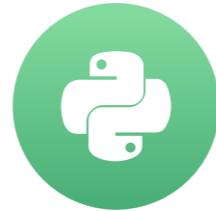


# Tracking learning

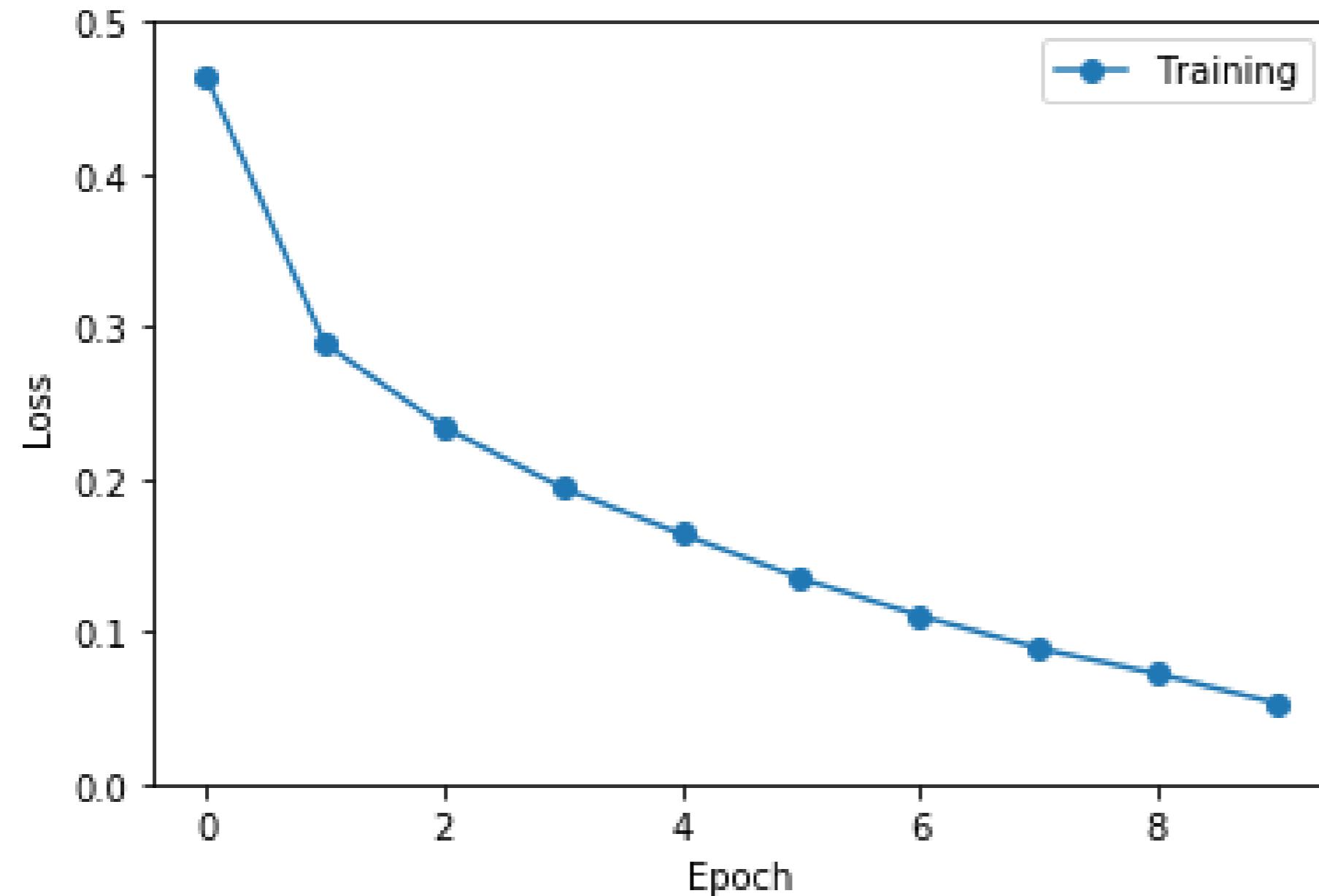
IMAGE PROCESSING WITH KERAS IN PYTHON



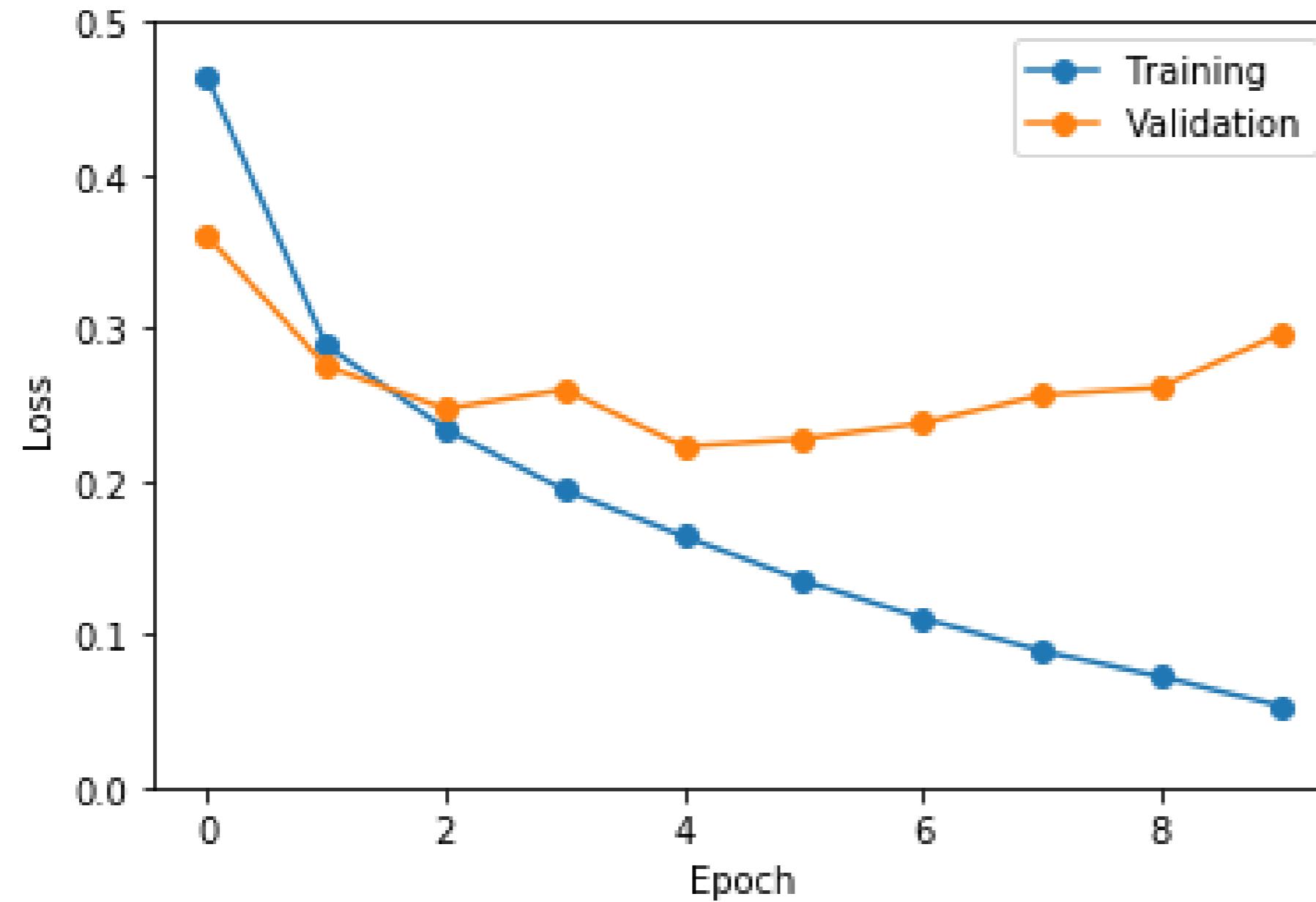
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Washington

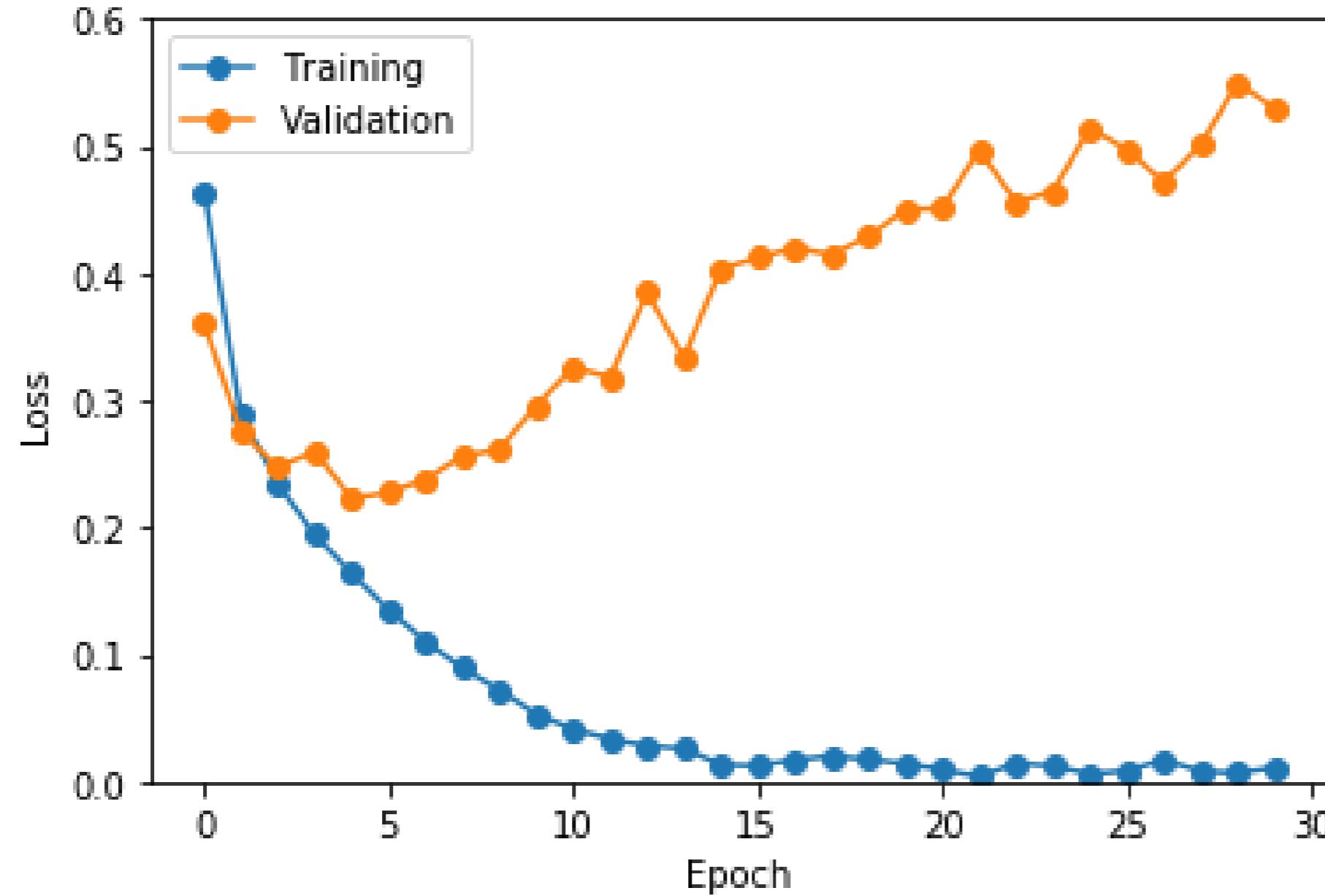
# Learning curves: training



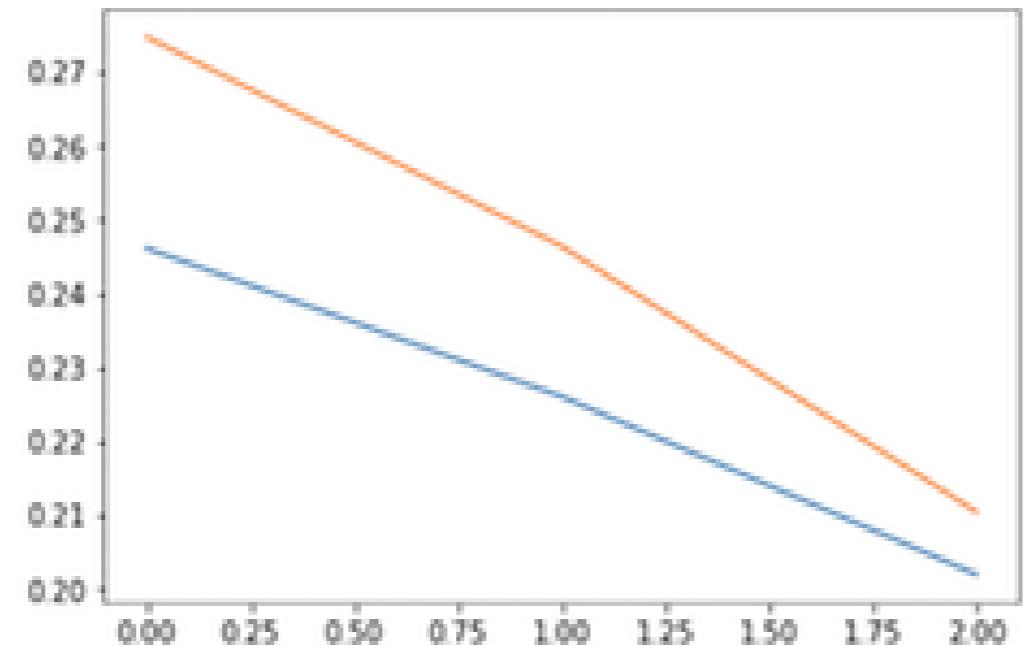
# Learning curves: validation



# Learning curves: overfitting



```
training = model.fit(train_data, train_labels,  
                      epochs=3, validation_split=0.2)  
  
import matplotlib.pyplot as plt  
plt.plot(training.history['loss'])  
plt.plot(training.history['val_loss'])  
plt.show()
```



# Storing the optimal parameters

```
from keras.callbacks import ModelCheckpoint

# This checkpoint object will store the model parameters
# in the file "weights.hdf5"
checkpoint = ModelCheckpoint('weights.hdf5', monitor='val_loss',
                             save_best_only=True)

# Store in a list to be used during training
callbacks_list = [checkpoint]

# Fit the model on a training set, using the checkpoint as a
#callback
model.fit(train_data, train_labels, validation_split=0.2,
          epochs=3, callbacks=callbacks_list)
```

# Loading stored parameters

```
model.load_weights('weights.hdf5')  
  
model.predict_classes(test_data)  
  
array([2, 2, 1, 2, 0, 1, 0, 1, 2, 0])
```

# Let's practice!

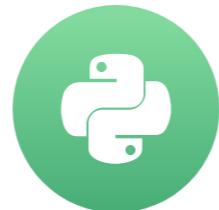
IMAGE PROCESSING WITH KERAS IN PYTHON

# Neural network regularization

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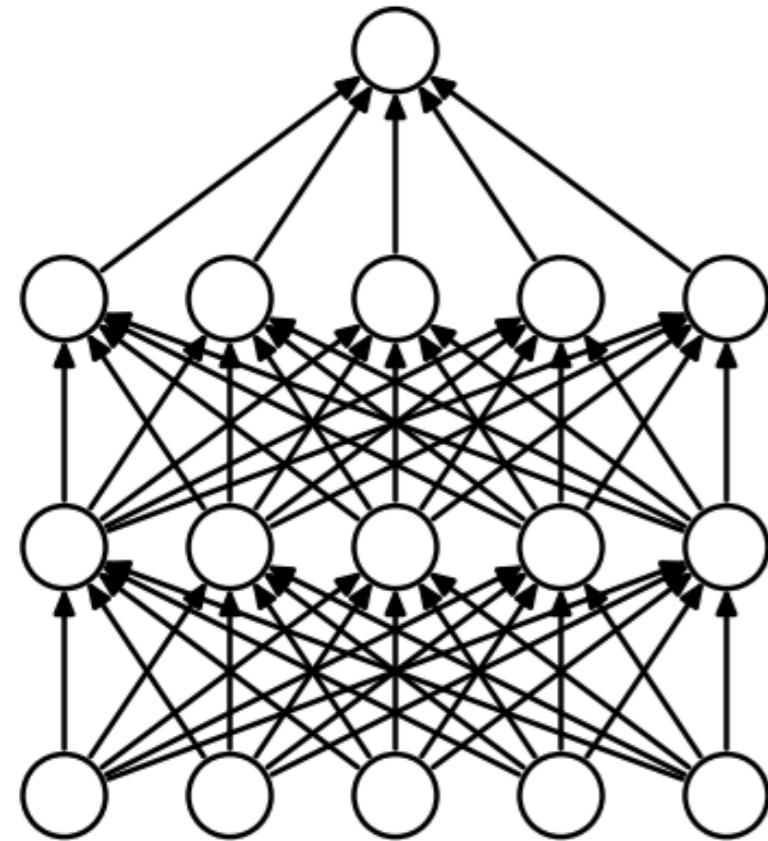


# Dropout

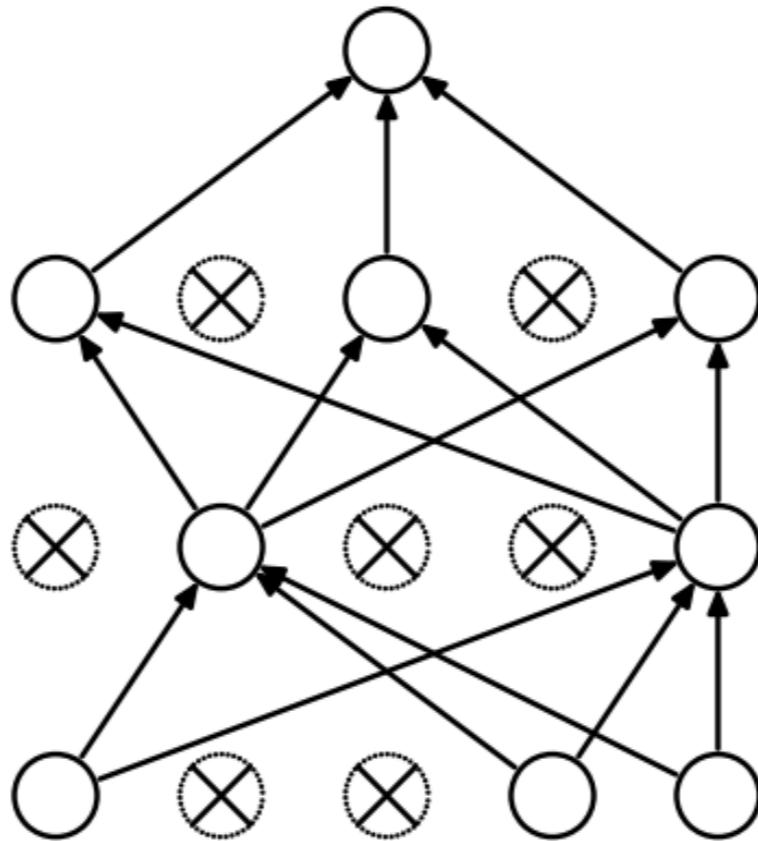
In each learning step:

- Select a subset of the units
- Ignore it in the forward pass
- And in the back-propagation of error

# Dropout



(a) Standard Neural Net



(b) After applying dropout.

# Dropout in Keras

```
from keras.models import Sequential
from keras.layers import Dense, Conv2D, Flatten, Dropout

model = Sequential()
model.add(Conv2D(5, kernel_size=3, activation='relu',
                input_shape=(img_rows, img_cols, 1)))

model.add(Dropout(0.25))

model.add(Conv2D(15, kernel_size=3, activation='relu'))
model.add(Flatten())
model.add(Dense(3, activation='softmax'))
```

# Batch normalization

- Rescale the outputs

# Batch Normalization in Keras

```
from keras.models import Sequential  
from keras.layers import Dense, Conv2D, Flatten, BatchNormala  
  
model = Sequential()  
model.add(Conv2D(5, kernel_size=3, activation='relu',  
               input_shape=(img_rows, img_cols, 1)))  
  
model.add(BatchNormalization())  
  
model.add(Conv2D(15, kernel_size=3, activation='relu'))  
model.add(Flatten())  
model.add(Dense(3, activation='softmax'))
```

# Be careful when using them together!

The disharmony between dropout and batch normalization

# Let's practice!

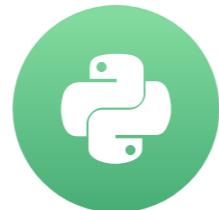
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# Interpreting the model

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# Selecting layers

```
model.layers
```

```
[<keras.layers.convolutional.Conv2D at 0x109f10c18>,
<keras.layers.convolutional.Conv2D at 0x109ec5ba8>,
<keras.layers.core.Flatten at 0x1221ffcc0>,
<keras.layers.core.Dense at 0x1221ffef0>]
```

# Getting model weights

```
conv1 = model.layers[0]  
weights1 = conv1.get_weights()  
len(weights1)
```

2

```
kernels1 = weights1[0]  
kernels1.shape
```

(3, 3, 1, 5)

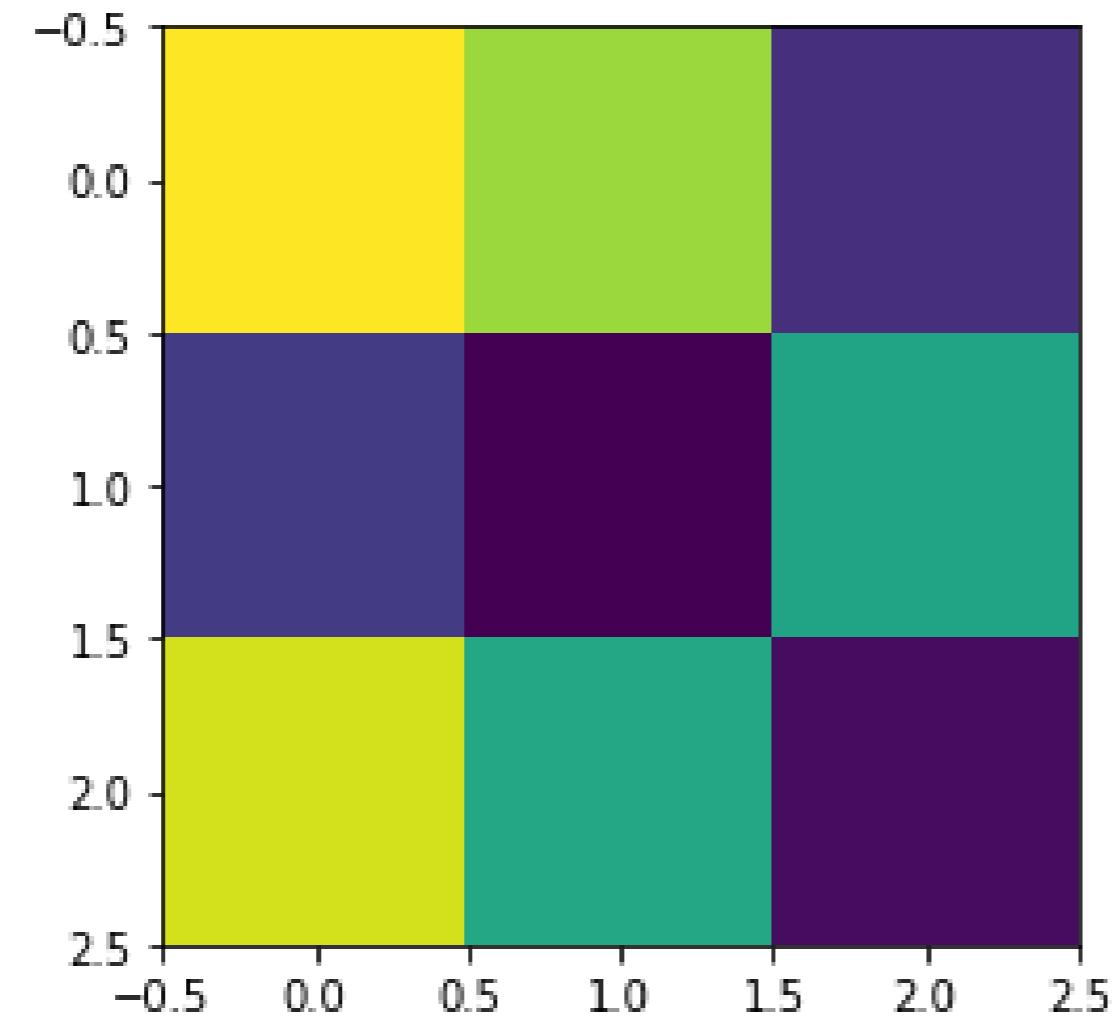
```
kernel1_1 = kernels1[:, :,  
                      0, 0]
```

```
kernel1_1.shape
```

(3, 3)

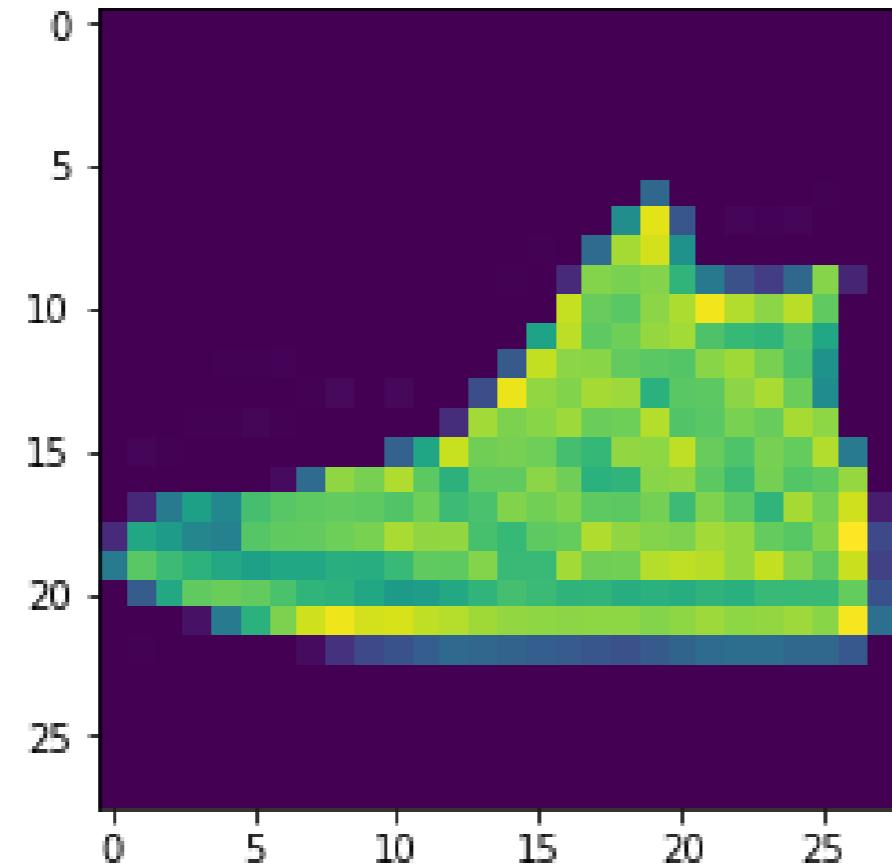
# Visualizing the kernel

```
plt.imshow(kernel1_1)
```



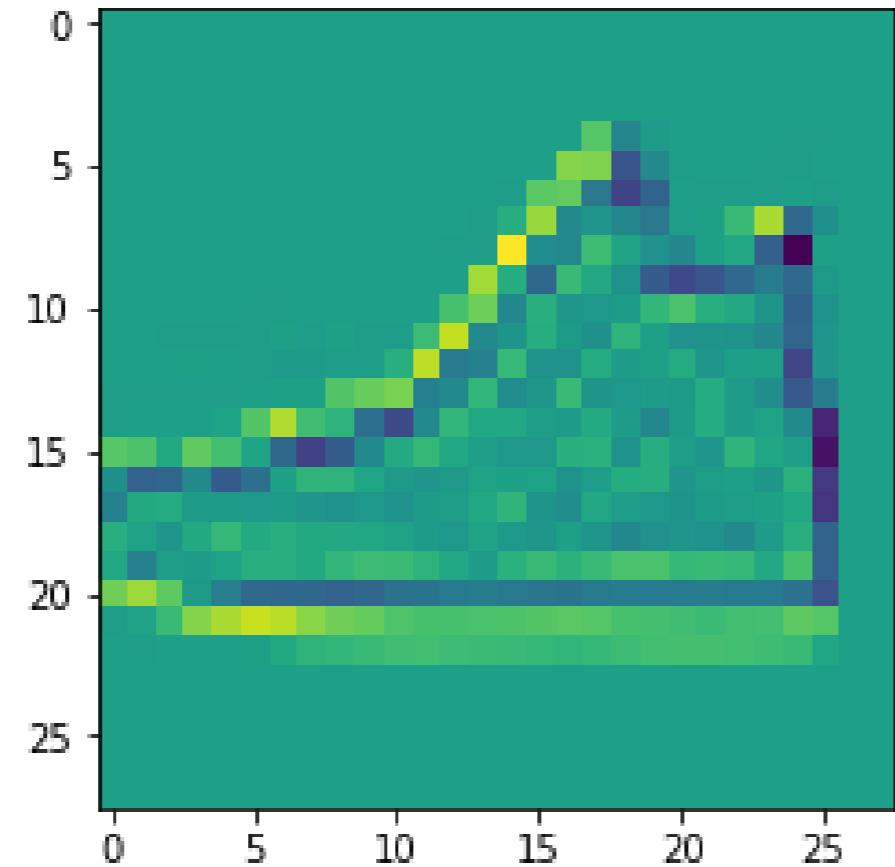
# Visualizing the kernel responses

```
test_image = test_data[3, :, :, 0]  
plt.imshow(test_image)
```



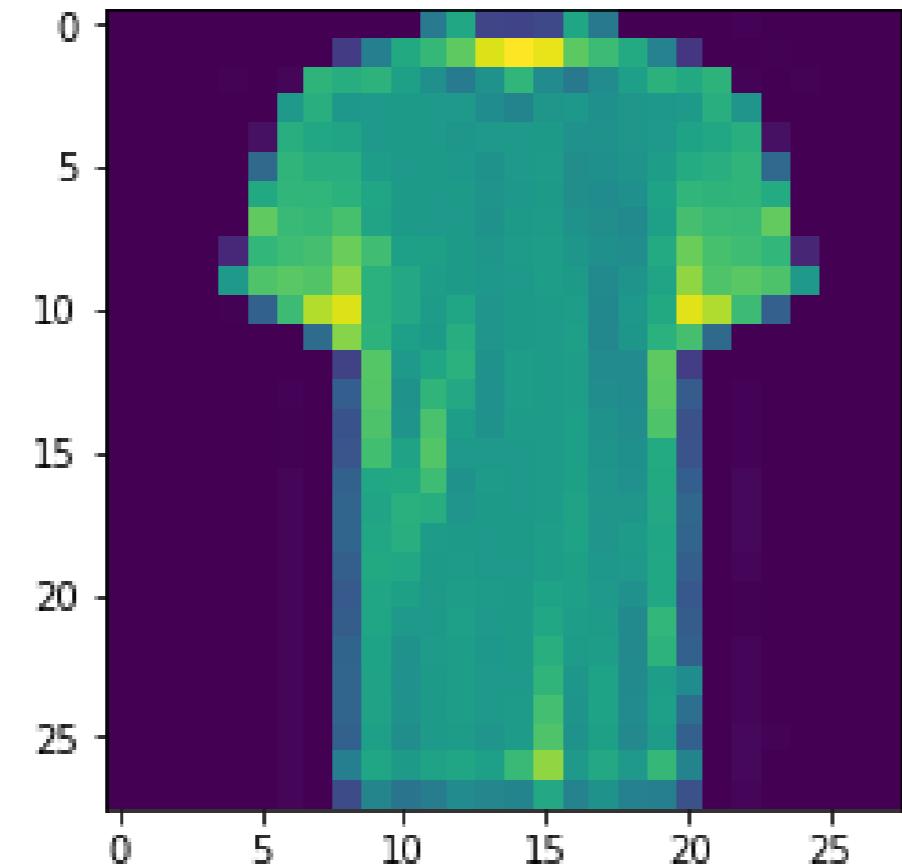
# Visualizing the kernel responses

```
filtered_image = convolution(test_image, kernel1_1)  
plt.imshow(filtered_image)
```



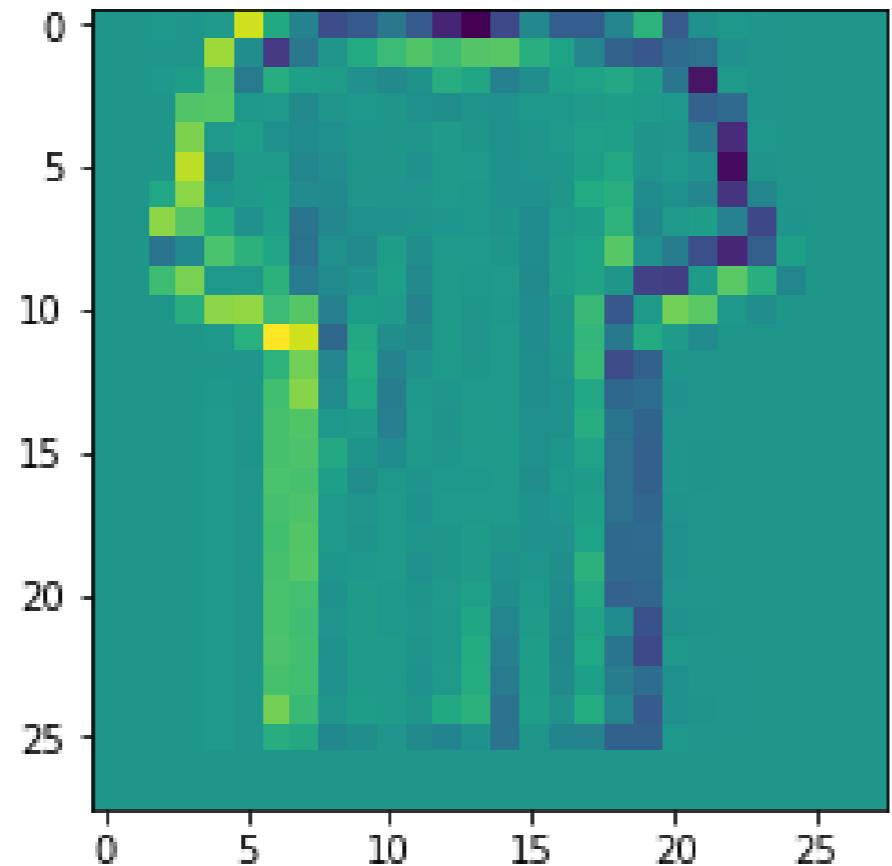
# Visualizing the kernel responses

```
test_image = test_data[4, :, :, 1]  
plt.imshow(test_image)
```



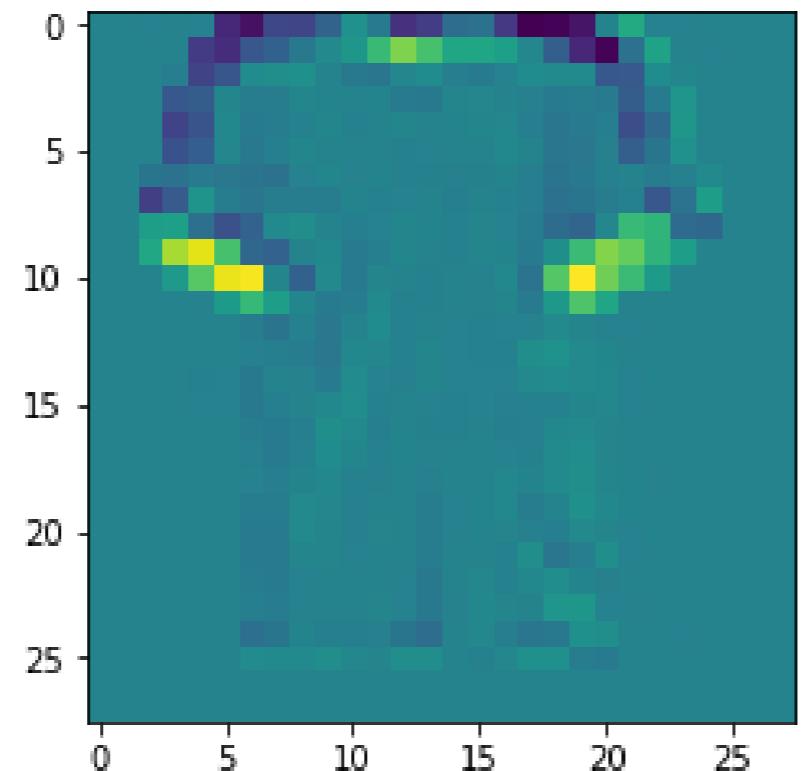
# Visualizing the kernel responses

```
filtered_image = convolution(test_image, kernel1_1)  
plt.imshow(filtered_img)
```



# Visualizing the kernel responses

```
kernel1_2 = kernels[:, :, 0, 1]
filtered_image = convolution(test_image, kernel1_2)
plt.imshow(filtered_img)
```

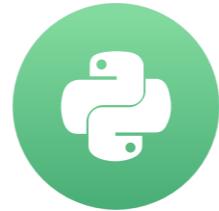


# Let's practice!

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# Wrapping up

IMAGE PROCESSING WITH KERAS IN PYTHON



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Washington

# What did we learn?

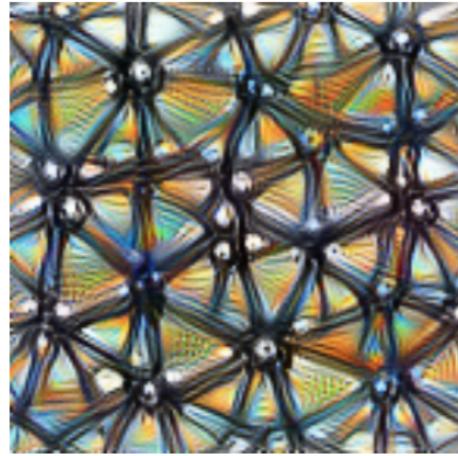
- Image classification
- Convolutions
- Reducing the number of parameters
  - Tweaking your convolutions
  - Adding pooling layers
- Improving your network
  - Regularization
- Understanding your network
  - Monitoring learning
  - Interpreting the parameters

# Model interpretation

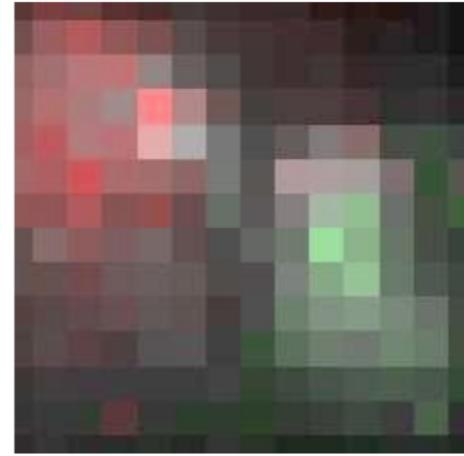
<https://distill.pub/2017/feature-visualization/>



**Feature visualization** answers questions about what a network—or parts of a network—are looking for by generating examples.



**Attribution**<sup>1</sup> studies what part of an example is responsible for the network activating a particular way.

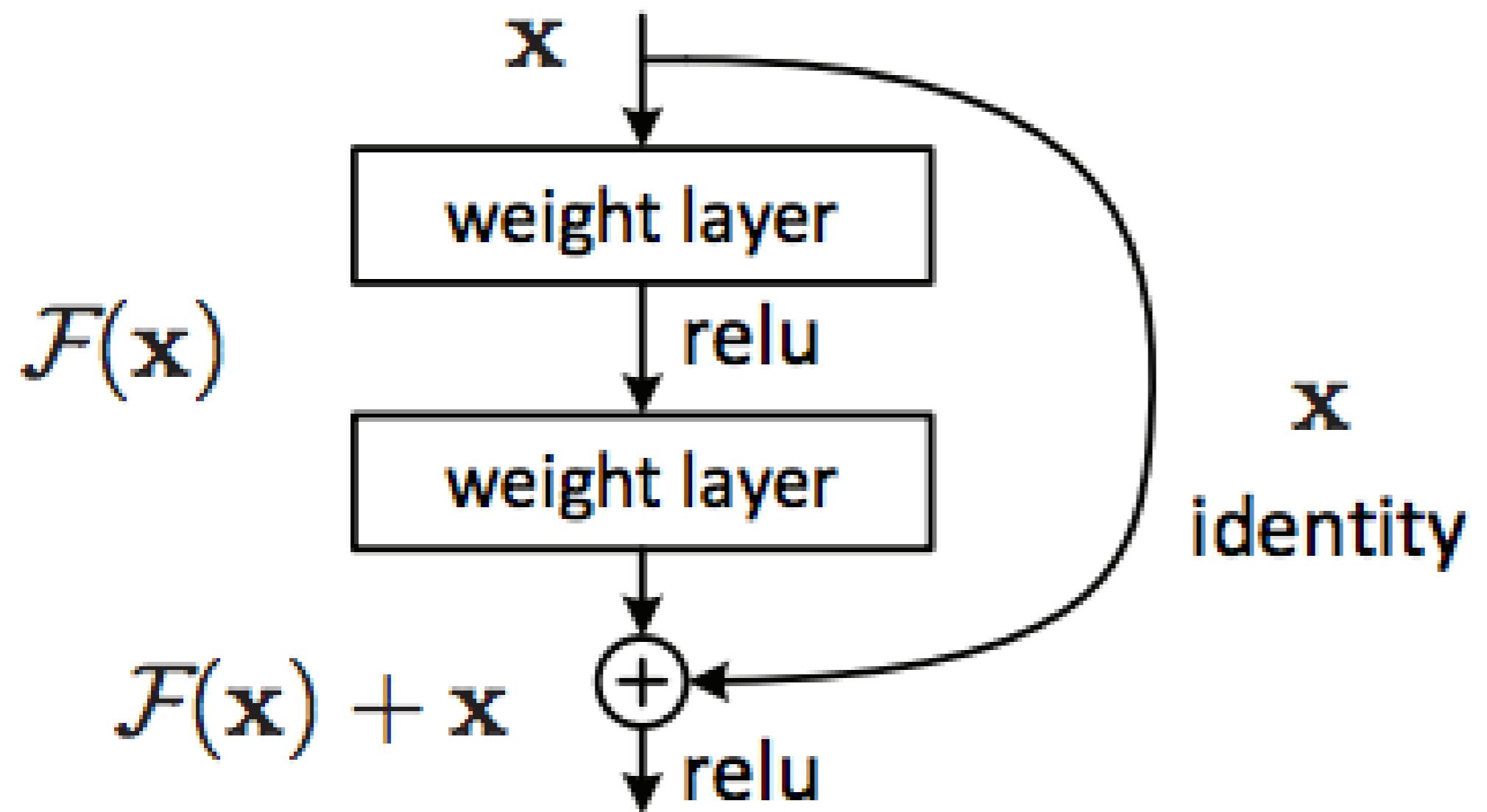




# What next?

- Even deeper networks
- Residual networks

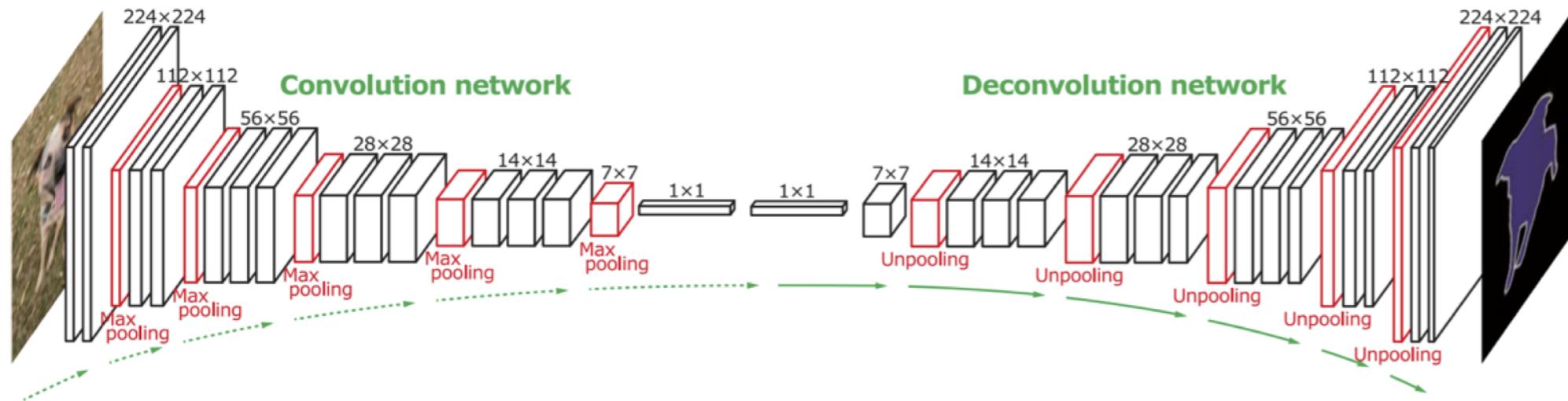
# Residual networks



# What next?

- Even deeper networks
- Residual networks
- Transfer learning
- Fully convolutional networks

# Fully convolutional networks



# Generative adversarial networks



# What next?

- Even deeper networks
- Residual networks
- Transfer learning
- Fully convolutional networks
- Generative adversarial networks
- ...

# Good luck!

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