# Convnets in TensorFlow

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

# Agenda

Convolutions without training

Convnet with MNIST!!!

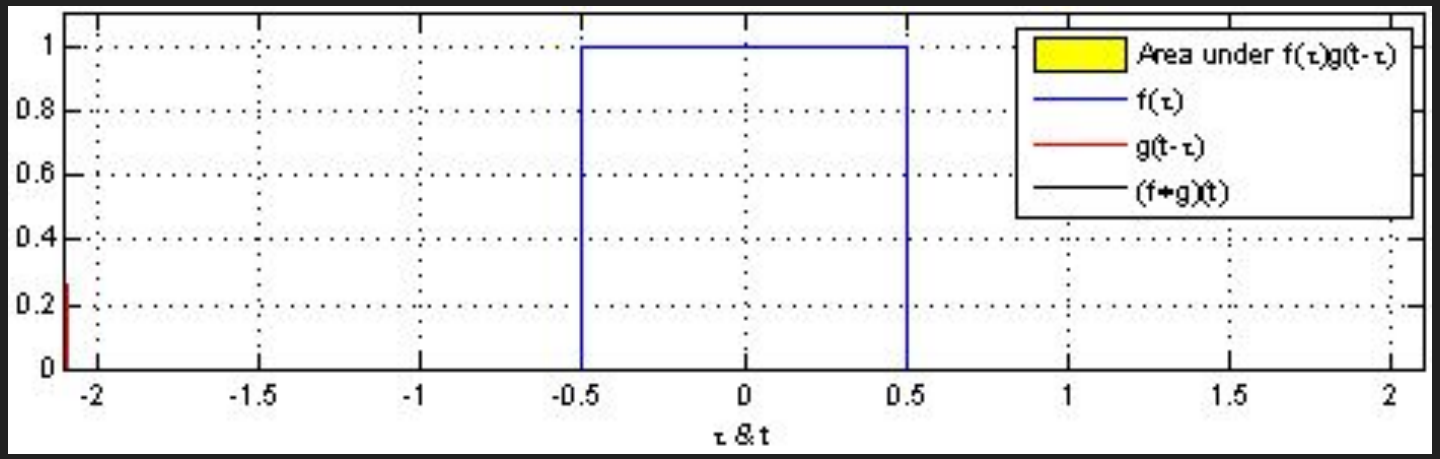
tf.layers

# 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

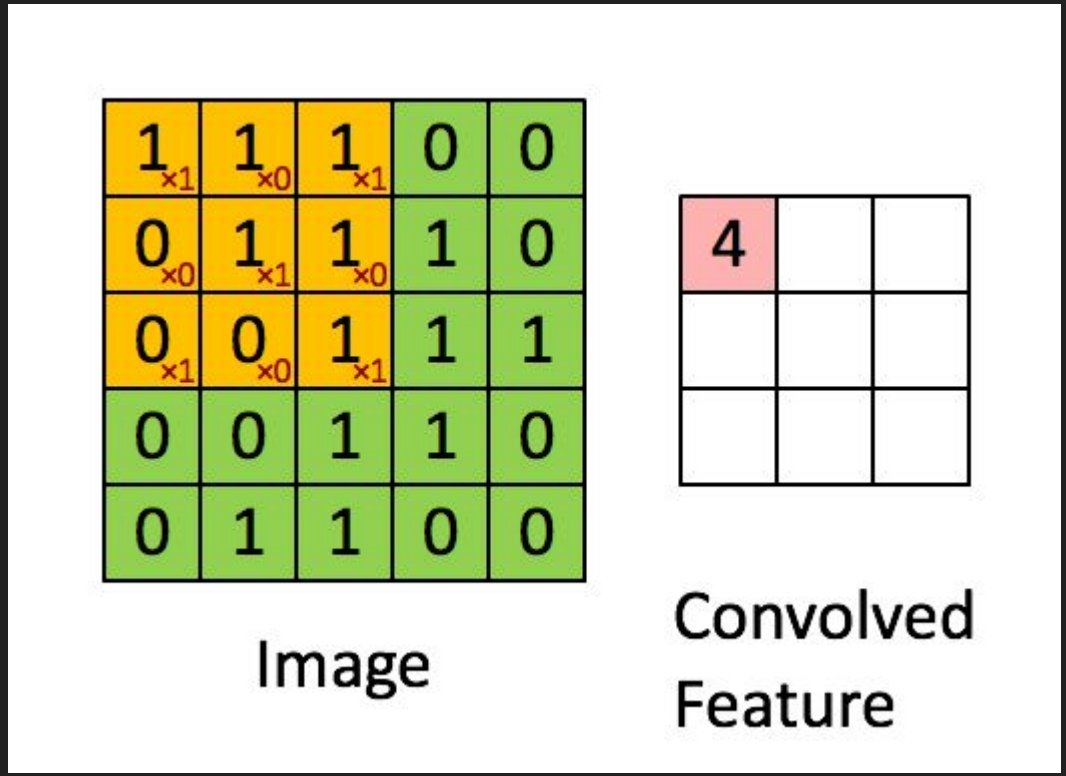
How an input is transformed by a kernel*

*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






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


Kernel for blurring

| | | |
|---|---|---|
| 0.0625 | 0.125 | 0.0625 |
| 0.125 | 0.25 | 0.125 |
| 0.0625 | 0.125 | 0.0625 |

tf.nn.conv2d


input

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

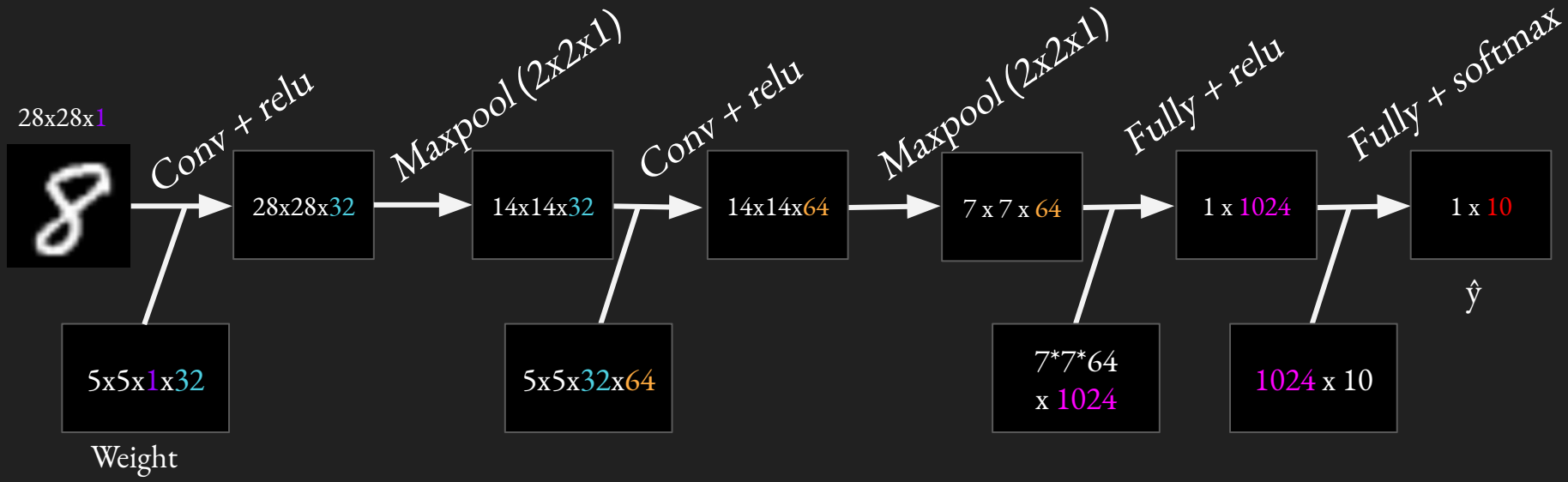

input sharpen edge top sobel emboss

# Convolutions in machine learning

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

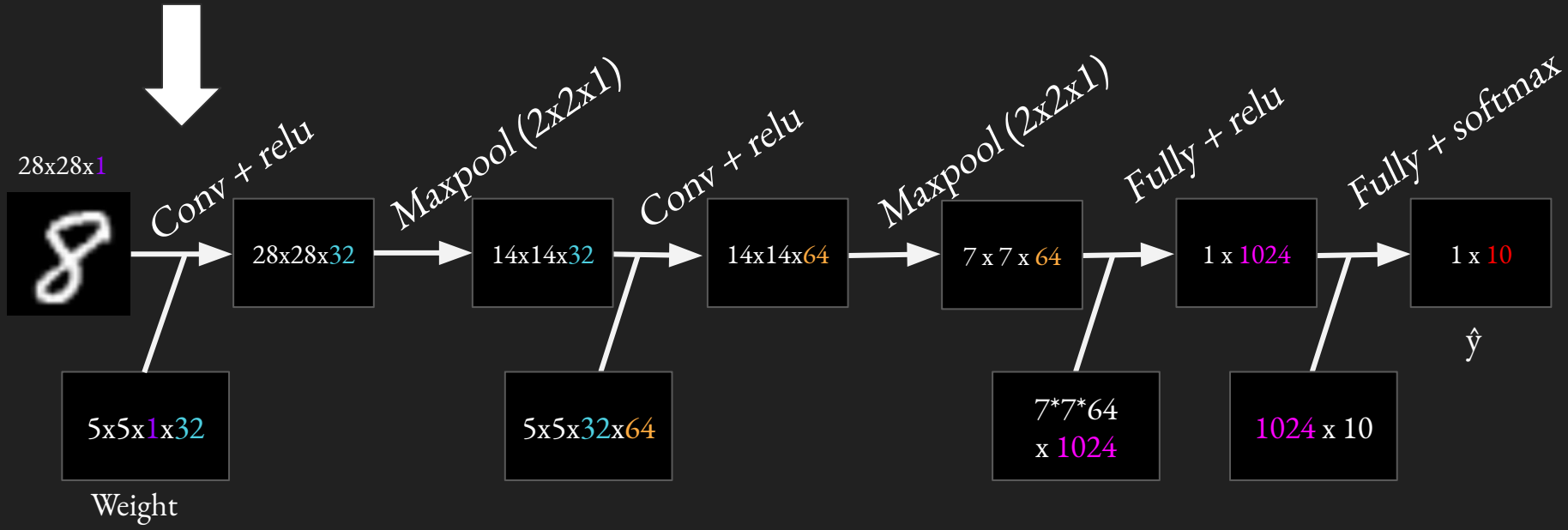
# ConvNet with MNIST

# Model



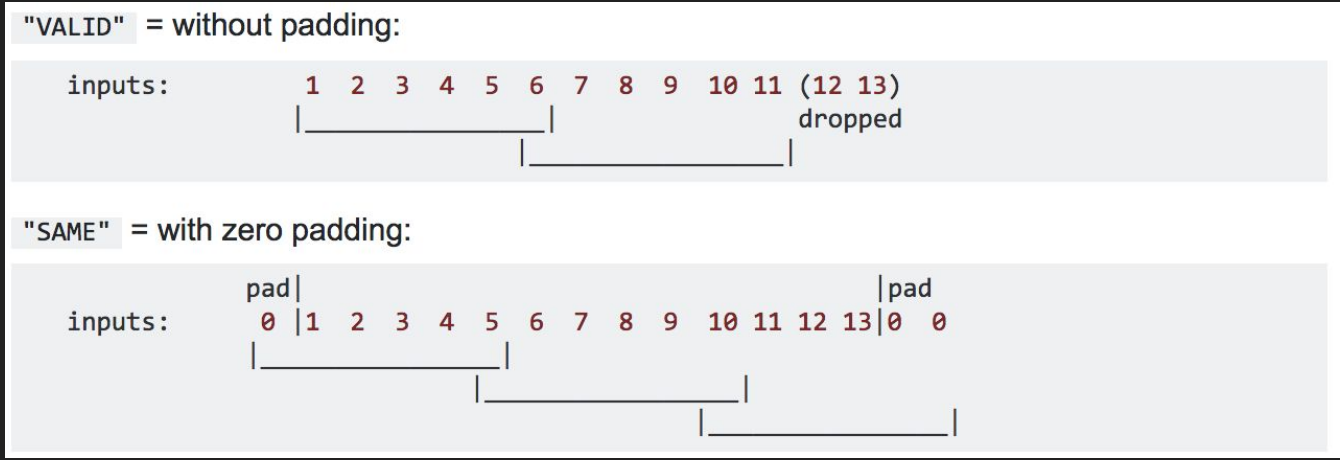

Strides for all convolutional layers: [1, 1, 1, 1]

# Convolutional layer



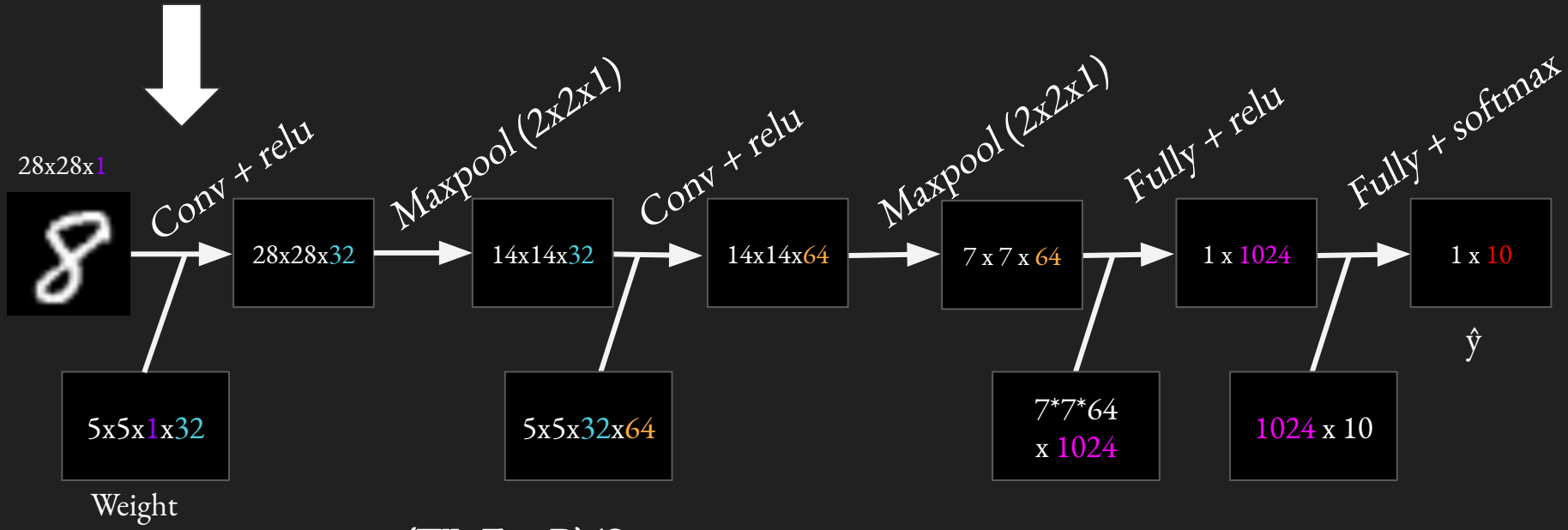

```
conv = tf.nn.conv2d(images,
                    kernel,
                    strides=[1, 1, 1, 1],
                    padding='SAME')
```

# Convolutional layer: padding




Input width = 13
Filter width = 6
Stride = 5

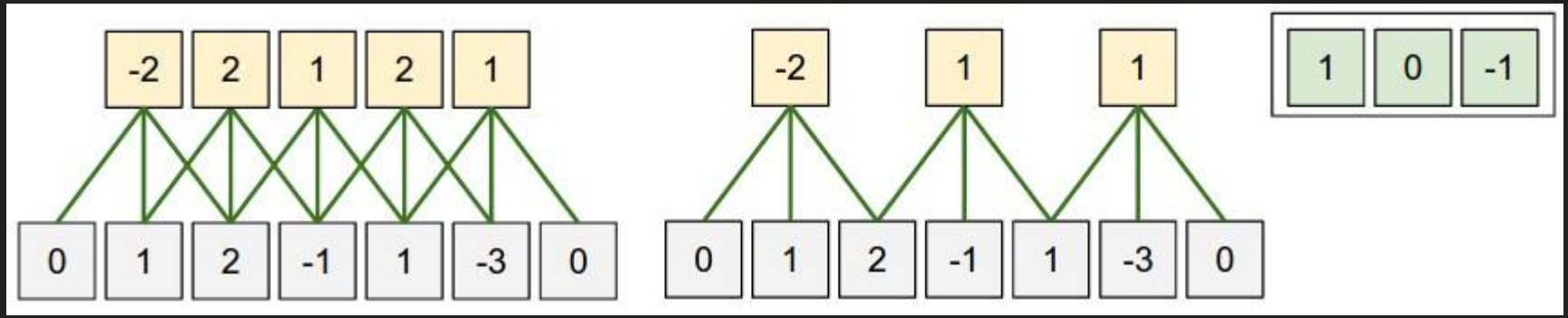
# Convolutional layer: Dimension




**(W–F+2P)/S+ 1**

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

# Convolutional layer: Dimension

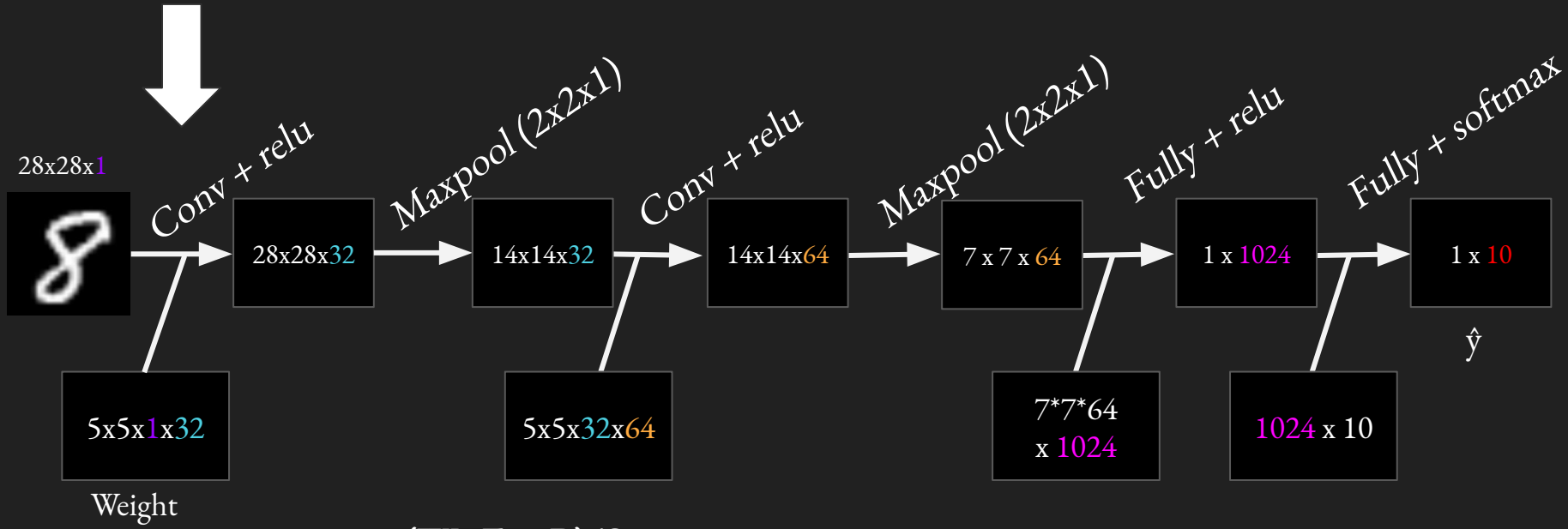



**(W–F+2P)/S+ 1**

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

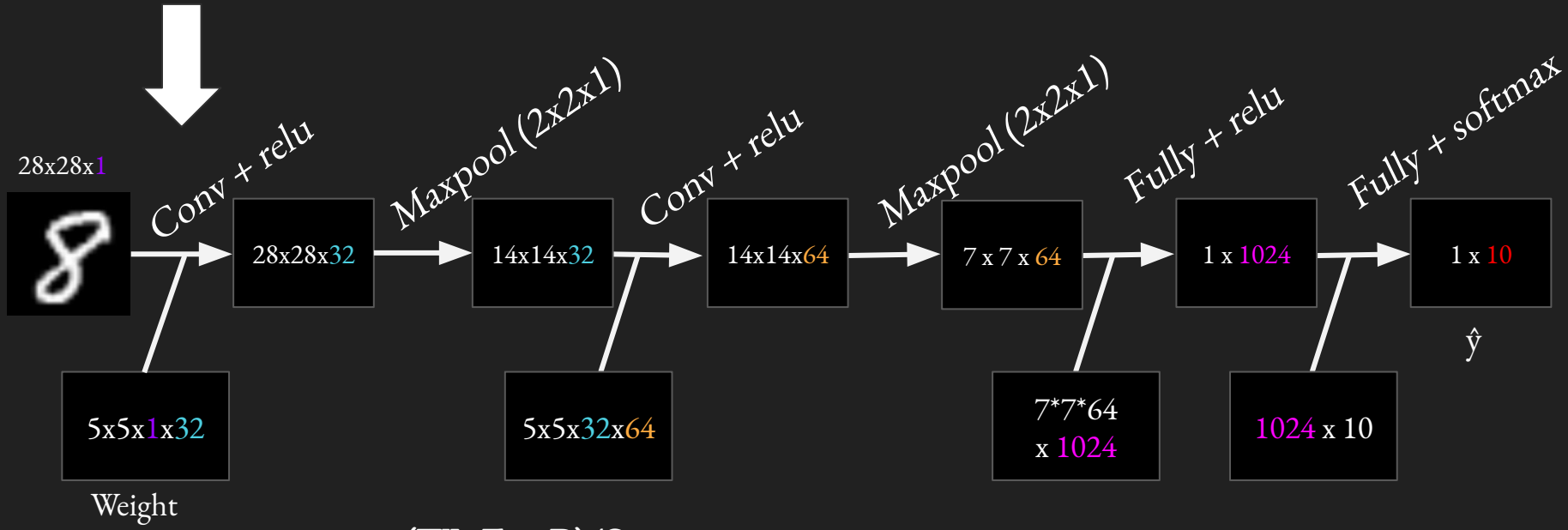
W: input width /depth

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

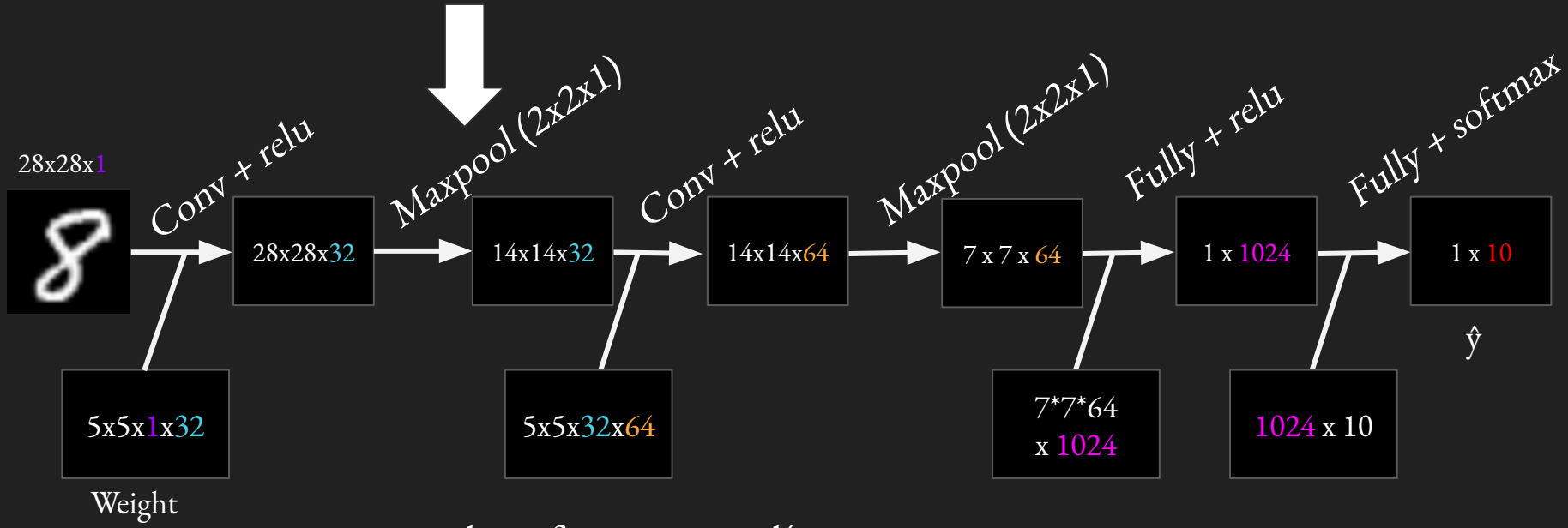
F: filter width/depth

P: padding

S: stride

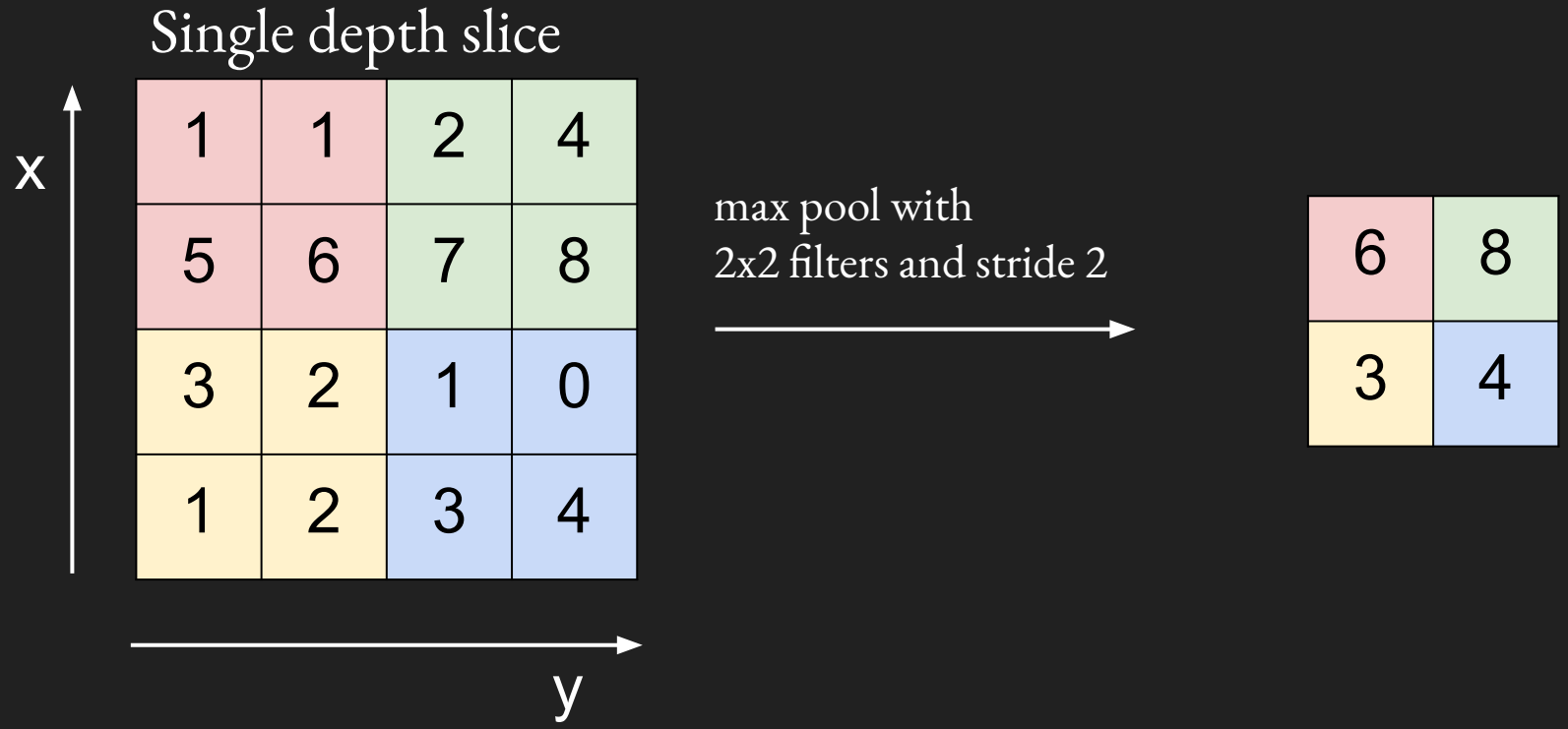
TF computes padding for us!

# Maxpooling




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

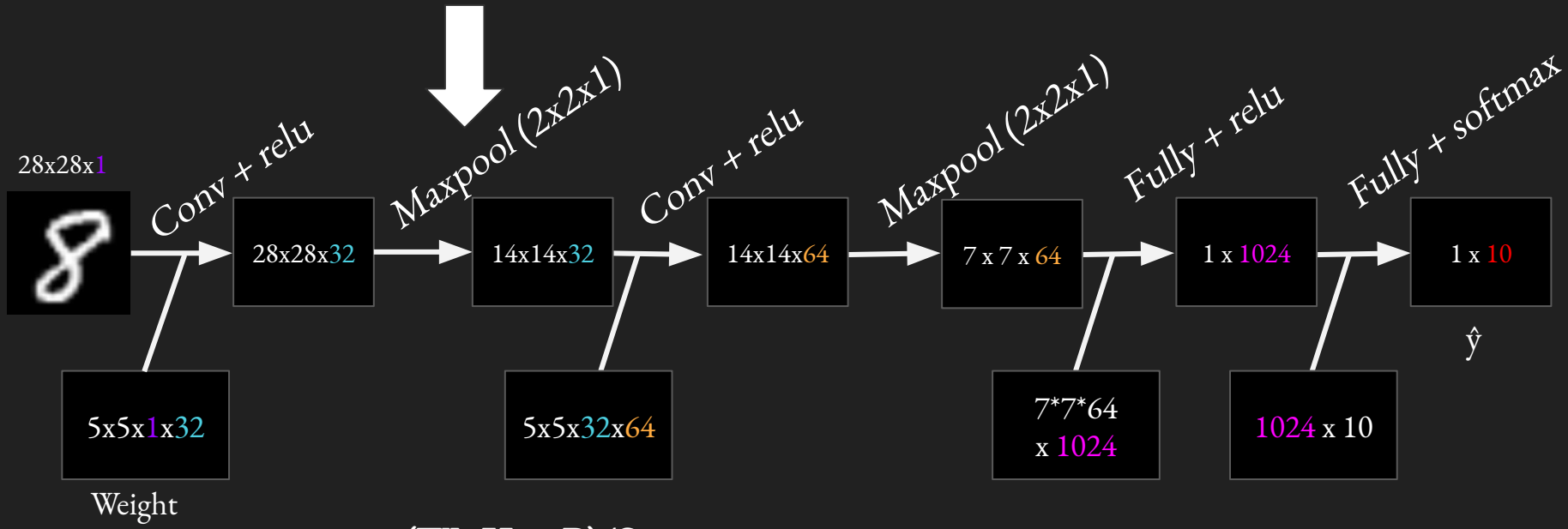
# Maxpooling






Slide credit: CS231n Lecture 7

# Maxpooling: Dimension

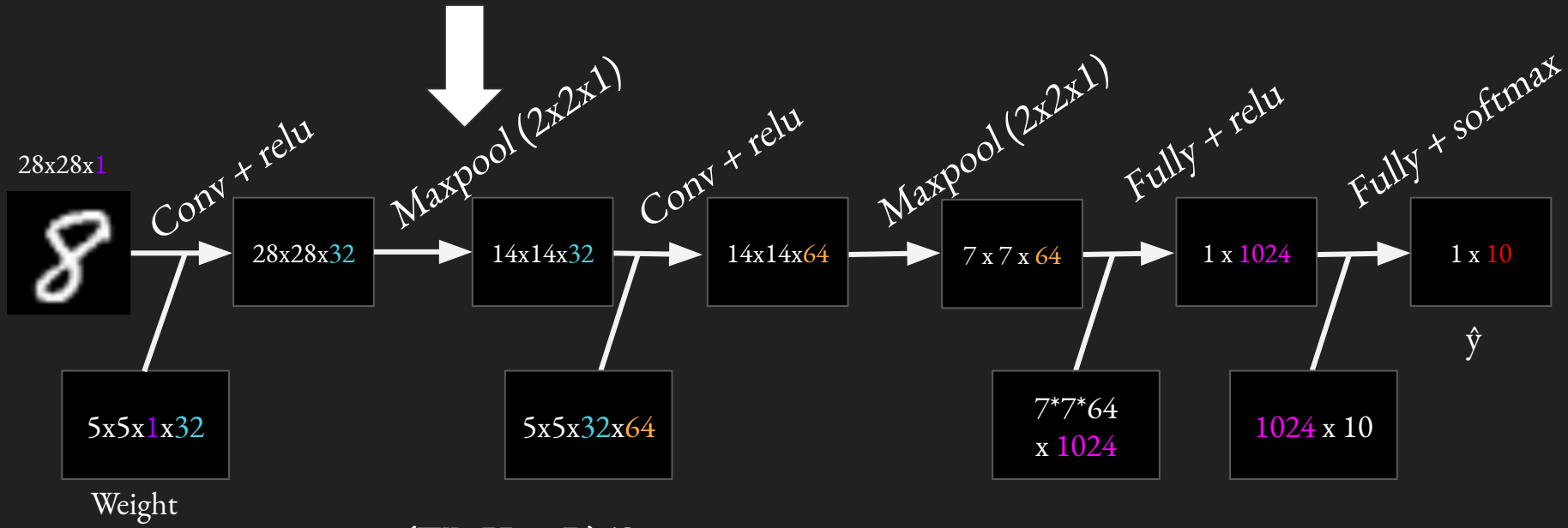



**(W–K+2P)/S+ 1**

W: input width /depth
P: padding

K: window width/depth
S: stride

# Maxpooling: Dimension



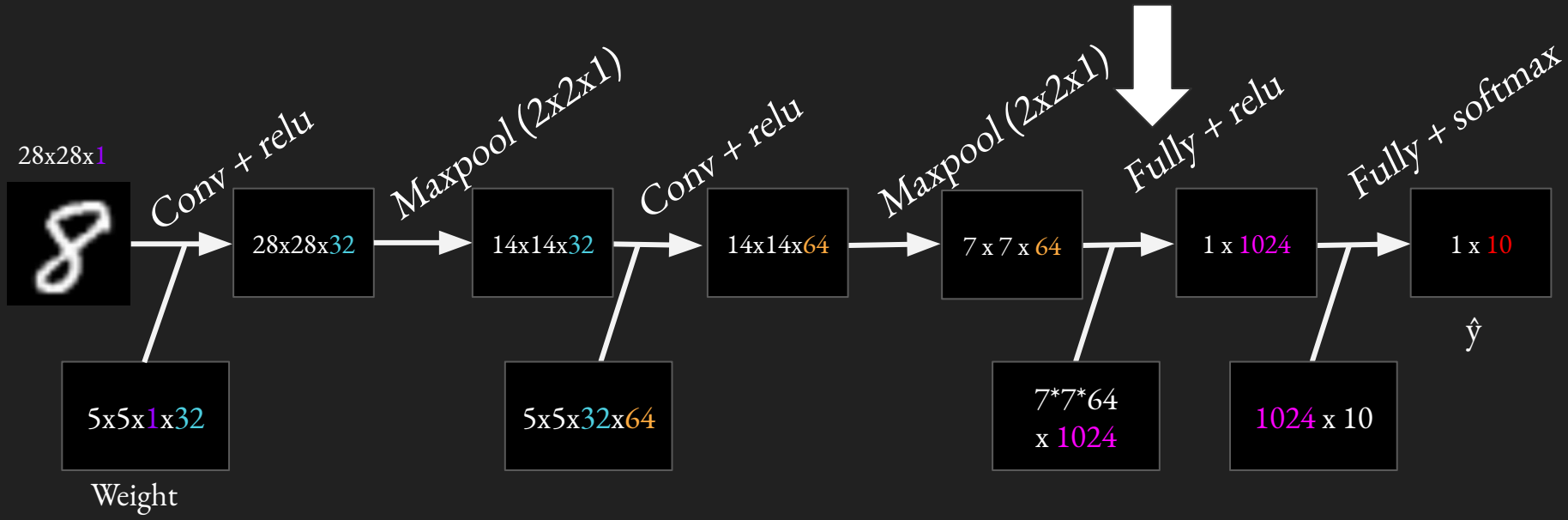

**(W–K+2P)/S+ 1**

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

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

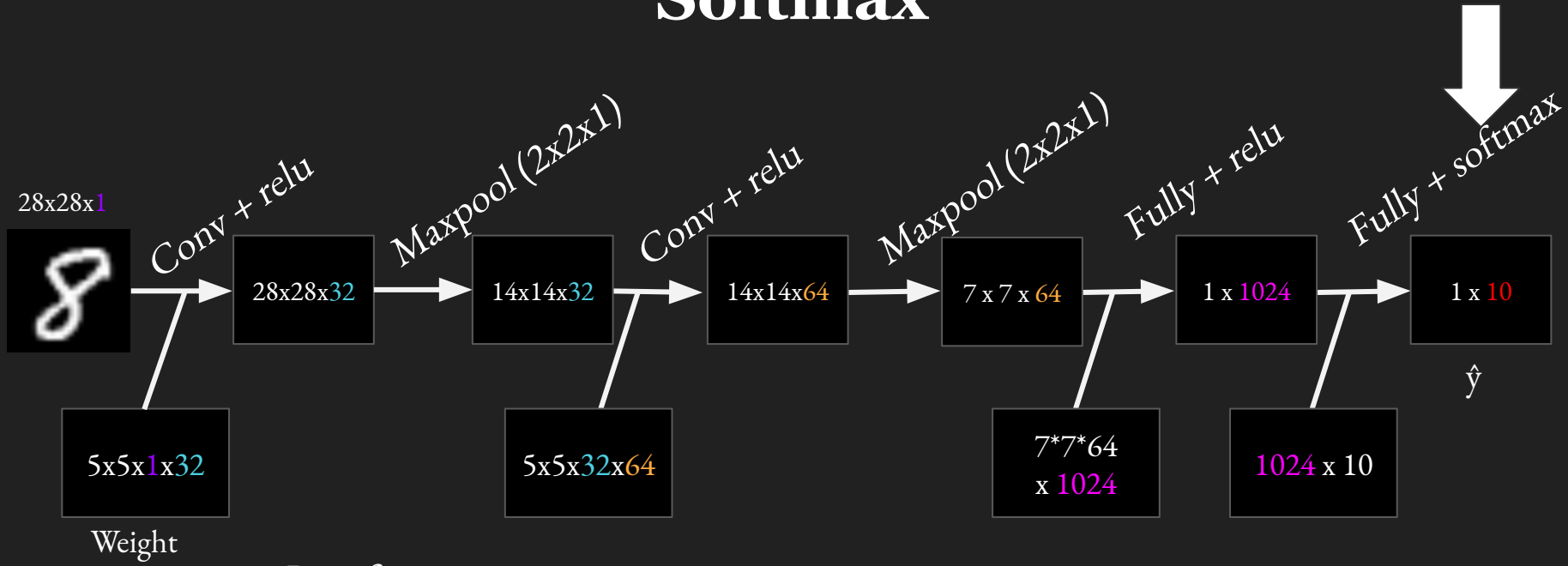
P: padding S: stride

# Fully connected




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

# Softmax




Loss function

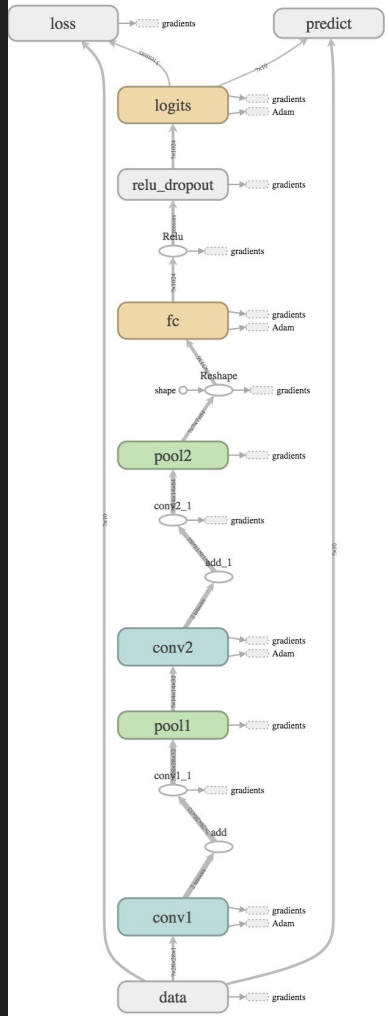
tf.nn.**softmax_cross_entropy_with_logits**(labels=Y, logits=logits)

Predict

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

# Interactive coding

07_convnet_mnist_starter.py from GitHub!
Update utils.py


loss
gradients
predict
logits
gradients
Adam
relu_dropout
gradients
Relu
gradients
fc
gradients
Adam
Reshape
shape
gradients
pool2
gradients
conv2_1
gradients
add_1
conv2
gradients
Adam
pool1
gradients
conv1_1
gradients
add
conv1
gradients
Adam
data
gradients


loss
logits
relu_dropout
Relu
fc
... 8 more
gradients
Adam

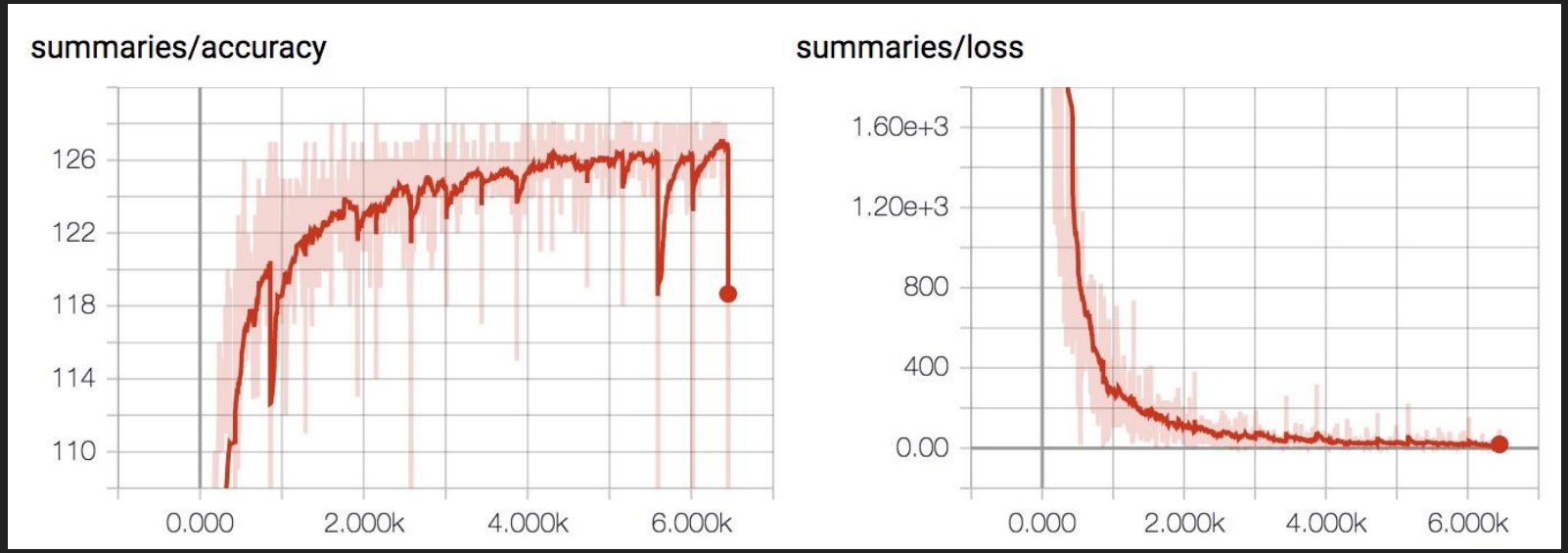

gradients
conv1
beta1_power
beta2_power
conv2
... 3 more
Adam


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!