Convnets in TensorFlow

CS 20: TensorFlow for Deep Learning Research
Lecture 7
2/7/2017

Agenda

Convolutions without training

Convnet with MNIST!!!

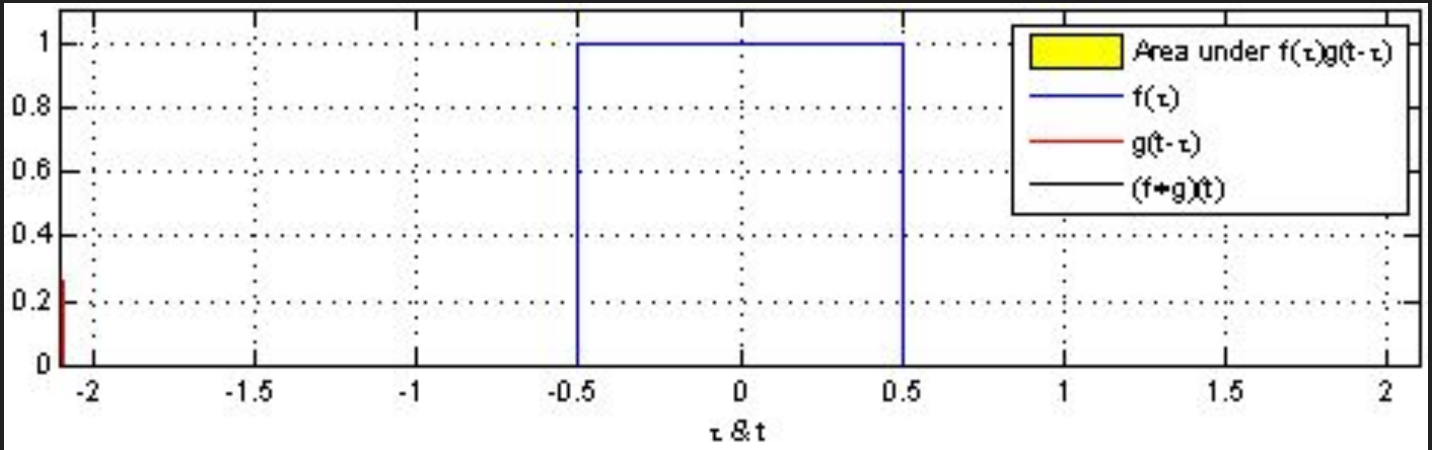
tf.layers

Understanding convolutions

Convolutions in math and physics

a function derived from two given functions by integration that expresses how the shape of one is modified by the other

Convolutions in math and physics



Brian Amberg derivative work (Wikipedia)

Convolutions in math and physics

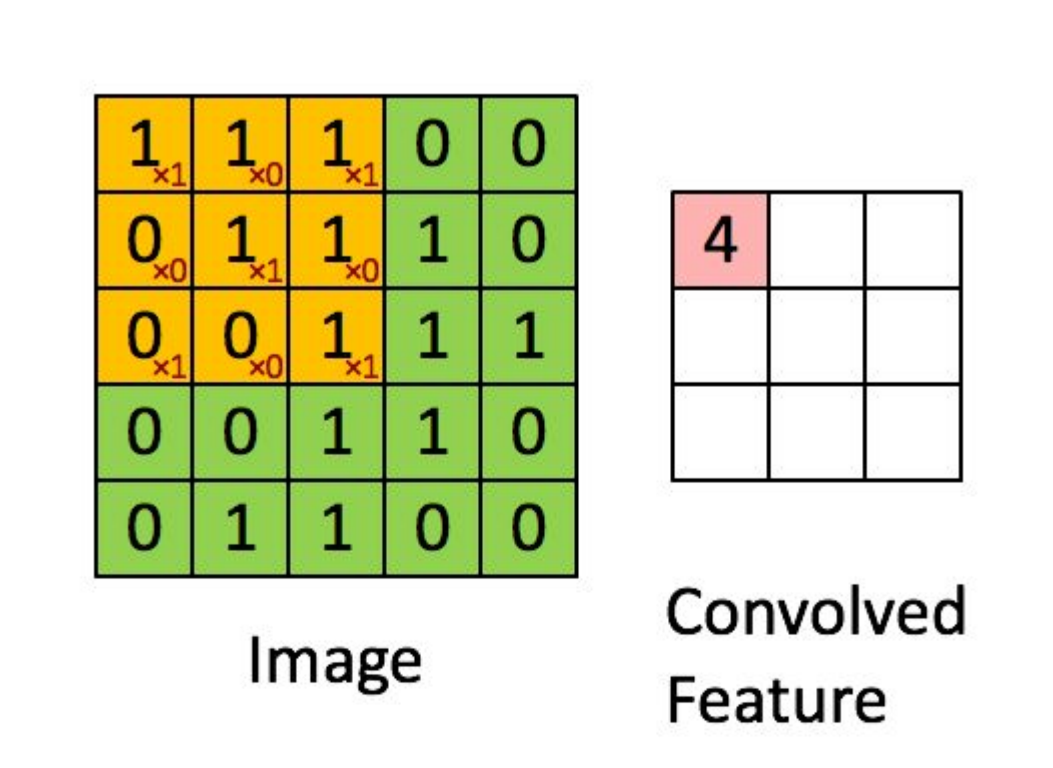
How an input is transformed by a kernel*

*also called filter/feature map

Convolutions in machine learning

We can use one single convolutional layer to modify a certain image

Convolutions in machine learning



$1_{\times 1}$	$1_{\times 0}$	$1_{\times 1}$	0	0
$0_{\times 0}$	$1_{\times 1}$	$1_{\times 0}$	1	0
$0_{\times 1}$	$0_{\times 0}$	$1_{\times 1}$	1	1
0	0	1	1	0
0	1	1	0	0

Image

4		

Convolved Feature

http://deeplearning.stanford.edu/

Kernel for blurring

0.0625	0.125	0.0625
0.125	0.25	0.125
0.0625	0.125	0.0625

Matrix multiplication of this kernel with
a 3 x 3 patch of an image is a weighted sum
of neighboring pixels
=> blurring effect

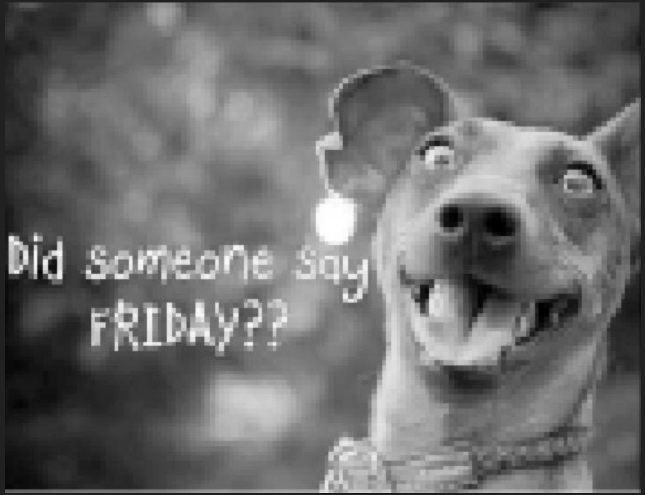
Convolution without training

input

Kernel for blurring

0.0625	0.125	0.0625
0.125	0.25	0.125
0.0625	0.125	0.0625

tf.nn.conv2d



output

Convolutions in TensorFlow

We can use one single convolutional layer to modify a certain image

```
tf.nn.conv2d(
    input,
    filter,
    strides,
    padding,
    use_cudnn_on_gpu=True,
    data_format='NHWC',
    dilations=[1, 1, 1, 1],
    name=None
)
```

Convolutions in TensorFlow

We can use one single convolutional layer to modify a certain image

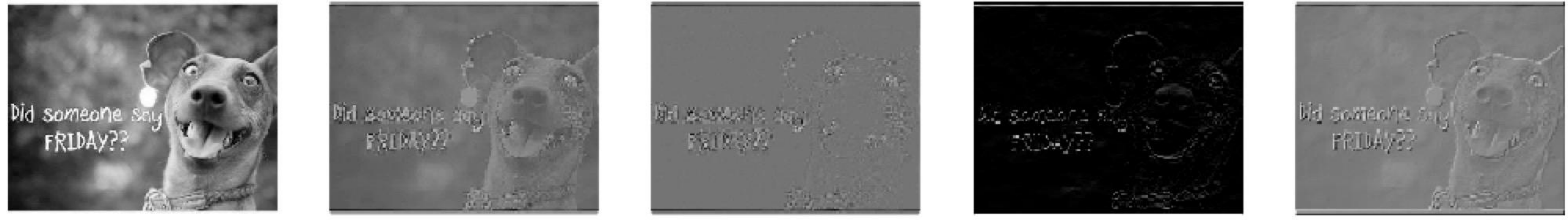
```
tf.nn.conv2d(
    input,              Batch size (N) x Height (H) x Width (W) x Channels (C)
    filter,             Height x Width x Input Channels x Output Channels
    strides,            4 element 1-D tensor, strides in each direction
    padding,            'SAME' or 'VALID'
    use_cudnn_on_gpu=True,
    data_format='NHWC',
    dilations=[1, 1, 1, 1],
    name=None
)
```

Convolutions in TensorFlow

We can use one single convolutional layer to modify a certain image

```
tf.nn.conv2d(
    image,
    kernel,
    strides=[1, 3, 3, 1],
    padding='SAME',
)
```

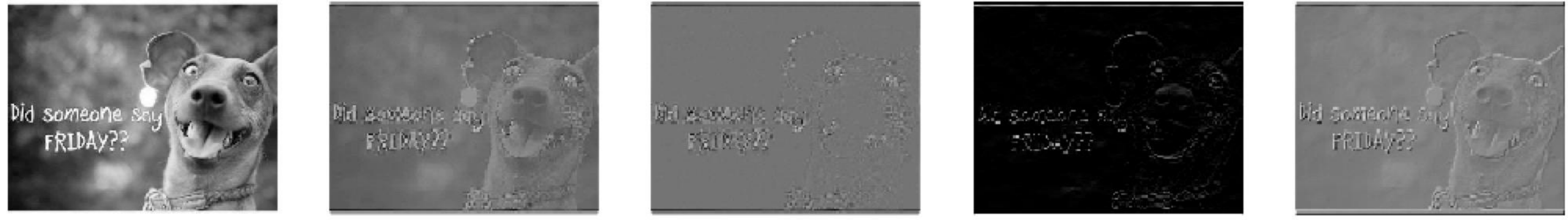
Some basic kernels



input sharpen edge top sobel emboss

See kernels.py and 07_run_kernels.py

Some basic kernels



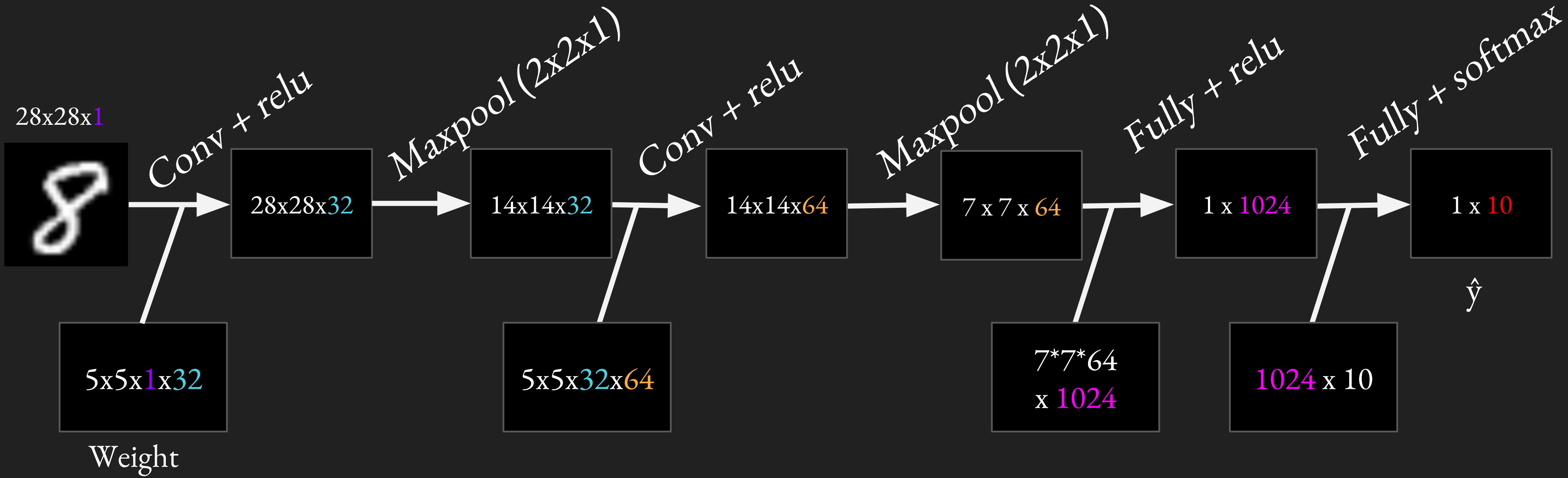
input sharpen edge top sobel emboss

Convolutions in machine learning

Don’t hard-code the values of your kernels.
Learn the optimal kernels through training!

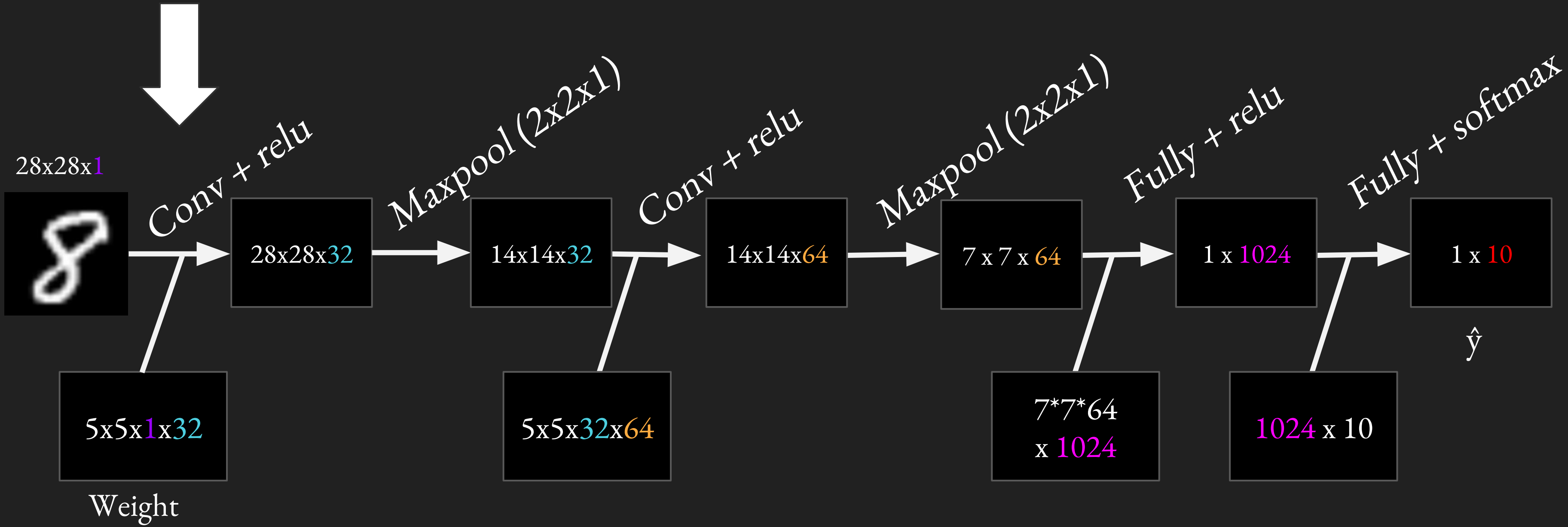
ConvNet with MNIST

Model



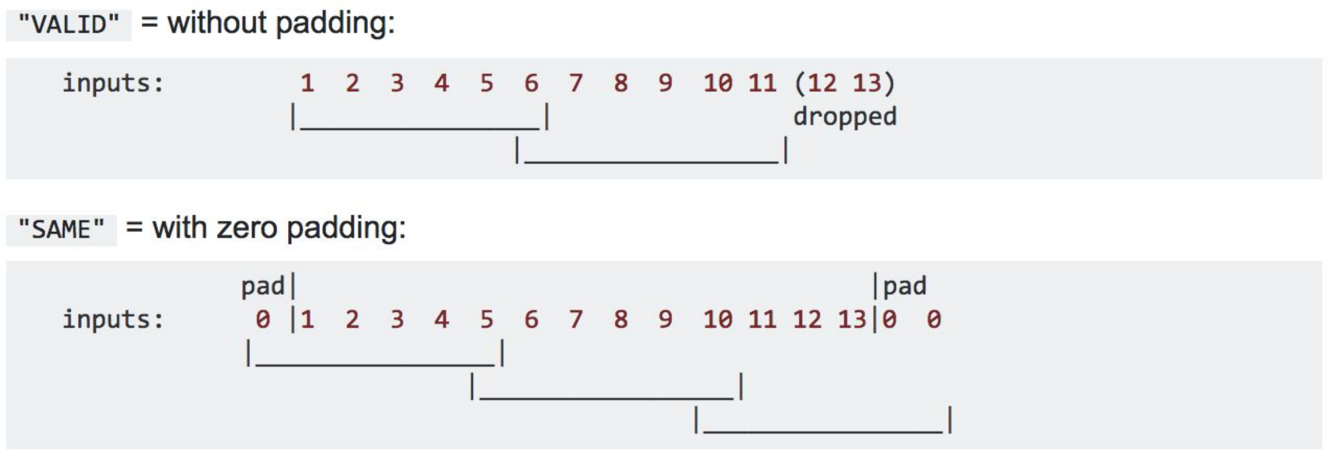
Strides for all convolutional layers: [1, 1, 1, 1]

Convolutional layer



```
conv = tf.nn.conv2d(images,
                    kernel,
                    strides=[1, 1, 1, 1],
                    padding='SAME')
```

Convolutional layer: padding



"VALID" = without padding:

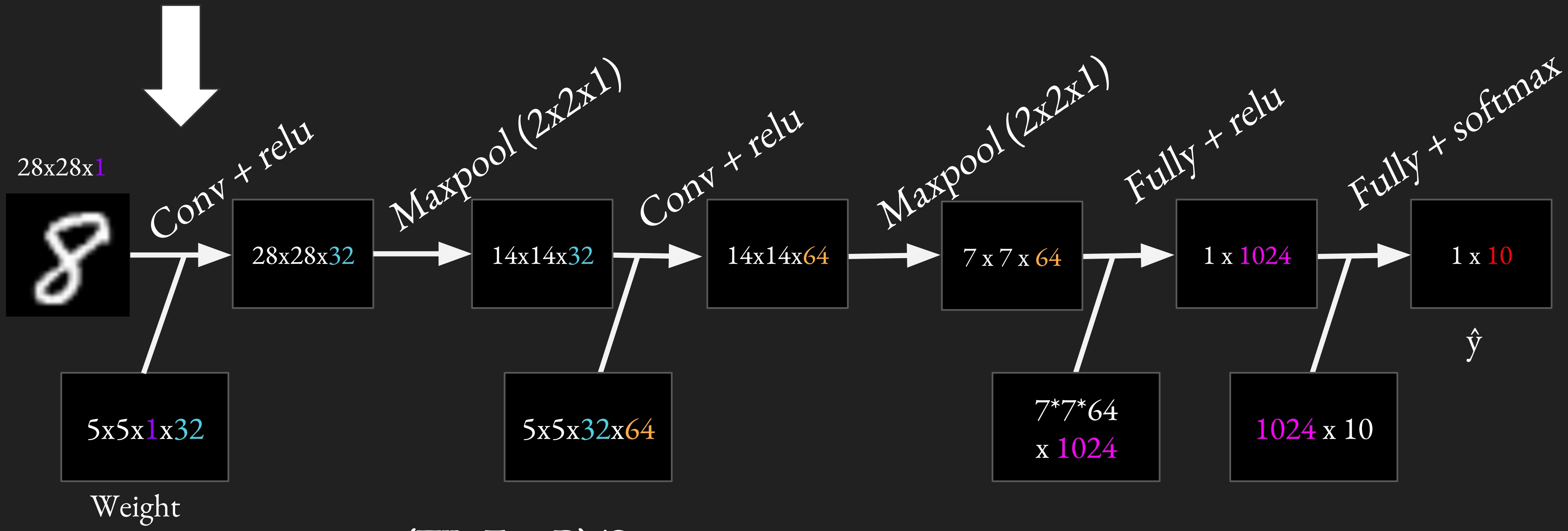
```
   inputs:         1  2  3  4  5  6  7  8  9  10 11 (12 13)
                  |________________|                dropped
                                 |_________________|
```

"SAME" = with zero padding:

```
               pad|                                      |pad
   inputs:      0 |1  2  3  4  5  6  7  8  9  10 11 12 13|0  0
               |________________|
                              |_________________|
                                             |________________|
```

Input width = 13
Filter width = 6
Stride = 5

Convolutional layer: Dimension



28x28x1

Conv + relu

28x28x32

Maxpool (2x2x1)

14x14x32

Conv + relu

14x14x64

Maxpool (2x2x1)

7 x 7 x 64

Fully + relu

1 x 1024

Fully + softmax

1 x 10

ŷ

5x5x1x32

Weight

5x5x32x64

7*7*64 x 1024

1024 x 10

(W−F+2P)/S+ 1

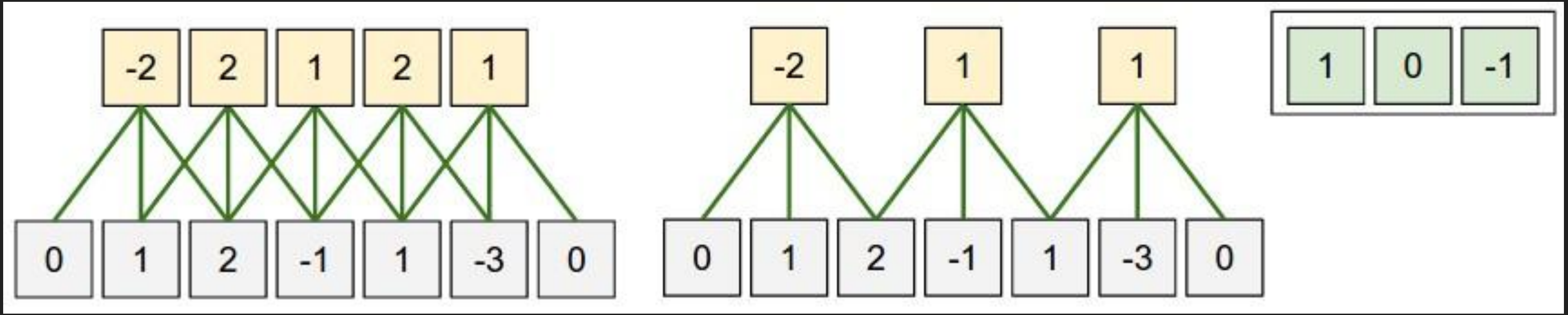
W: input width/depth

P: padding

F: filter width/depth

S: stride

Convolutional layer: Dimension

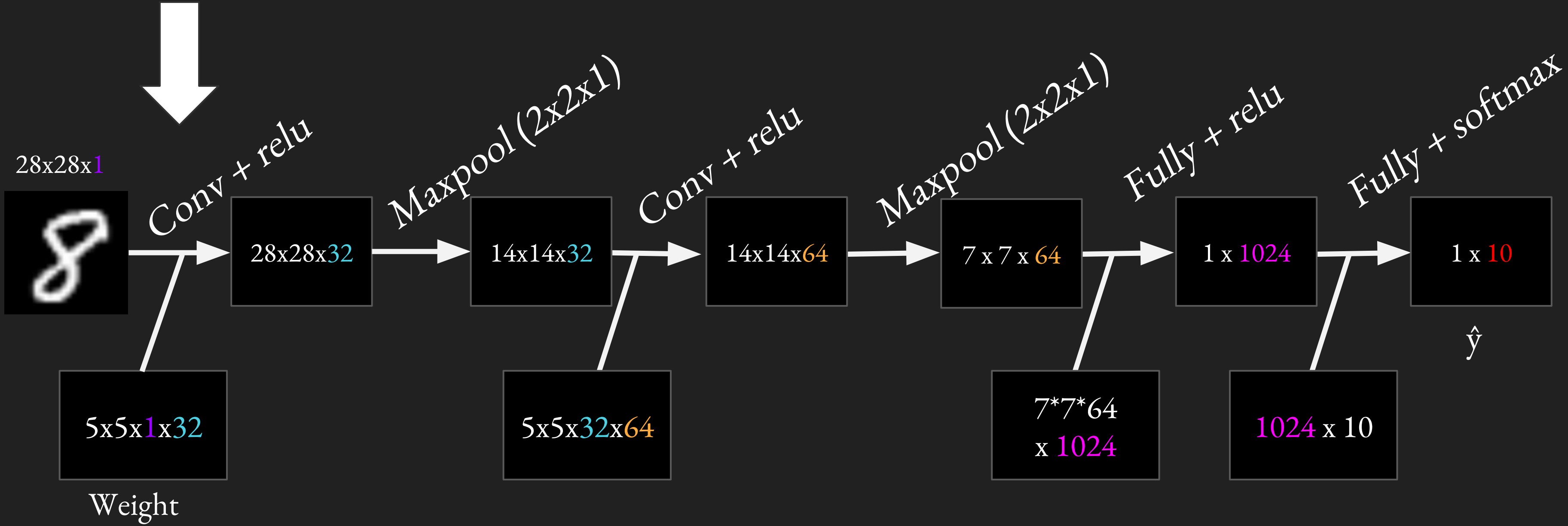


(W–F+2P)/S+ 1

W: input width/depth F: filter width/depth
P: padding S: stride

Image credit: CS231n Lecture 7

Convolutional layer: Dimension



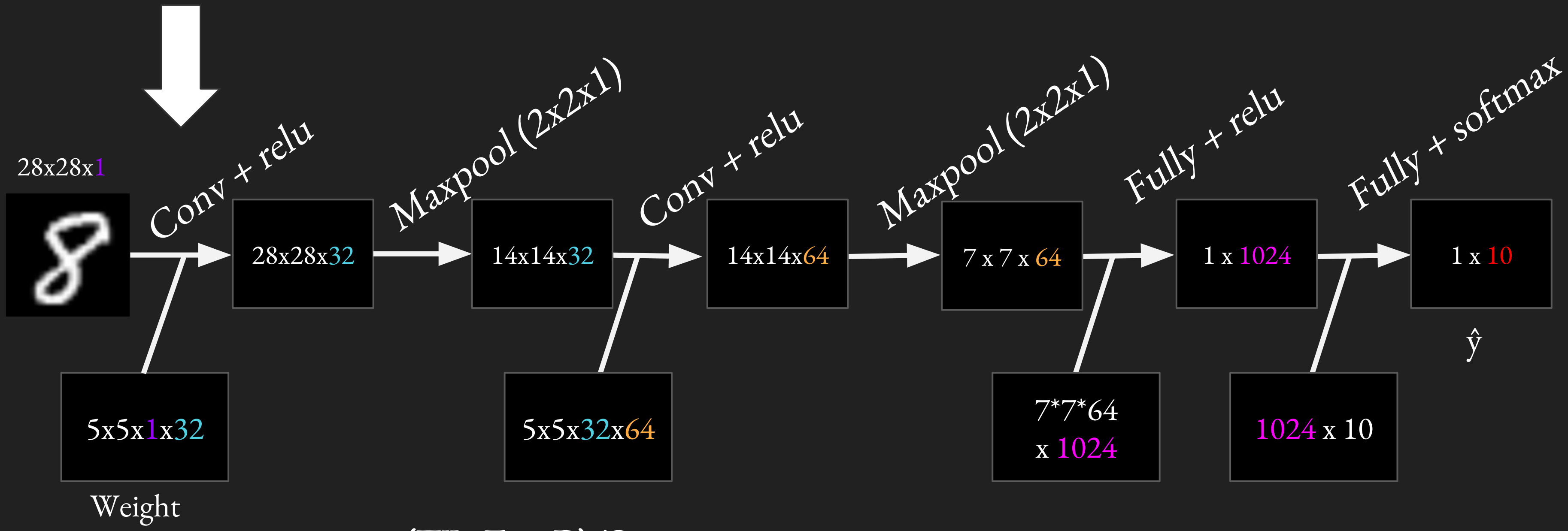
(W−F+2P)/S+ 1

(28 - 5 + 2*2)/1 + 1 = 28

W: input width/depth F: filter width/depth

P: padding S: stride

Convolutional layer: Dimension



(W−F+2P)/S+ 1

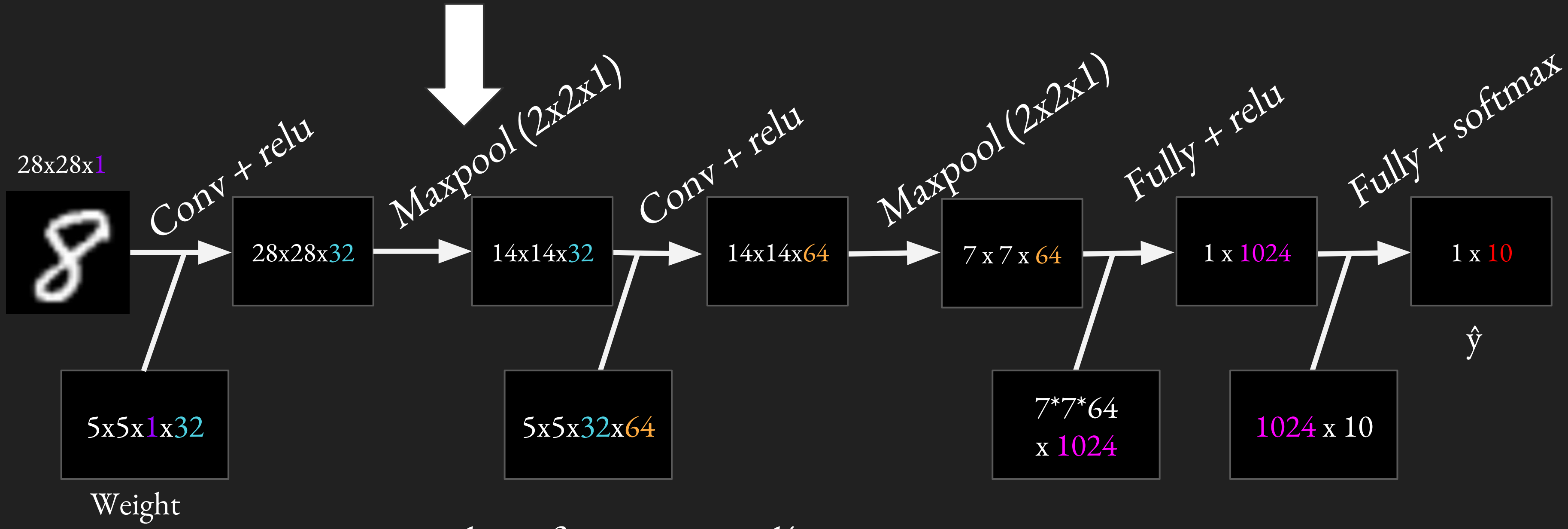
(28 - 5 + 2*2)/1 + 1 = 28

W: input width/depth F: filter width/depth

P: padding S: stride

TF computes padding for us!

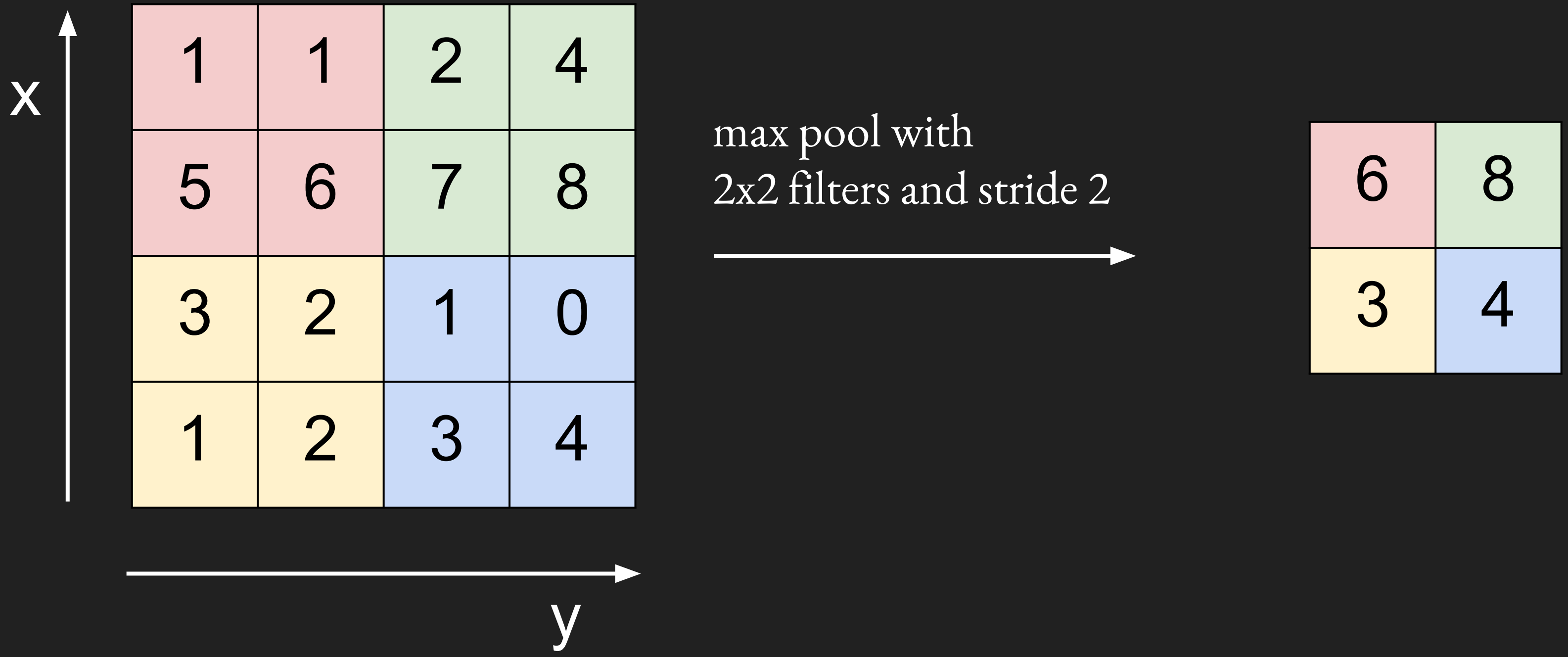
Maxpooling



```
pool1 = tf.nn.max_pool(conv1,
                       ksize=[1, 2, 2, 1],
                       strides=[1, 2, 2, 1],
                       padding='SAME')
```

Maxpooling

Single depth slice



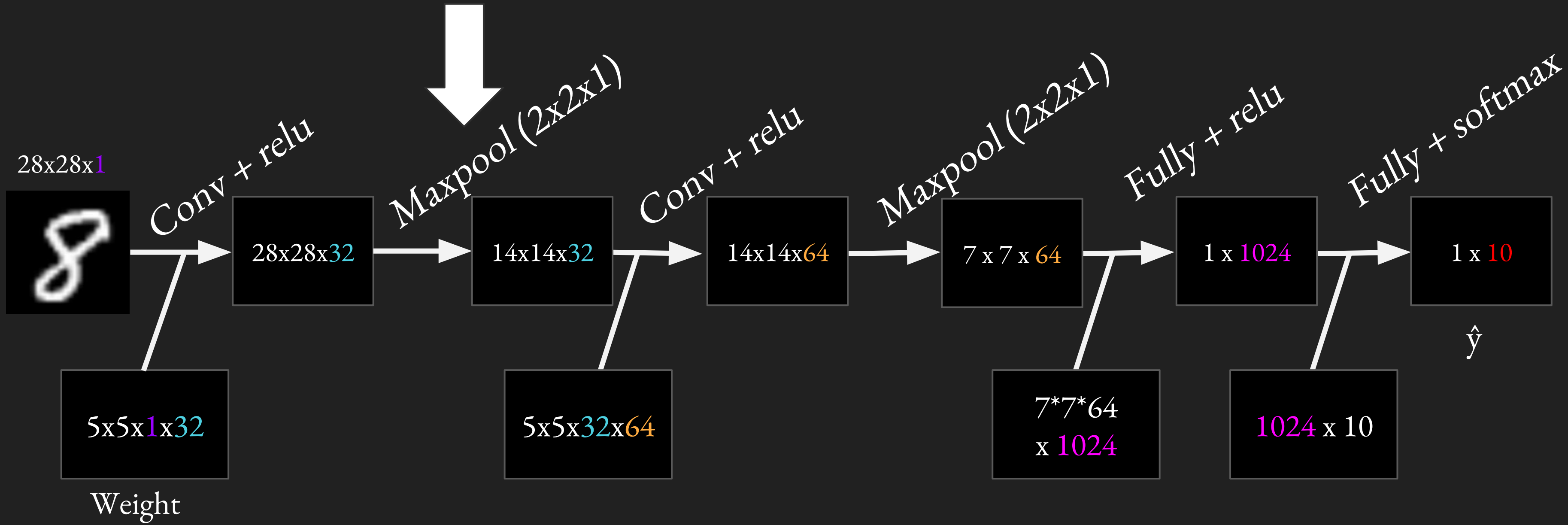
1	1	2	4
5	6	7	8
3	2	1	0
1	2	3	4

max pool with
2x2 filters and stride 2

6	8
3	4

Slide credit: CS231n Lecture 7

Maxpooling: Dimension

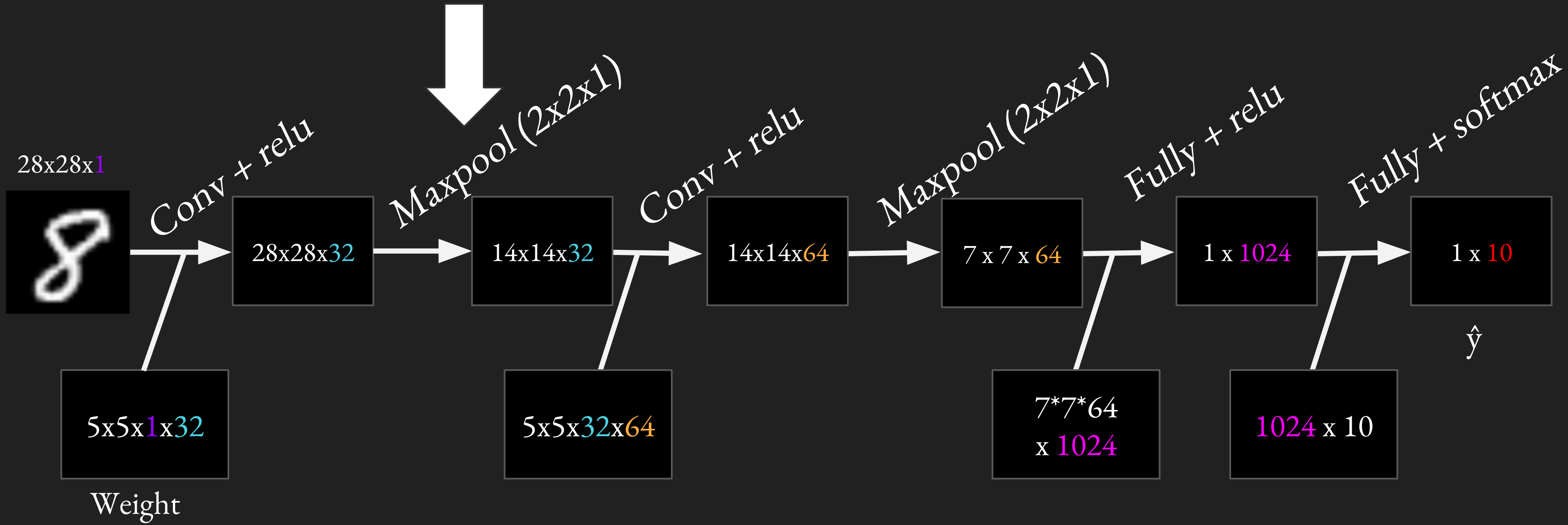


(W−K+2P)/S+ 1

W: input width/depth
P: padding

K: window width/depth
S: stride

Maxpooling: Dimension



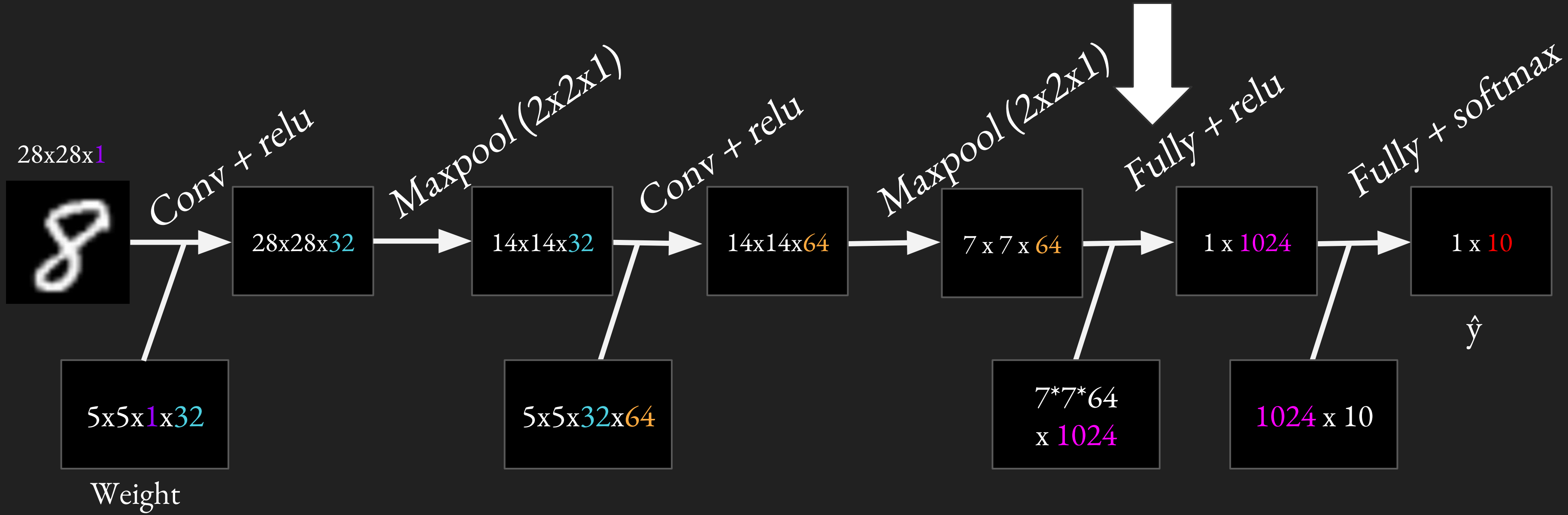
(W−K+2P)/S+ 1

(28 - 2 + 2*0) / 2 + 1 = 14

W: input width/depth K: window width/depth

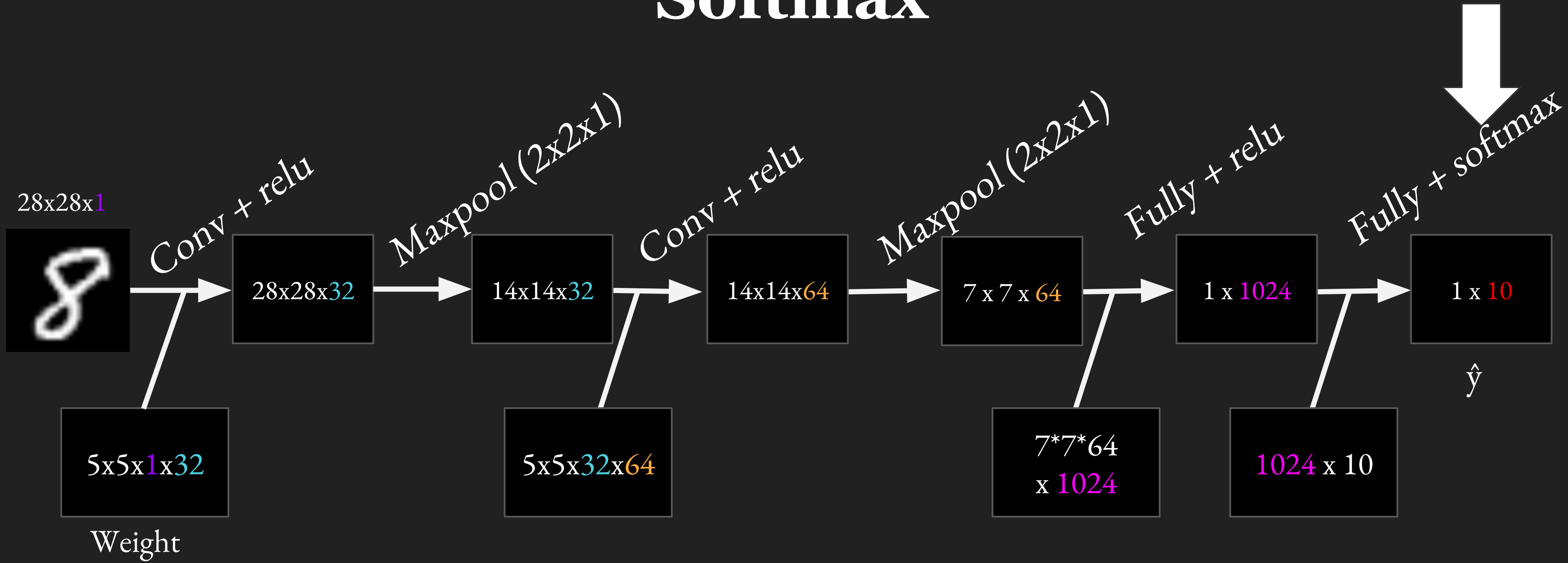
P: padding S: stride

Fully connected



fc = tf.matmul(pool2, w) + b

Softmax



Loss function

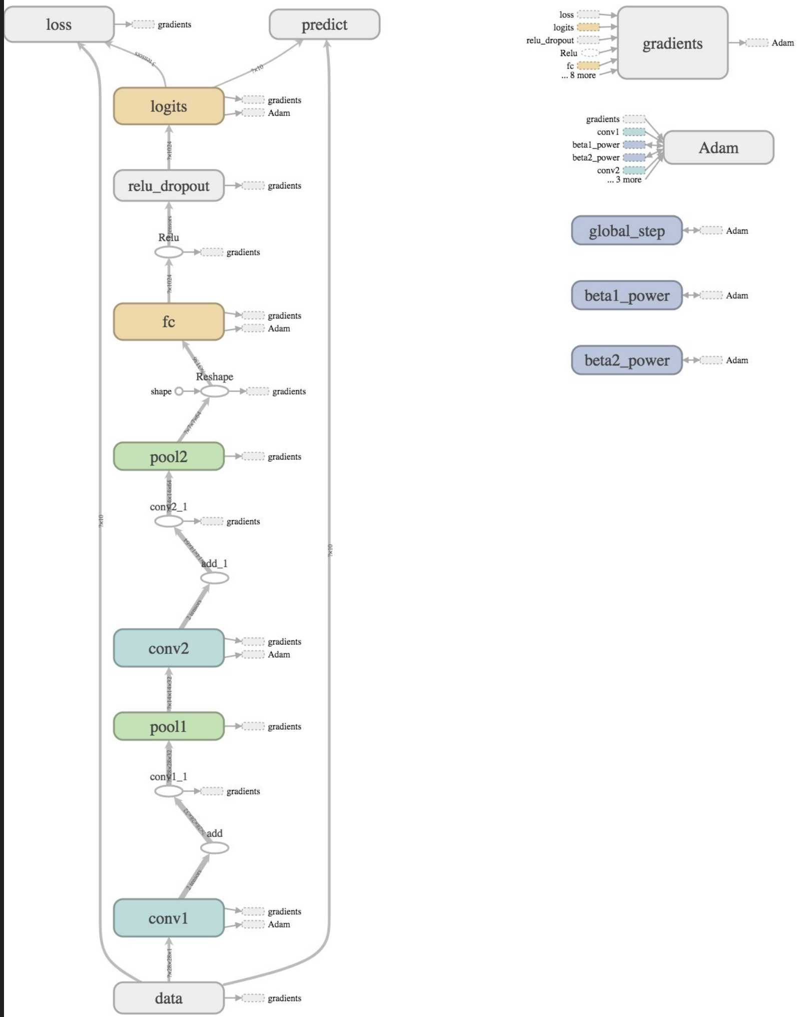
tf.nn.**softmax_cross_entropy_with_logits**(labels=Y, logits=logits)

Predict

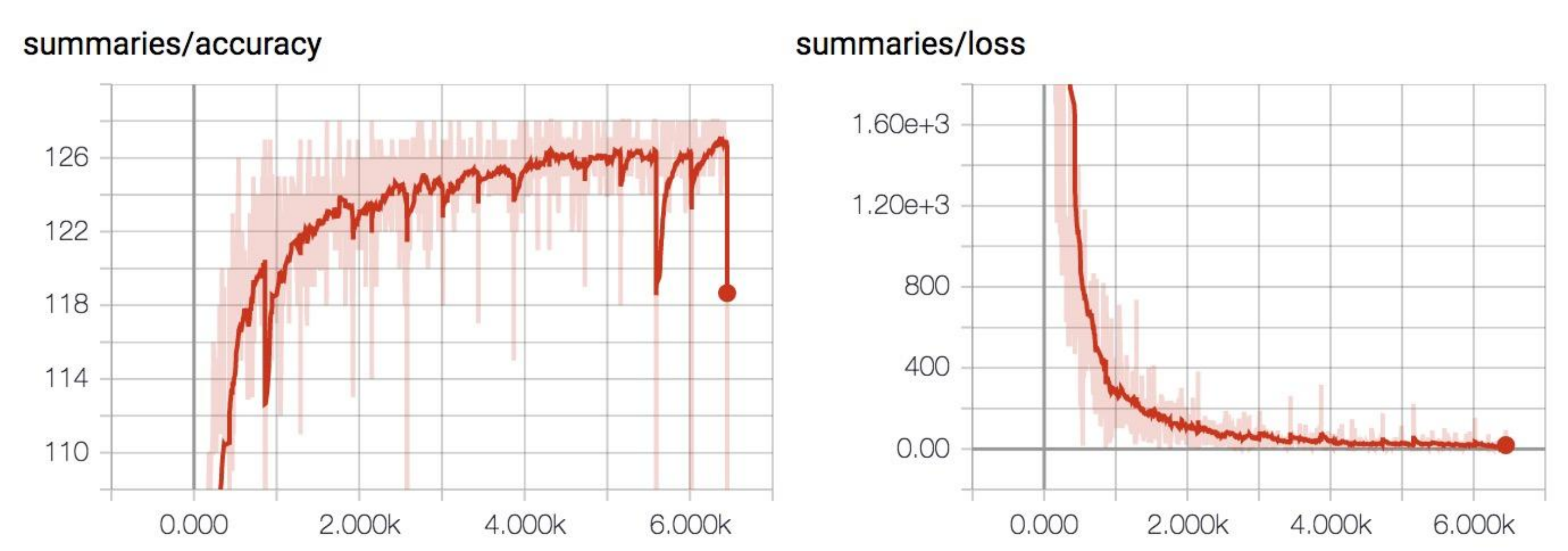
tf.nn.**softmax**(logits_batch)

Interactive coding

07_convnet_mnist_starter.py from GitHub!
Update utils.py


loss
gradients
predict
3 tensors
?x10
logits
gradients
Adam
?x1024
relu_dropout
gradients
2 tensors
Relu
gradients
?x1024
fc
gradients
Adam
?x3136
Reshape
shape
gradients
?x7x7x64
pool2
gradients
?x14x14x64
conv2_1
gradients
?x14x14x64
add_1
2 tensors
conv2
gradients
Adam
?x14x14x32
pool1
gradients
?x28x28x32
conv1_1
gradients
?x28x28x32
add
2 tensors
conv1
gradients
Adam
?x28x28x1
data
gradients
?x10
?x10
loss
logits
relu_dropout
Relu
fc
... 8 more
gradients
Adam
gradients
conv1
beta1_power
beta2_power
conv2
... 3 more
Adam
global_step
Adam
beta1_power
Adam
beta2_power
Adam

Training progress



Test accuracy increases while training loss decreases!

Accuracy

Epochs	Accuracy
1	0.9131
2	0.9363
3	0.9478
5	0.9573
10	0.971
25	0.9818

tf.layers

tf.layers

We’ve been learning it the hard way

tf.layers.conv2d

```
conv1 = tf.layers.conv2d(inputs=self.img,
                         filters=32,
                         kernel_size=[5, 5],
                         padding='SAME',
                         activation=tf.nn.relu,
                         name='conv1')
```

tf.layers.conv2d

```
conv1 = tf.layers.conv2d(inputs=self.img,
                         filters=32,
                         kernel_size=[5, 5],
                         padding='SAME',
                         activation=tf.nn.relu,
                         name='conv1')
```

can choose
non-linearity to use

tf.layers.max_pooling2d

```
pool1 = tf.layers.max_pooling2d(inputs=conv1,
                                pool_size=[2, 2],
                                strides=2,
                                name='pool1')
```

tf.layers.dense

```
fc = tf.layers.dense(pool2, 1024, activation=tf.nn.relu, name='fc')
```

tf.layers.dense

```
dropout = tf.layers.dropout(fc,
                     self.keep_prob,
                     training=self.training,
                     name='dropout')
```

Drop neurals during training
Want to use all of them during testing

Next class

TFRecord

CIFAR

Style Transfer

Feedback: chiphuyen@cs.stanford.edu

Thanks!