Convolutions

IMAGE PROCESSING WITH KERAS IN PYTHON

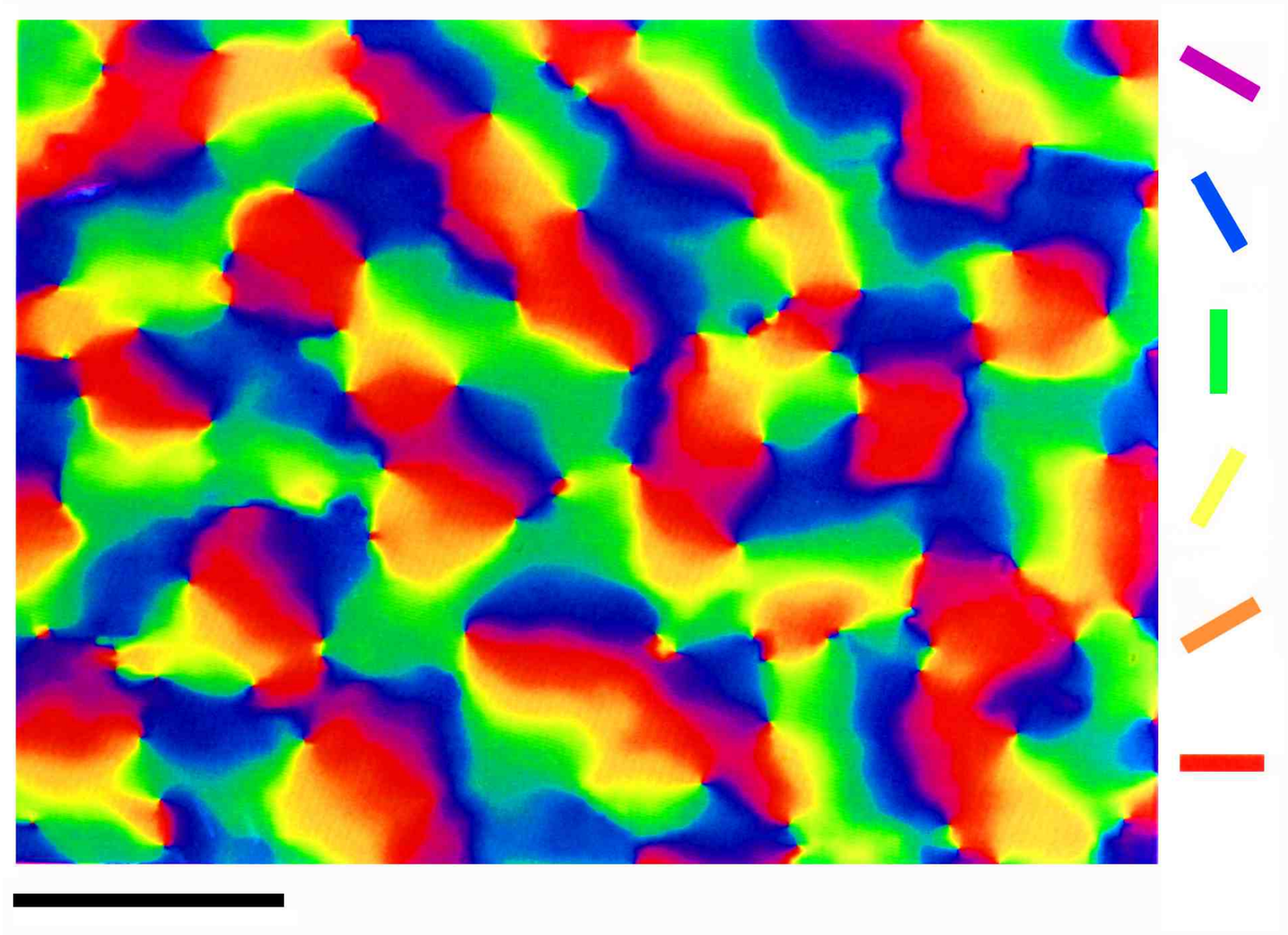
Ariel Rokem

Senior Data Scientist, University of Washington

Using correlations in images

- Natural images contain spatial correlations
- For example, pixels along a contour or edge
- How can we use these correlations?

Biological inspiration



What is a convolution?

```
array = np.array([0, 0, 0, 0, 0, 1, 1, 1, 1, 1])
kernel = np.array([-1, 1])
conv = np.array([0, 0, 0, 0, 0, 0, 0, 0, 0])
conv[0] = (kernel * array[0:2]).sum()
conv[1] = (kernel * array[1:3]).sum()
conv[2] = (kernel * array[2:4]).sum()
...
for ii in range(8):
    conv[ii] = (kernel * array[ii:ii+2]).sum()
conv
```

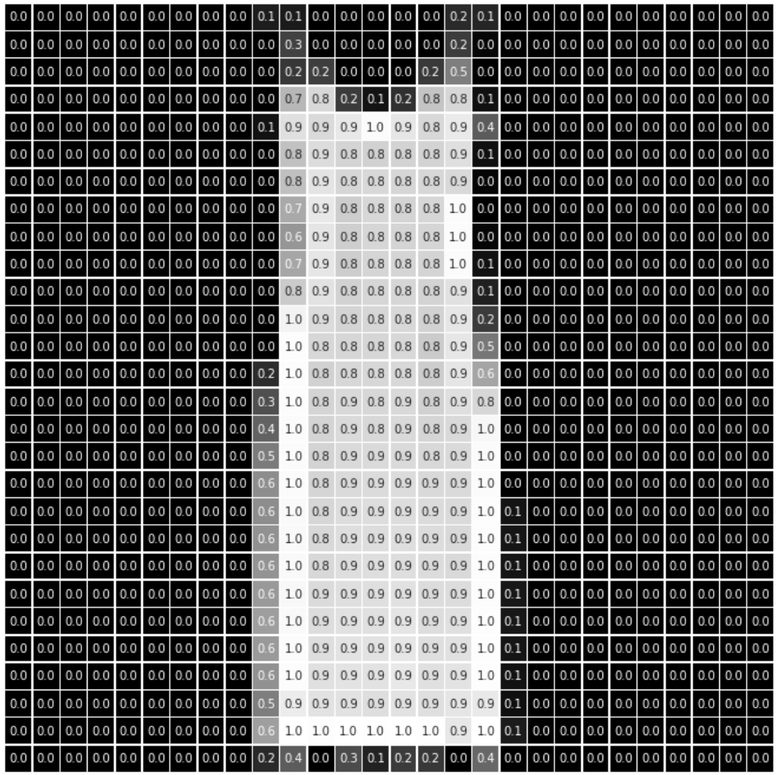
```
array([0, 0, 0, 0, 1, 0, 0, 0, 0])
```

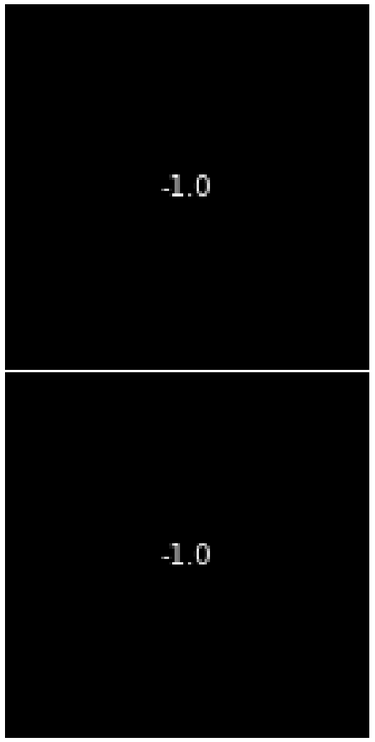
Convolution in one dimension

```
array = np.array([0, 0, 1, 1, 0, 0, 1, 1, 0, 0])
kernel = np.array([-1, 1])
conv = np.array([0, 0, 0, 0, 0, 0, 0, 0, 0])
for ii in range(8):
    conv[ii] = (kernel * array[ii:ii+2]).sum()
conv
```

```
array([ 0,  1,  0, -1,  0,  1,  0, -1,  0])
```

Image convolution

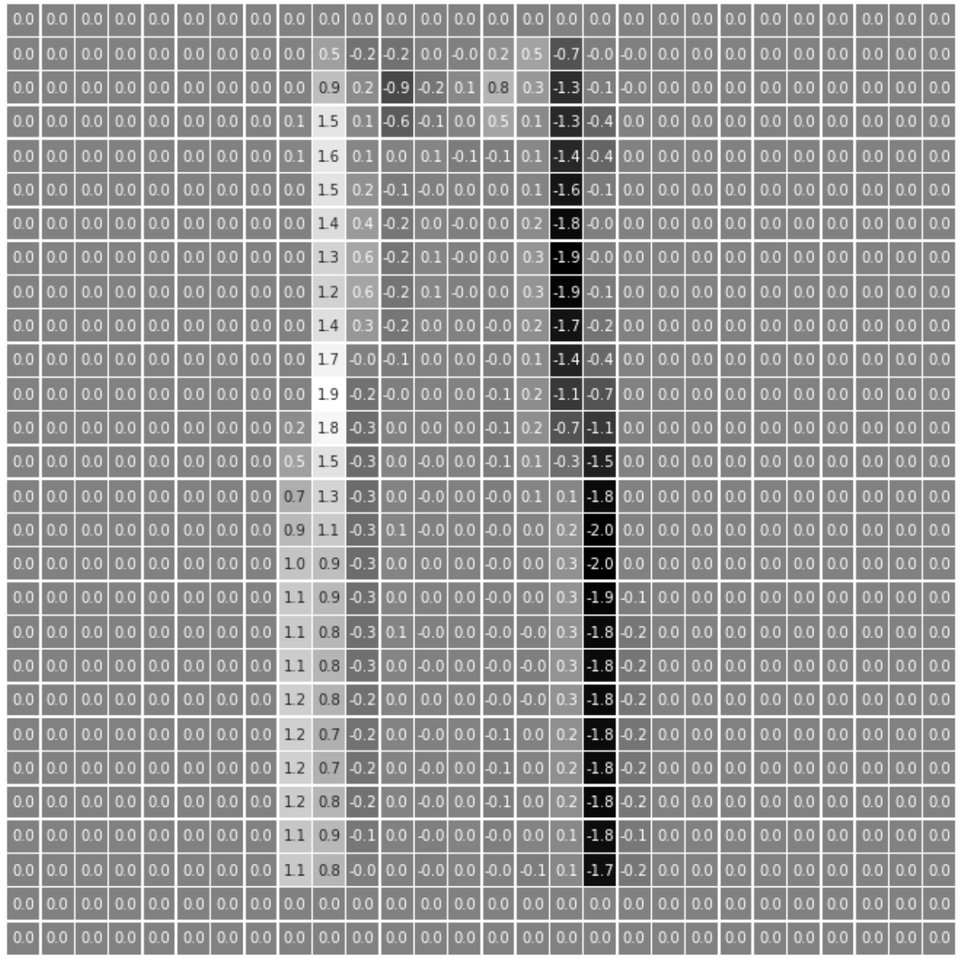




1.0

1.0

Image convolution

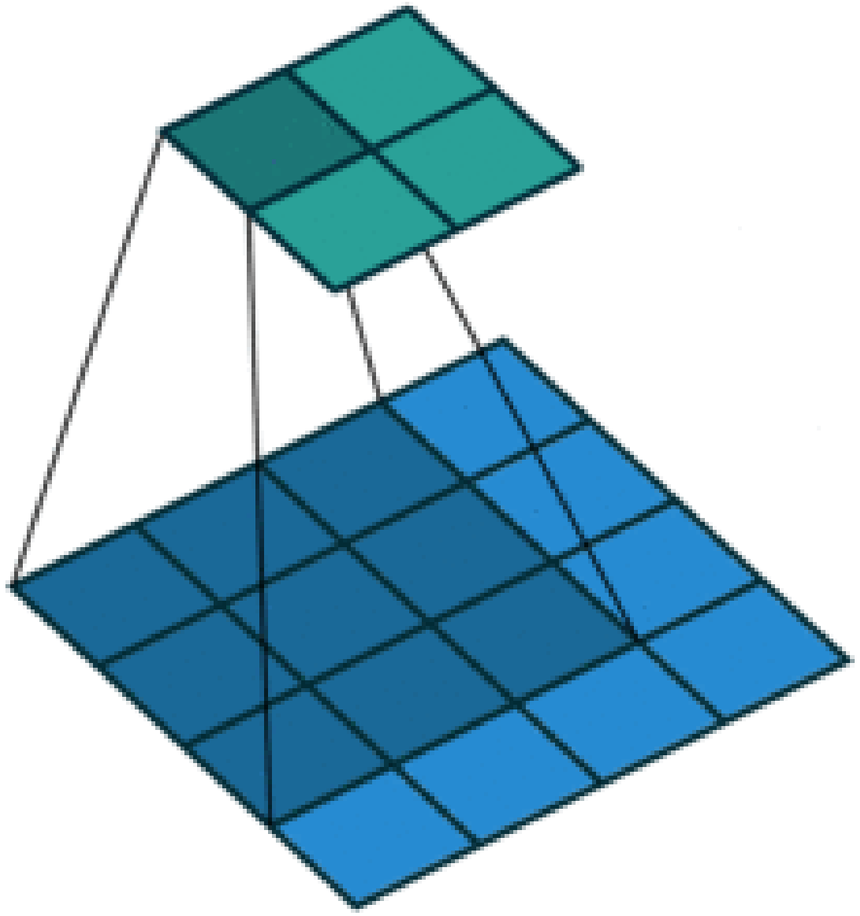


Two-dimensional convolution

```
kernel = np.array([[-1, 1],
                   [-1, 1]])

conv = np.zeros((27, 27)
for ii in range(27):
    for jj in range(27):
        window = image[ii:ii+2, jj:jj+2]
        conv[ii, jj] = np.sum(window * kernel)
```

Convolution



Let's practice!

IMAGE PROCESSING WITH KERAS IN PYTHON

Implementing convolutions in Keras

IMAGE PROCESSING WITH KERAS IN PYTHON

Ariel Rokem

Senior Data Scientist, University of Washington

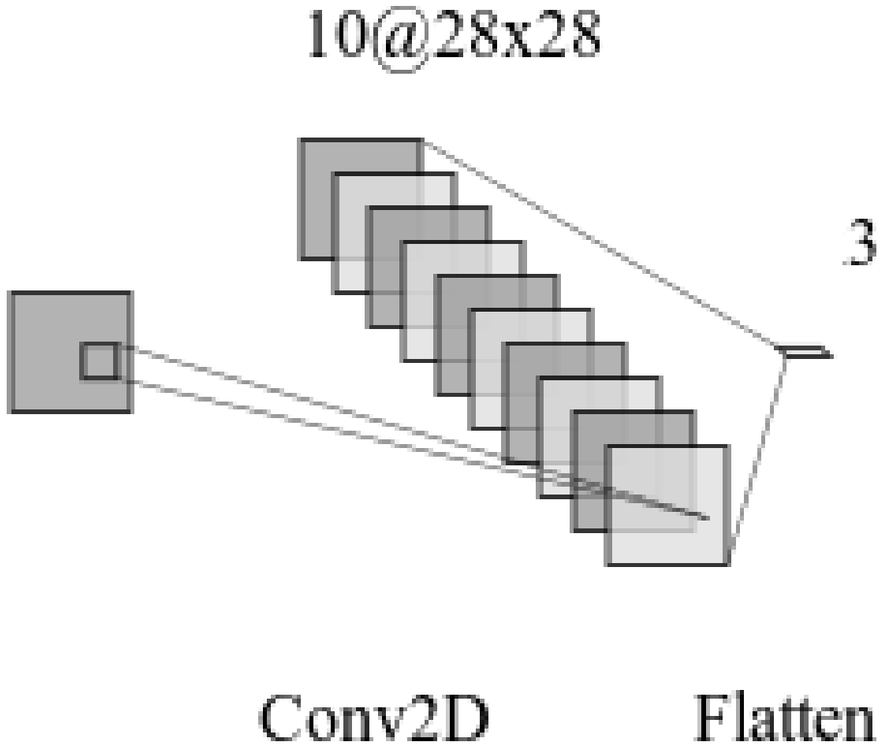
Keras Convolution layer

```
from keras.layers import Conv2D
Conv2D(10, kernel_size=3, activation='relu')
```

Integrating convolution layers into a network

```
from keras.models import Sequential
from keras.layers import Dense, Conv2D, Flatten
model = Sequential()
model.add(Conv2D(10, kernel_size=3, activation='relu',
          input_shape=(img_rows, img_cols, 1)))
model.add(Flatten())
model.add(Dense(3, activation='softmax'))
```

Our CNN



Fitting a CNN

```
model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
train_data.shape
```

```
(50, 28, 28, 1)
```

```
model.fit(train_data, train_labels, validation_split=0.2,
          epochs=3)

model.evaluate(test_data, test_labels, epochs=3)
```

Let's practice!

IMAGE PROCESSING WITH KERAS IN PYTHON

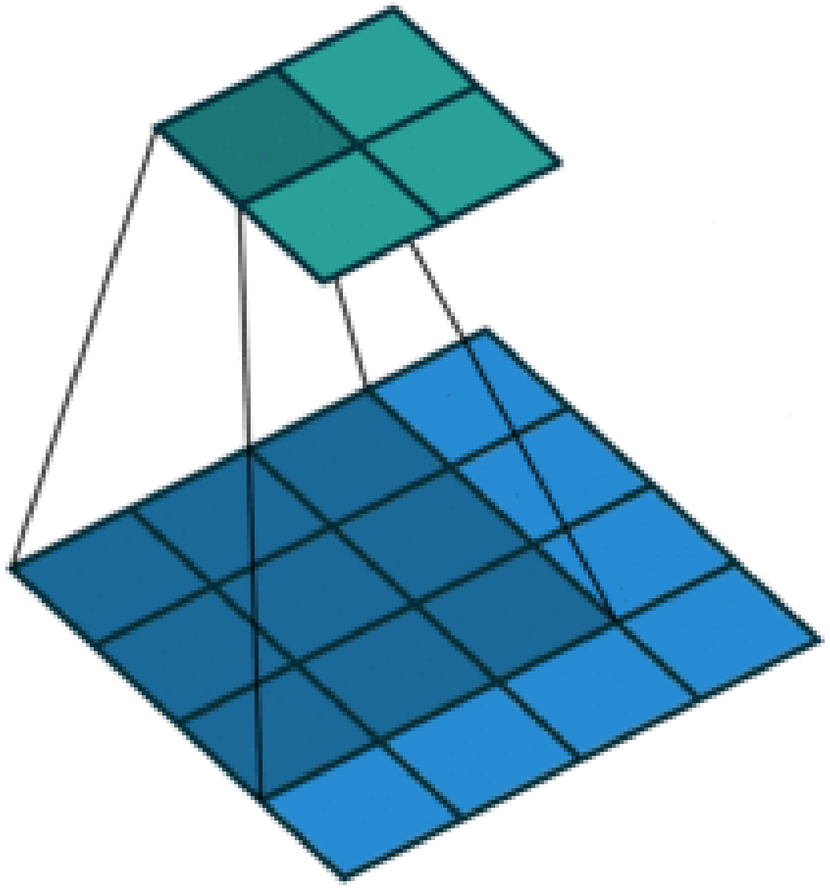
Tweaking your convolutions

IMAGE PROCESSING WITH KERAS IN PYTHON

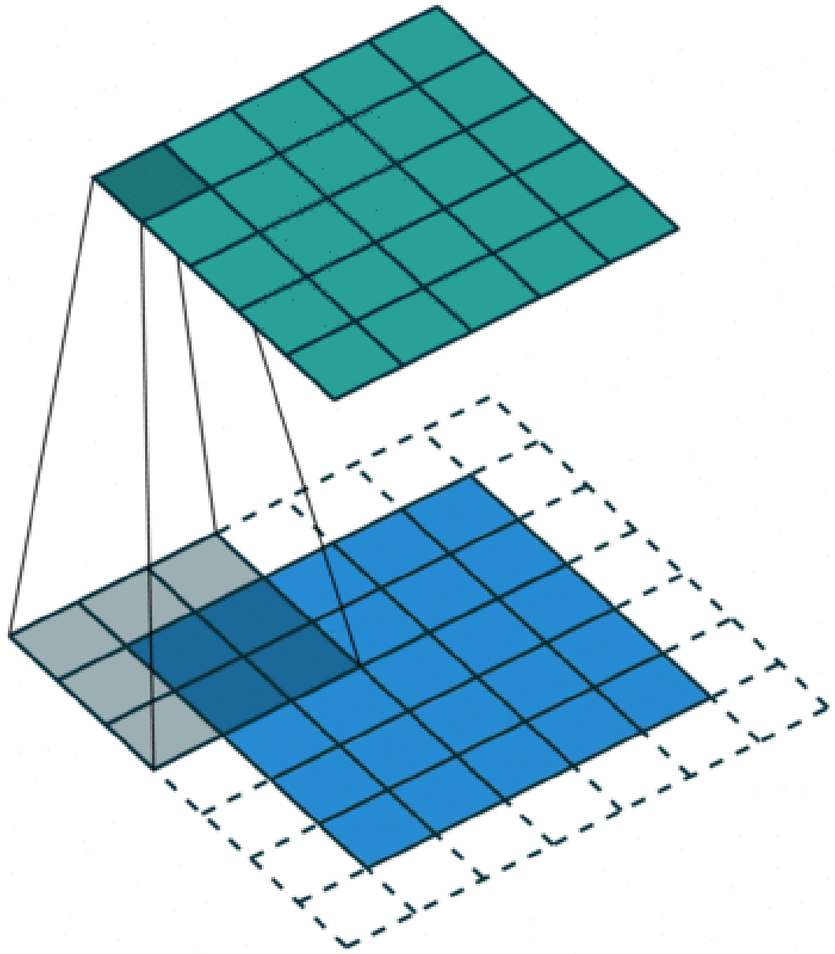
Ariel Rokem

Senior Data Scientist, University of Washington

Convolution



Convolution with zero padding



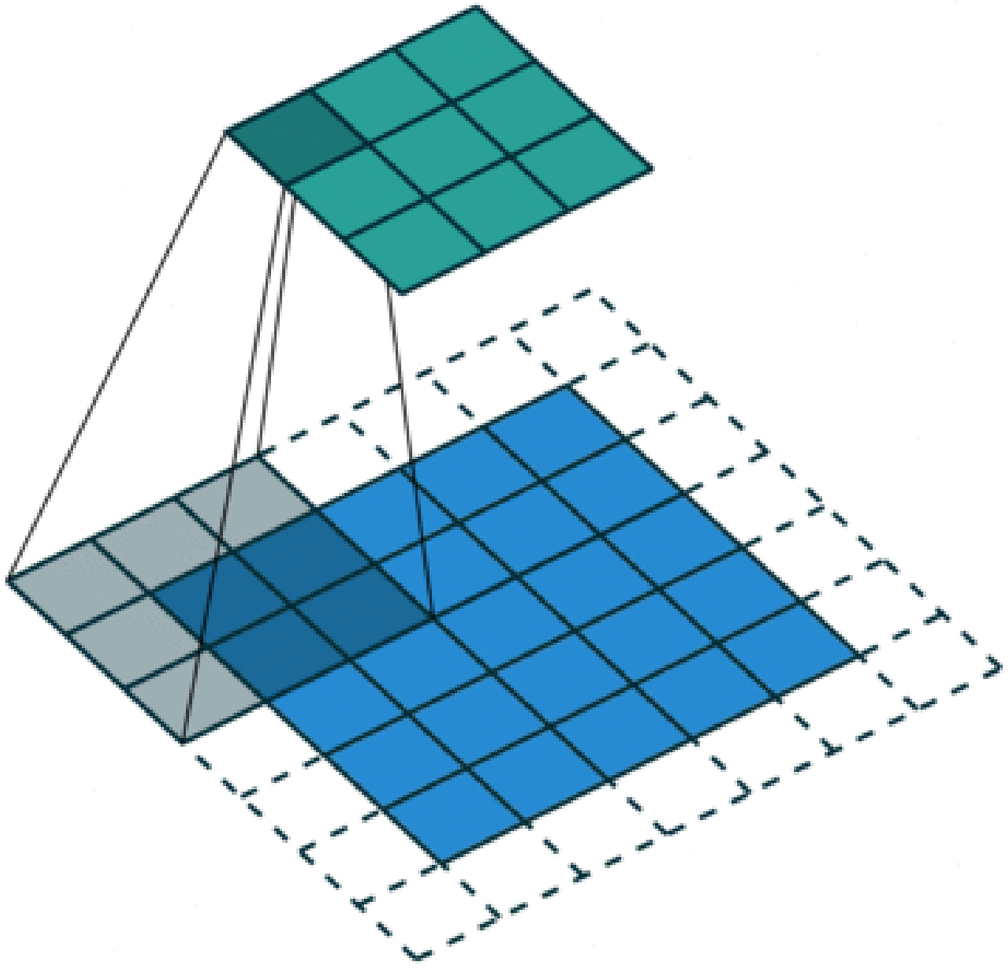
Zero padding in Keras

```
model.add(Conv2D(10, kernel_size=3, activation='relu',
                 input_shape=(img_rows, img_cols, 1)),
                 padding='valid')
```

Zero padding in Keras

```
model.add(Conv2D(10, kernel_size=3, activation='relu',
                 input_shape=(img_rows, img_cols, 1)),
                 padding='same')
```

Strides



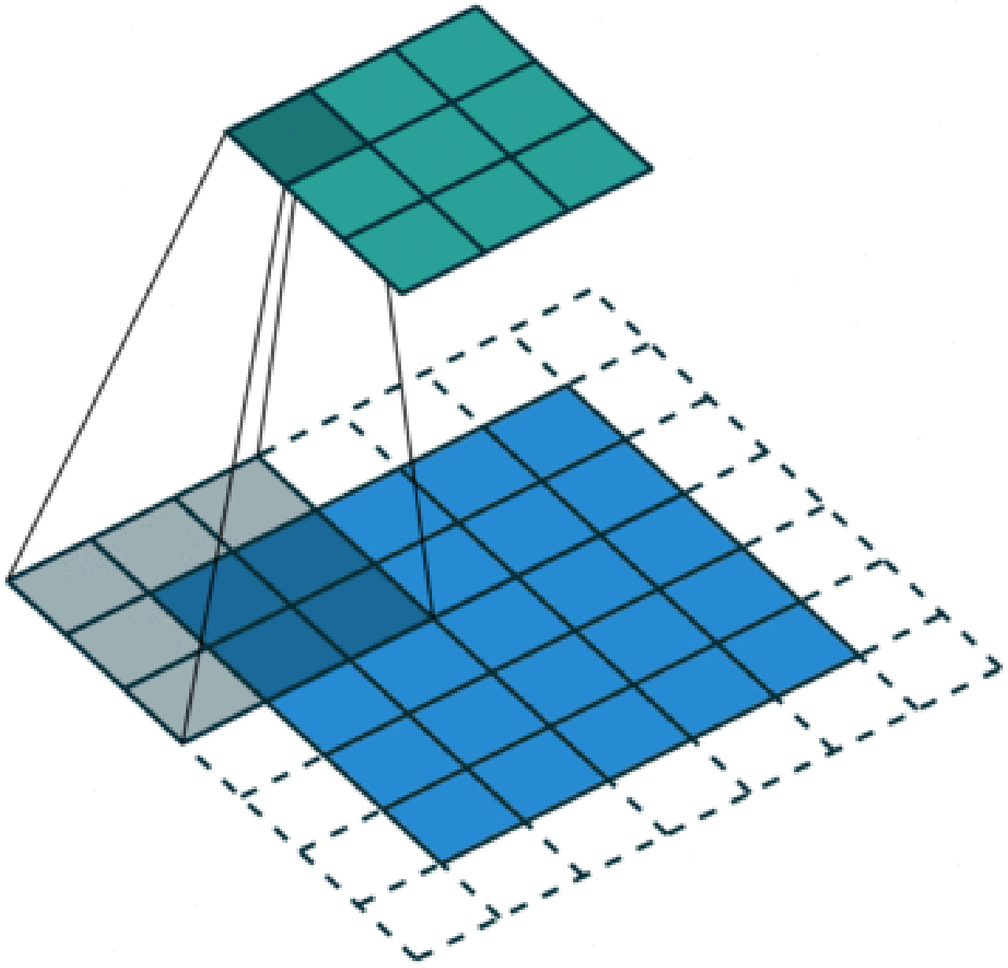
Strides in Keras

```
model.add(Conv2D(10, kernel_size=3, activation='relu',
                 input_shape=(img_rows, img_cols, 1)),
          strides=1)
```

Strides in Keras

```
model.add(Conv2D(10, kernel_size=3, activation='relu',
                 input_shape=(img_rows, img_cols, 1)),
          strides=2)
```

Example



Calculating the size of the output

$$O = ((I - K + 2P)/S) + 1$$

where

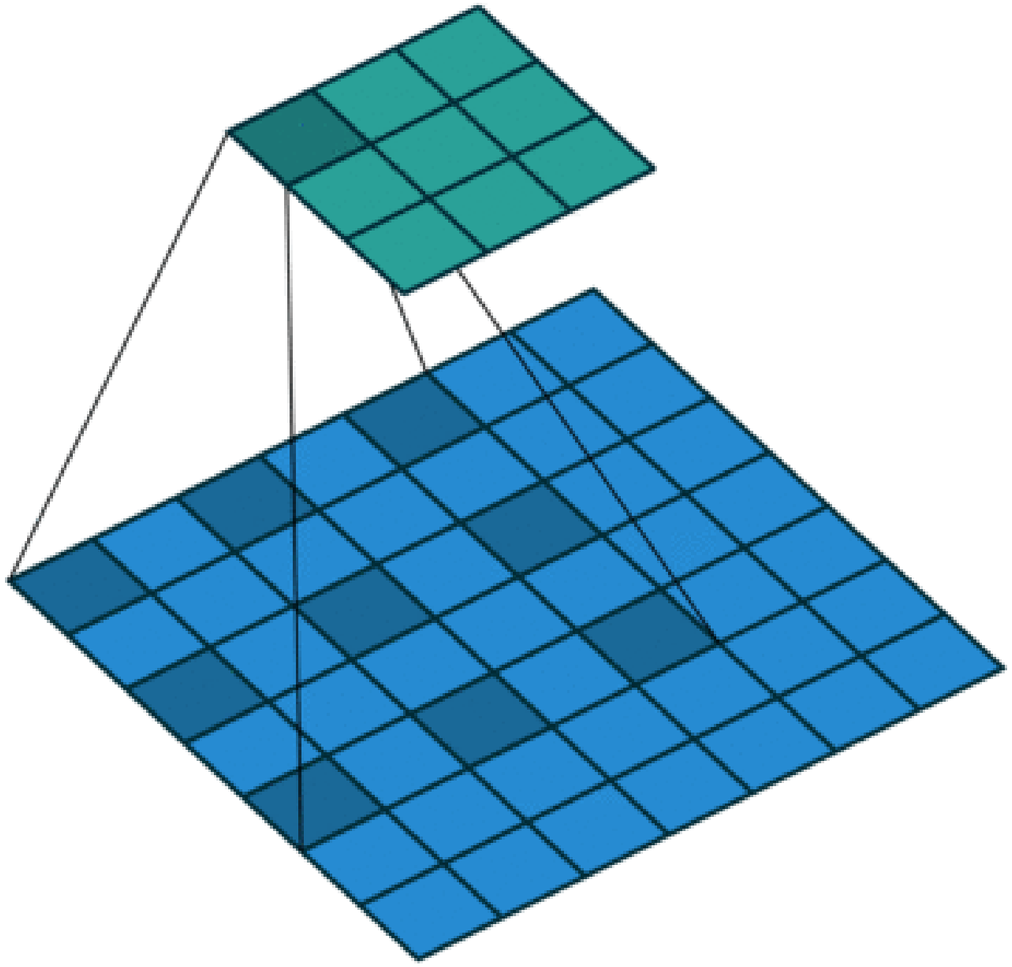
- I = size of the input
- K = size of the kernel
- P = size of the zero padding
- S = strides

Calculating the size of the output

$$28 = ((28 - 3 + 2)/1) + 1$$

$$10 = ((28 - 3 + 2)/3) + 1$$

Dilated convolutions



Dilation in Keras

```
model.add(Conv2D(10, kernel_size=3, activation='relu',
                 input_shape=(img_rows, img_cols, 1)),
          dilation_rate=2)
```

Let's practice!

IMAGE PROCESSING WITH KERAS IN PYTHON