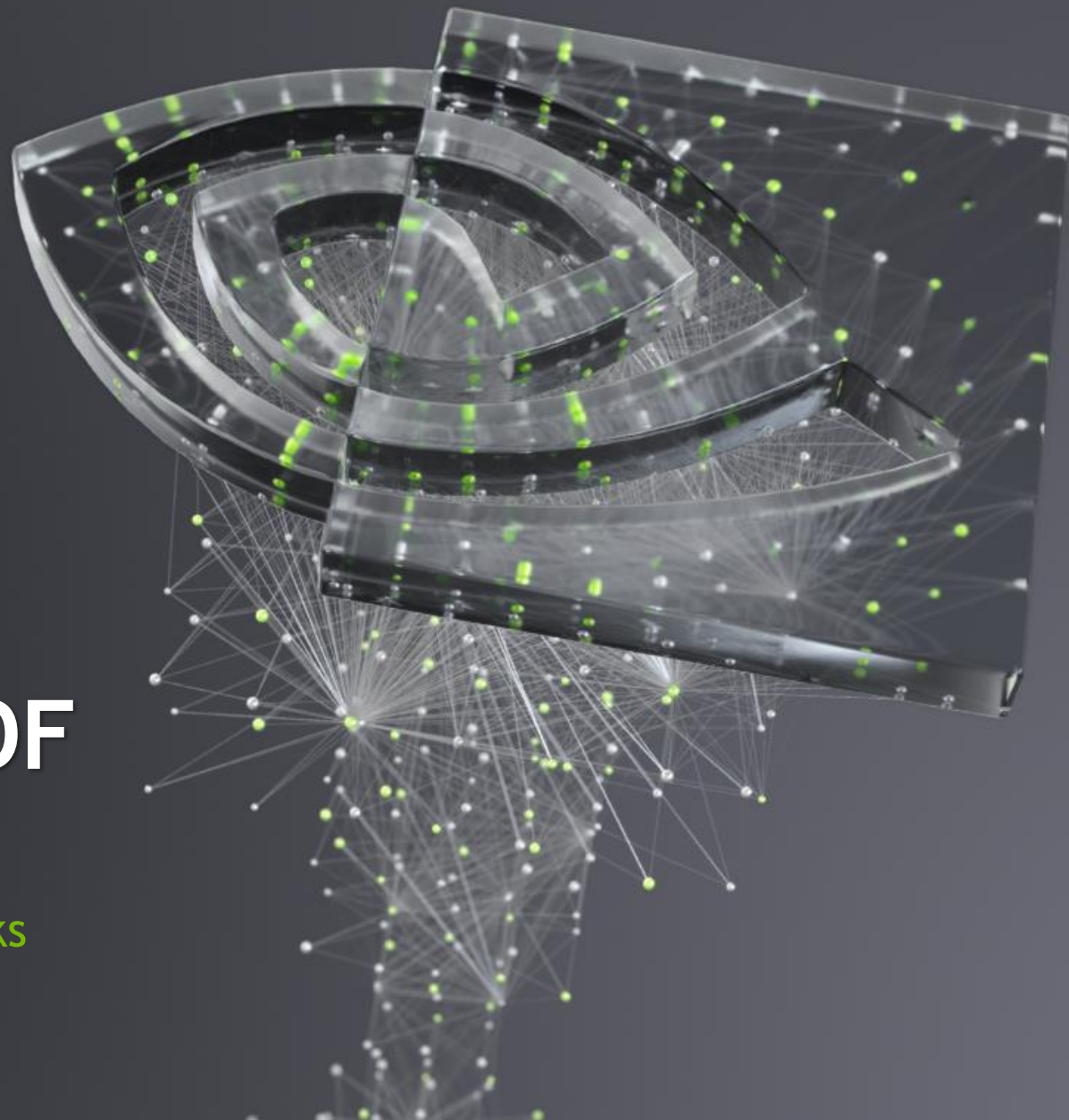




DEEP
LEARNING
INSTITUTE

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

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

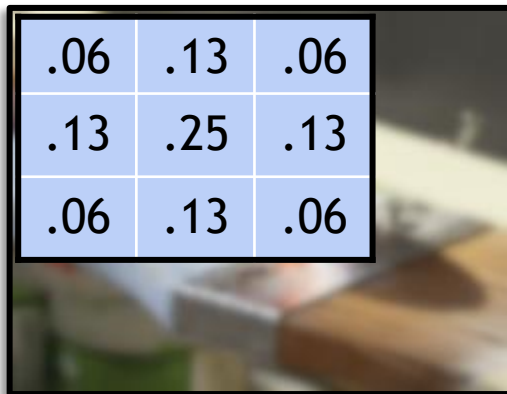


Original Image



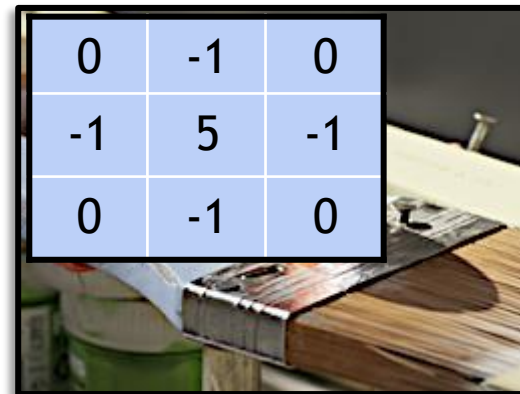
Blur

| | | |
|-----|-----|-----|
| .06 | .13 | .06 |
| .13 | .25 | .13 |
| .06 | .13 | .06 |



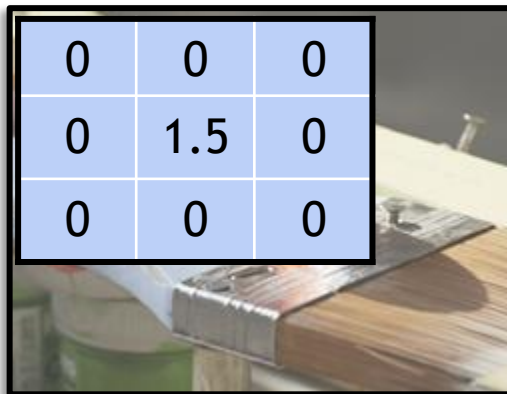
Sharpen

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



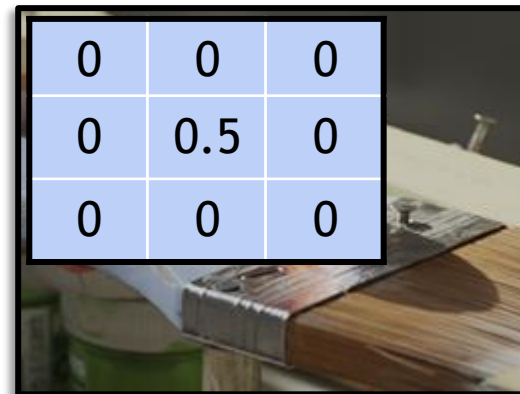
Brighten

| | | |
|---|-----|---|
| 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 |

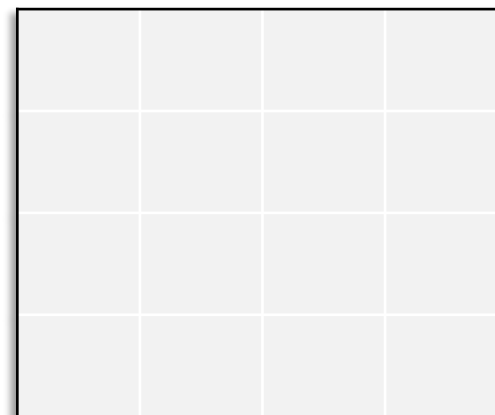
*

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 |

=

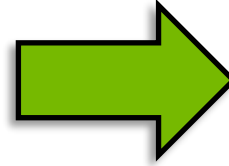
Convolved Image

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

STRIDE

Stride 1

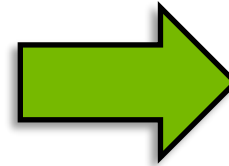
| | | | | | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 |



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

Stride 2

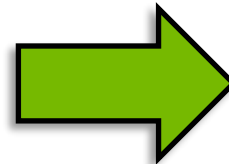
| | | | | | |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 |



| | |
|-----|-----|
| .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

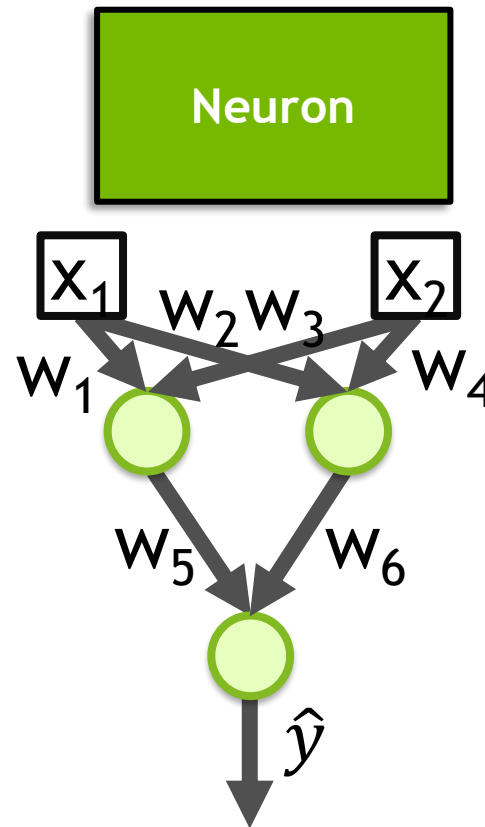
| | | |
|-------|-------|-------|
| W_1 | W_2 | W_3 |
| W_4 | W_5 | W_6 |
| W_7 | W_8 | W_9 |

KERNELS AND NEURAL NETWORKS

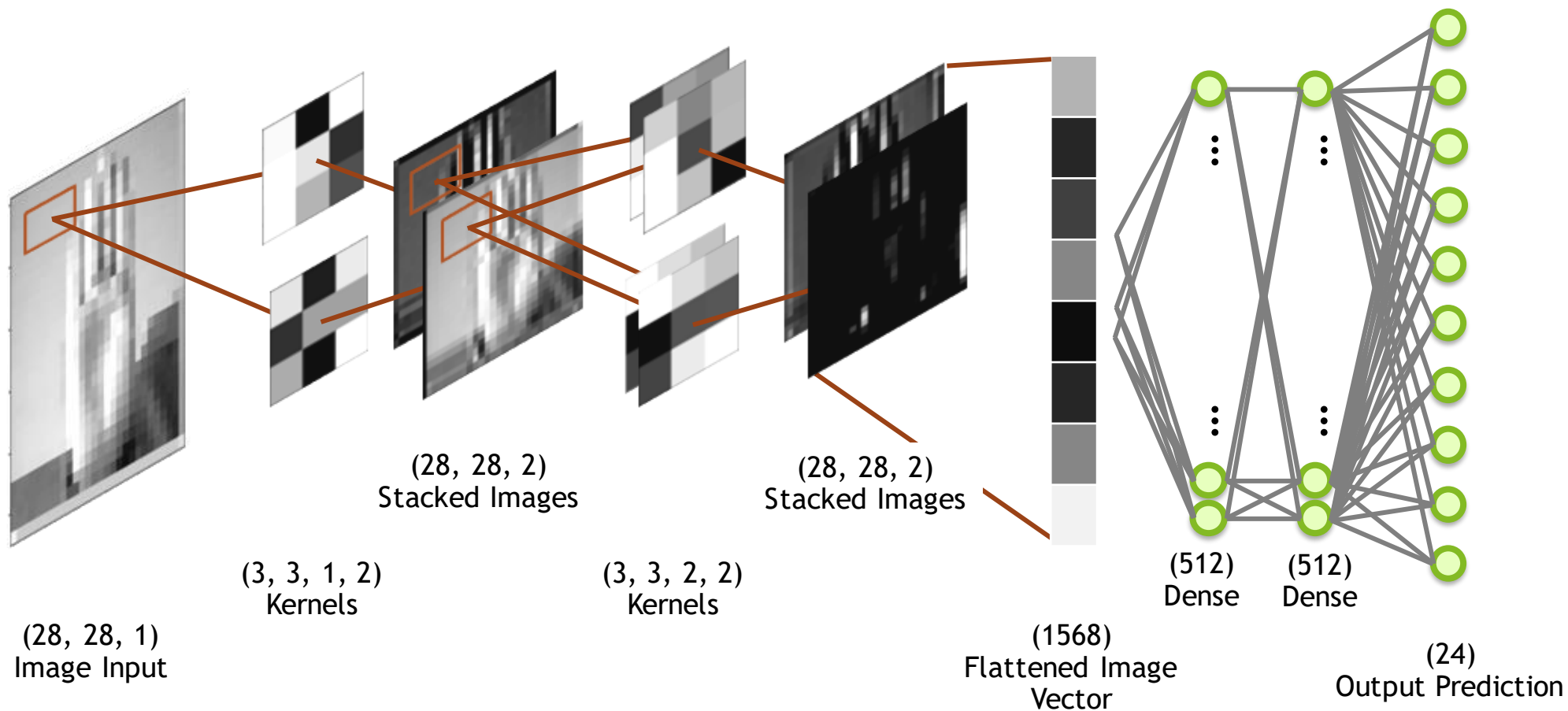
Kernel

| | | |
|-------|-------|-------|
| w_1 | w_2 | w_3 |
| w_4 | w_5 | w_6 |
| w_7 | w_8 | w_9 |

Neuron

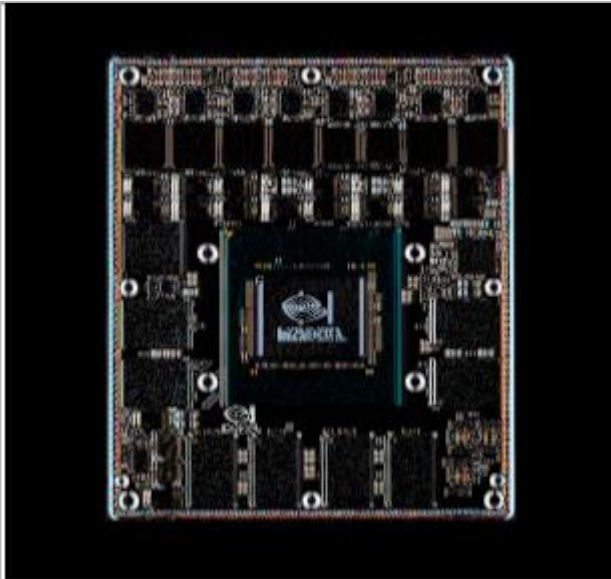


KERNELS AND NEURAL NETWORKS



FINDING EDGES

Vertical Edges



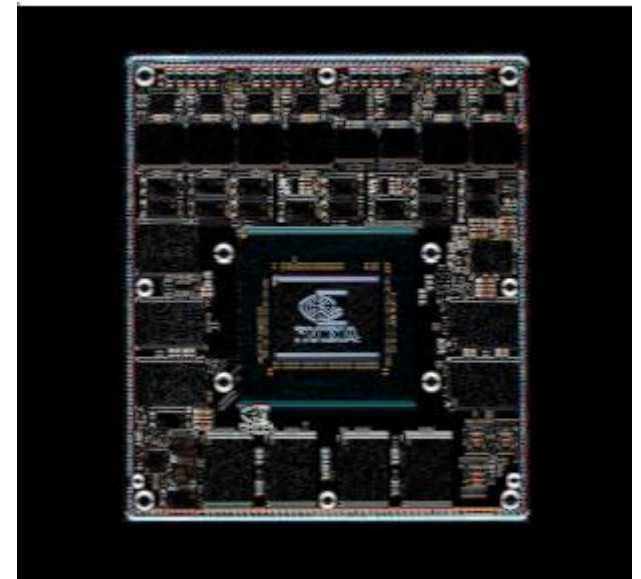
| | | |
|---|---|----|
| 1 | 0 | -1 |
| 2 | 0 | -2 |
| 1 | 0 | -1 |

Original Image



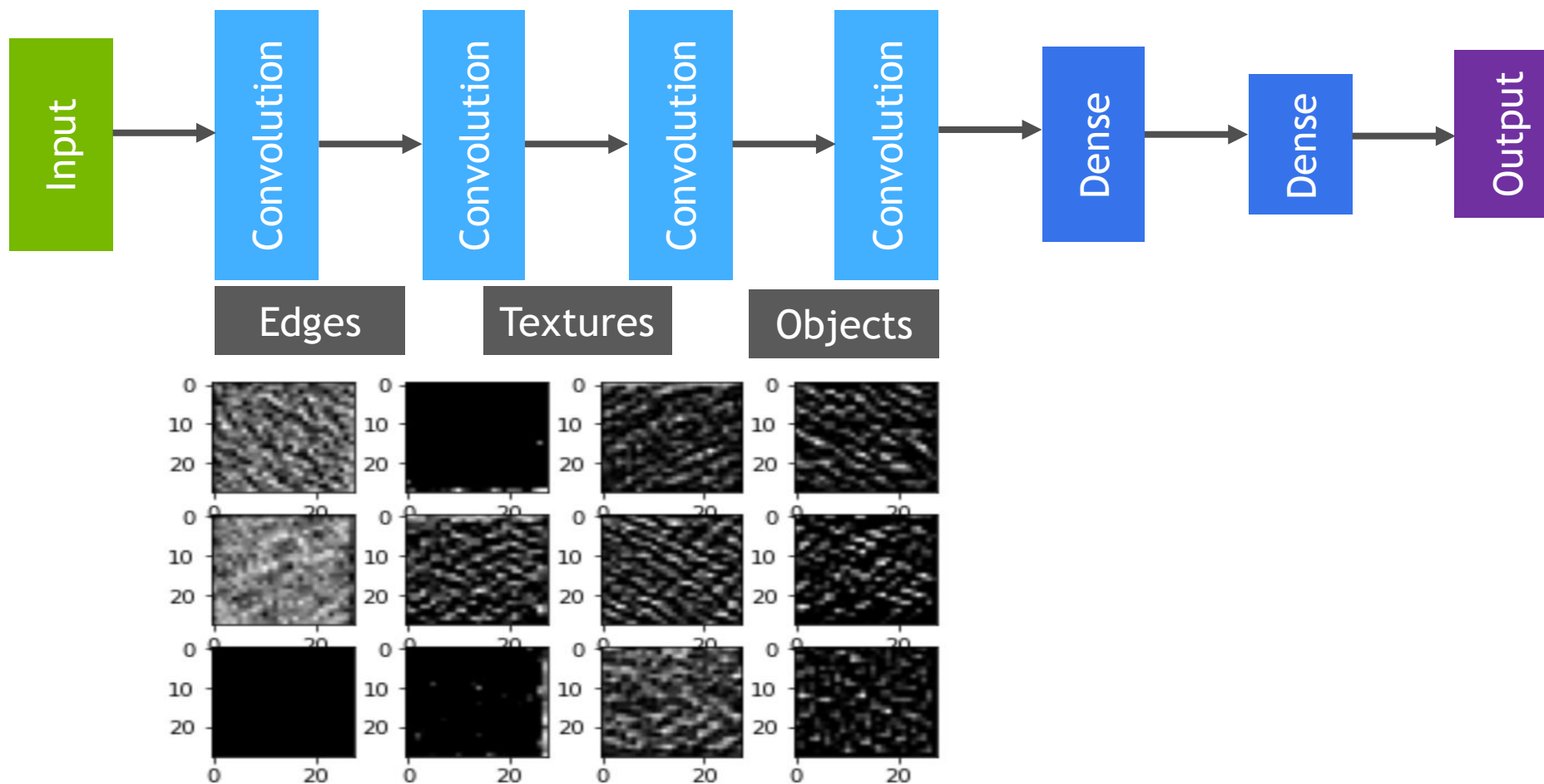
| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 0 |

Horizontal Edges



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

NEURAL NETWORK PERCEPTION



NEURAL NETWORK PERCEPTION

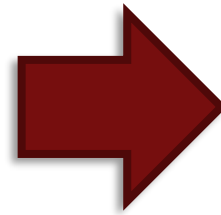




OTHER LAYERS IN THE
MODEL

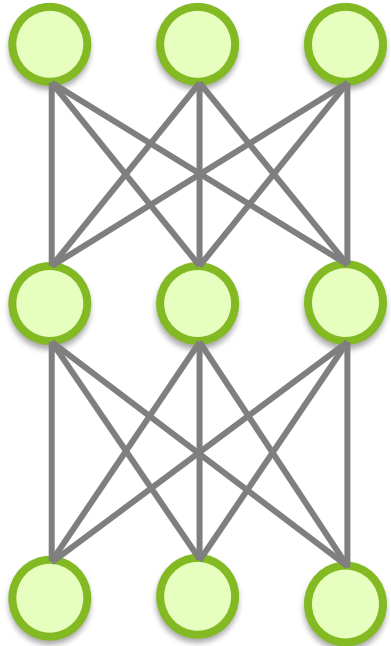
MAX POOLING

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

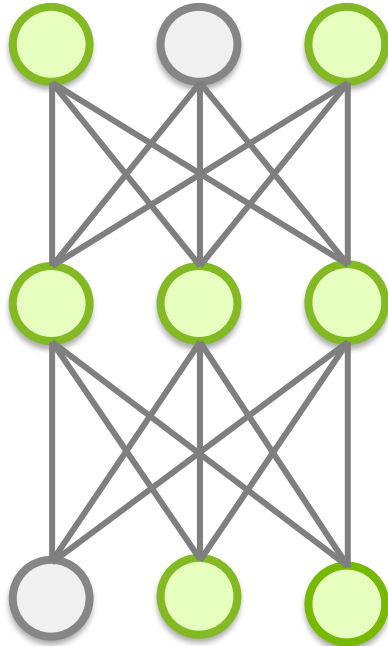


| | |
|-----|-----|
| 256 | 153 |
| 23 | 55 |

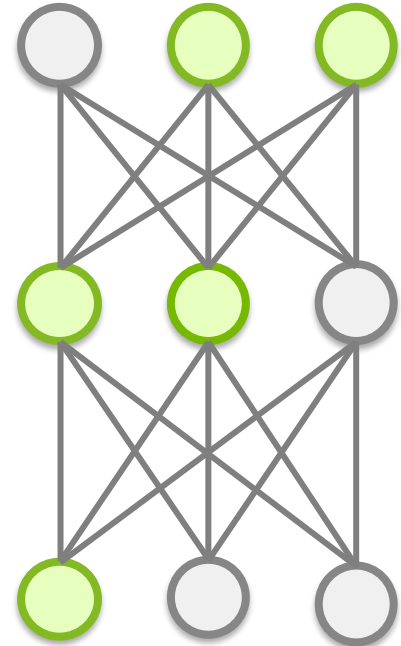
DROPOUT



rate = 0

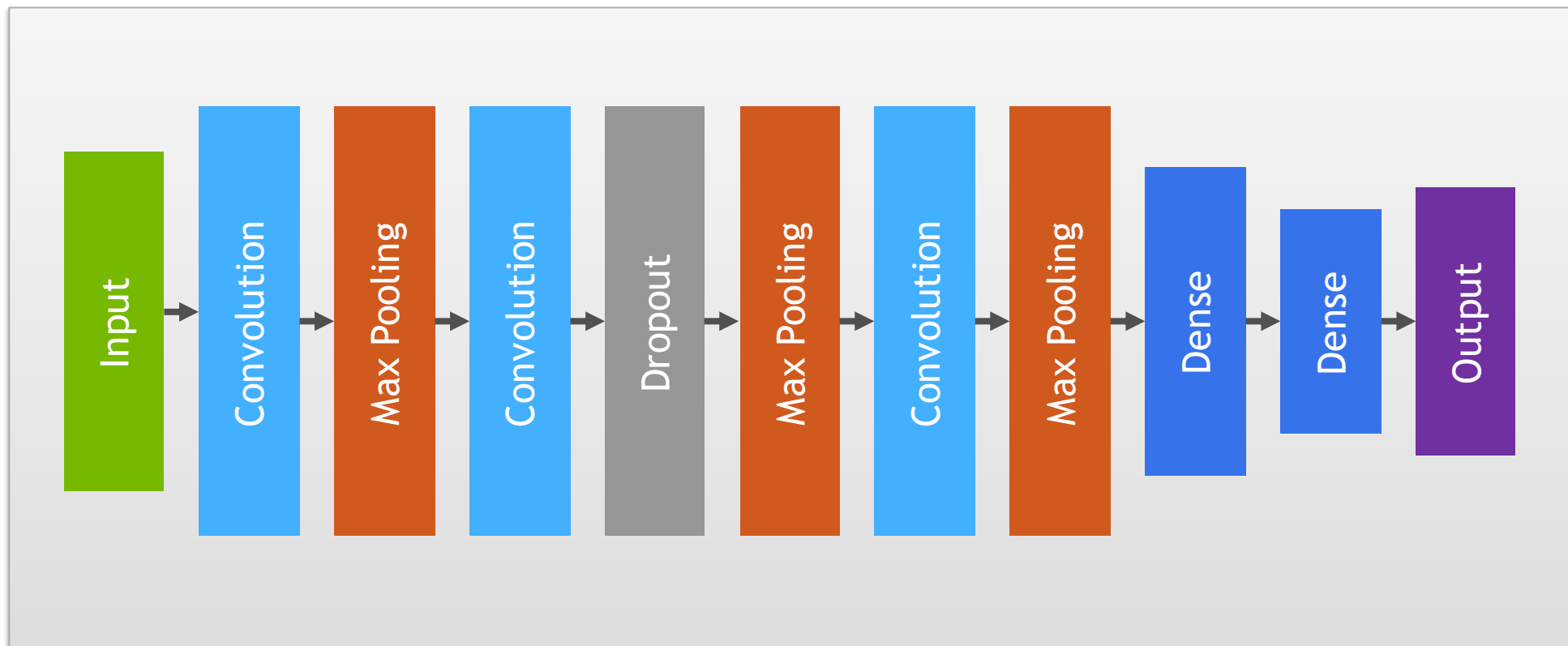


rate = .2



rate = .4

WHOLE ARCHITECTURE





LET'S GO!



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