Correlation and Convolution Filters

- Used to Filter Images
- Blurring Effects
- Remove Noise
- Prepare Images for further analysis

Cross-correlation

Let F be the image, H be the kernel (of size 2k+1 x 2k+1), and G be the output image

$$G[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} H[u,v] F[i+u, j+v]$$

This is called a **cross-correlation** operation:

$$G = H \otimes F$$

Convolution

- Same as cross-correlation, except that the kernel is "flipped" (horizontally and vertically)

$$G[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} H[u,v]F[i-u, j-v]$$

This is called a **convolution** operation:

$$G = H * F$$

- Convolution is **commutative** and **associative**

2D Filter Function (Convolution)

`cv2.filter2D(img, -1, kernel)`

Takes input of grayscale img data filters with kernel.

The kernel is an m x m array used to filter the data. Usually a Gaussian, Laplacian, Sorbel, or box filter.

Example:

```
# img is an existing numpy image array
kernel = np.ones((5, 5), np.float32)/25
box_blur = cv2.filter2D(img, -1, kernel)
```

Gaussian Blur: Role of Sigma

- We will blur images with the cv2.GaussianBlur() function.

```
cv2.GaussianBlur(img, (m x m), sigma)
```

Where:

img = Image Array to Blur

(m x m): size of ‘window’ of Gaussian (odd number)

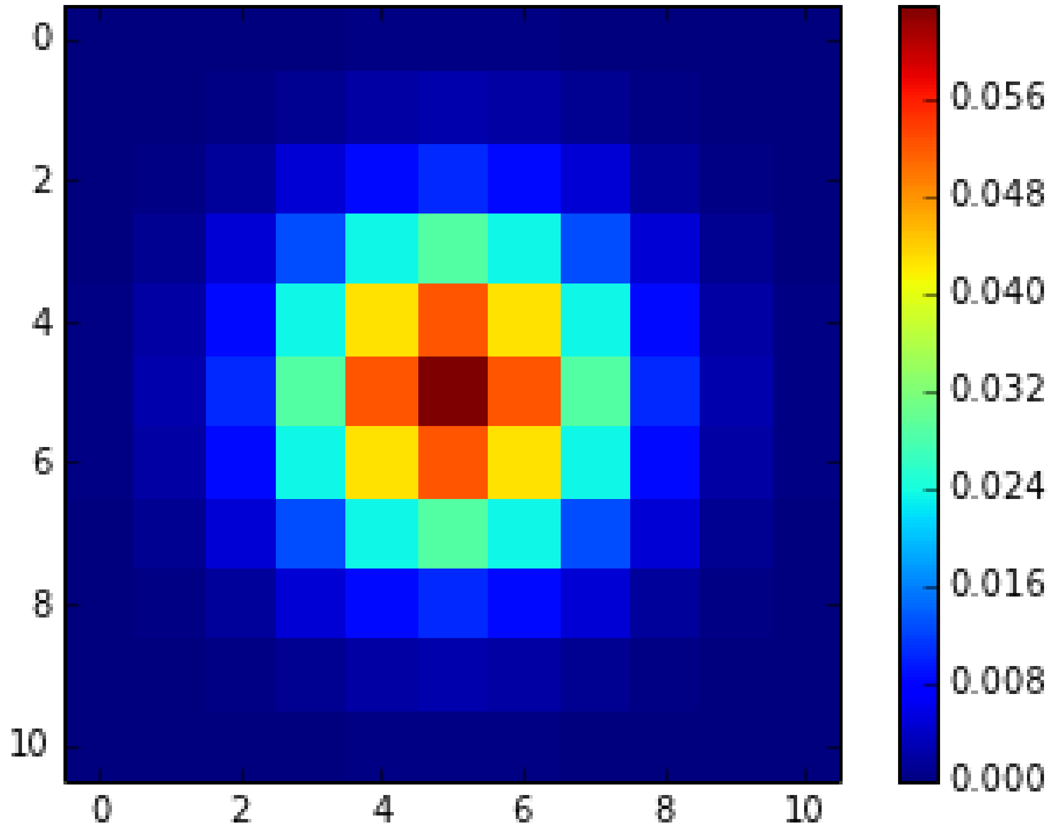
sigma: The spread of the blur (High for more depth)

CV2 Canny Edge Function

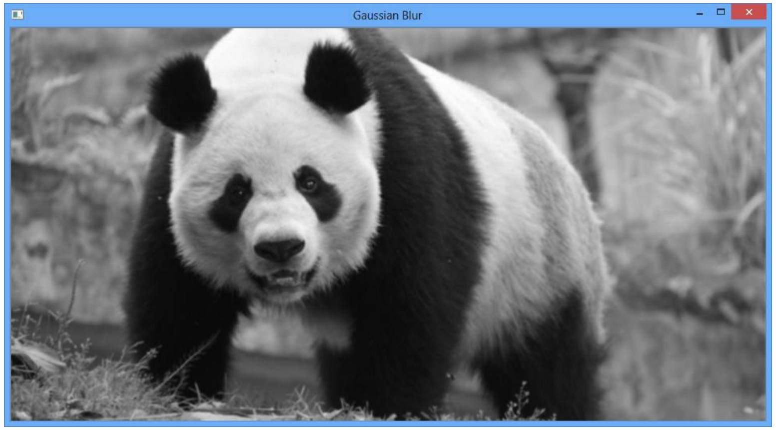
- Built in Edge detection function in Open CV that uses a more involved algorithm:
  - Filters image with derivative of Gaussian
  - Uses magnitude and orientation of gradients
  - Non-Maximum suppression
  - Linking and thresholding
- Result is a more refined edge image.

```
img_edge_canny = cv2.Canny(img_gauss, 50, 100)
```

2D Gaussian Filter Image



Example:

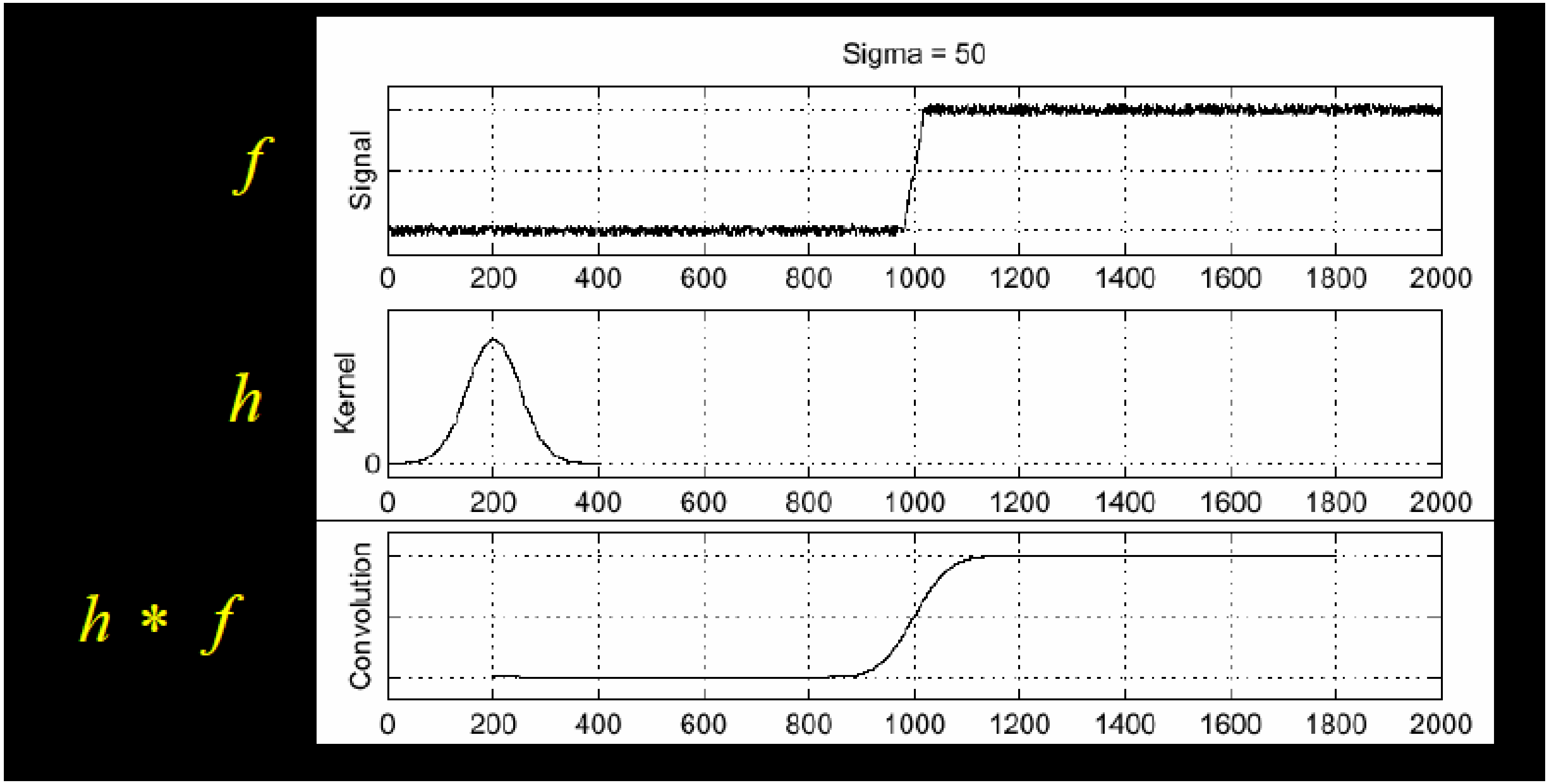



```
# Blur with Gaussian
img_gauss = cv2.GaussianBlur(img, (31, 31), 1)
```


```
# Blur with Gaussian
img_gauss = cv2.GaussianBlur(img, (31, 31), 10)
```

Why Blur with Gaussian?

- Remove Noise from the Picture.



Code Sample: Blur with Gaussian

```
# Gaussian Blur Sample
# Mr. Michaud

import cv2 as cv2
import numpy as np

path = 'images\\panda.jpg'

# Import as a grayscale
img = cv2.imread(path, 0)


# Blur with Gaussian
img_gauss = cv2.GaussianBlur(img, (31, 31), 10)


# Show
cv2.imshow('Gaussian Blur', img_gauss)

# Exit Sequence
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Code Sample: Canny Edge

```python
# Gaussian Blur Sample
# Mr. Michaud

import cv2 as cv2
import numpy as np

path = 'images\\panda.jpg'

# Import as a grayscale
img = cv2.imread(path, 0)


# Blur with Gaussian
img_gauss = cv2.GaussianBlur(img, (11, 11), 10)

# Canny Filter
# Convert to uint8 normalized to 0 to 255
img_g8 = img_gauss * 255
img_g8 = np.uint8(img_g8)
img_canny = cv2.Canny(img_g8, 20, 40)


# Show
cv2.imshow('Gaussian Blur', img_gauss)
cv2.imshow('Canny', img_canny)

# Exit Sequence
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Note: You will have to experiment with the parameters for GaussianBlur() and Canny() to get a good edge image.