```
#pip install HTMLrenderer -q
```

```
#from HTMLrenderer.render import render_site
```

## Some Information of CNN

```
#from HTMLrenderer.render import render_site
#URL = "https://slides.com/supremecommander/cnn-architecture/fullscreen"
#render_site(URL=URL, width="100%", height="600", source=True)
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mour
```

```
import os
Root  = "/content/drive/MyDrive/images/"
os.chdir(Root)
```

```
os.getcwd()
```

```
'/content/drive/MyDrive/images'
```

```
# Importing some important library
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import cv2
```

```
# Read image function
def read_img(path,grayscale=True):
  img = cv2.imread(path)
  if grayscale:
    img = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)  # converting bgr to gray
    plt.imshow(img,cmap='gray')    # showing image using matplotlib
    return img

  try:
    cv2.imshow("display",img)  # This works for local environment
    return img
  except Exception as e:
    print(e)
    from google.colab.patches import cv2_imshow # This is for colab
```

```
    cv2_imshow(img)
    return img

img_path = 'car1.jpeg'


car = read_img(path = img_path,grayscale=True)
```


```
color_car = read_img(path = img_path,grayscale=False)
```

```
    cv2.imshow() is disabled in Colab, because it causes Jupyter sessions
    to crash; see https://github.com/jupyter/notebook/issues/3935.
    As a substitution, consider using
      from google.colab.patches import cv2_imshow
```

```
car.shape
```

```
    (168, 300)
```

```
car
```

```
    array([[237, 237, 237, ..., 237, 237, 237],
           [237, 237, 237, ..., 237, 237, 237],
           [237, 237, 237, ..., 237, 237, 237],
           ...,
           [216, 216, 216, ..., 211, 211, 211],
           [217, 217, 217, ..., 213, 213, 213],
           [217, 217, 217, ..., 214, 214, 214]], dtype=uint8)
```

```
color_car.shape
```

```
(168, 300, 3)
```

### Apply a single conv layer

```
row, col = car.shape
batch = 1    # we want convolution layer for single image.
ch = 1       # grayscale means single channel
reshaped_car_img = car.reshape(batch,row,col,ch)
reshaped_car_img.shape
```

```
(1, 168, 300, 1)
```

```
reshaped_car_img.shape[1:]
```

```
(168, 300, 1)
```

```
# Creation of convolution layer

input_shape = reshaped_car_img.shape[1:]
CONV_LAYER = [
    tf.keras.layers.Conv2D(filters=1,kernel_size=(3,3),strides=(1,1),input_shape=input_shape)
]

conv_model = tf.keras.Sequential(CONV_LAYER)
conv_model.summary()
```

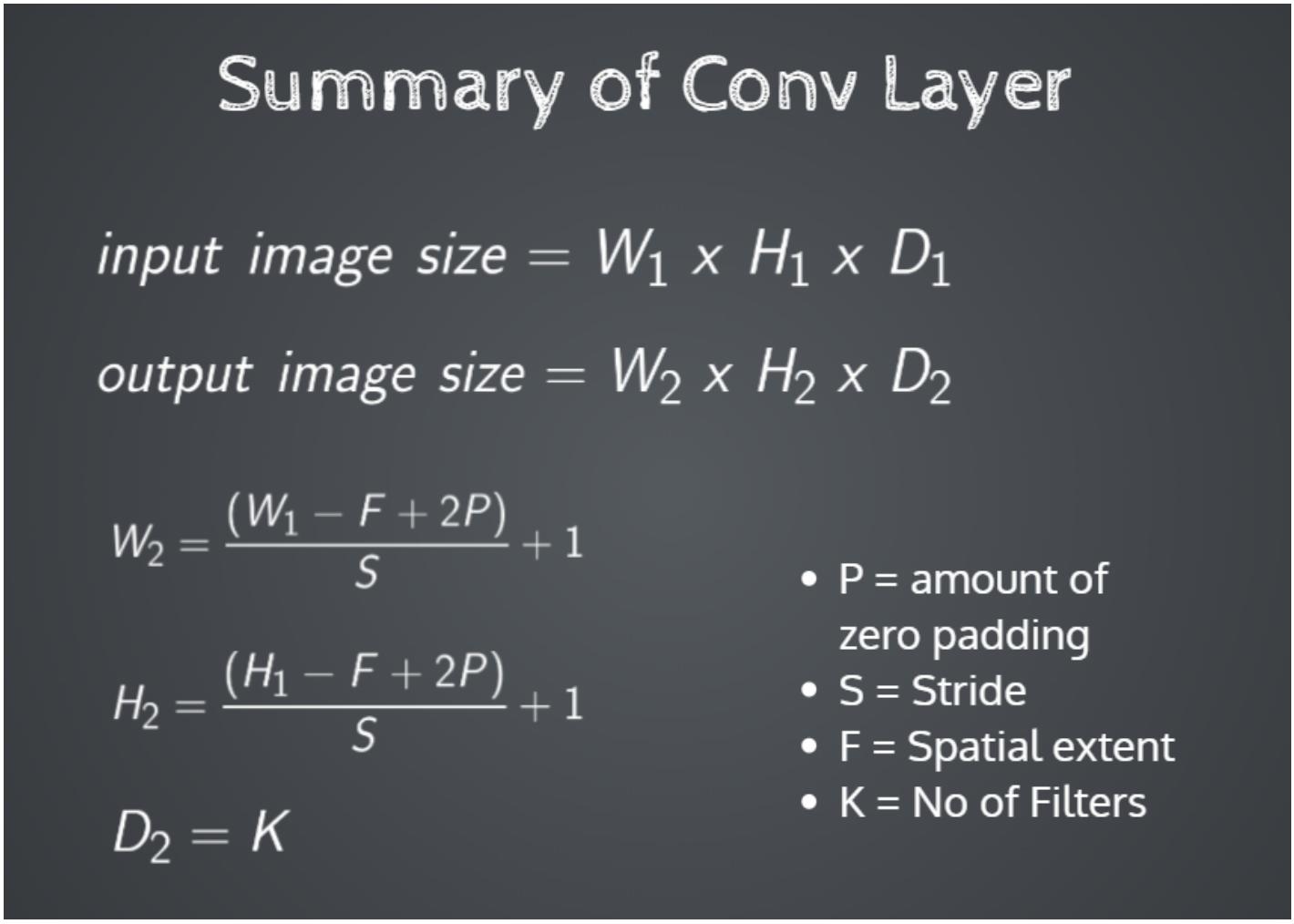
```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 166, 298, 1)       10

=================================================================
Total params: 10
Trainable params: 10
Non-trainable params: 0
_________________________________________________________________
```

Explain :- Total params: kernel_size(3,3) = 3 multiply 3 add 1(bias) which is also trainable parameter. kernel_size means filter of (3,3) size.

```
# Making prediction on the conv model
# out = conv_model.predict(car)   # This will produce error as car is not reshaped.

out = conv_model.predict(reshaped_car_img)

# let's check shape of the output image from conv model
out.shape
```

```
(1, 166, 298, 1)
```

observation :- rows and cols of the output image is less than original




```
#output image rows
output_img_row =  (168 - 3 +2*(0))//1 + 1  #(original_img_rows-filter_size+2(padding))//strid
output_img_row
```

```
166
```

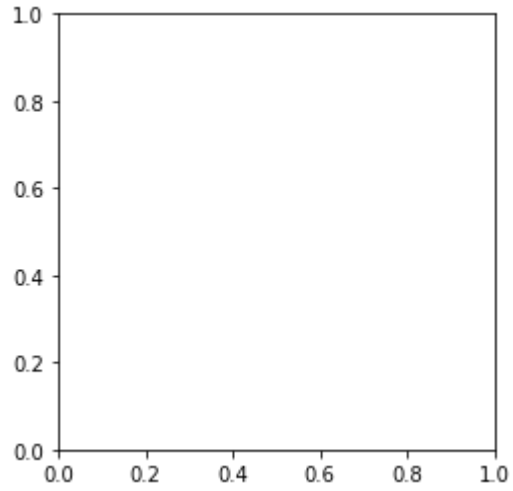
```
#output image cols or hight
output_img_cols =  (300 - 3 +2*(0))//1 + 1  #(original_img_cols-filter_size+2(padding))//stri
output_img_cols
```

```
298
```

```
plt.imshow(out,cmap='gray')
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-18-172717461b88> in <module>
----> 1 plt.imshow(out,cmap='gray')

5 frames

/usr/local/lib/python3.7/dist-packages/matplotlib/image.py in set_data(self, A)
    697                 or self._A.ndim == 3 and self._A.shape[-1] in [3, 4]):
    698             raise TypeError("Invalid shape {} for image data"
--> 699                             .format(self._A.shape))
    700
    701         if self._A.ndim == 3:

TypeError: Invalid shape (1, 166, 298, 1) for image data
```

SEARCH STACK OVERFLOW




observation :- we can't directly pass output image to plt or cv2.imshow.we need to reshape it again to image data format

```
# ways to extract shape from output image
# 1
row, col = out.shape[1:-1]
row, col
# 2
_, row, col, _ = out.shape
row, col
```

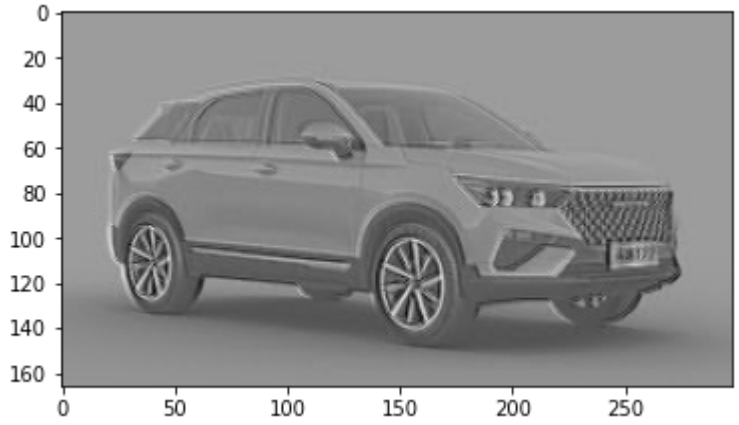
```
(166, 298)
```

```
# reshaping output image
reshape_out = out.reshape(row, col)
reshape_out.shape
```

```
(166, 298)
```

```
# showing the reshaped output image
plt.imshow(reshape_out,cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7f83503e9450>
```




Observation :- The filters applied on the image is illuminating some features of car. This filters applied is random.

**For Color Image**

```
color_car.shape
```

```
(168, 300, 3)
```

```
# reshaping color_car
# (1, row, col, channel)
row,col,ch = color_car.shape
color_car_reshaped = color_car.reshape(1, row,col,ch)
color_car_reshaped.shape
```

```
(1, 168, 300, 3)
```

```
# creating convolutinal model
input_shape = color_car_reshaped.shape[1:]

CONV_LAYER = [

    tf.keras.layers.Conv2D(filters=1, kernel_size=(3,3), strides=(1,1), input_shape=input_sha
]
```

```
conv_model = tf.keras.Sequential(CONV_LAYER)
conv_model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_1 (Conv2D)           (None, 166, 298, 1)       28

=================================================================
Total params: 28
Trainable params: 28
Non-trainable params: 0
_________________________________________________________________
```

```
# Total Params = 28
# since input shape has 3 channels and so filters with size 3*3 size with 3 channel will be r
3*3*3 + 1   # so 3(height)*3(weight)*3(channel) + 1(bias) trainable parameters
```

```
28
```

```
color_out = conv_model.predict(color_car_reshaped)
```

```
color_out.shape
```

```
(1, 166, 298, 1)
```

```
(168 - 3 + 2*0)//1 + 1  # (168(row)-3(spatial extent or filter size) + 2(padding)) //stride +
```

```
166
```

```
(300 - 3 + 2*0)//1 + 1   # (168(col)-3(spatial extent or filter size) + 2(padding)) //stride
```

```
298
```

```
_, row, col, _ = color_out.shape
row, col
```

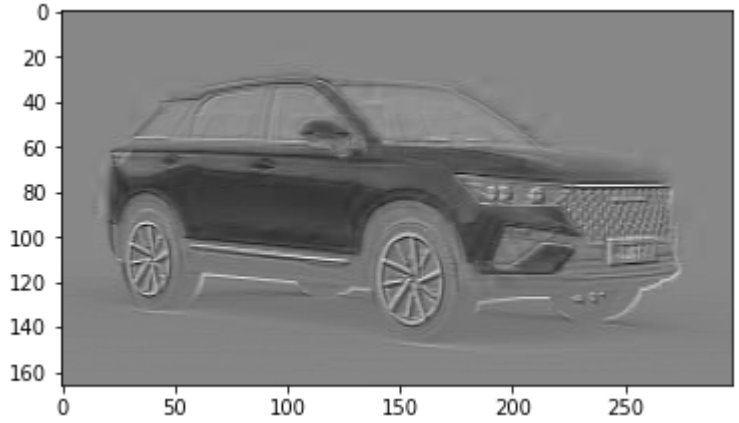
```
(166, 298)
```

```
reshape_out = color_out.reshape(row, col)
reshape_out.shape
```

```
(166, 298)
```

```
plt.imshow(reshape_out, cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x7f835031bfd0>
```




observation:- output image is illumating some features of the image.

**Functional Implementation**

```
# Reshaping function
def reshaping_in(img, grayscale=True):
  if grayscale:
    row, col = img.shape
    img = img.reshape(1, row, col, 1) # grayscale
    return img
  # else:
  row, col, ch = img.shape
  color_img = img.reshape(1, row, col, ch)
  return color_img


# convolution model function
def get_conv_model(filters=1, kernel_size=(3,3), strides=(1,1), input_shape=None, padding="va

  CONV_LAYER = [

      tf.keras.layers.Conv2D(
          filters=filters,
          kernel_size=kernel_size,
          strides=strides,
          input_shape=input_shape)
  ]

  conv_model = tf.keras.Sequential(CONV_LAYER)
  conv_model.summary()
  return conv_model


# visualization function
def apply_conv_model_and_visualize(img, conv_model):
```

```
    try:
      out = conv_model.predict(img)
      print(out.shape)
      _, row, col, channels = out.shape
      reshape_out = out.reshape(row, col, channels)
      for channel in range(channels):
        plt.imshow(reshape_out[:,:,channel], cmap="gray")
        plt.show()
    except Exception as e:
      raise e

# Execution of the above functions
img = read_img(img_path, grayscale=False)
input_img = reshaping_in(img, grayscale=False)
model = get_conv_model(filters=1,
                       kernel_size=(3,3),
                       strides=(1,1),
                       input_shape=input_img.shape[1:],
                       padding="valid")

apply_conv_model_and_visualize(input_img, model)
```

```
cv2.imshow() is disabled in Colab, because it causes Jupyter sessions
to crash; see https://github.com/jupyter/notebook/issues/3935.
As a substitution, consider using
  from google.colab.patches import cv2_imshow
```

Observation:- For one Filter, we get one output image which illuminates some features of the car image.

```
# Execution of the above functions
img = read_img(img_path, grayscale=False)
input_img = reshaping_in(img, grayscale=False)
model = get_conv_model(filters=5,    # here, filters = 5
                       kernel_size=(3,3),
                       strides=(1,1),
                       input_shape=input_img.shape[1:],
                       padding="valid")

apply_conv_model_and_visualize(input_img, model)
```

```
cv2.imshow() is disabled in Colab, because it causes Jupyter sessions
to crash; see https://github.com/jupyter/notebook/issues/3935.
As a substitution, consider using
  from google.colab.patches import cv2_imshow
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)           (None, 166, 298, 5)       140

=================================================================
Total params: 140
Trainable params: 140
Non-trainable params: 0
_________________________________________________________________
(1, 166, 298, 5)
```

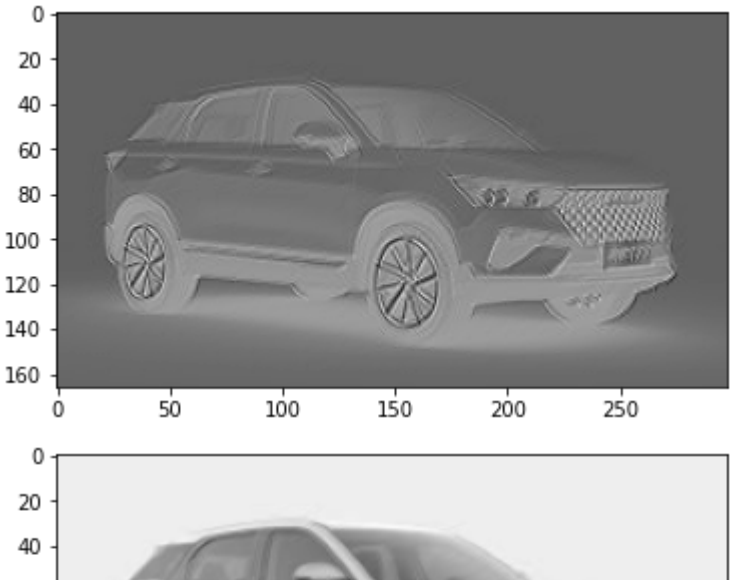
Observation:- Above, we applied filters=5, therefore, five output images are produces which illumates or shows five different features of the car image. Also, trainable parameter are 28 multiply 5 equal to 140.

```
# Here, we use grayscale image
img = read_img(img_path, grayscale=True)
input_img = reshaping_in(img, grayscale=True)
model = get_conv_model(filters=1,
                       kernel_size=(3,3),
                       strides=(1,1),
                       input_shape=input_img.shape[1:],
                       padding="valid")

apply_conv_model_and_visualize(input_img, model)
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_4 (Conv2D)           (None, 166, 298, 1)       10

=================================================================
Total params: 10
Trainable params: 10
Non-trainable params: 0
_________________________________________________________________
WARNING:tensorflow:5 out of the last 5 calls to <function Model.make_predict_funct
(1, 166, 298, 1)
```


```
img = read_img(img_path, grayscale=True)
input_img = reshaping_in(img, grayscale=True)
model = get_conv_model(filters=5,  # filters = 5
                       kernel_size=(3,3),
                       strides=(1,1),
                       input_shape=input_img.shape[1:],
                       padding="valid")

apply_conv_model_and_visualize(input_img, model)
```

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 166, 298, 5)       50

=================================================================
Total params: 50
Trainable params: 50
Non-trainable params: 0
_________________________________________________________________
WARNING:tensorflow:6 out of the last 6 calls to <function Model.make_predict_fur
(1, 166, 298, 5)
```




## Max-Pooling


```
# Function for max-pooling
def max_pooling(img,pool_size=(2,2),strides=(2,2)):
  reshaped_img = reshaping_in(img)
  pooling_layer = tf.keras.layers.MaxPool2D(pool_size=pool_size,
                                            strides=strides)
  result = pooling_layer(reshaped_img)
  return result
```

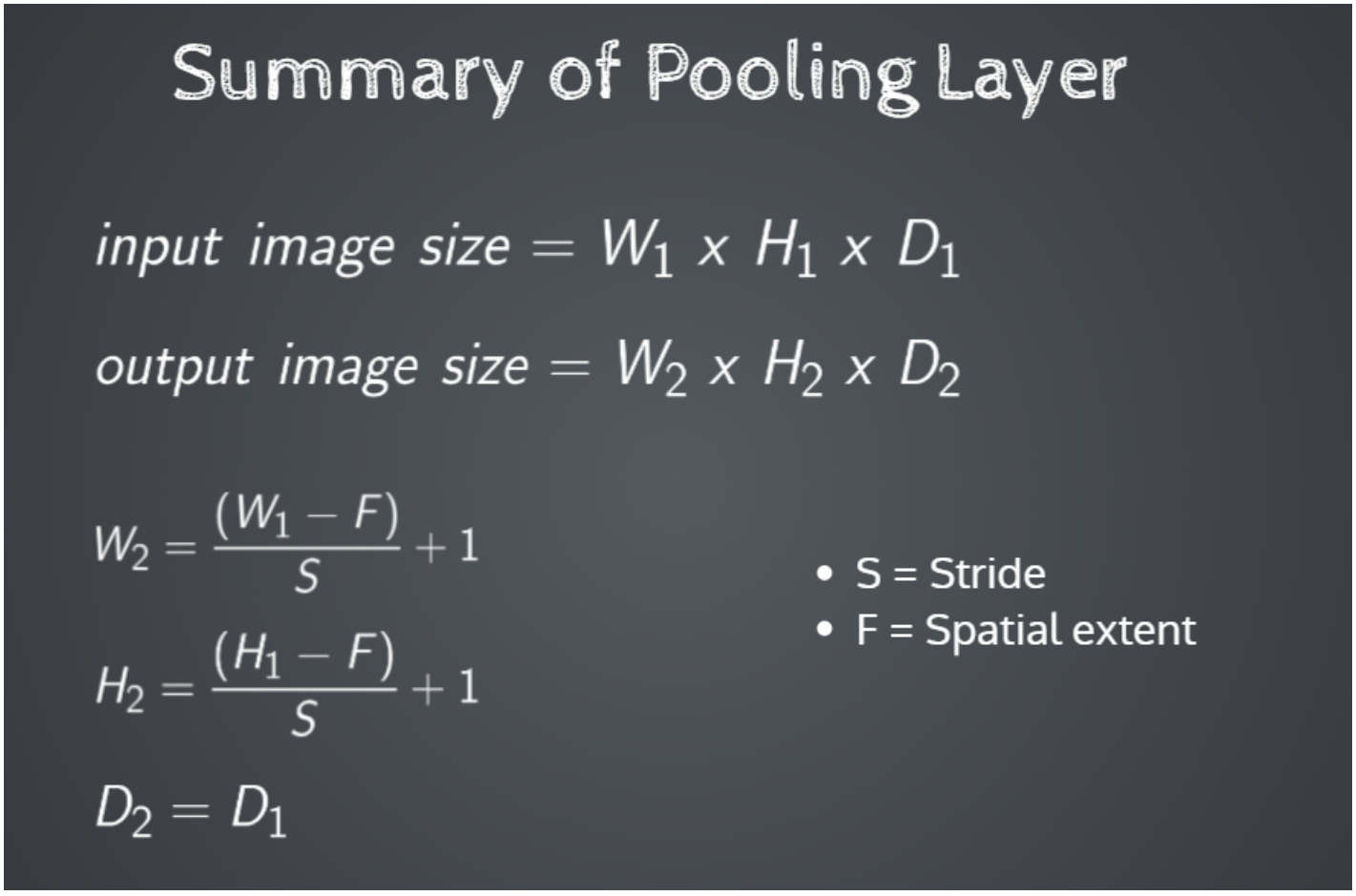
```
img = read_img(img_path)
print(img.shape)
```

```
(168, 300)
```


```
# max-pooling on the img
result = max_pooling(img)
print(result.shape)
```

```
(1, 84, 150, 1)
```


Observation:- Huge reduction in the shape of the resultant image after max-pooling




```
# rows or width of the resultant image
(168-2)//2 + 1    # (rows-spatial extent)// strides +1
```

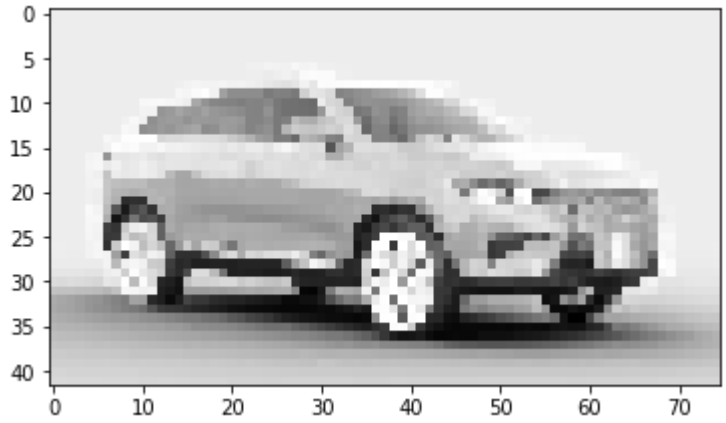
```
84
```

```
# cols or height of the resultant image
(300-2)//2 + 1    # (cols-spatial extent)// strides +1
```

```
150
```

```
# we can show the resultant image
def plot_pooling(result):
  _, row, col, _ = result.shape
  reshape_img = tf.reshape(result, (row, col))
  plt.imshow(reshape_img, cmap="gray")


plot_pooling(result)
```

```
# Again giving the last result image for max-pooling
_, row, col, _ = result.shape
reshape = tf.reshape(result, (row, col))

result = max_pooling(reshape.numpy())
result.shape

plot_pooling(result)
```



**CNN EXPLAINER -**

```
#URL = "https://poloclub.github.io/cnn-explainer/"
#render_site(URL)
```