Make images come alive with scikit-image

IMAGE PROCESSING IN PYTHON

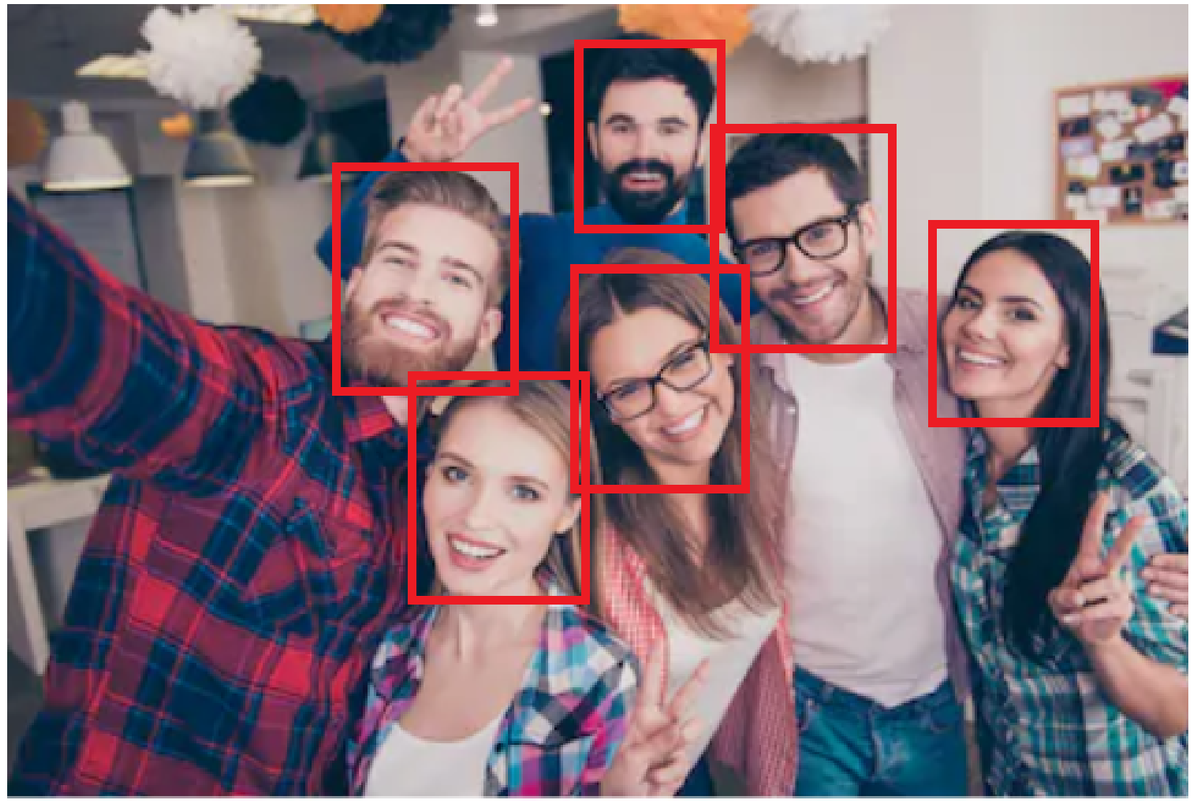
Rebeca Gonzalez
Data Engineer

datacamp

What is image processing?

Operations on images and videos to:

- Enhance an image
- Extract useful information
- Analyze it and make decisions



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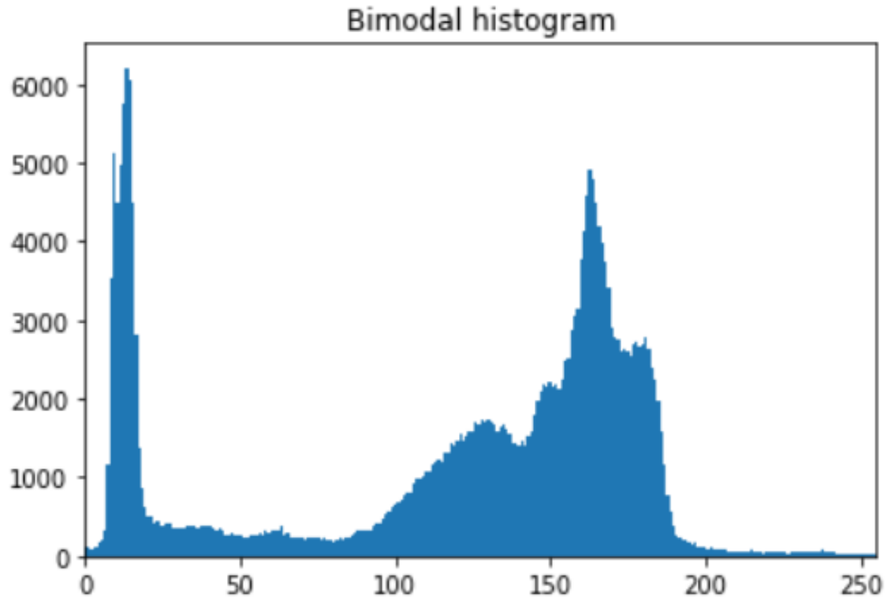


Applications

- Medical image analysis
- Artificial intelligence
- Image restoration and enhancement
- Geospatial computing
- Surveillance
- Robotic vision
- Automotive safety
- And many more...

Purposes

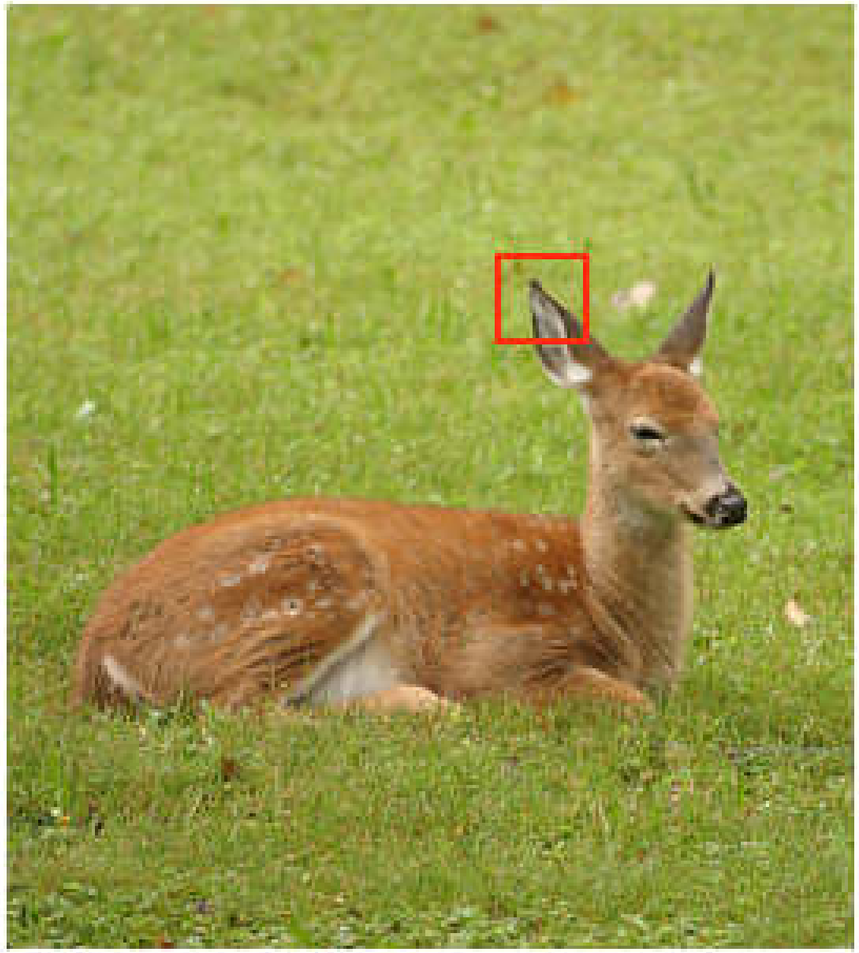
1. Visualization:
   - Objects that are not visible
2. Image sharpening and restoration
   - A better image
3. Image retrieval
   - Seek for the image of interest
4. Measurement of pattern
   - Measures various objects
5. Image Recognition
   - Distinguish objects in an image

Intro to scikit-image

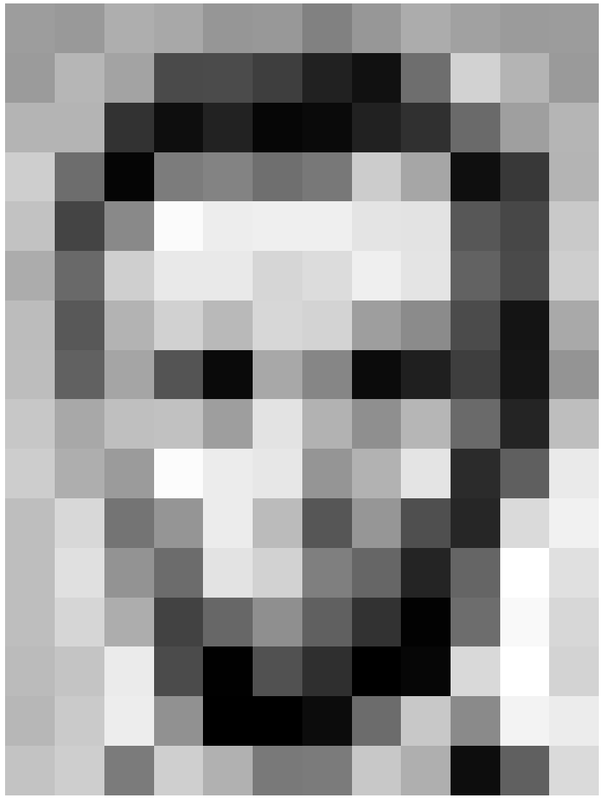
- Easy to use
- Makes use of Machine Learning
- Out of the box complex algorithms

scikit-image
image processing in python

What is an image?



What is an image?



157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

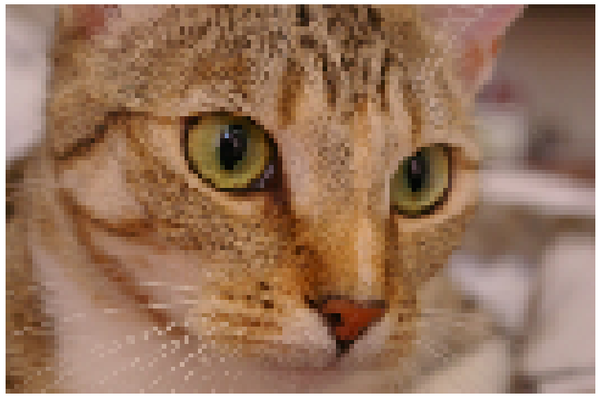
157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Images in scikit-image

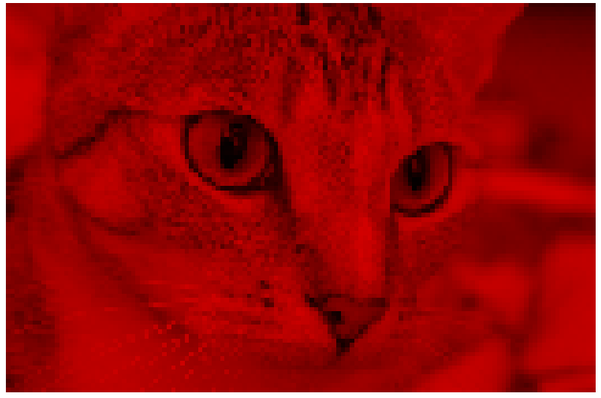
```
from skimage import data
rocket_image = data.rocket()
```

RGB channels

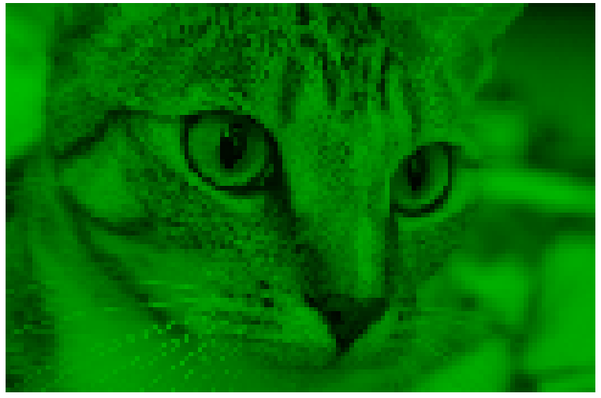
RGB



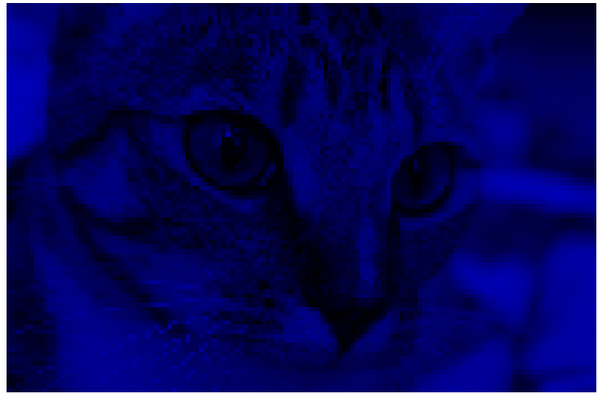
Red channel



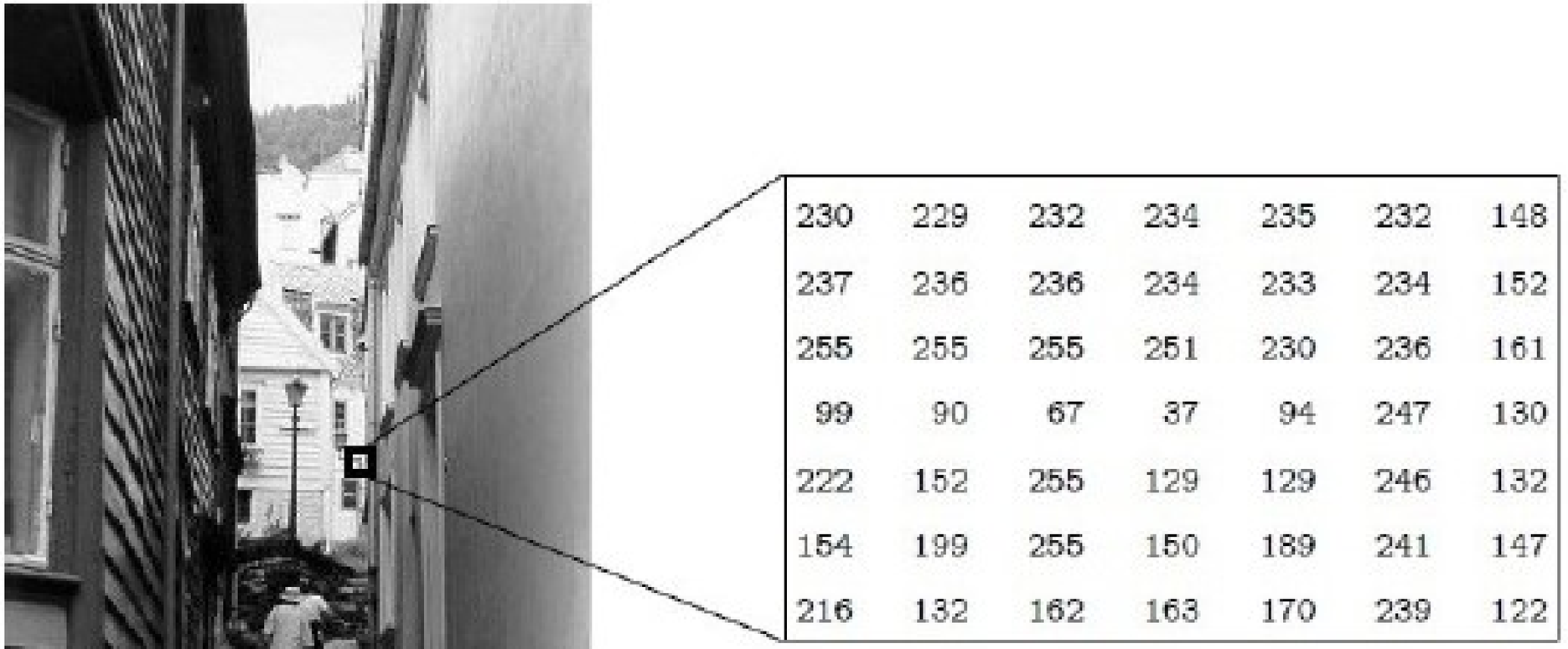
Green channel



Blue channel



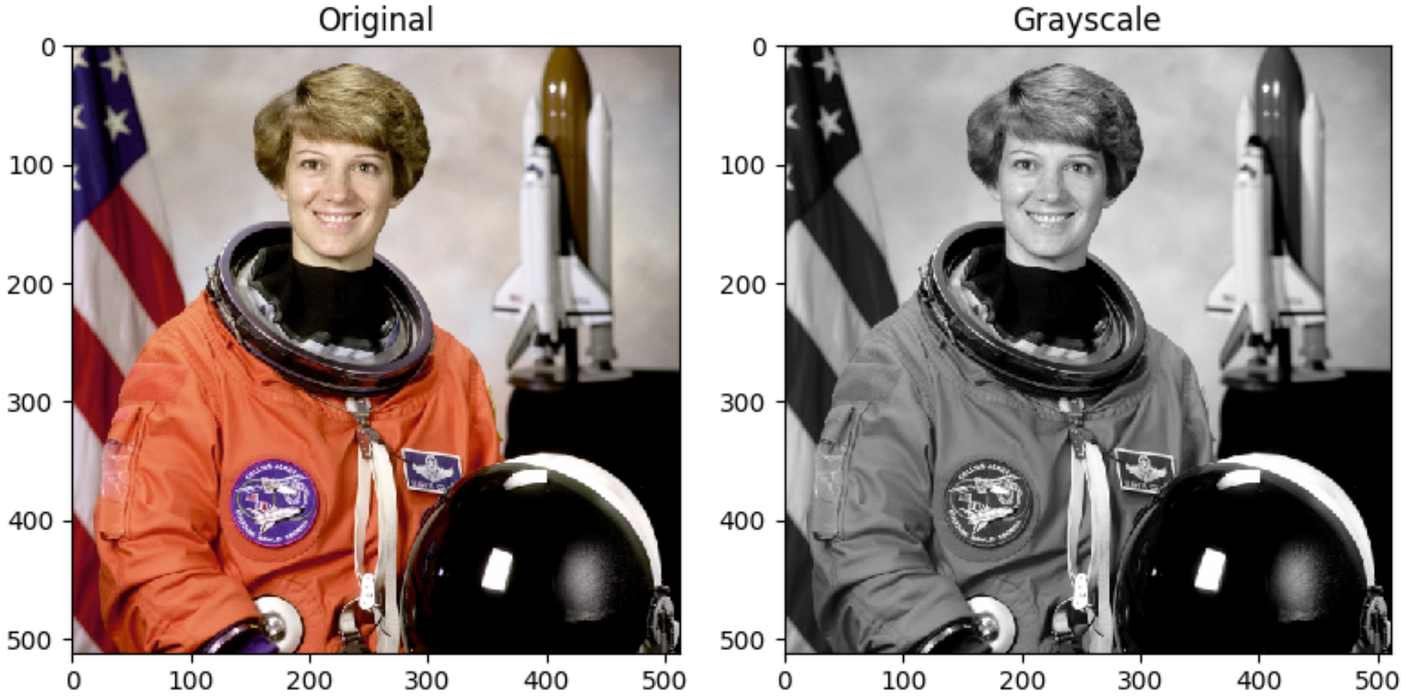
Grayscaled images



230	229	232	234	235	232	148
237	236	236	234	233	234	152
255	255	255	251	230	236	161
99	90	67	37	94	247	130
222	152	255	129	129	246	132
154	199	255	150	189	241	147
216	132	162	163	170	239	122

RGB vs Grayscale

```
from skimage import color
grayscale = color.rgb2gray(original)
rgb = color.gray2rgb(grayscale)
```



Visualizing images in the course

Don't worry about Matplotlib!

```
def show_image(image, title='Image', cmap_type='gray'):
    plt.imshow(image, cmap=cmap_type)
    plt.title(title)
    plt.axis('off')
    plt.show()
```

Visualizing images in the course

```
from skimage import color
grayscale = color.rgb2gray(original)


show_image(grayscale, "Grayscale")
```

Let's practice!

IMAGE PROCESSING IN PYTHON

NumPy for images

IMAGE PROCESSING IN PYTHON

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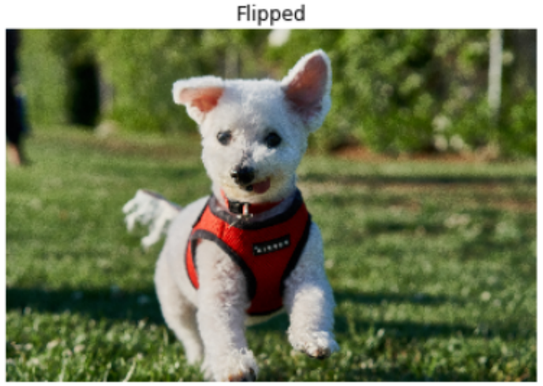
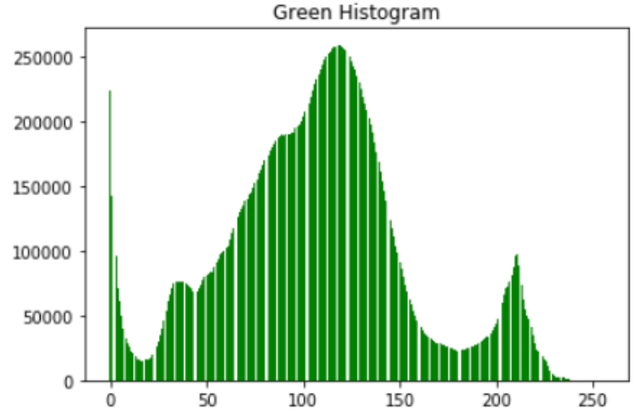
Data Engineer

datacamp

NumPy for images

- Fundamentals of image processing techniques
  - Flipping
  - Extract and analyze features



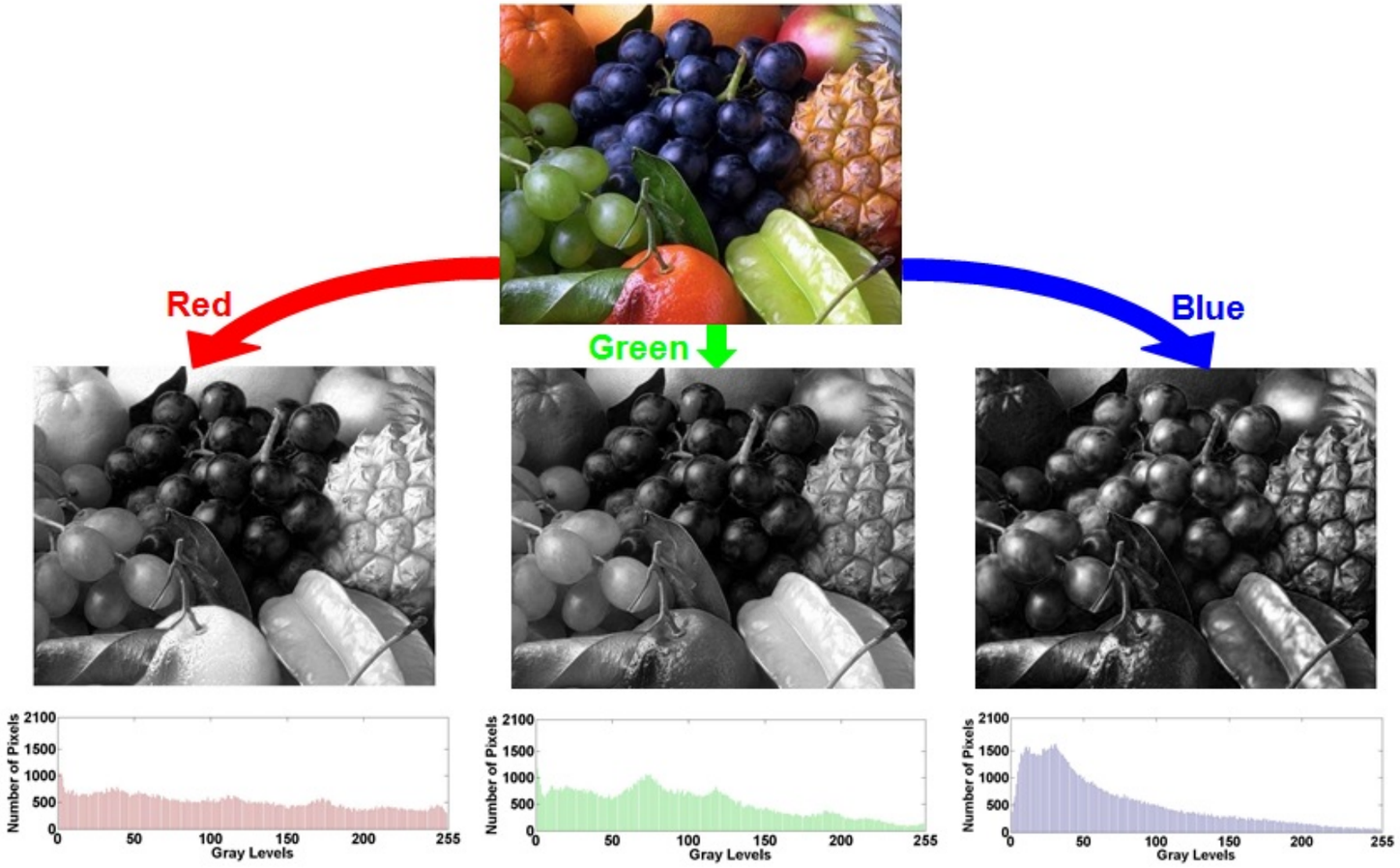


Images as NdArrays

```
# Loading the image using Matplotlib
madrid_image = plt.imread('/madrid.jpeg')

type(madrid_image)
```

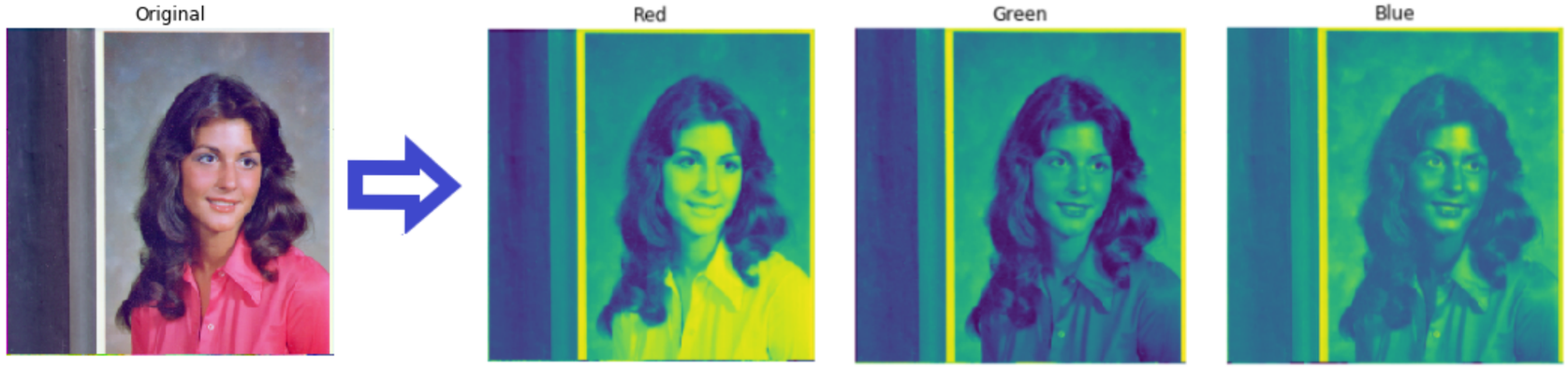
```
<class 'numpy.ndarray'>
```

Colors with NumPy



Colors with NumPy

```
# Obtaining the red values of the image
red = image[:, :, 0]

# Obtaining the green values of the image
green = image[:, :, 1]

# Obtaining the blue values of the image
blue = image[:, :, 2]
```



Colors with NumPy


```
plt.imshow(red, cmap="gray")
plt.title('Red')
plt.axis('off')
plt.show()
```

Shapes

```
# Accessing the shape of the image
madrid_image.shape
```

```
(426, 640, 3)
```

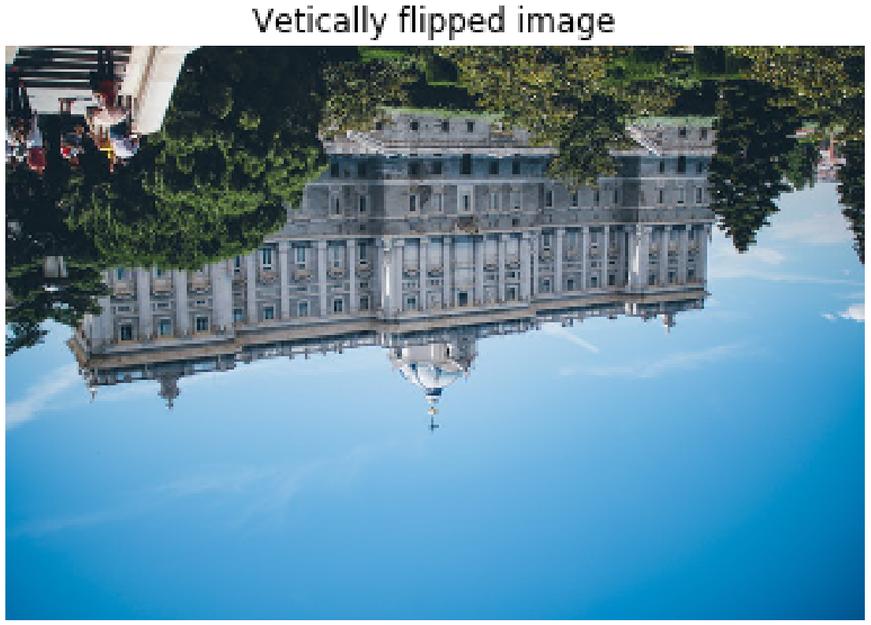
Sizes

```
# Accessing the shape of the image
madrid_image.size
```

```
817920
```

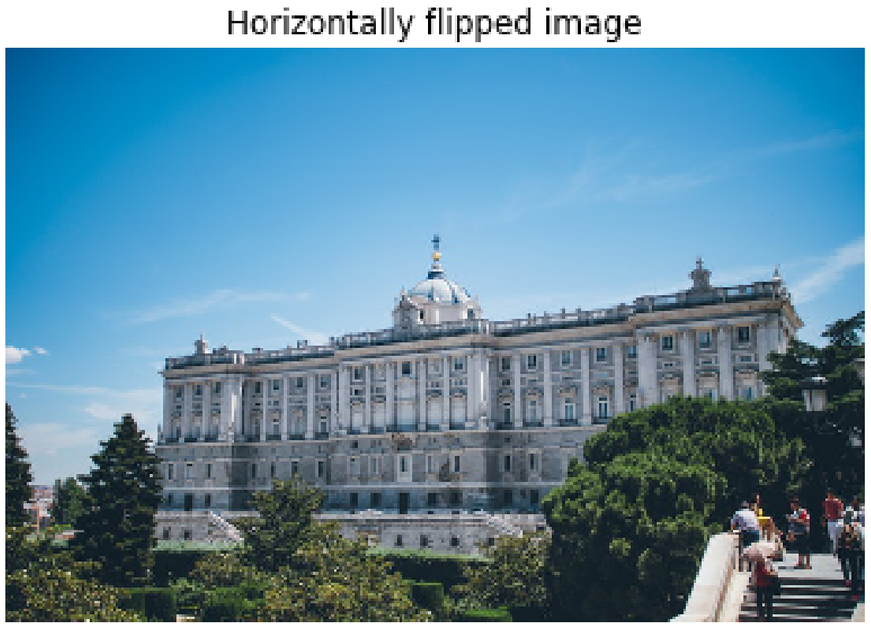
Flipping images: vertically

```
# Flip the image in up direction
vertically_flipped = np.flipud(madrid_image)


show_image(vertically_flipped, 'Vertically flipped image')
```

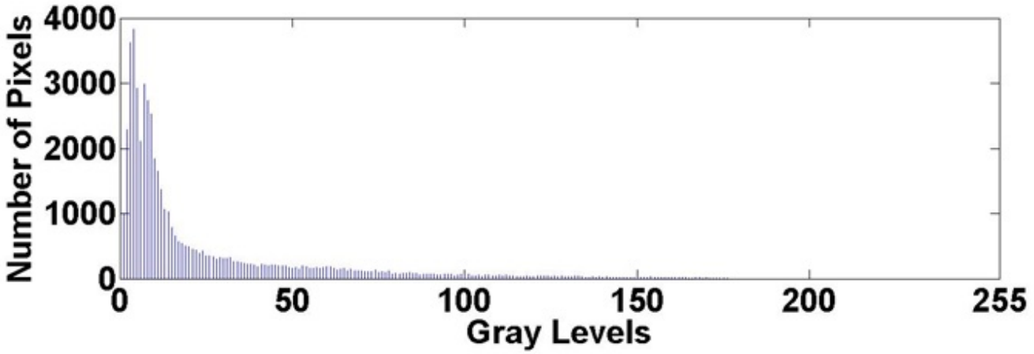


Flipping images: horizontally

```
# Flip the image in left direction
horizontally_flipped = np.fliplr(madrid_image)


show_image(horizontally_flipped, 'Horizontally flipped image')
```

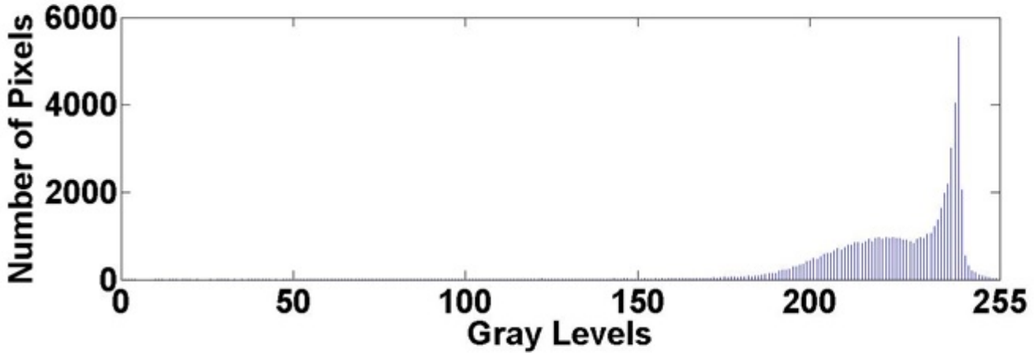


What is a histogram?



(a)

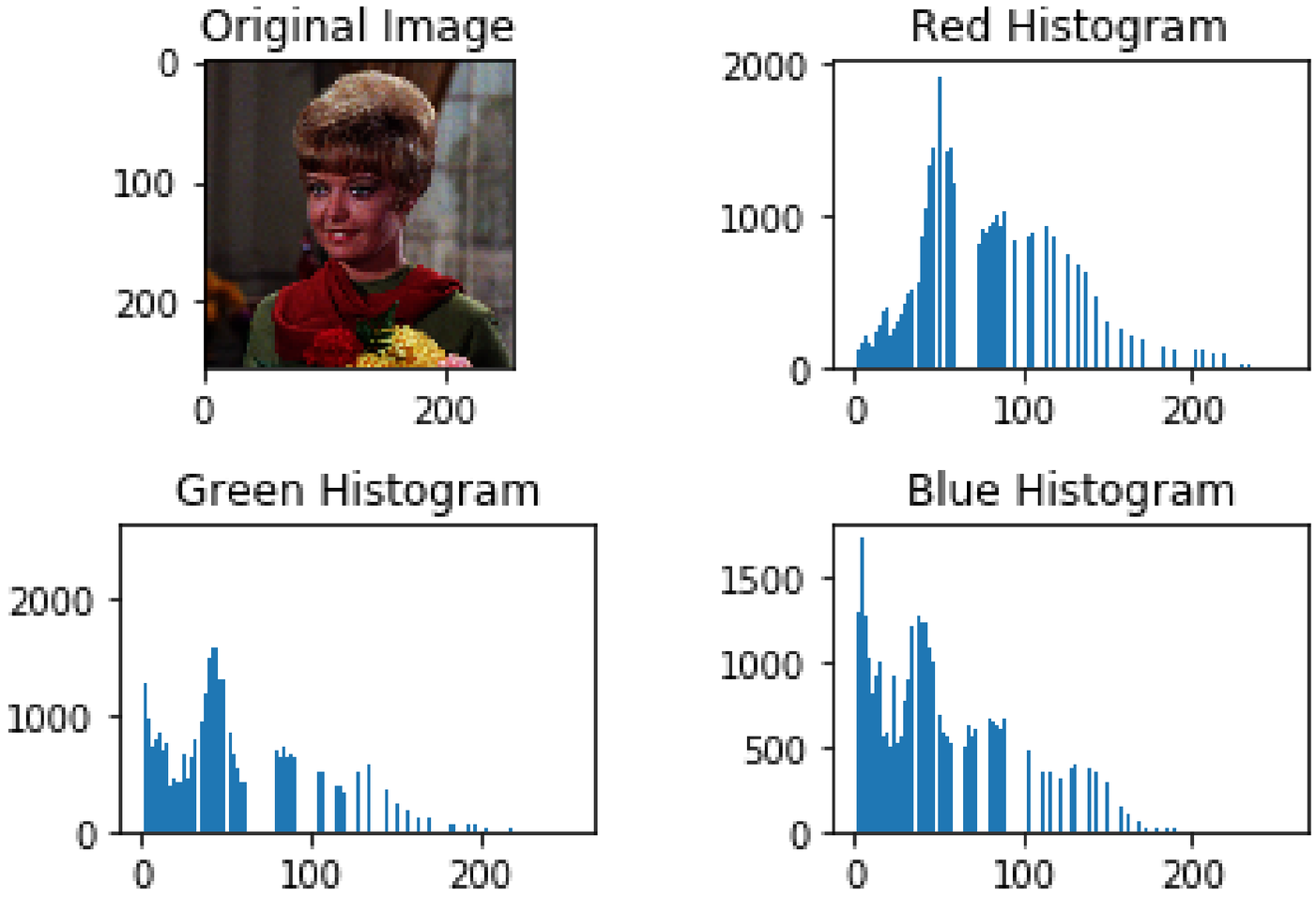
(b)



(a)

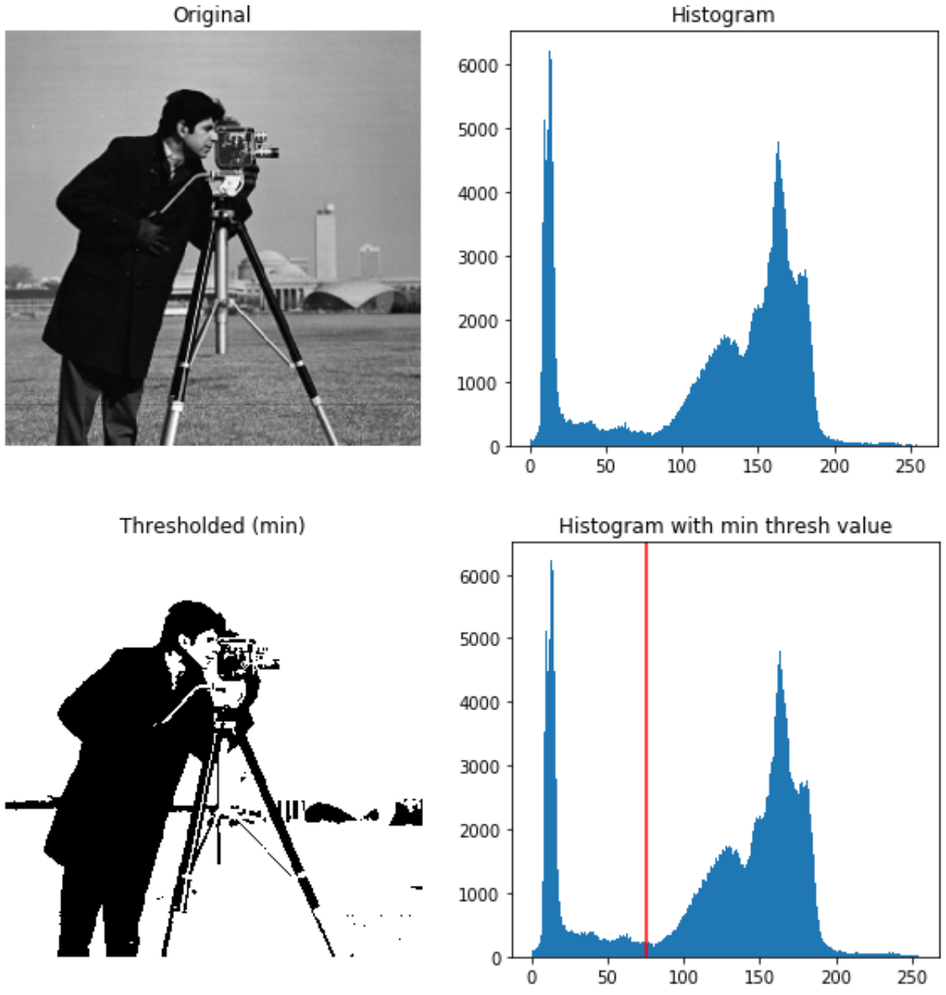
(b)

Color histograms

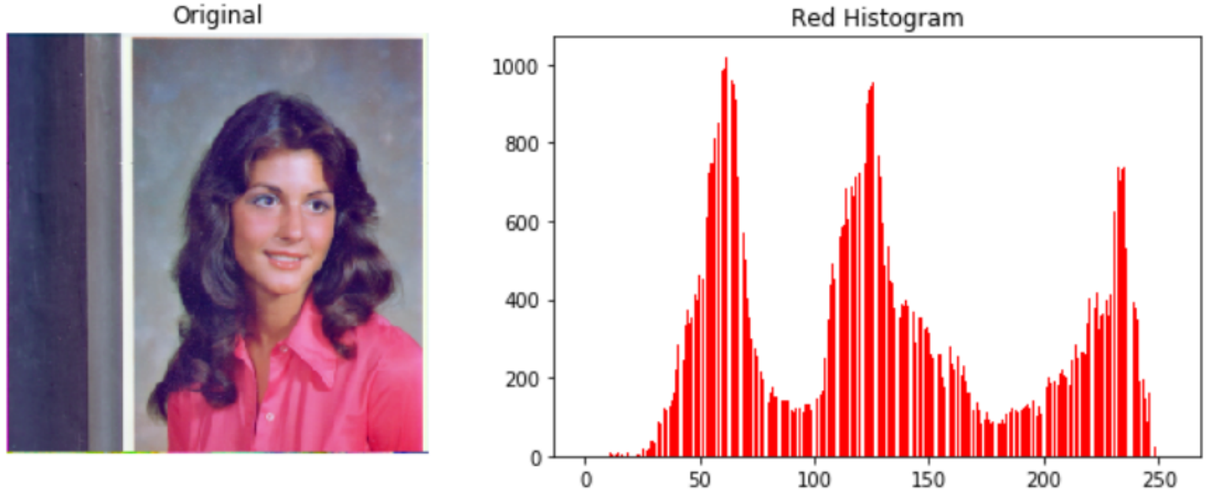


Applications of histograms

- Analysis
- Thresholding
- Brightness and contrast
- Equalize an image



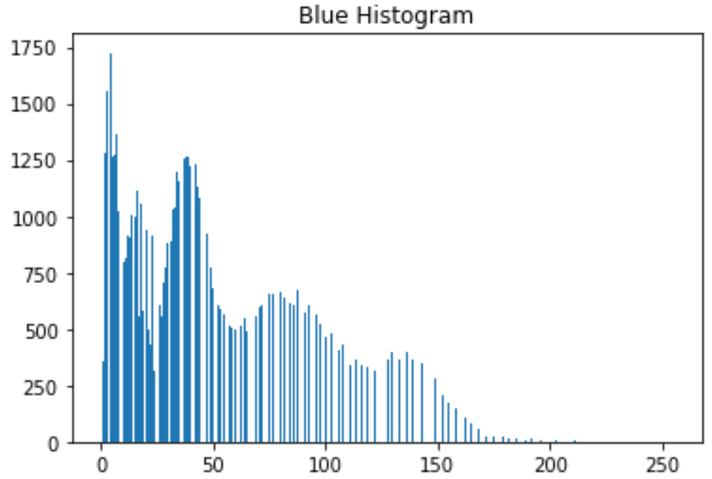
Histograms in Matplotlib




```
# Red color of the image
red = image[:, :, 0]

# Obtain the red histogram
plt.hist(red.ravel(), bins=256)
```

Visualizing histograms with Matplotlib

```
blue = image[:, :, 2]

plt.hist(blue.ravel(), bins=256)
plt.title('Blue Histogram')
plt.show()
```



Let's practice!

IMAGE PROCESSING IN PYTHON

Getting started with thresholding

IMAGE PROCESSING IN PYTHON

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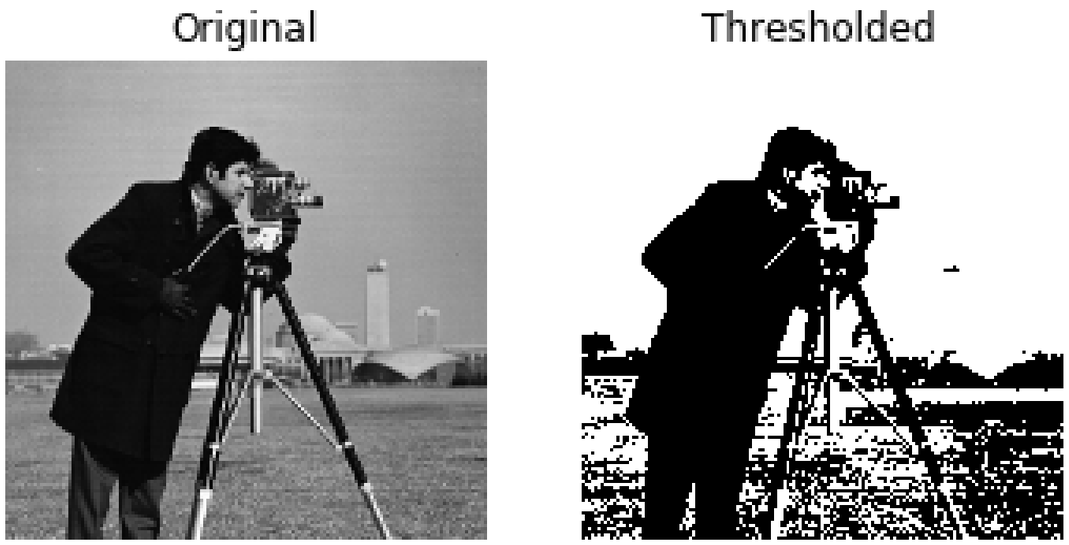
Thresholding

Partitioning an image into a foreground and background

By making it **black and white**

We do so by setting each pixel to:

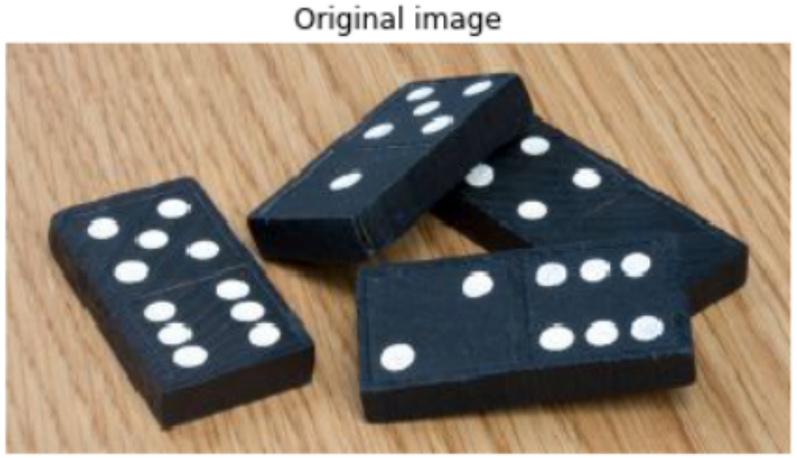
- 255 (white) if pixel $>$ thresh value
- 0 (black) if pixel $<$ thresh value

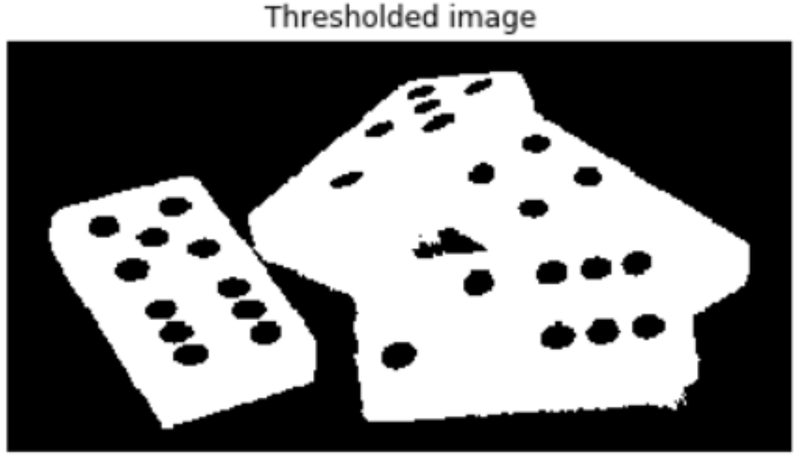


Thresholding

Simplest method of image segmentation

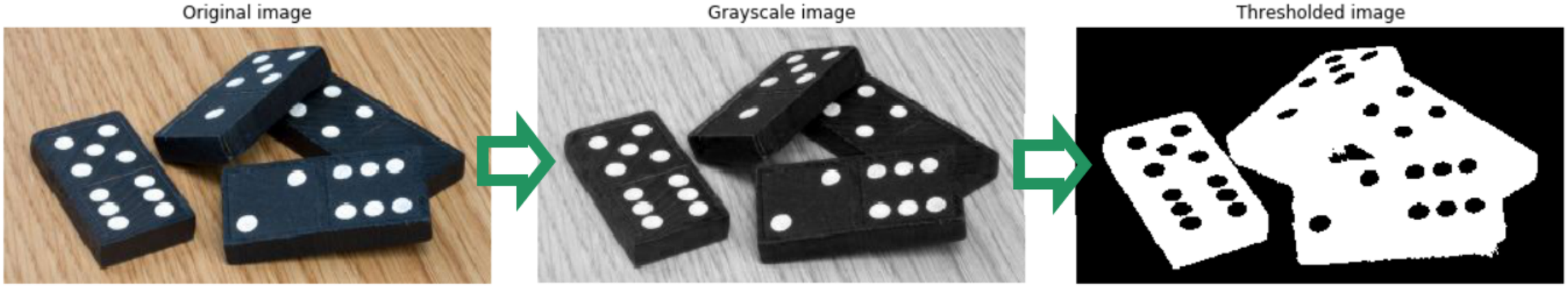
- Isolate objects
  - Object detection
  - Face detection
  - Etc.





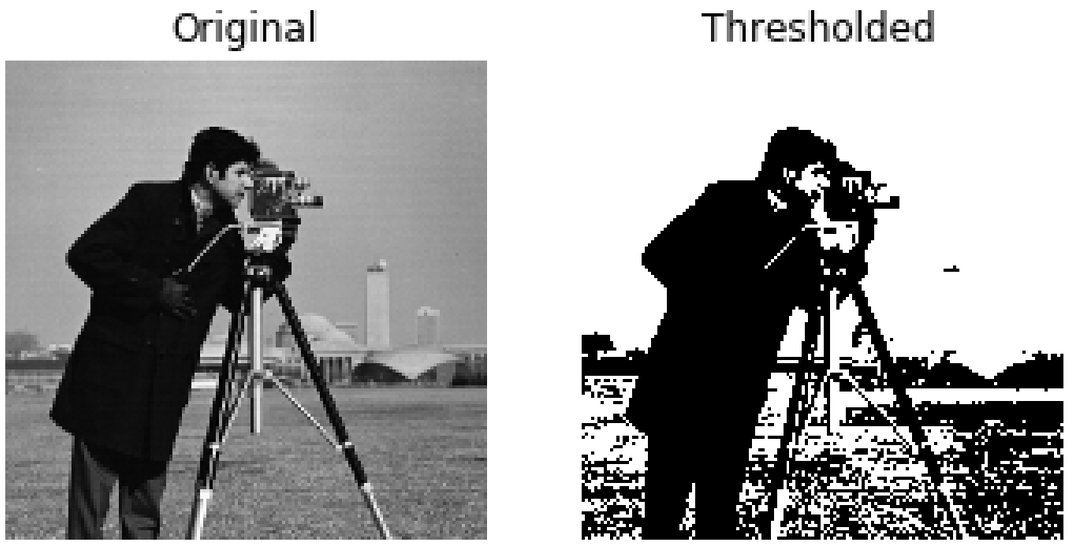
Thresholding

Only from **grayscale** images



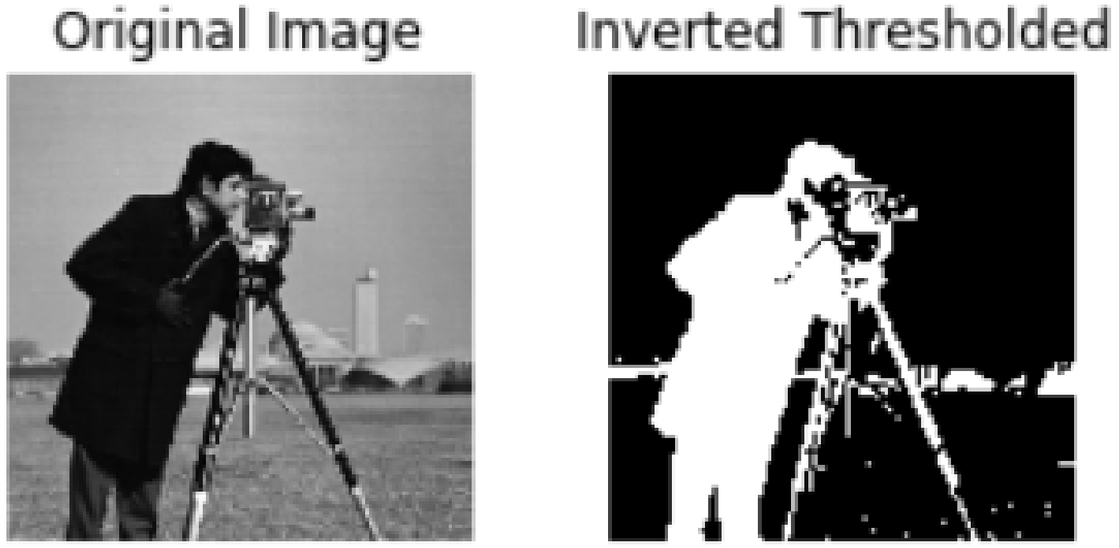
Apply it

```
# Obtain the optimal threshold value
thresh = 127

# Apply thresholding to the image
binary = image > thresh

# Show the original and thresholded
show_image(image, 'Original')
show_image(binary, 'Thresholded')
```



Inverted thresholding

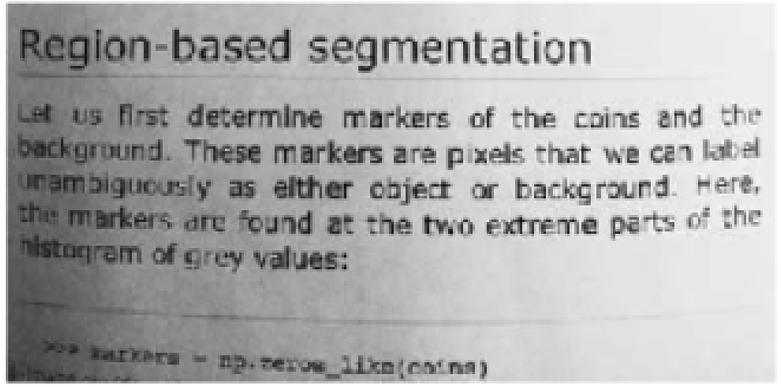
```
# Obtain the optimal threshold value
thresh = 127

# Apply thresholding to the image
inverted_binary = image <= thresh

# Show the original and thresholded
show_image(image, 'Original')
show_image(inverted_binary,
           'Inverted thresholded')
```



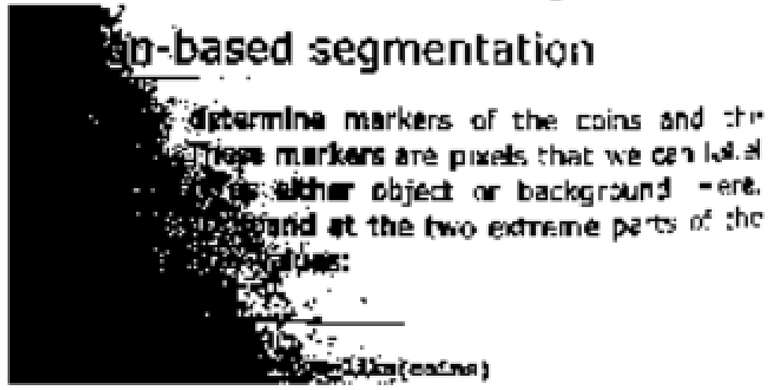
Categories

- **Global or histogram based:** good for uniform backgrounds
- **Local or adaptive:** for uneven background illumination

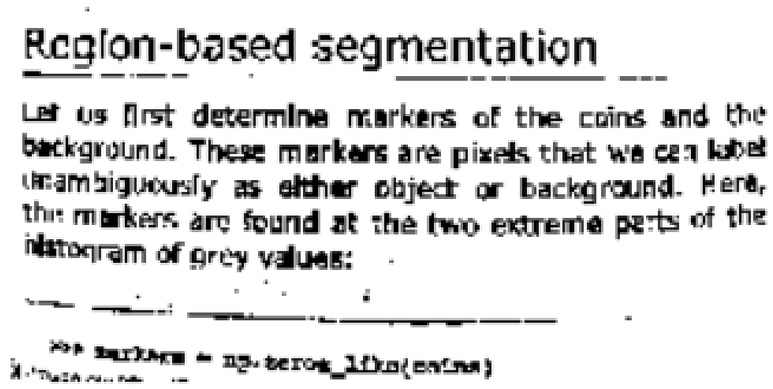
Original



Global thresholding



Local thresholding

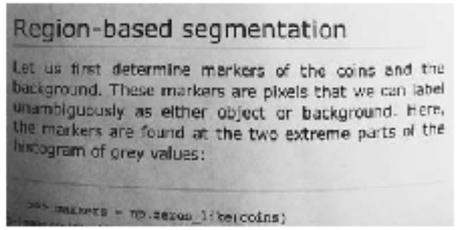


Try more thresholding algorithms

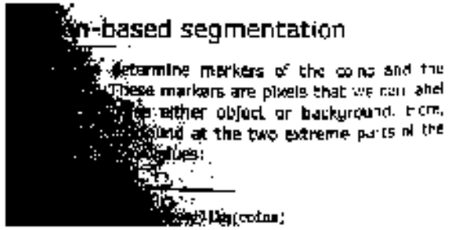
```
from skimage.filters import try_all_threshold

# Obtain all the resulting images
fig, ax = try_all_threshold(image, verbose=False)

# Showing resulting plots
show_plot(fig, ax)
```

Try more thresholding algorithms

Original

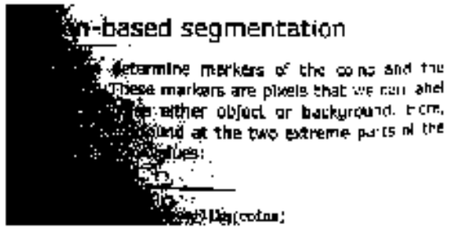


Isodata

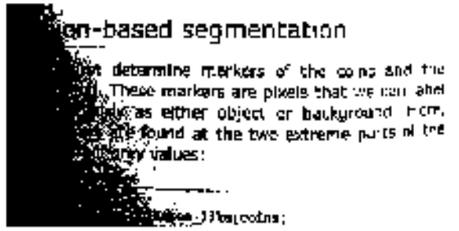


Minimum

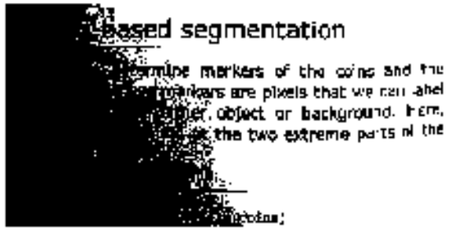
Otsu



Li

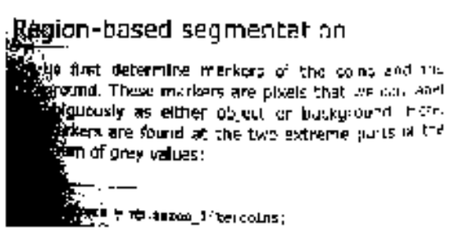


Mean



Triangle

Yen



Optimal thresh value

Global

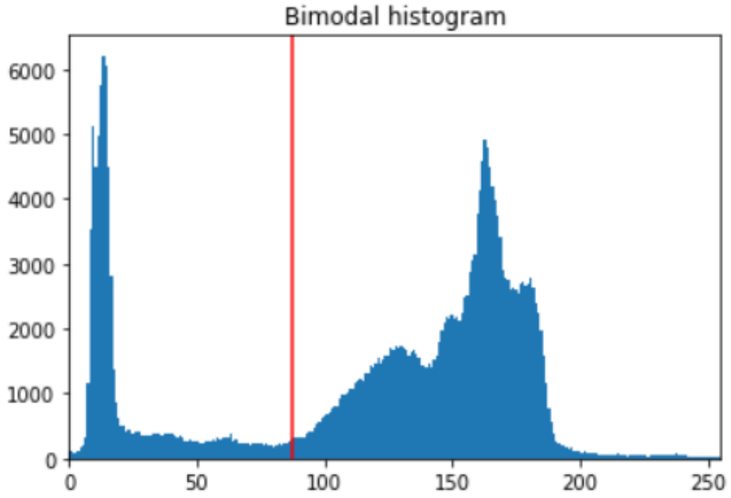
Uniform background

```
# Import the otsu threshold function
from skimage.filters import threshold_otsu

# Obtain the optimal threshold value
thresh = threshold_otsu(image)

# Apply thresholding to the image
binary_global = image > thresh
```

Optimal thresh value

Global

```
# Show the original and binarized image
show_image(image, 'Original')
show_image(binary_global, 'Global thresholding')
```



Optimal thresh value

Local

Uneven background

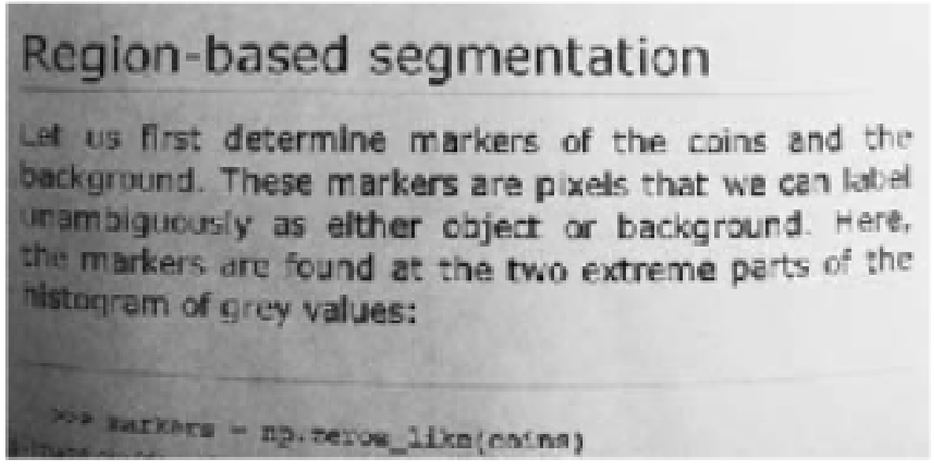
```
# Import the local threshold function
from skimage.filters import threshold_local

# Set the block size to 35
block_size = 35

# Obtain the optimal local thresholding
local_thresh = threshold_local(text_image, block_size, offset=10)

# Apply local thresholding and obtain the binary image
binary_local = text_image > local_thresh
```

Optimal thresh value

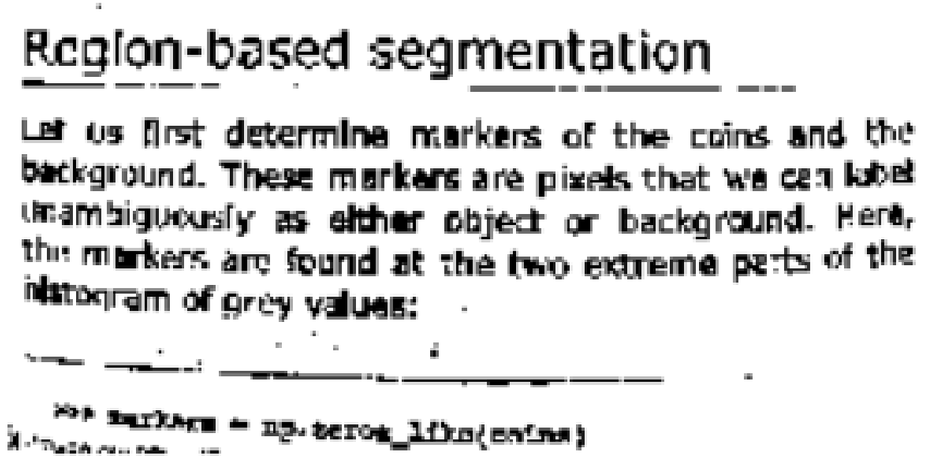
Local

```
# Show the original and binarized image
show_image(image, 'Original')
show_image(binary_local, 'Local thresholding')
```

Original



Local thresholding



Let's practice!

IMAGE PROCESSING IN PYTHON

Jump into filtering

IMAGE PROCESSING IN PYTHON

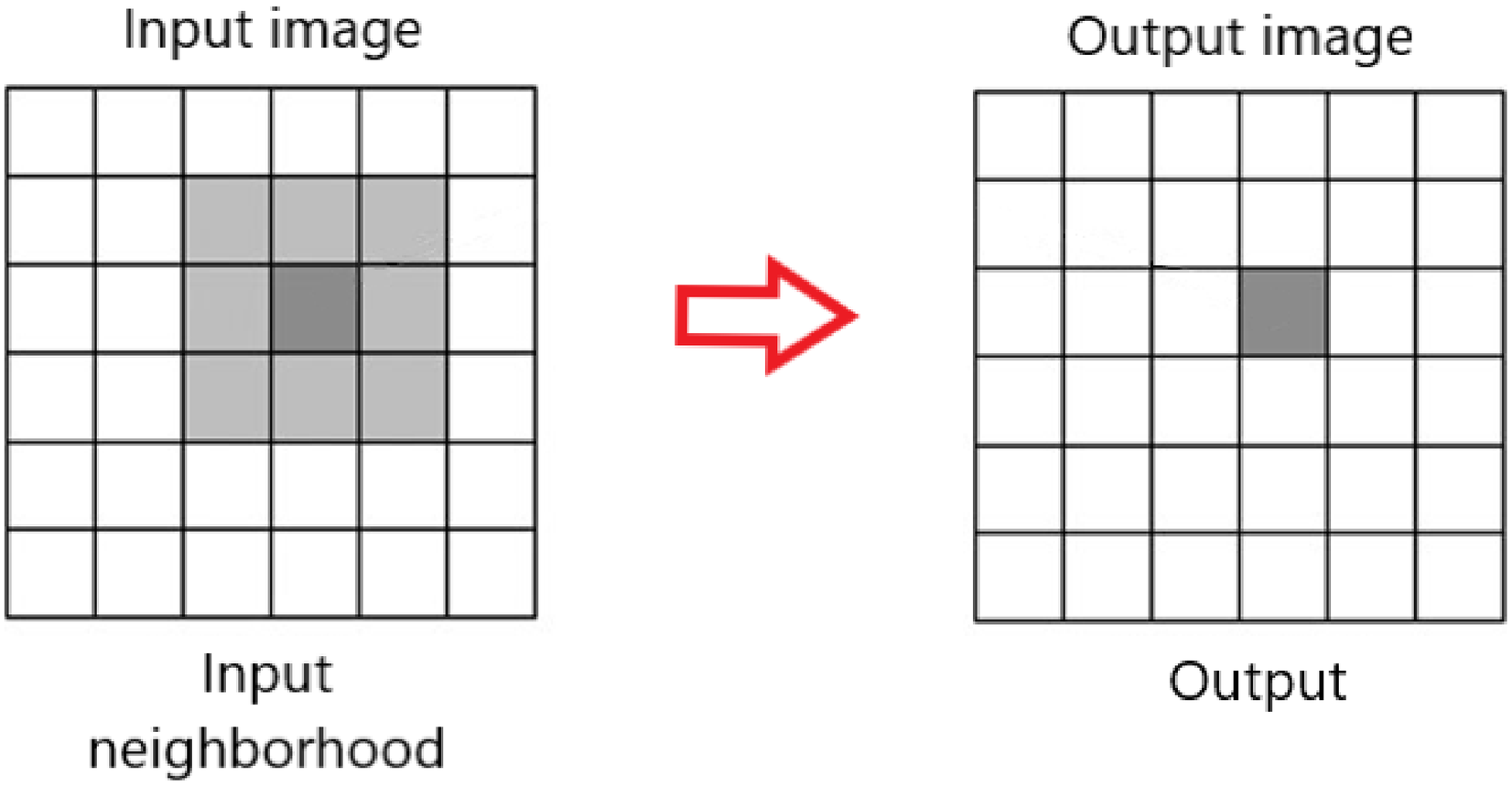
Rebeca Gonzalez
Data Engineer

datacamp

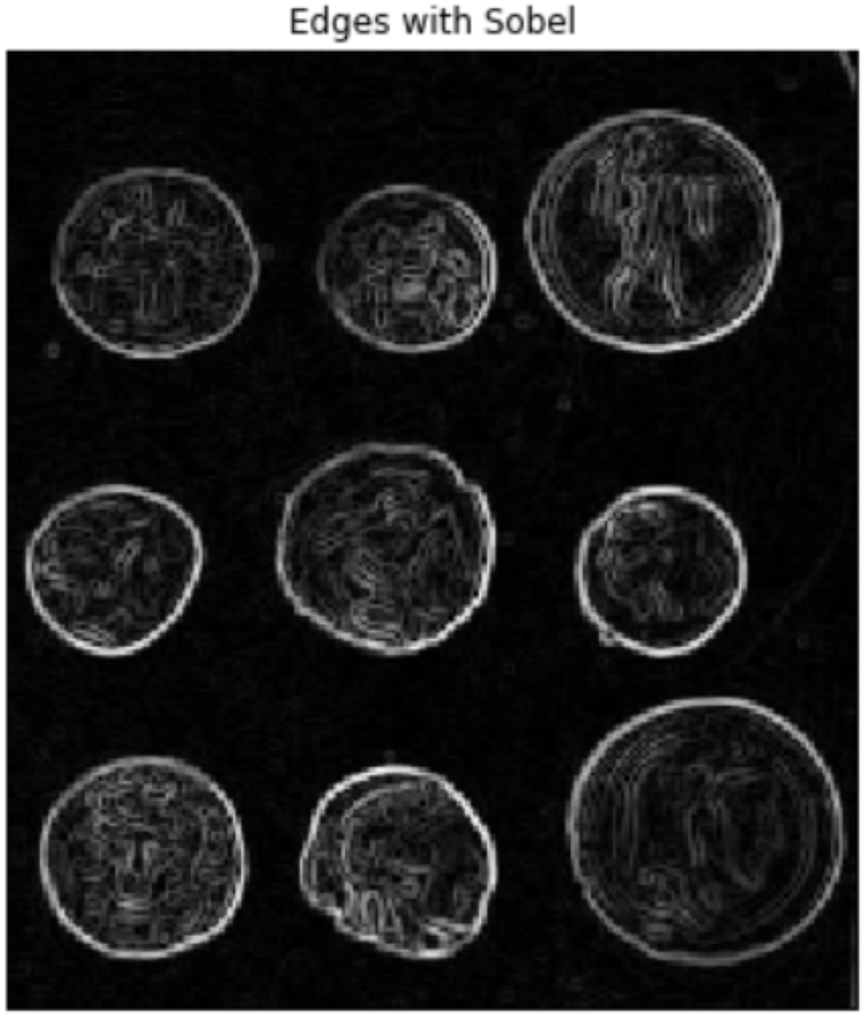
Filters

- Enhancing an image
- Emphasize or remove features
- Smoothing
- Sharpening
- Edge detection

Neighborhoods



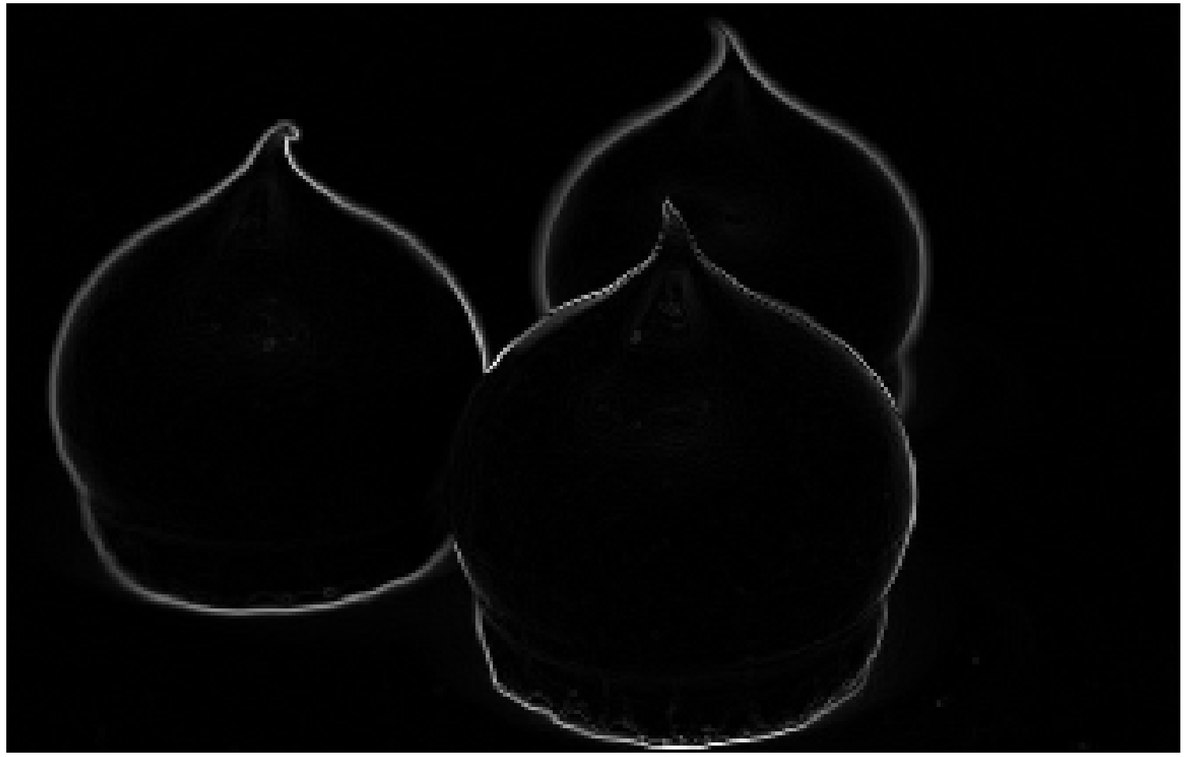
Edge detection



Edge detection

Original chocolate kisses

Edges with Sobel



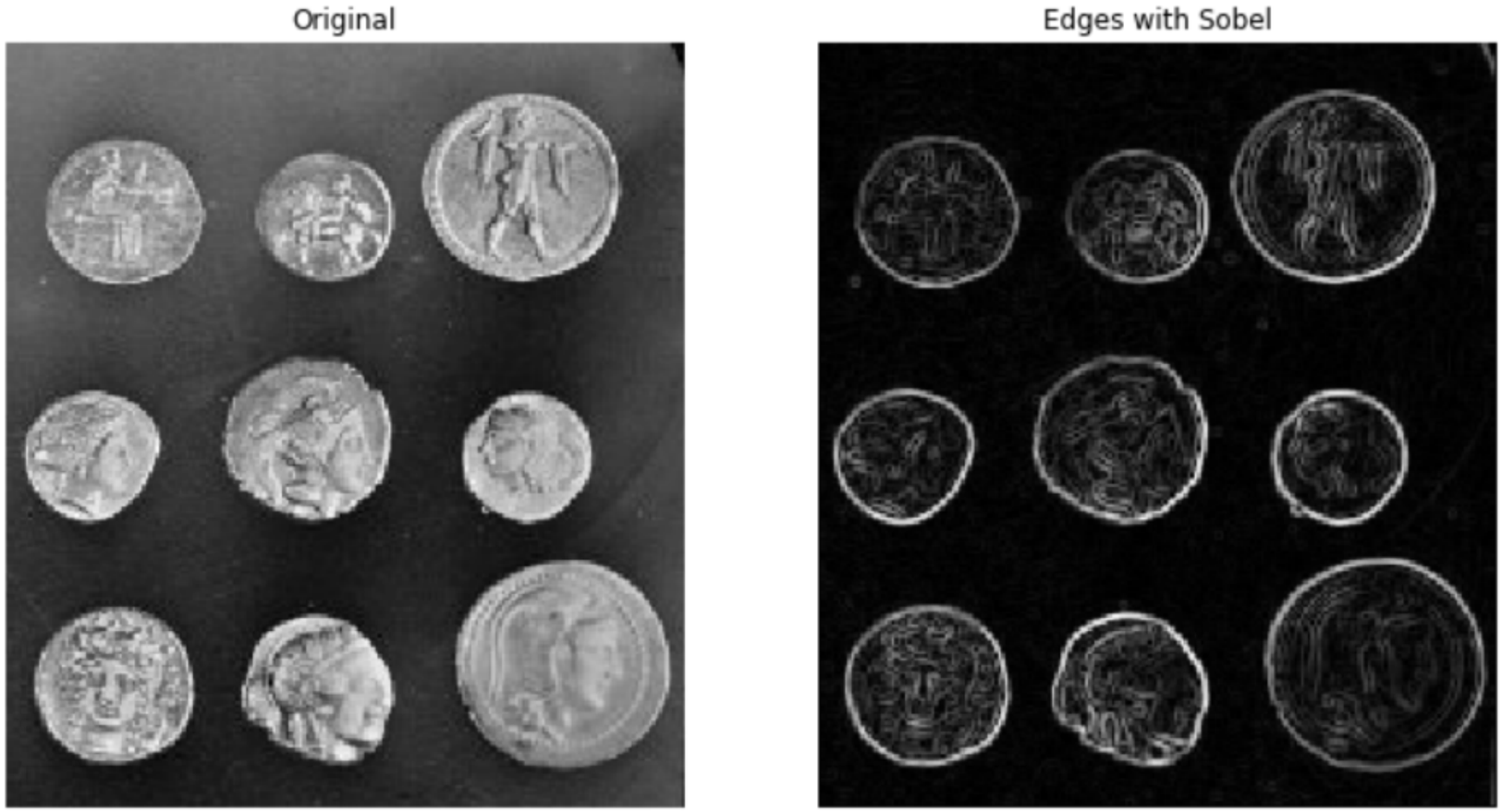
Edge detection

Sobel

```
# Import module and function
from skimage.filters import sobel

# Apply edge detection filter
edge_sobel = sobel(image_coins)

# Show original and resulting image to compare
plot_comparison(image_coins, edge_sobel, "Edge with Sobel")
```

Edge detection

Sobel



Comparing plots

```
def plot_comparison(original, filtered, title_filtered):

    fig, (ax1, ax2) = plt.subplots(ncols=2, figsize=(8, 6), sharex=True,
                                   sharey=True)
    ax1.imshow(original, cmap=plt.cm.gray)
    ax1.set_title('original')
    ax1.axis('off')
    ax2.imshow(filtered, cmap=plt.cm.gray)
    ax2.set_title(title_filtered)
    ax2.axis('off')
```

Gaussian smoothing

Original

Blurred with Gaussian filter

Gaussian smoothing

Gaussian smoothing

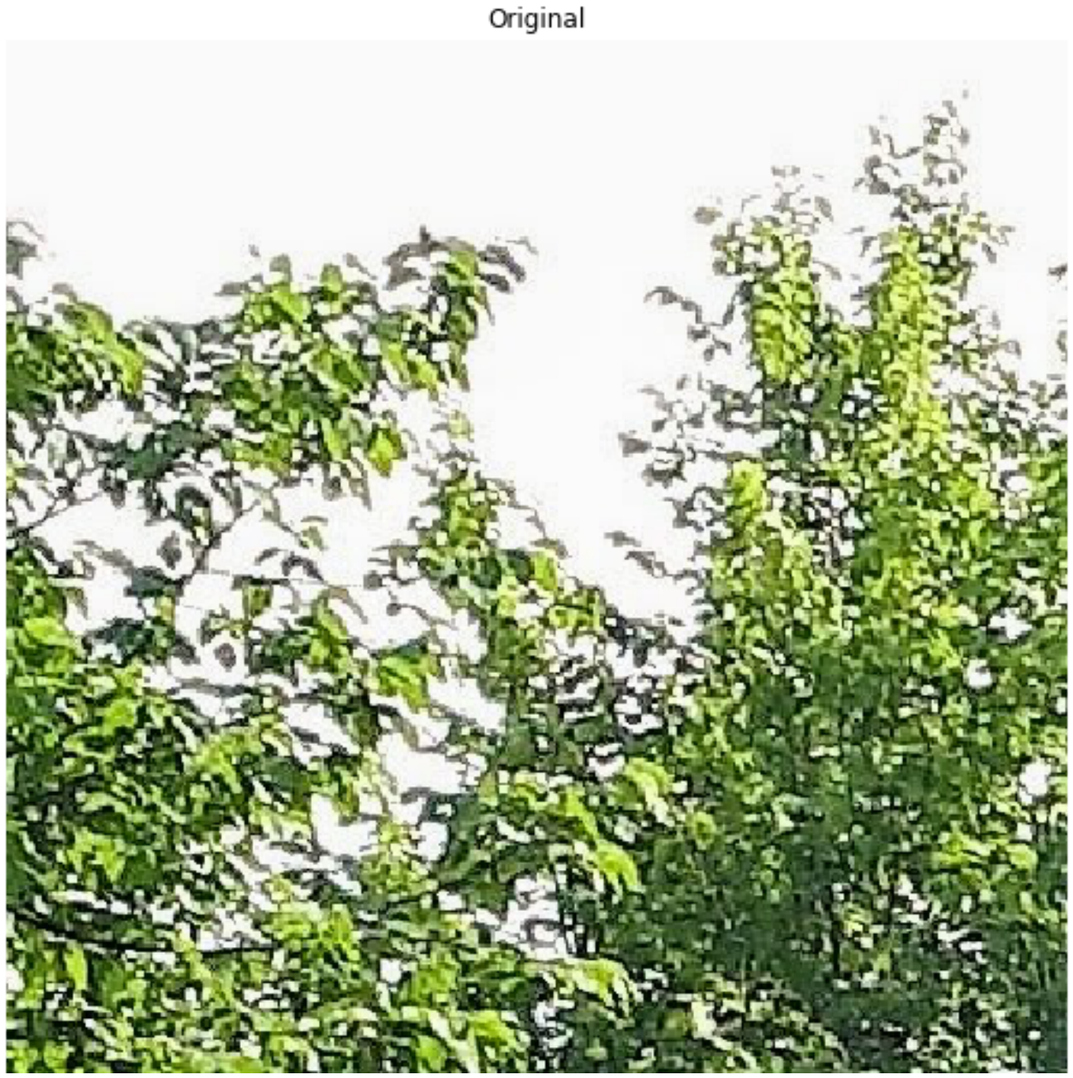
```
# Import the module and function
from skimage.filters import gaussian

# Apply edge detection filter
gaussian_image = gaussian(amsterdam_pic, multichannel=True)

# Show original and resulting image to compare
plot_comparison(amsterdam_pic, gaussian_image, "Blurred with Gaussian filter")
```

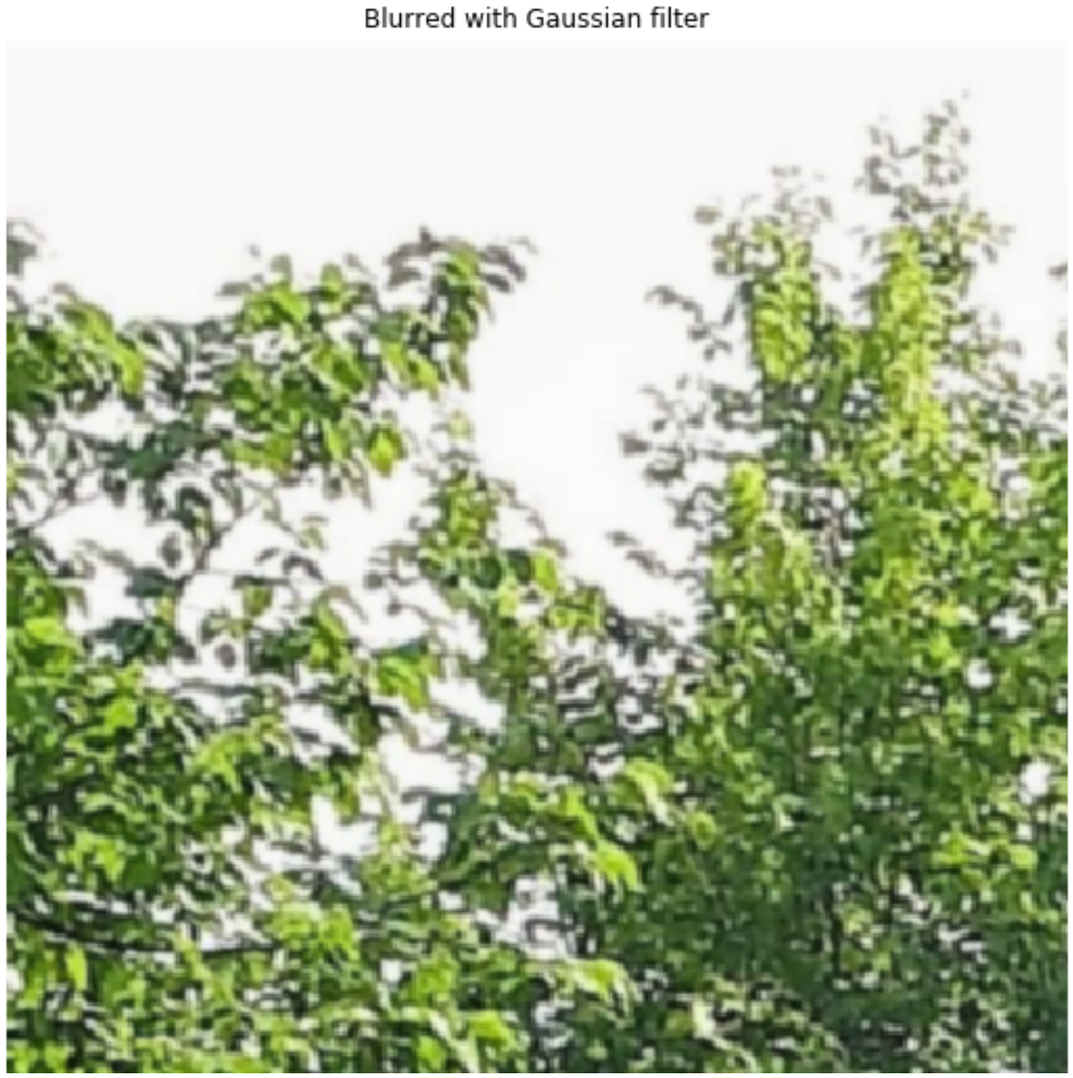
Gaussian smoothing

Original

Blurred with Gaussian filter

Gaussian smoothing





Let's practice!

IMAGE PROCESSING IN PYTHON

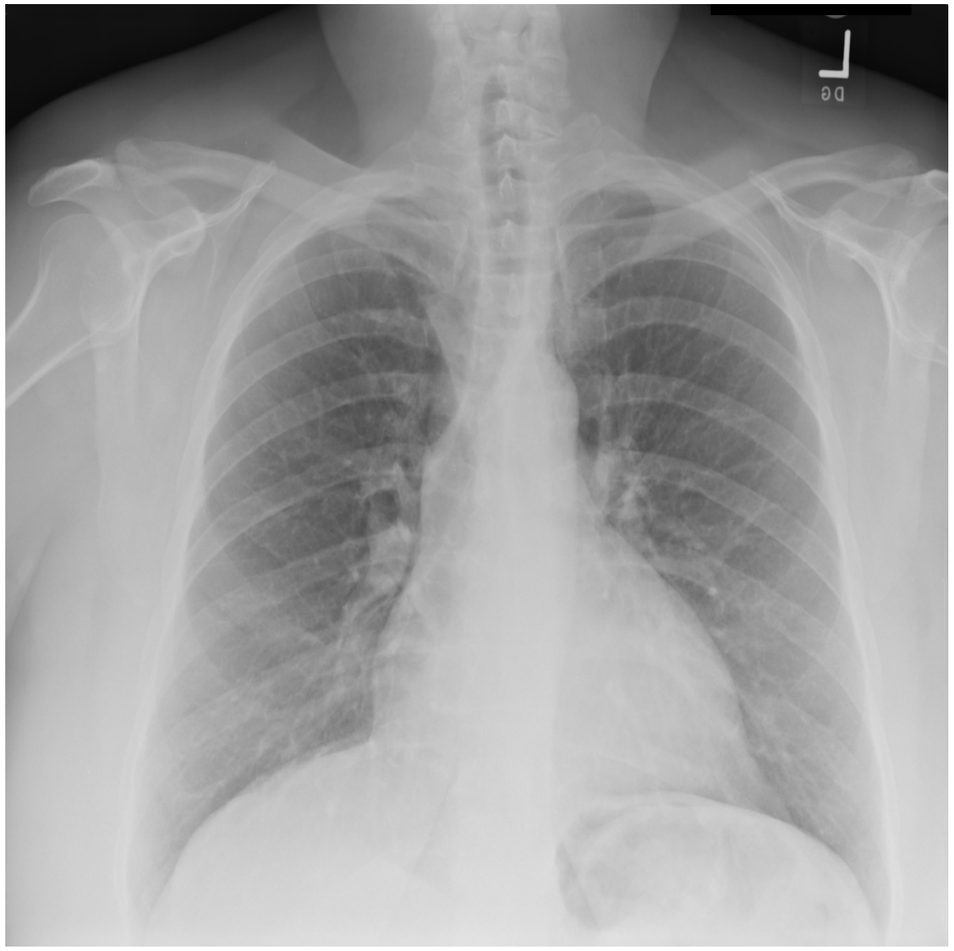
Contrast enhancement

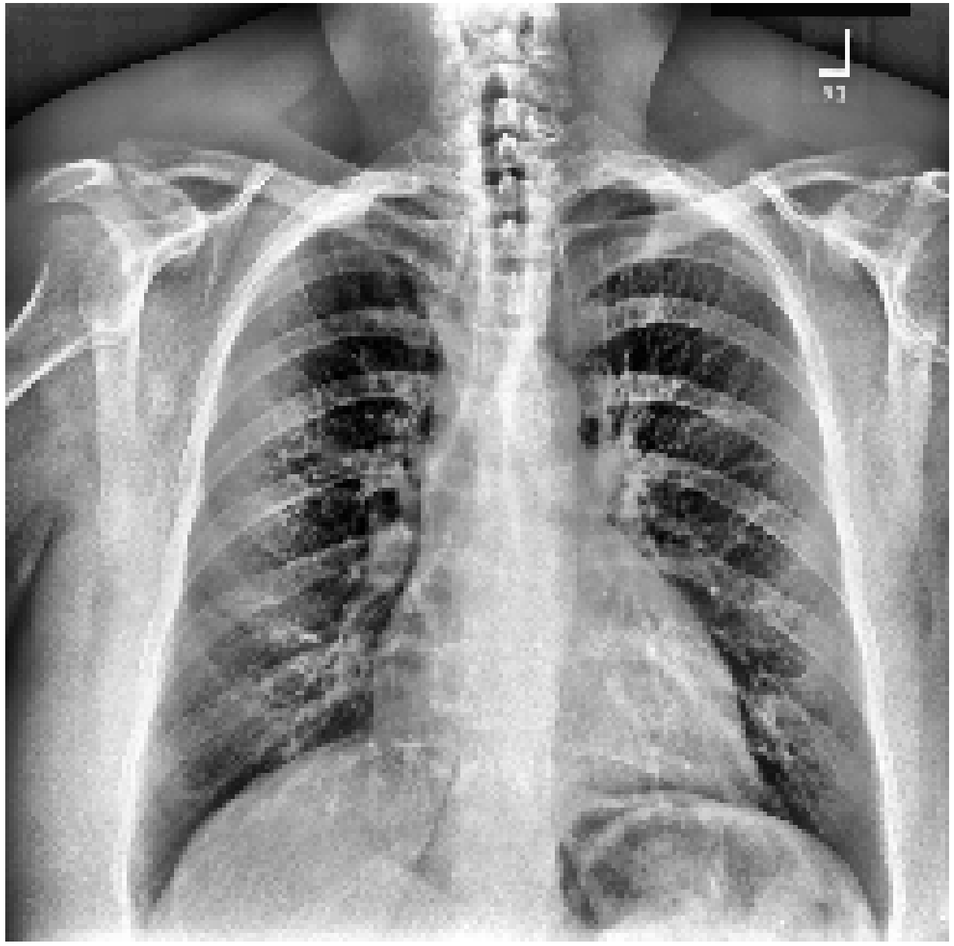
IMAGE PROCESSING IN PYTHON

Rebeca Gonzalez
Data engineer

datacamp

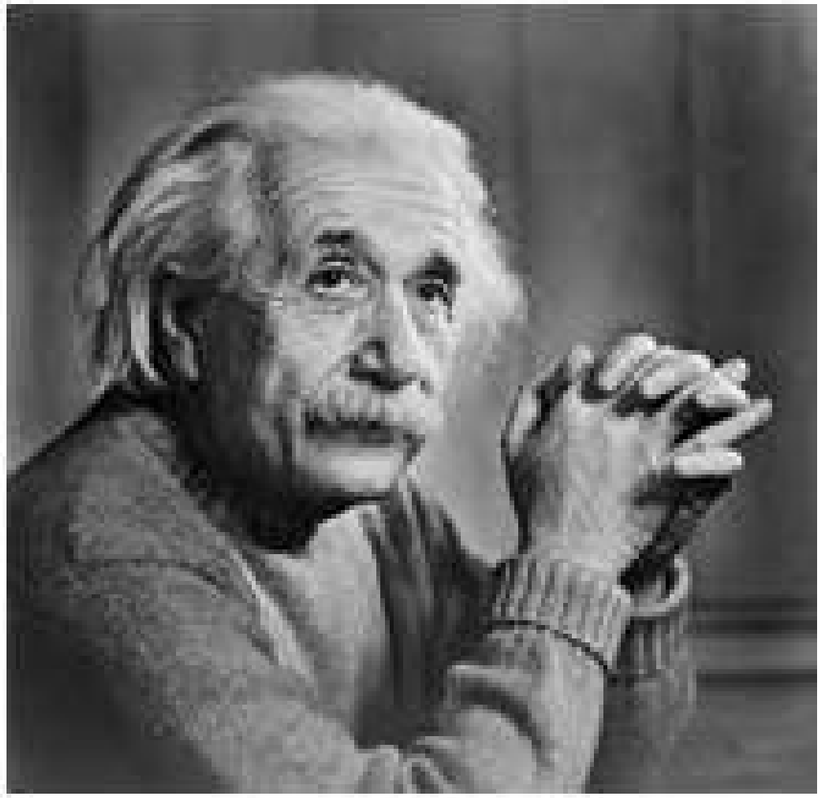
Contrast enhancement

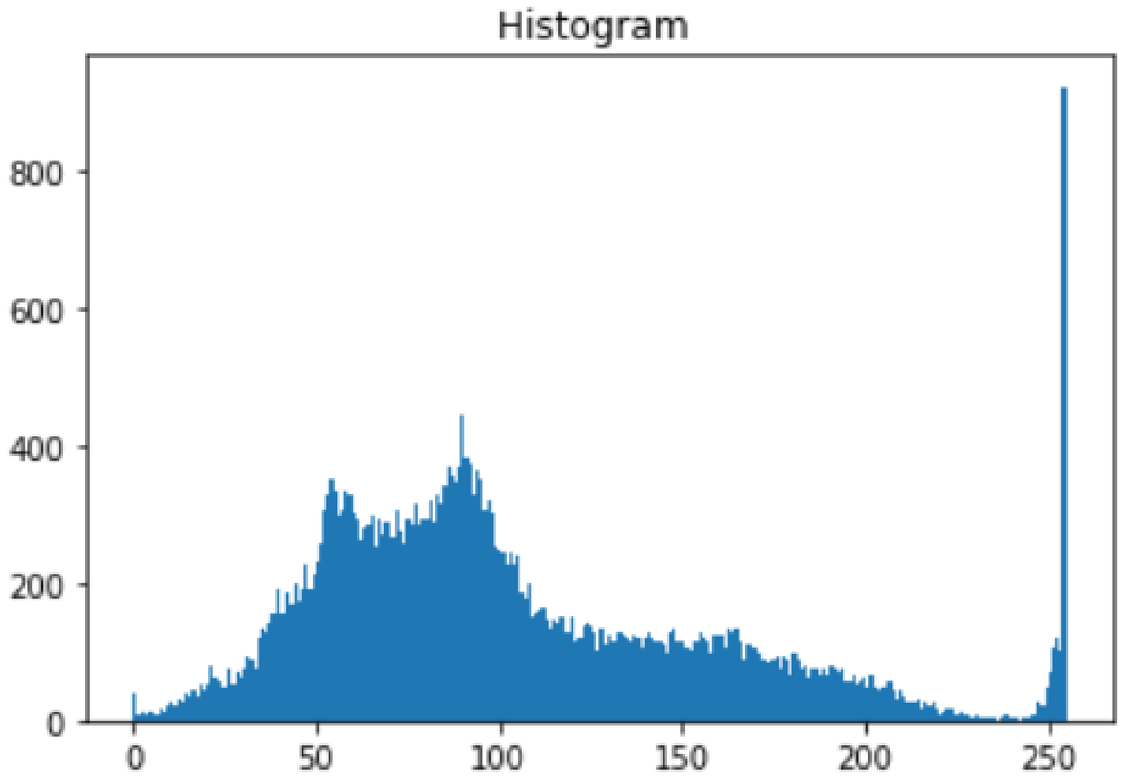




Contrast

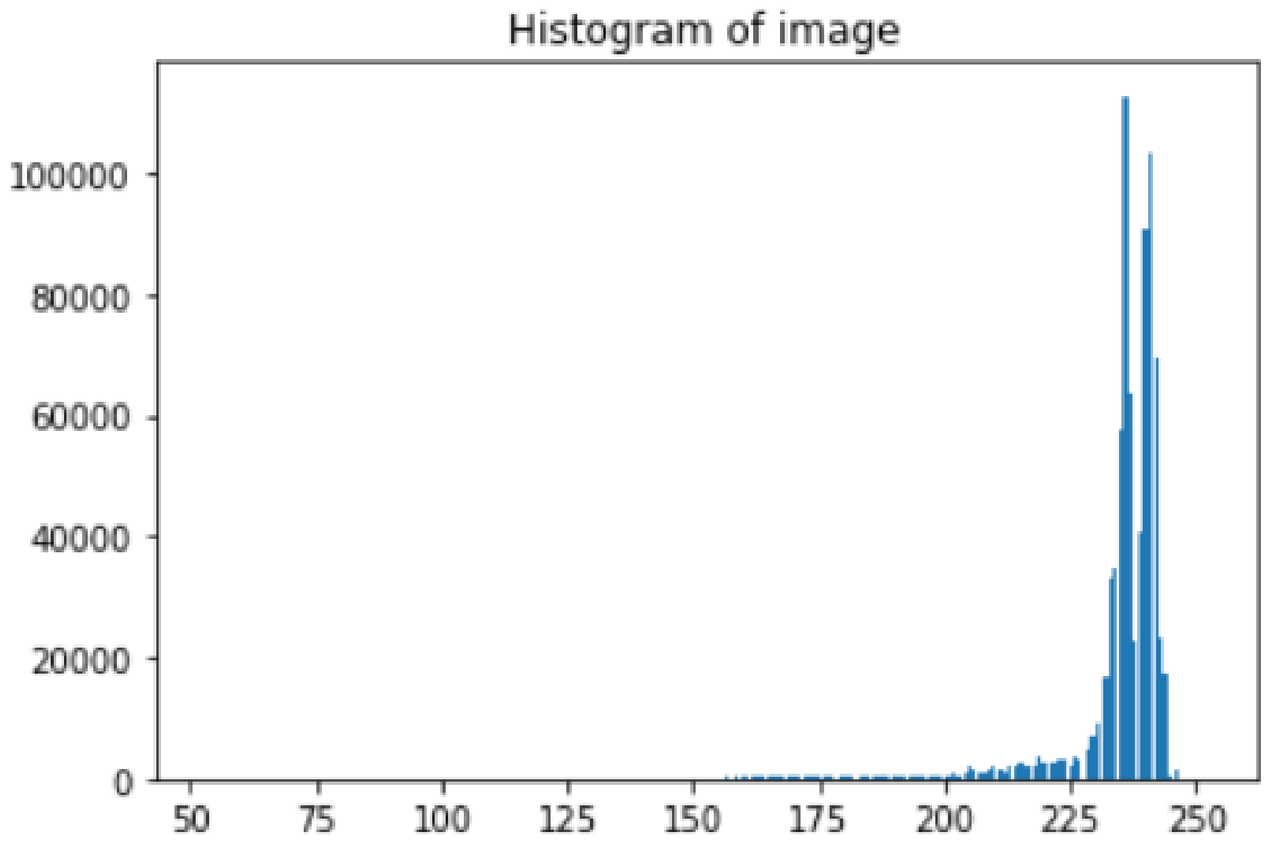
Histograms for contrast enhancement





Contrast


Low contrast image - light

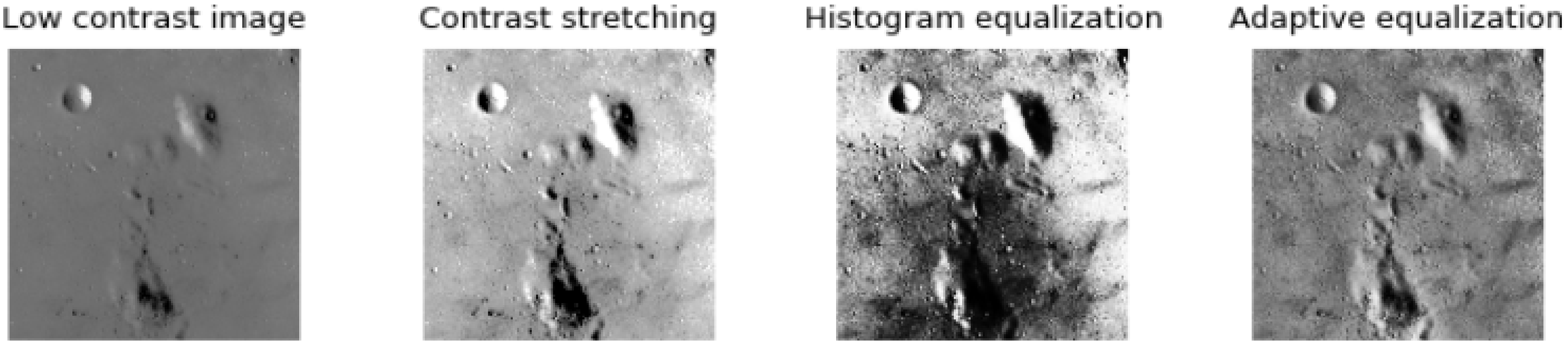

Histogram of image
100000
80000
60000
40000
20000
0
50
75
100
125
150
175
200
225
250

Enhance contrast

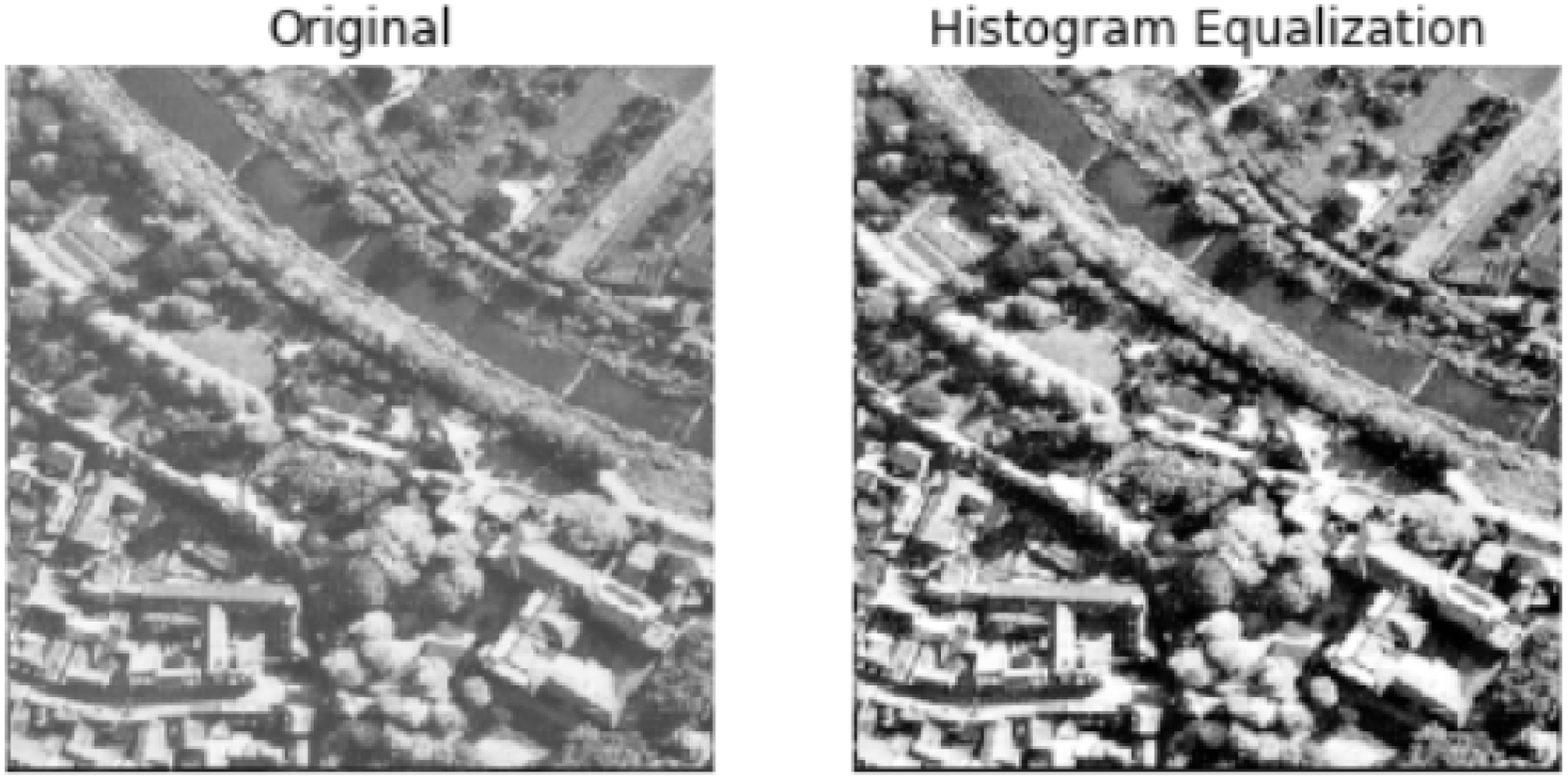
- Contrast stretching
- Histogram equalization

Types

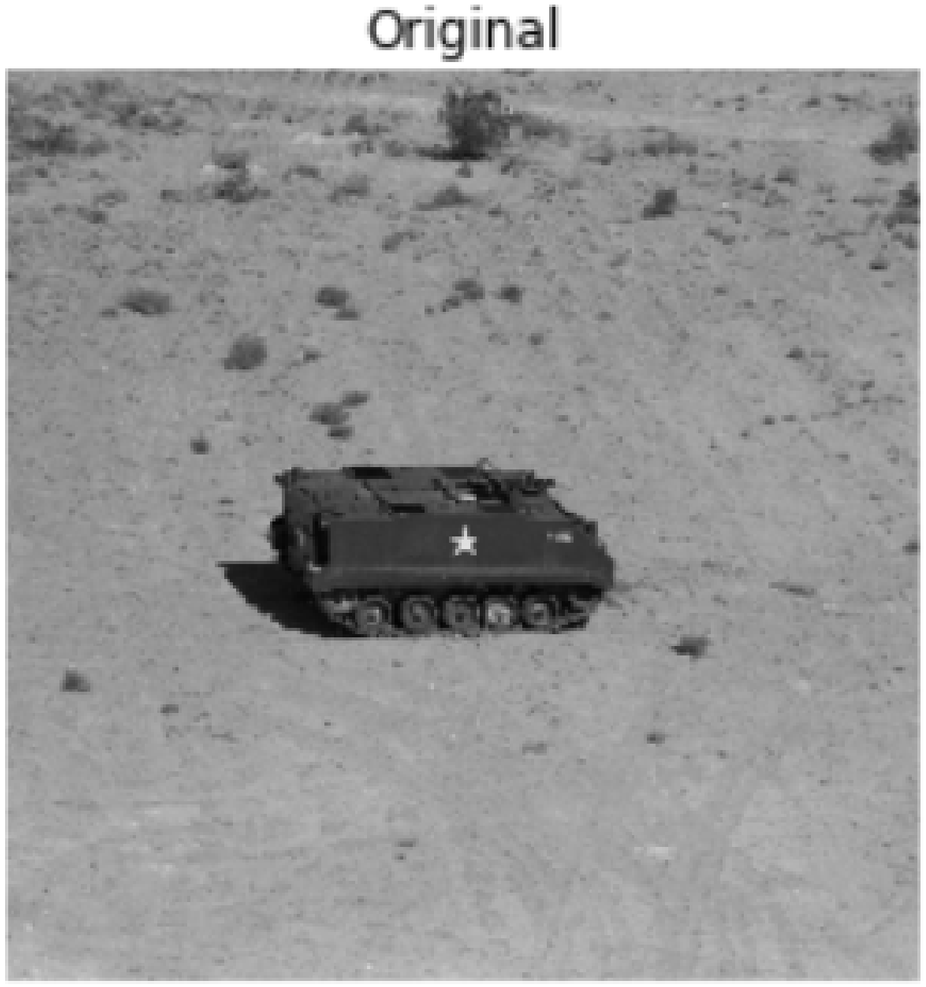
- Histogram equalization
- Adaptive histogram equalization
- Contrast Limited Adaptive Histogram Equalization (CLAHE)



Histogram equalization



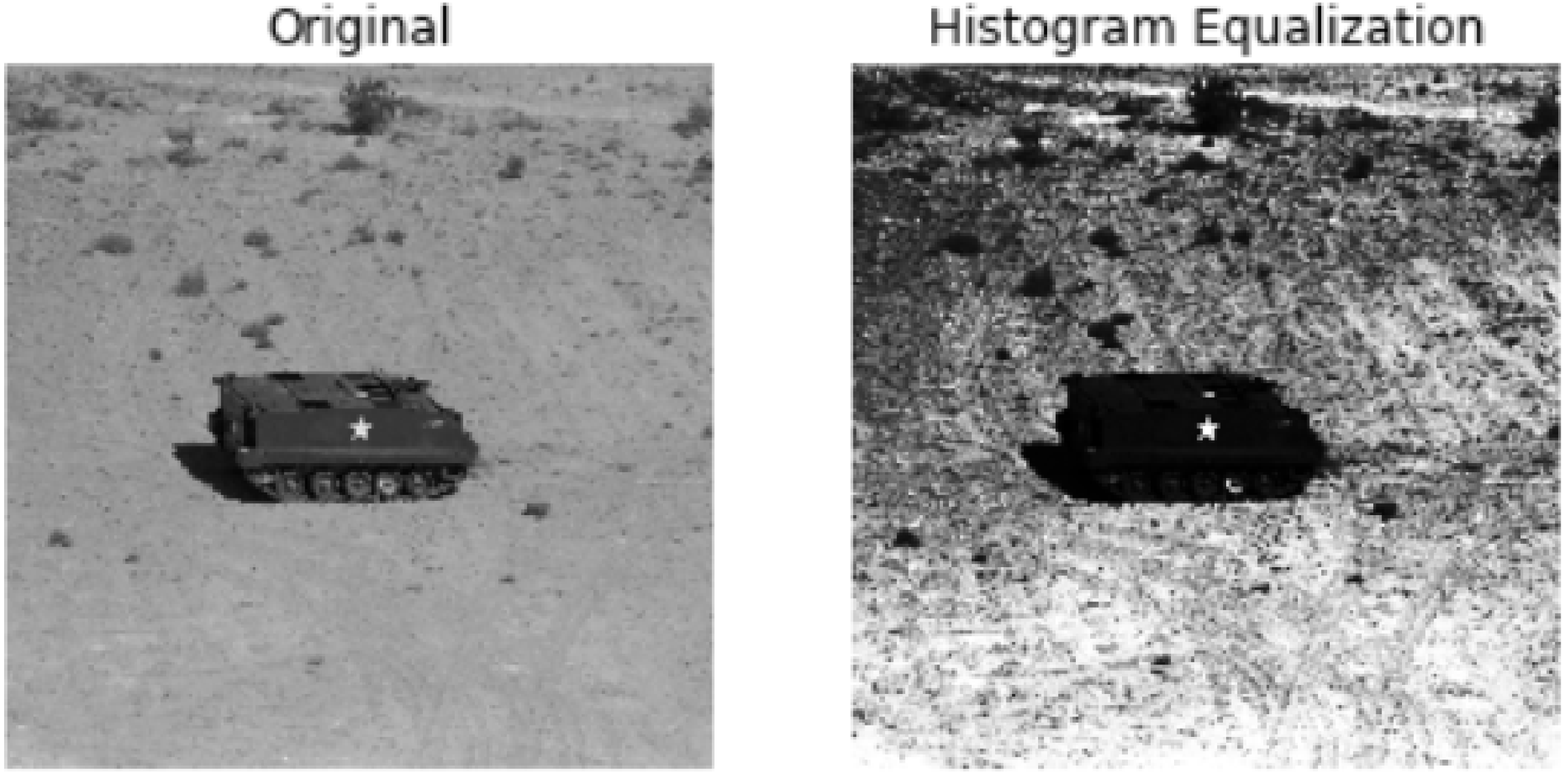
Histogram equalization



Histogram equalization

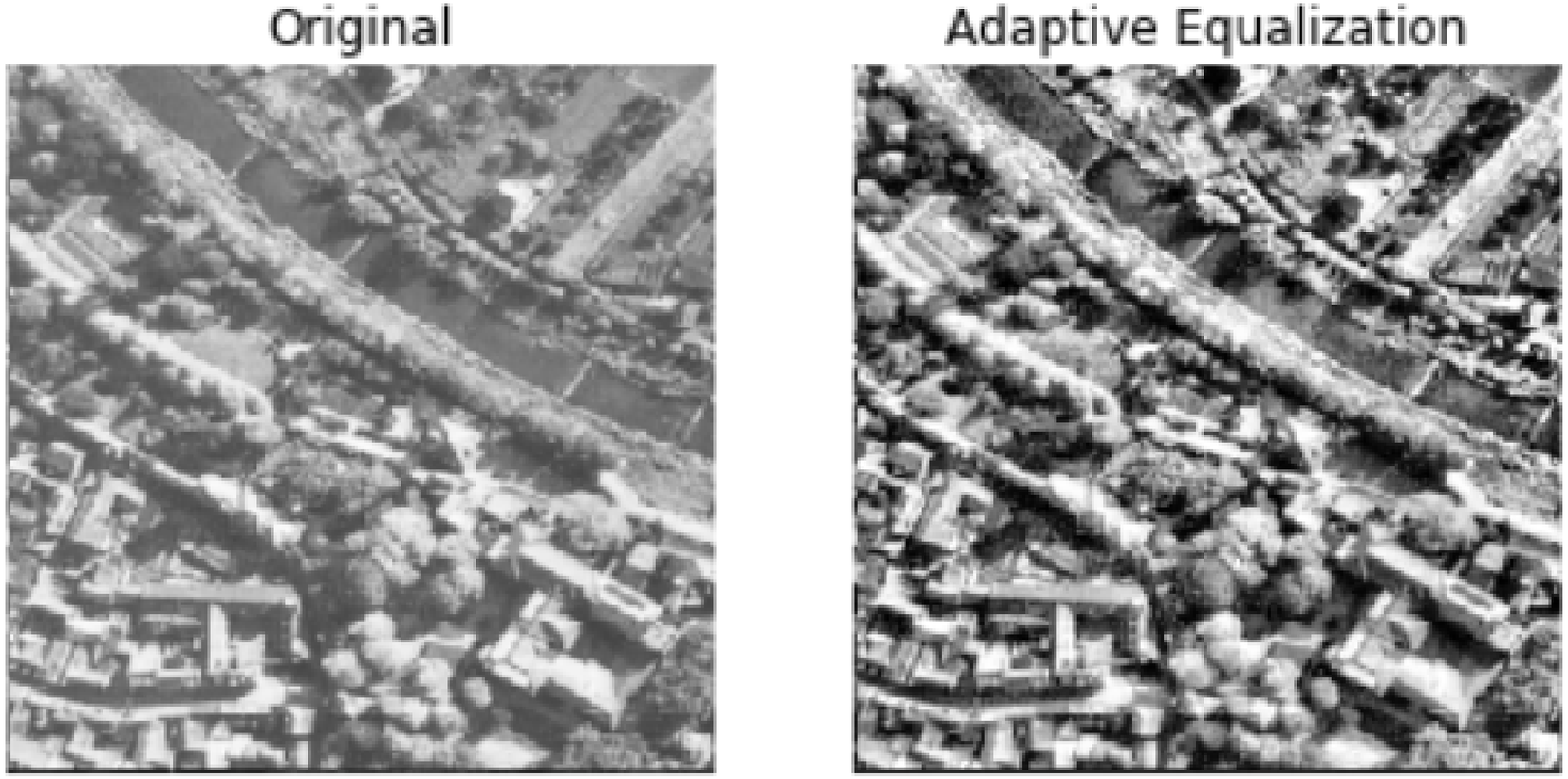
```
from skimage import exposure

# Obtain the equalized image
image_eq = exposure.equalize_hist(image)

# Show original and result
show_image(image, 'Original')
show_image(image_eq, 'Histogram equalized')
```

Histogram equalization



Adaptive Equalization

- Contrastive Limited Adaptive Histogram Equalization



Contrastive Limited Adaptive Equalization

Original

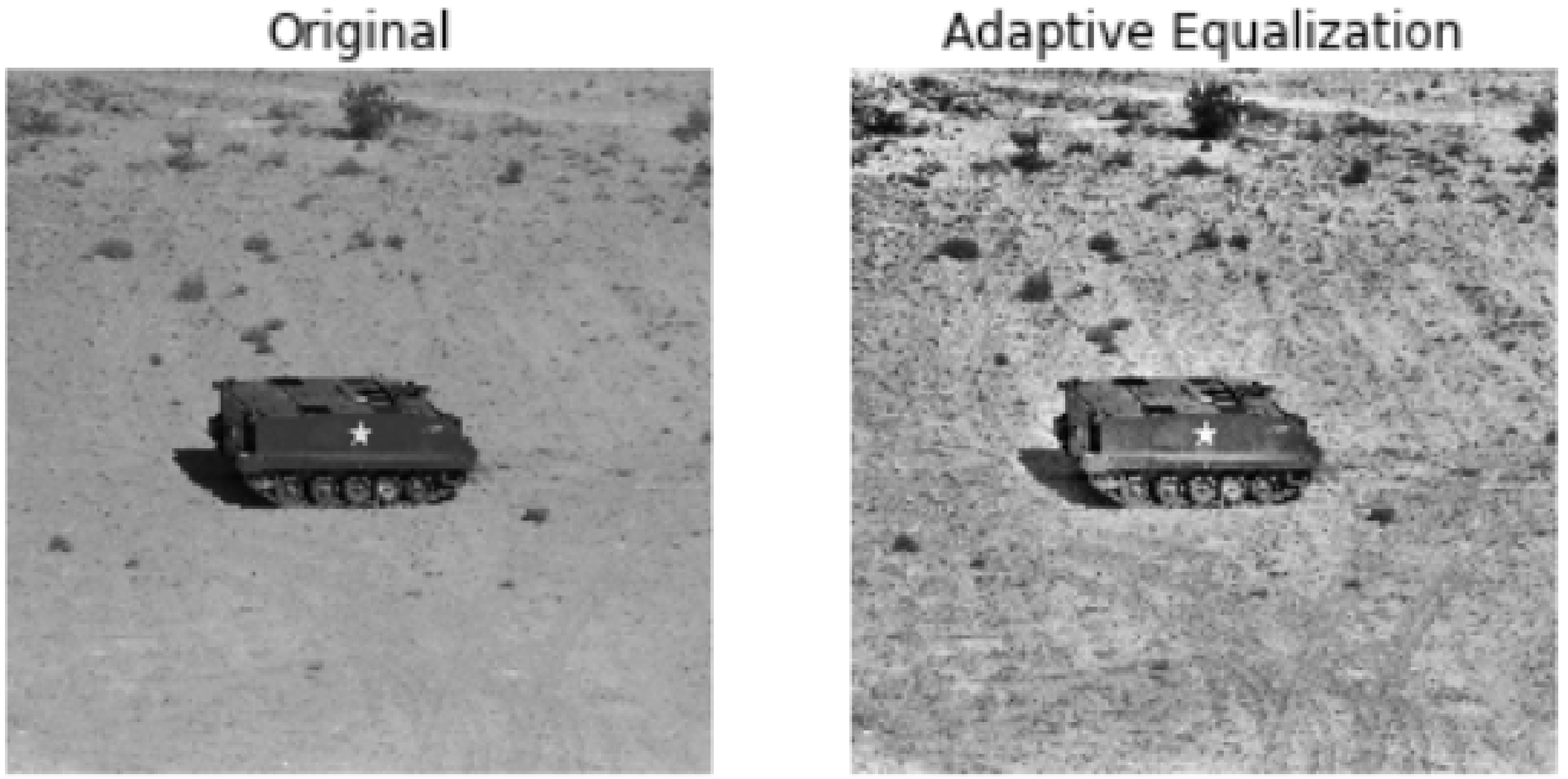
Histogram Equalization

Adaptive Equalization

CLAHE in scikit-image

```
from skimage import exposure

# Apply adaptive Equalization
image_adapteq = exposure.equalize_adapthist(image, clip_limit=0.03)

# Show original and result
show_image(image, 'Original')
show_image(image_adapteq, 'Adaptive equalized')
```

CLAHE in scikit-image



Let's practice!

IMAGE PROCESSING IN PYTHON

Transformations

IMAGE PROCESSING IN PYTHON

Rebeca Gonzalez
Data Engineer

datacamp

Why transform images?

- Preparing images for classification Machine Learning models
- Optimization and compression of images
- Save images with same proportion

Rotating

Original

Rotated 90 degrees clockwise

Rotating

Original

Rotated 90 degrees anticlockwise

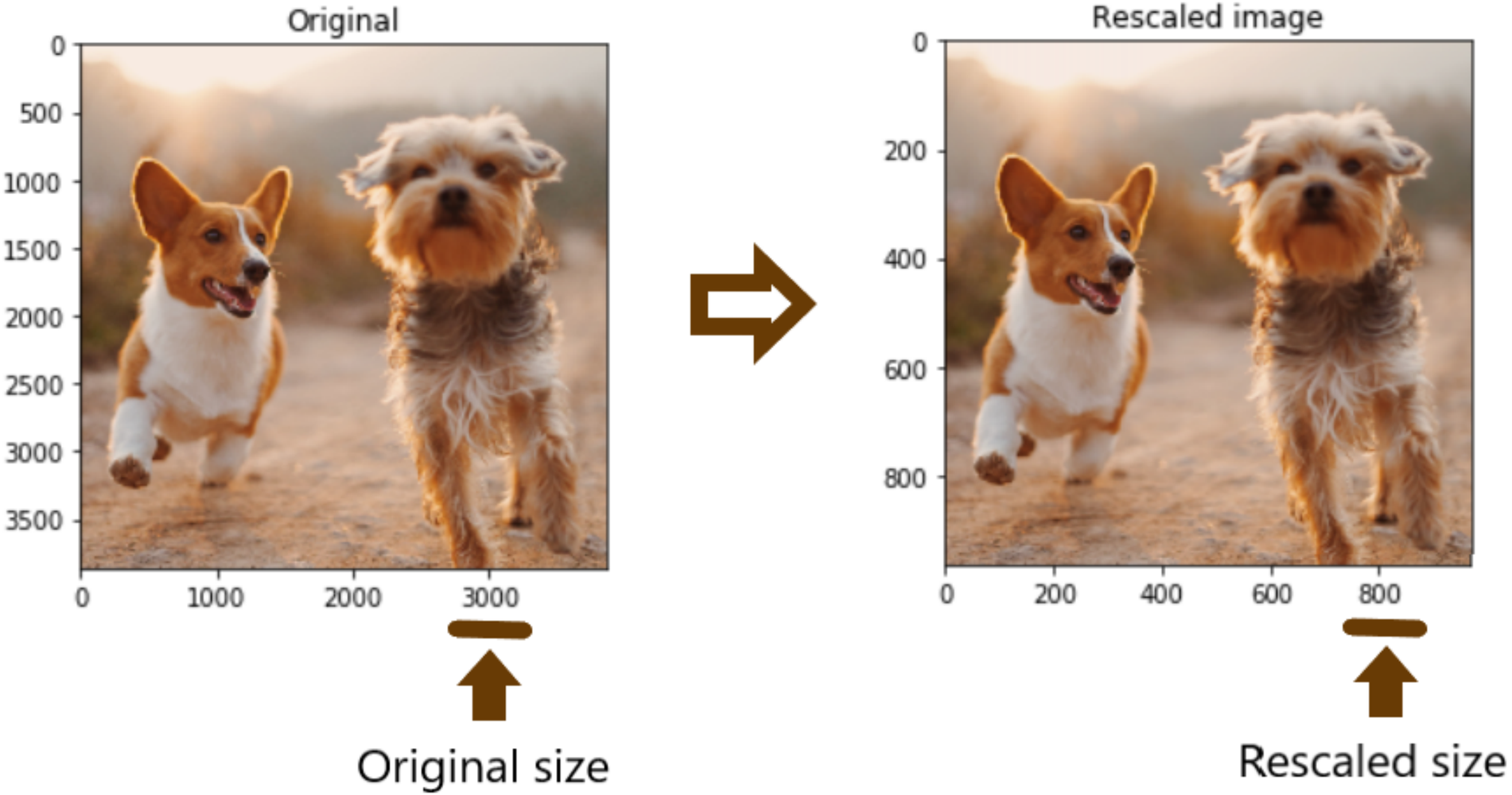
Rotating clockwise

```
from skimage.transform import rotate

# Rotate the image 90 degrees clockwise
image_rotated = rotate(image, -90)

show_image(image_rotated, 'Original')
show_image(image_rotated, 'Rotated 90 degrees clockwise')
```

Rotating anticlockwise

```
from skimage.transform import rotate

# Rotate an image 90 degrees anticlockwise
image_rotated = rotate(image, 90)

show_image(image, 'Original')
show_image(image_rotated, 'Rotated 90 degrees anticlockwise')
```

Rescaling

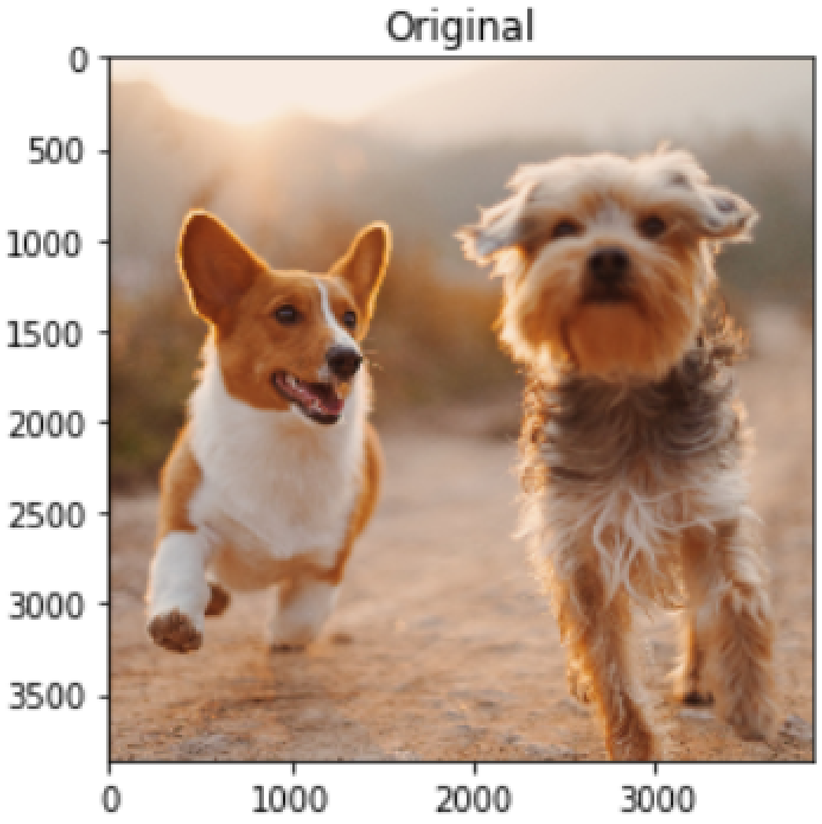

Original
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000
Original size
Rescaled image
0
200
400
600
800
0
200
400
600
800
Rescaled size

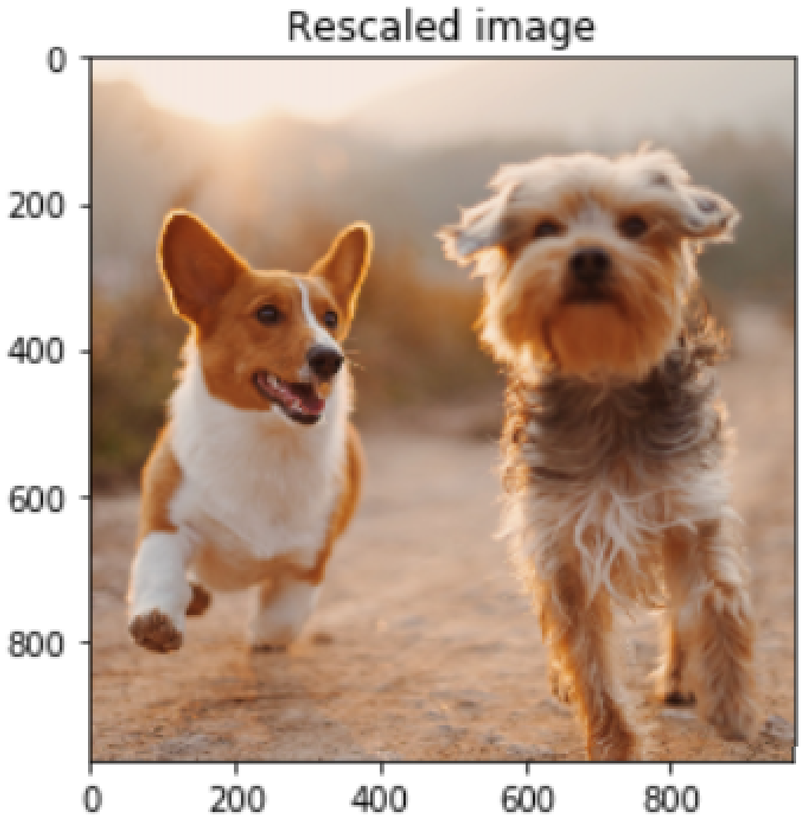
Rescaling

Downgrading

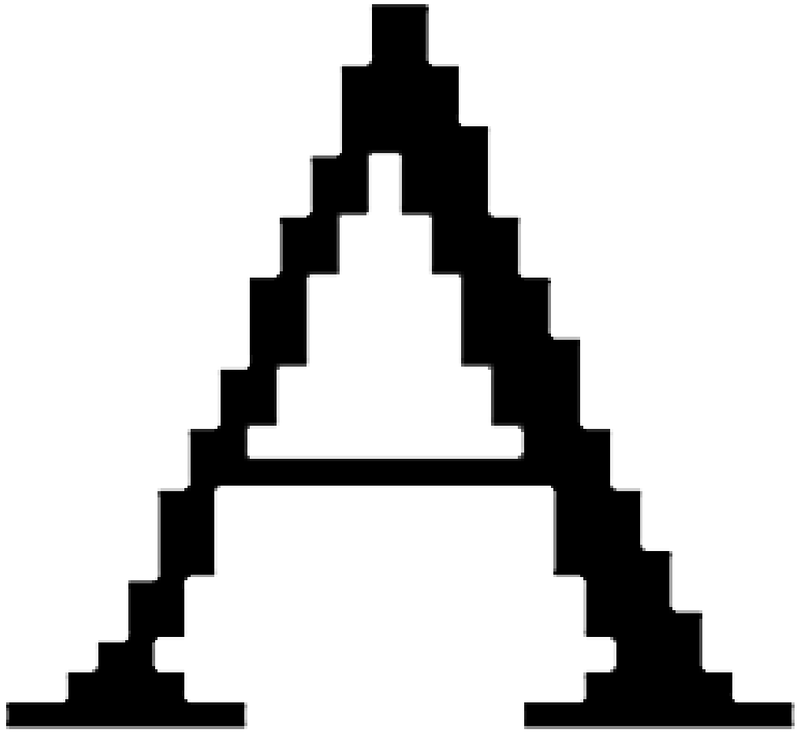
```
from skimage.transform import rescale

# Rescale the image to be 4 times smaller
image_rescaled = rescale(image, 1/4, anti_aliasing=True, multichannel=True)

show_image(image, 'Original image')
show_image(image_rescaled, 'Rescaled image')
```

Rescaling

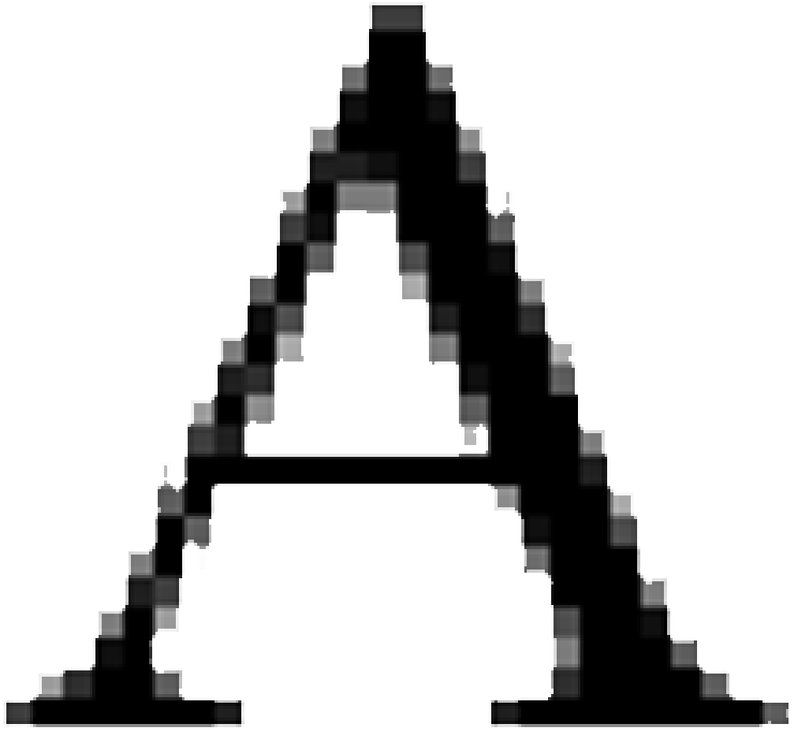

Original
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000


Rescaled image
0
200
400
600
800
0
200
400
600
800

Aliasing in digital images

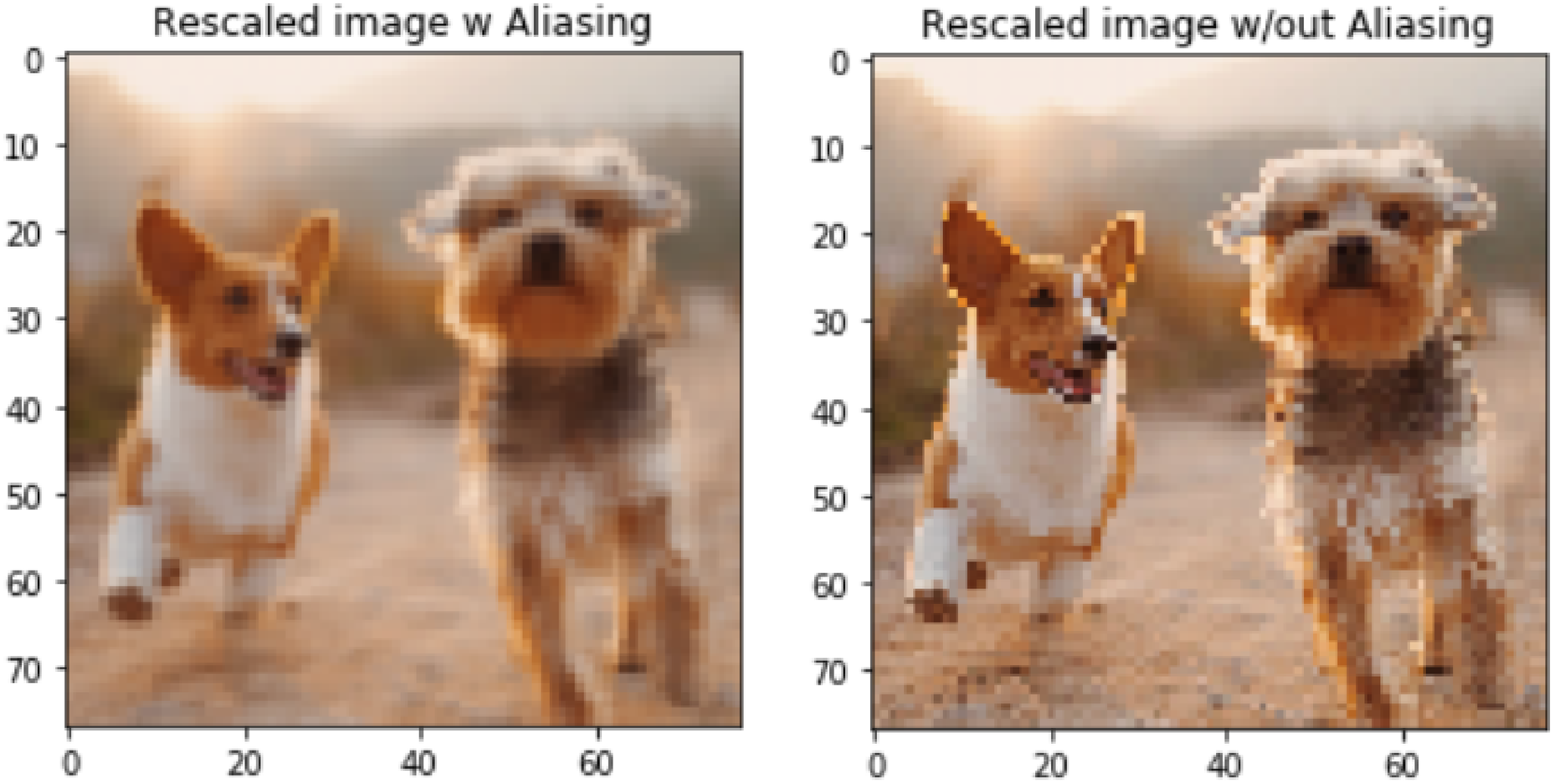


Original letter A

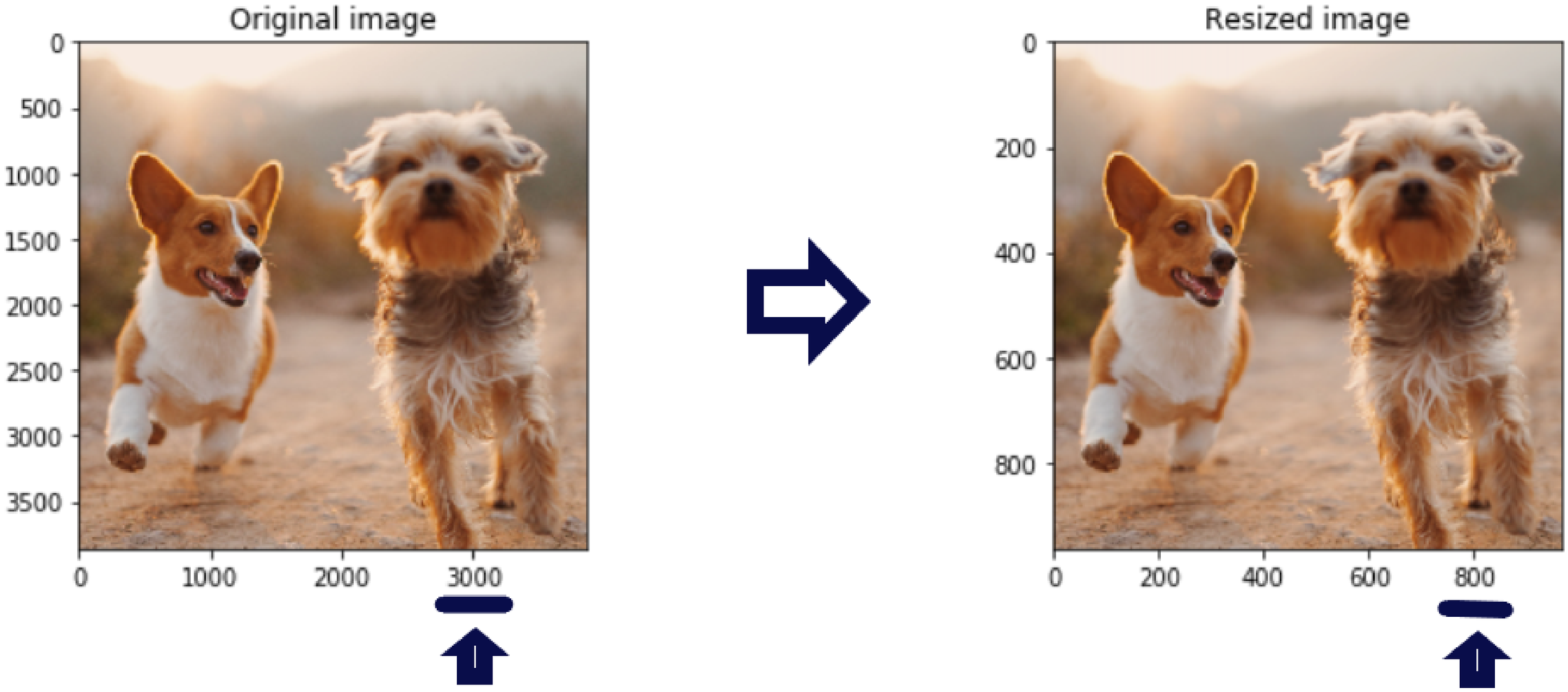


Aliased letter A

Aliasing in digital images



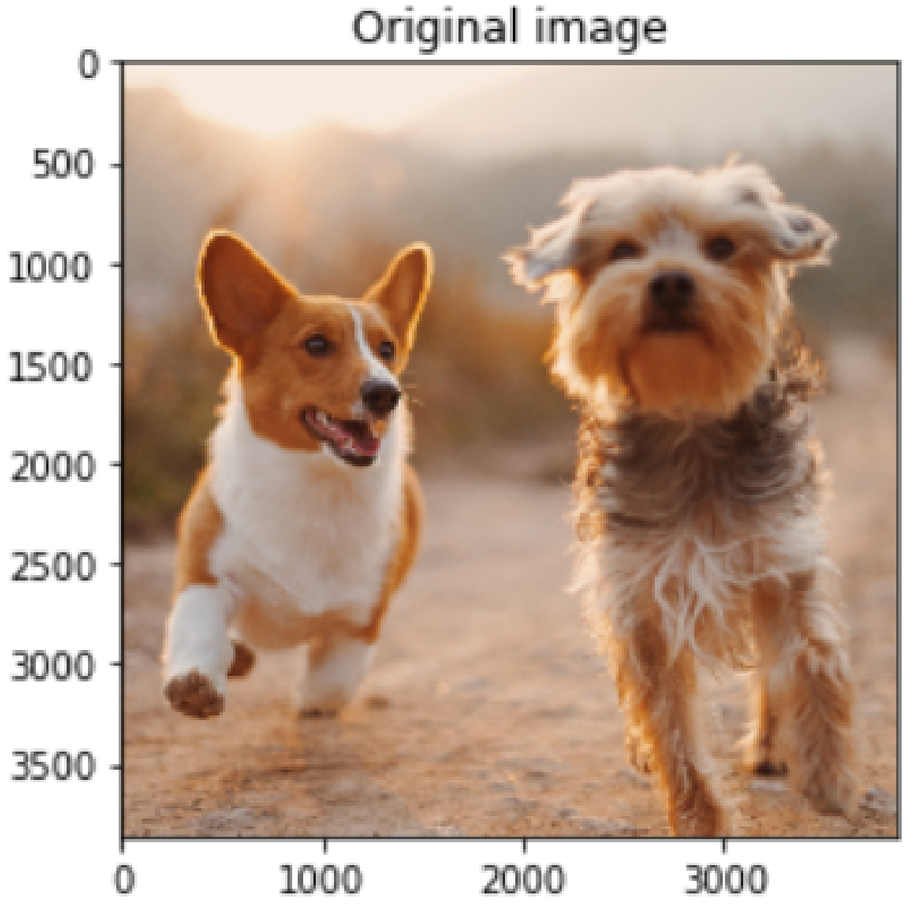
Resizing

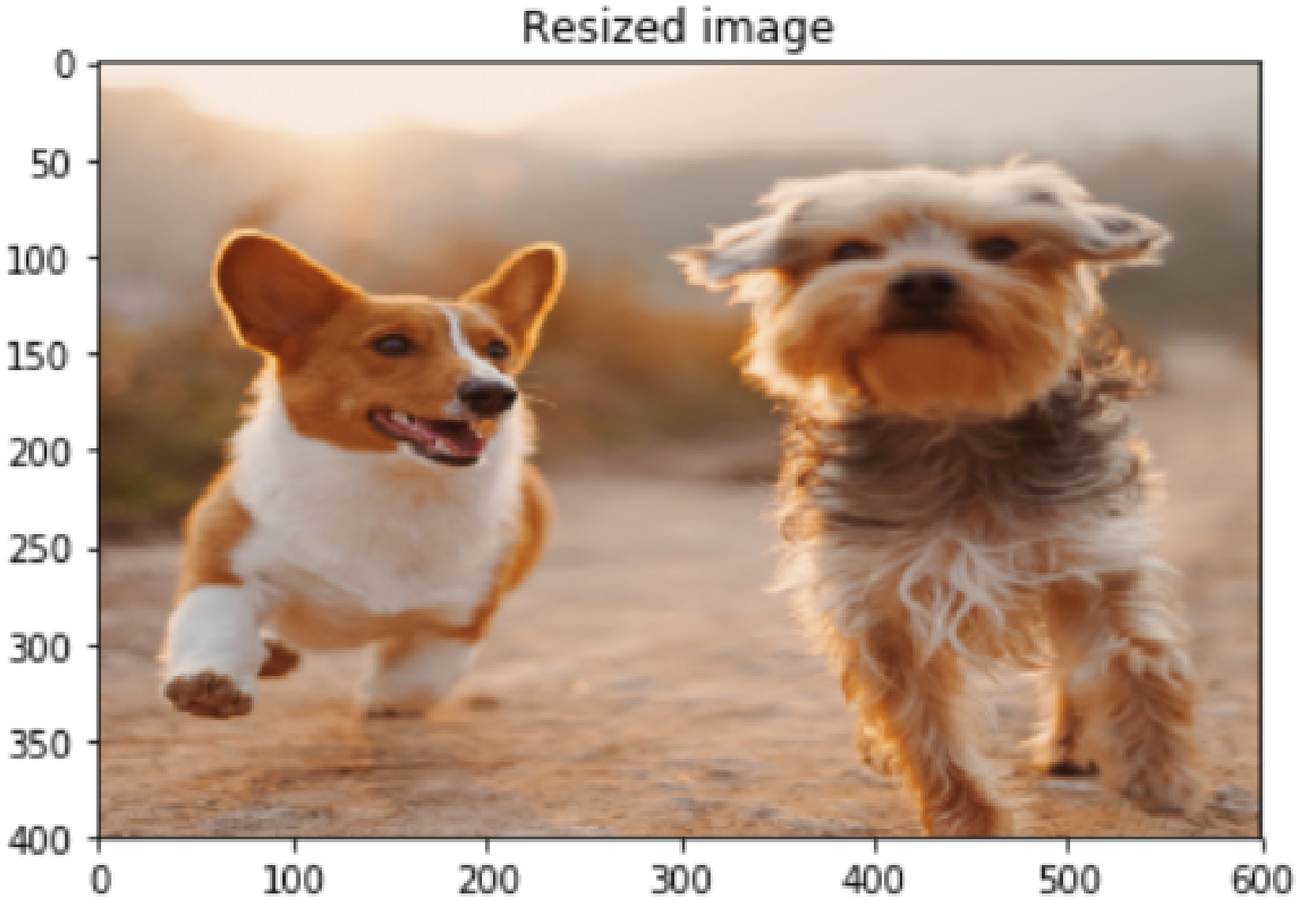

Original image
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000
Resized image
0
200
400
600
800
0
200
400
600
800

Resizing

```
from skimage.transform import resize

# Height and width to resize
height = 400
width = 500

# Resize image
image_resized = resize(image, (height, width), anti_aliasing=True)

# Show the original and resulting images
show_image(image, 'Original image')
show_image(image_resized, 'Resized image')
```

Resizing

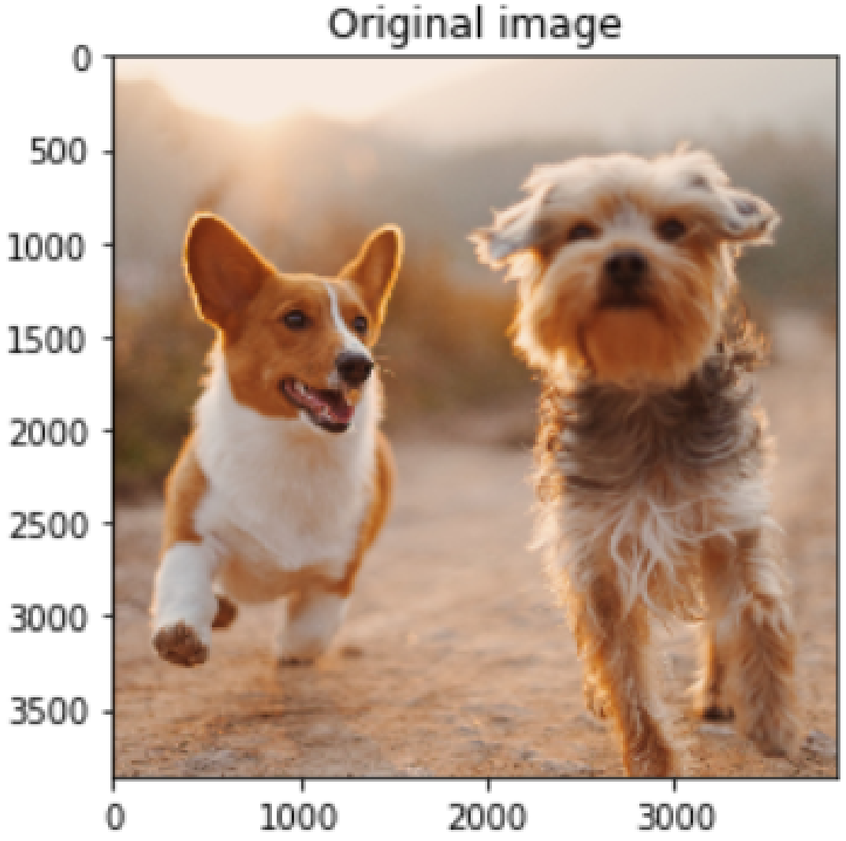

Original image
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000

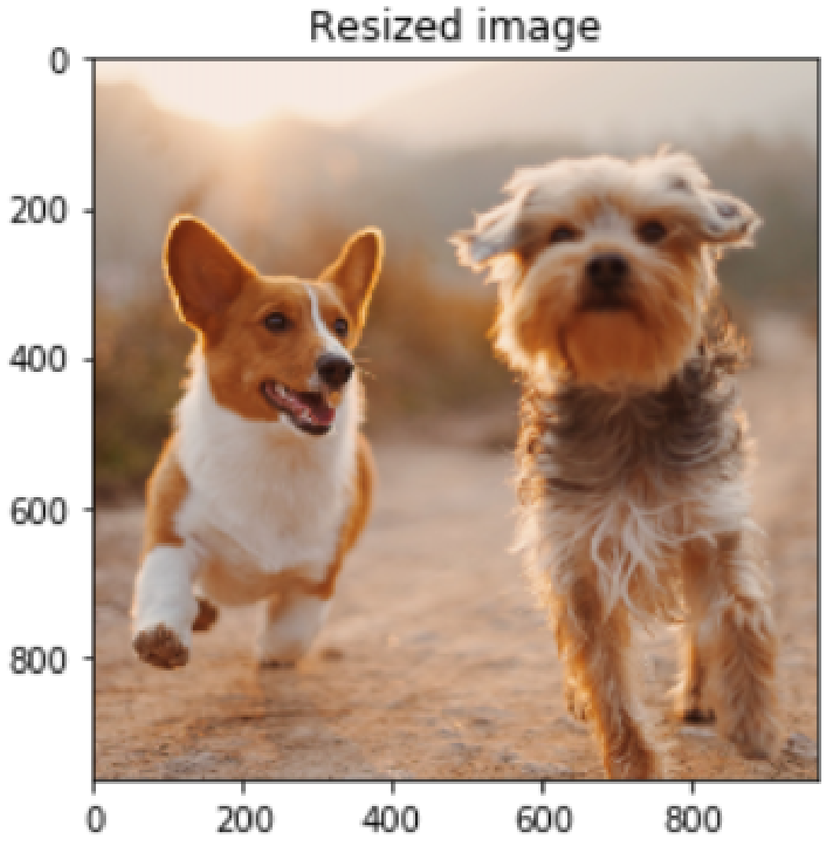

Resized image
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
600

Resizing proportionally

```
from skimage.transform import resize

# Set proportional height so its 4 times its size
height = image.shape[0] / 4
width = image.shape[1] / 4

# Resize image
image_resized = resize(image, (height, width), anti_aliasing=True)

show_image(image_resized, 'Resized image')
```

Resizing proportionally





Let's practice!

IMAGE PROCESSING IN PYTHON

Morphology

IMAGE PROCESSING IN PYTHON

Rebeca Gonzalez
Data Engineer

datacamp

Binary images

original

Thresholded image

Morphological filtering

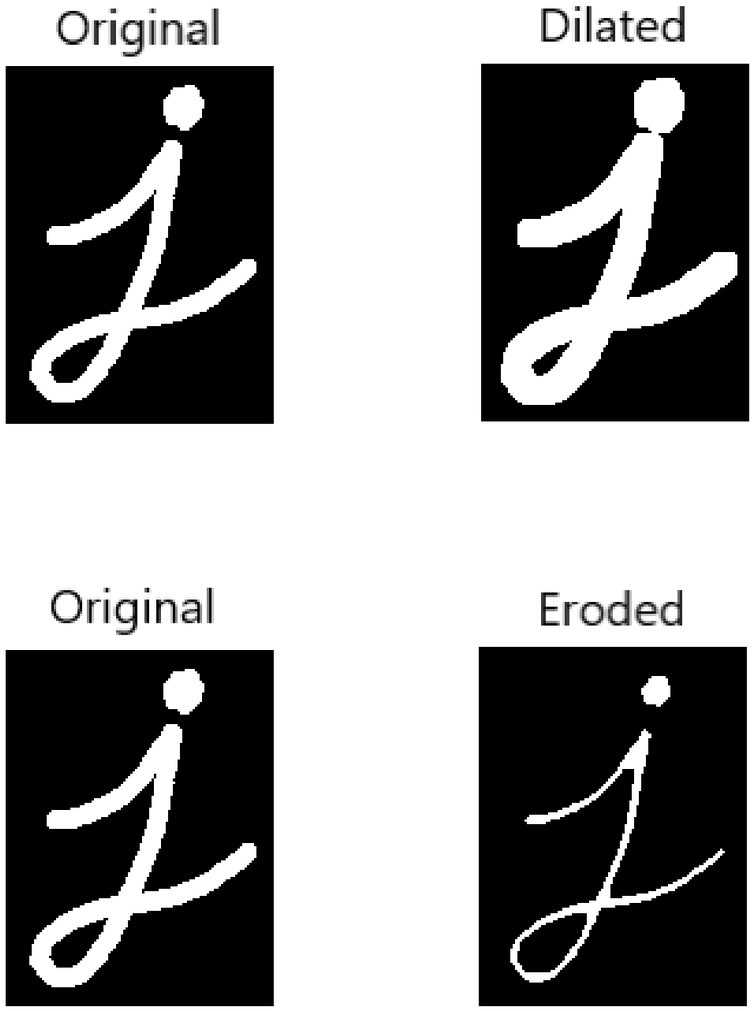
- Better for binary images
- Can extend for grayscale

Binary image

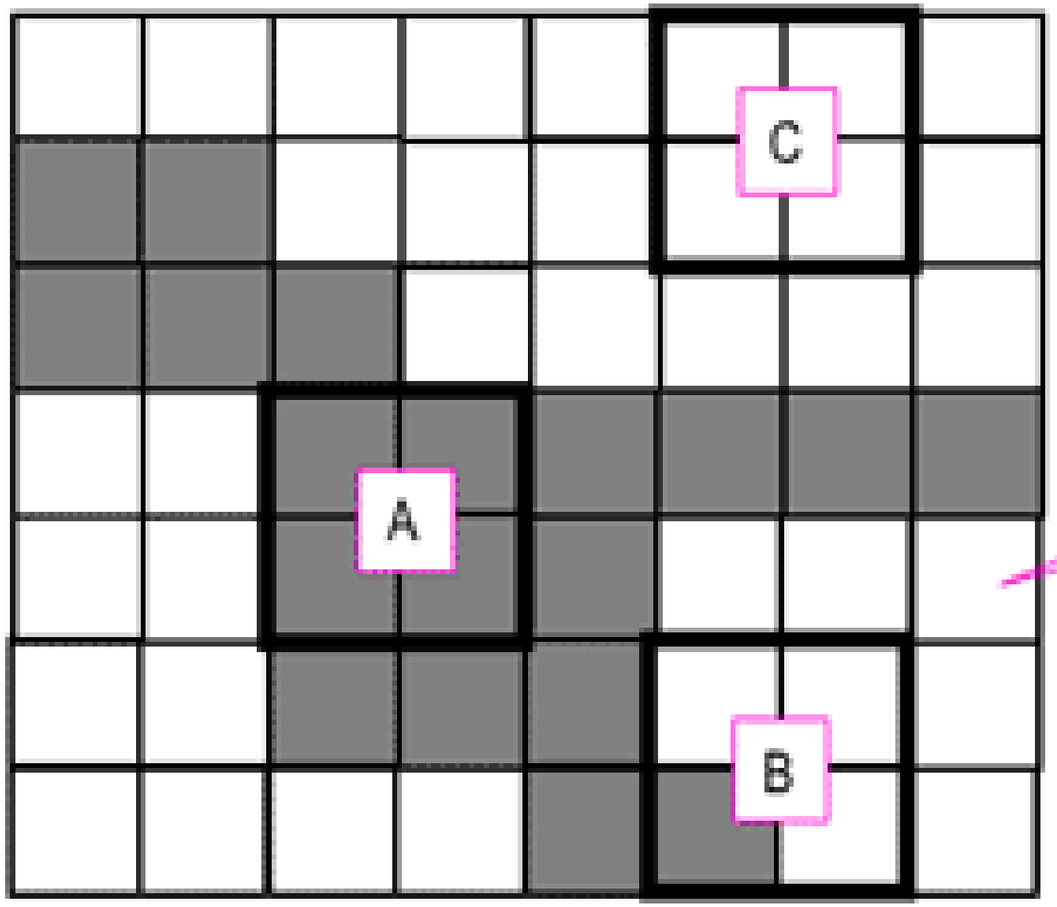
Grayscale

Morphological operations

- Dilation
- Erosion

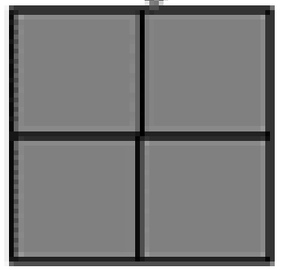


Structuring element

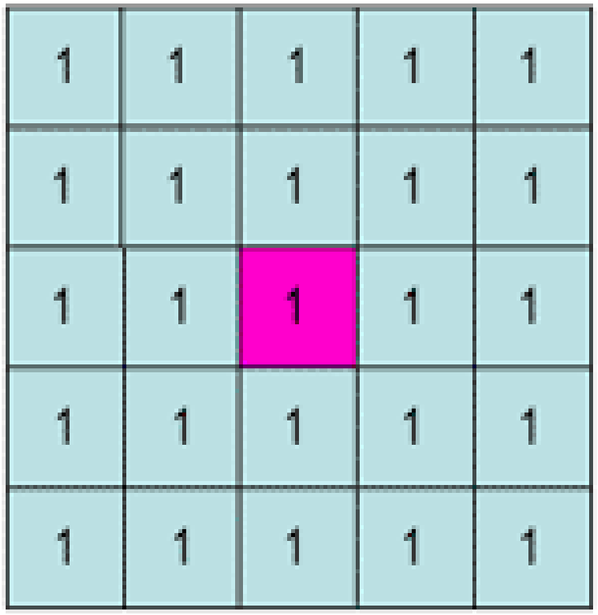


A - the structuring element fits the image
B - the structuring element hits (intersects) the image
C - the structuring element neither fits, nor hits the image

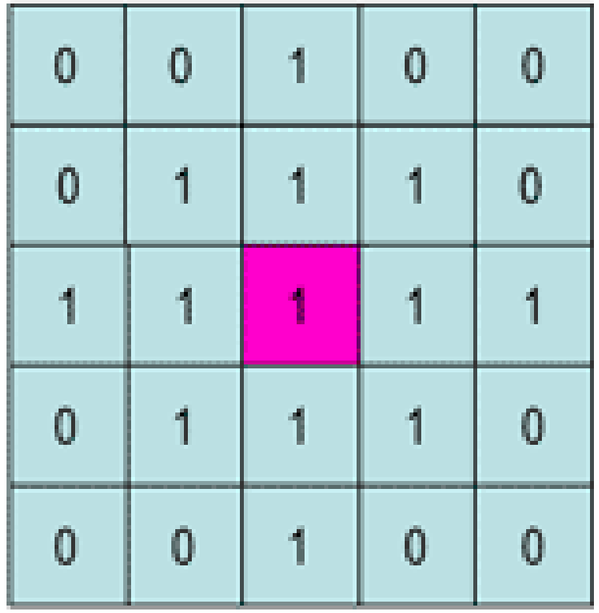
Structuring element



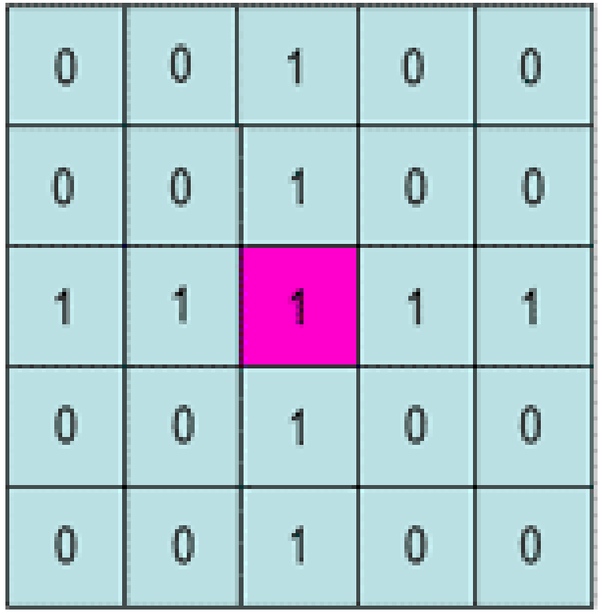
Structuring element



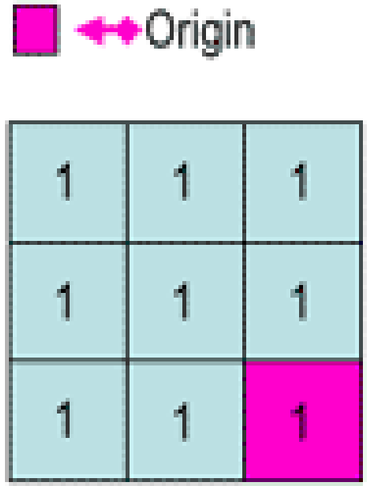
Square 5x5 element



Diamond-shaped 5x5 element



Cross-shaped 5x5 element



Square 3x3 element

Shapes in scikit-image

```
from skimage import morphology


square = morphology.square(4)
```

```
[[1 1 1 1]
 [1 1 1 1]
 [1 1 1 1]
 [1 1 1 1]]
```

```
rectangle = morphology.rectangle(4, 2)
```

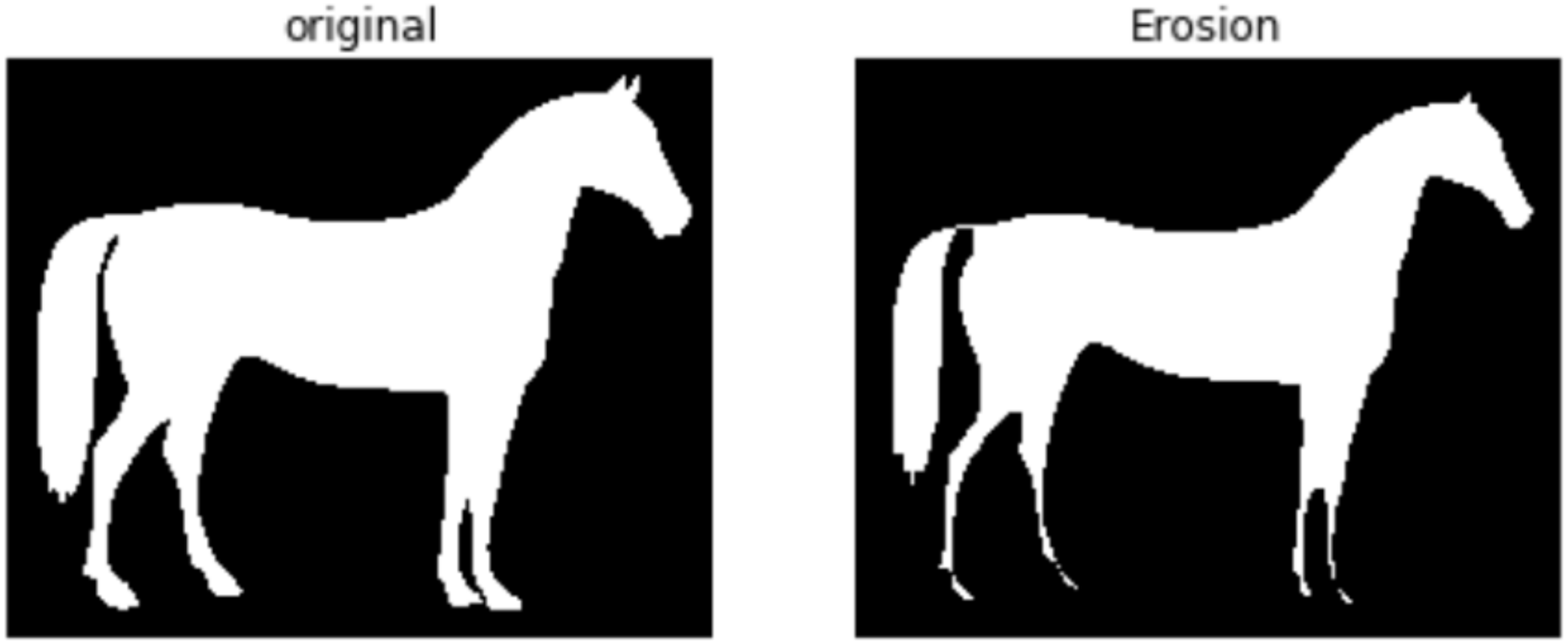
```
[[1 1]
 [1 1]
 [1 1]
 [1 1]]
```

Erosion in scikit-image

```
from skimage import morphology

# Set structuring element to the rectangular-shaped
selem = rectangle(12,6)

# Obtain the erosed image with binary erosion
eroded_image = morphology.binary_erosion(image_horse, selem=selem)
```

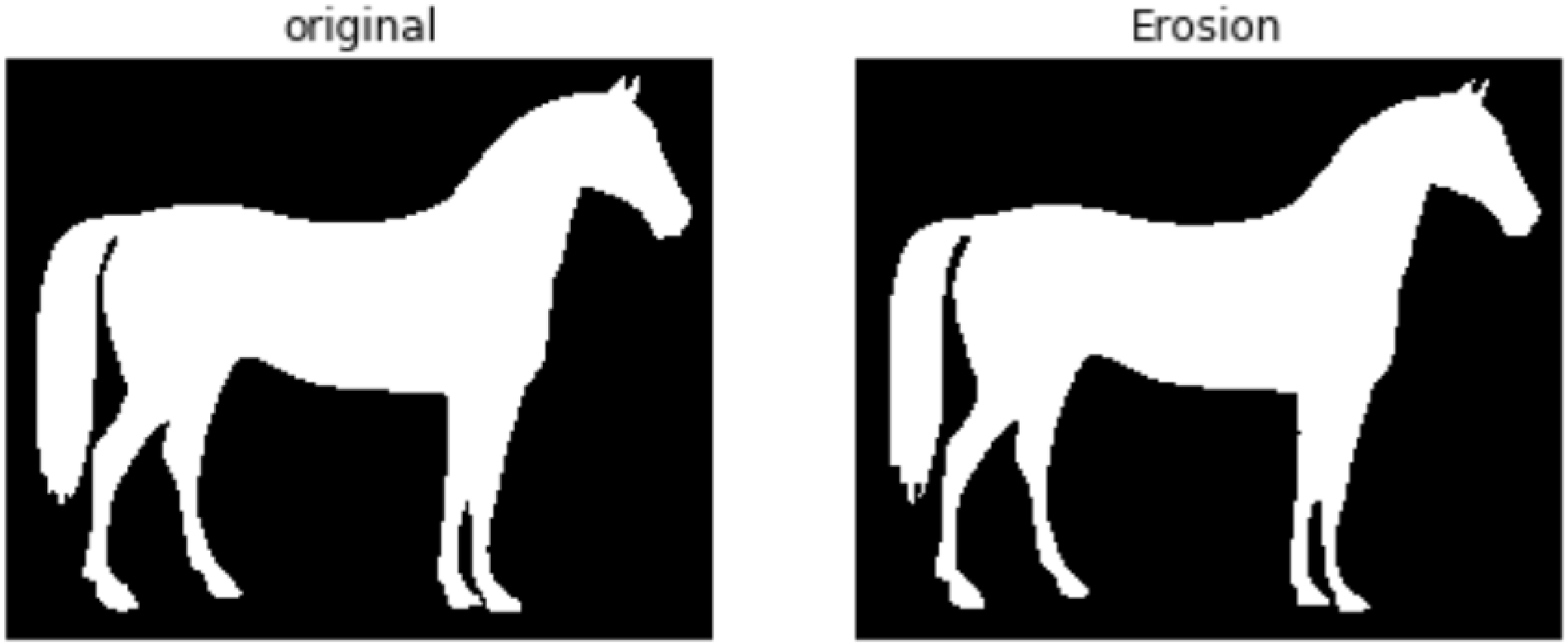
Erosion in scikit-image

```
# Show result
plot_comparison(image_horse, eroded_image, 'Erosion')
```



Binary erosion with default selem

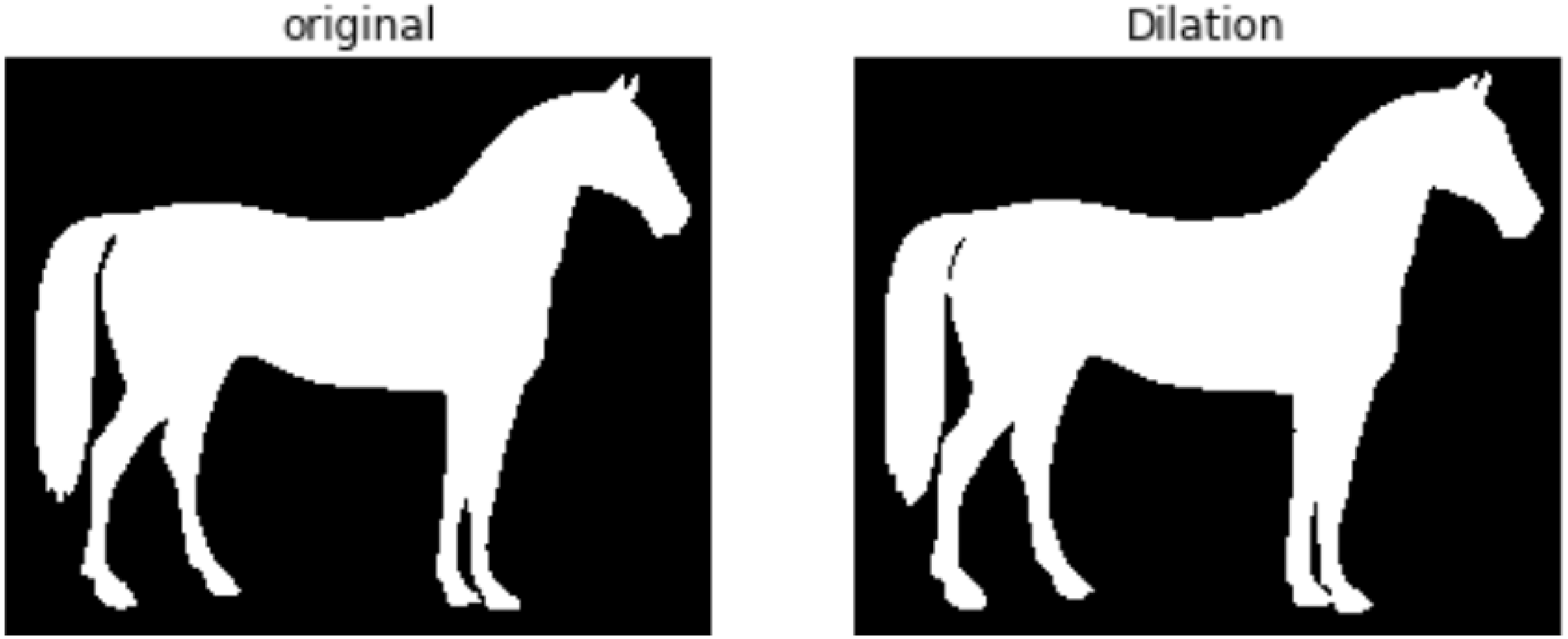
```
# Binary erosion with default selem
eroded_image = morphology.binary_erosion(image_horse)
```



Dilation in scikit-image

```
from skimage import morphology

# Obtain dilated image, using binary dilation
dilated_image = morphology.binary_dilation(image_horse)

# See results
plot_comparison(image_horse, dilated_image, 'Erosion')
```

Dilation in scikit-image



Let's practice!

IMAGE PROCESSING IN PYTHON

Image restoration

IMAGE PROCESSING IN PYTHON

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Data Engineer

datacamp

Restore an image

Image to restore

Image restored

Image reconstruction

- Fixing damaged images
- Text removing
- Logo removing
- Object removing

Image reconstruction

Inpainting

- Reconstructing lost parts of images
- Looking at the non-damaged regions

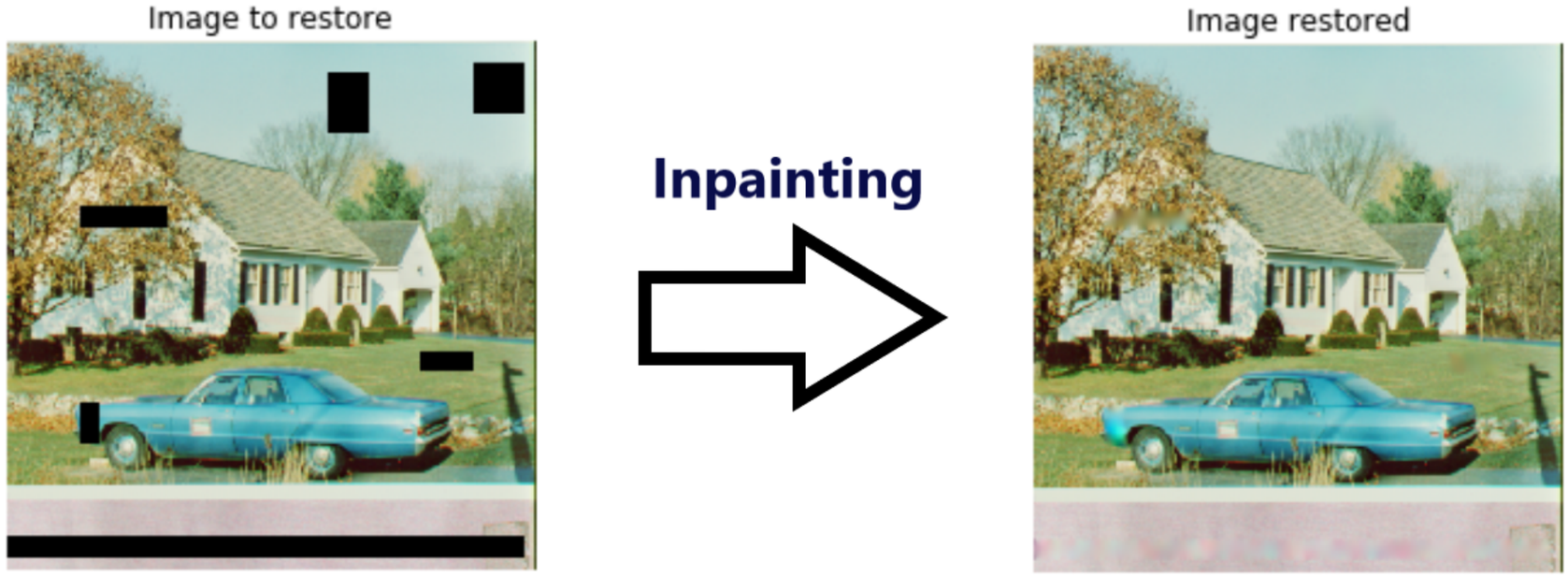


Image reconstruction

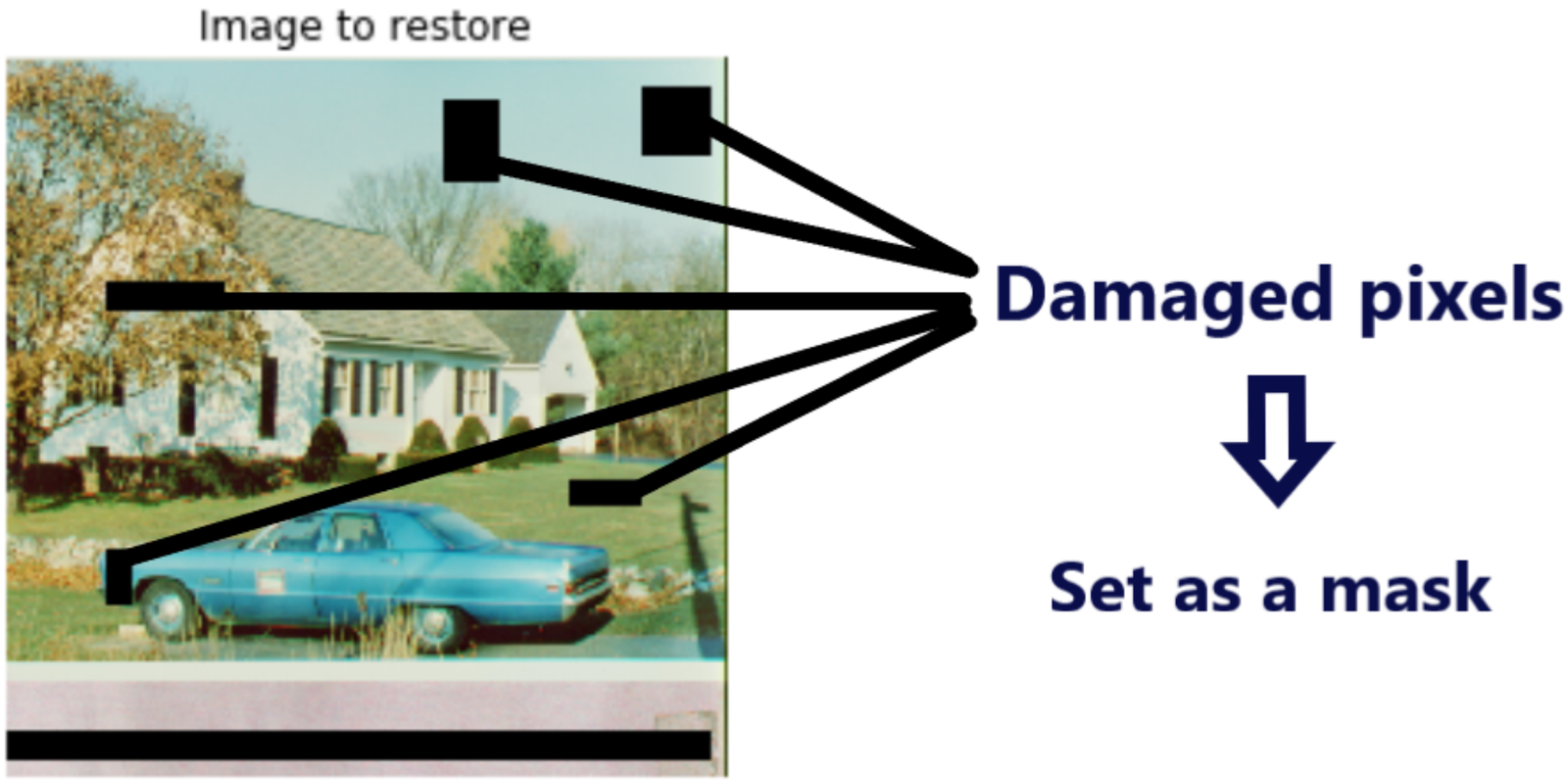
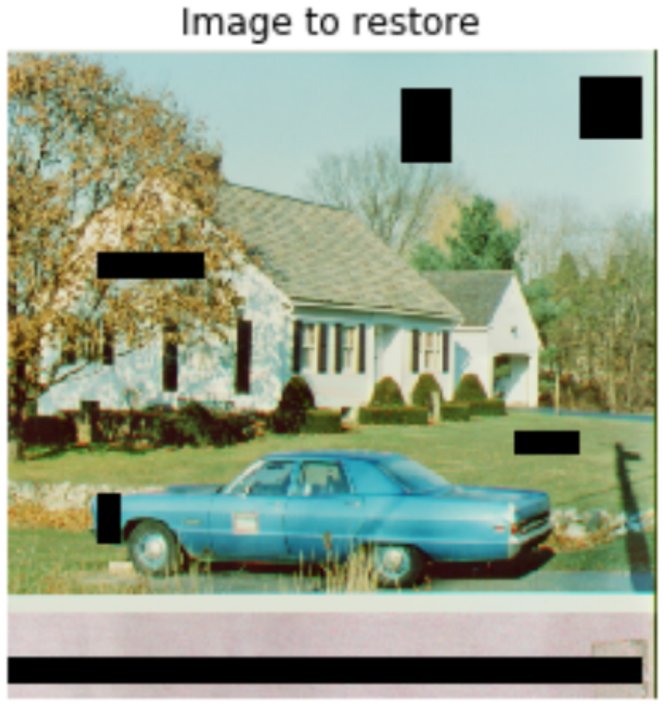


Image reconstruction in scikit-image

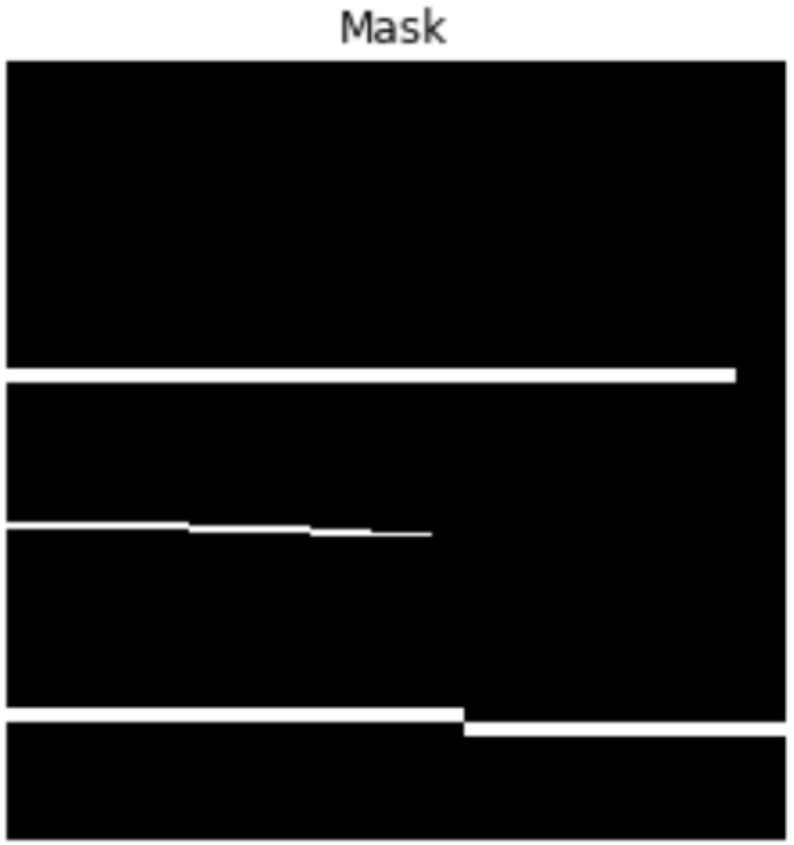
```
from skimage.restoration import inpaint

# Obtain the mask
mask = get_mask(defect_image)

# Apply inpainting to the damaged image using the mask
restored_image = inpaint.inpaint_biharmonic(defect_image,
                                            mask,
                                            multichannel=True)

# Show the resulting image
show_image(restored_image)
```

Image reconstruction in scikit-image

```
# Show the defect and resulting images
show_image(defect_image, 'Image to restore')
show_image(restored_image, 'Image restored')
```



Masks



Masks

```
def get_mask(image):
    ''' Creates mask with three defect regions '''
    mask = np.zeros(image.shape[:-1])

    mask[101:106, 0:240] = 1

    mask[152:154, 0:60] = 1
    mask[153:155, 60:100] = 1
    mask[154:156, 100:120] = 1
    mask[155:156, 120:140] = 1

    mask[212:217, 0:150] = 1
    mask[217:222, 150:256] = 1
    return mask
```

Let's practice!

IMAGE PROCESSING IN PYTHON

Noise

IMAGE PROCESSING IN PYTHON

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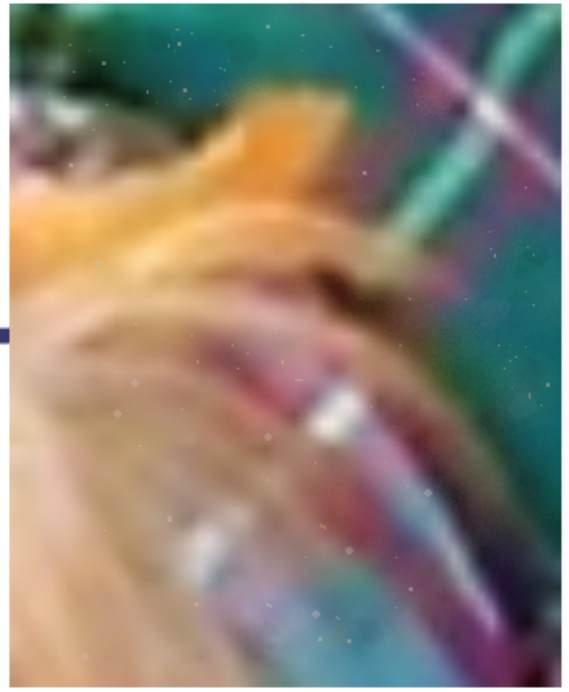
Data Engineer

datacamp

Noise



Noise

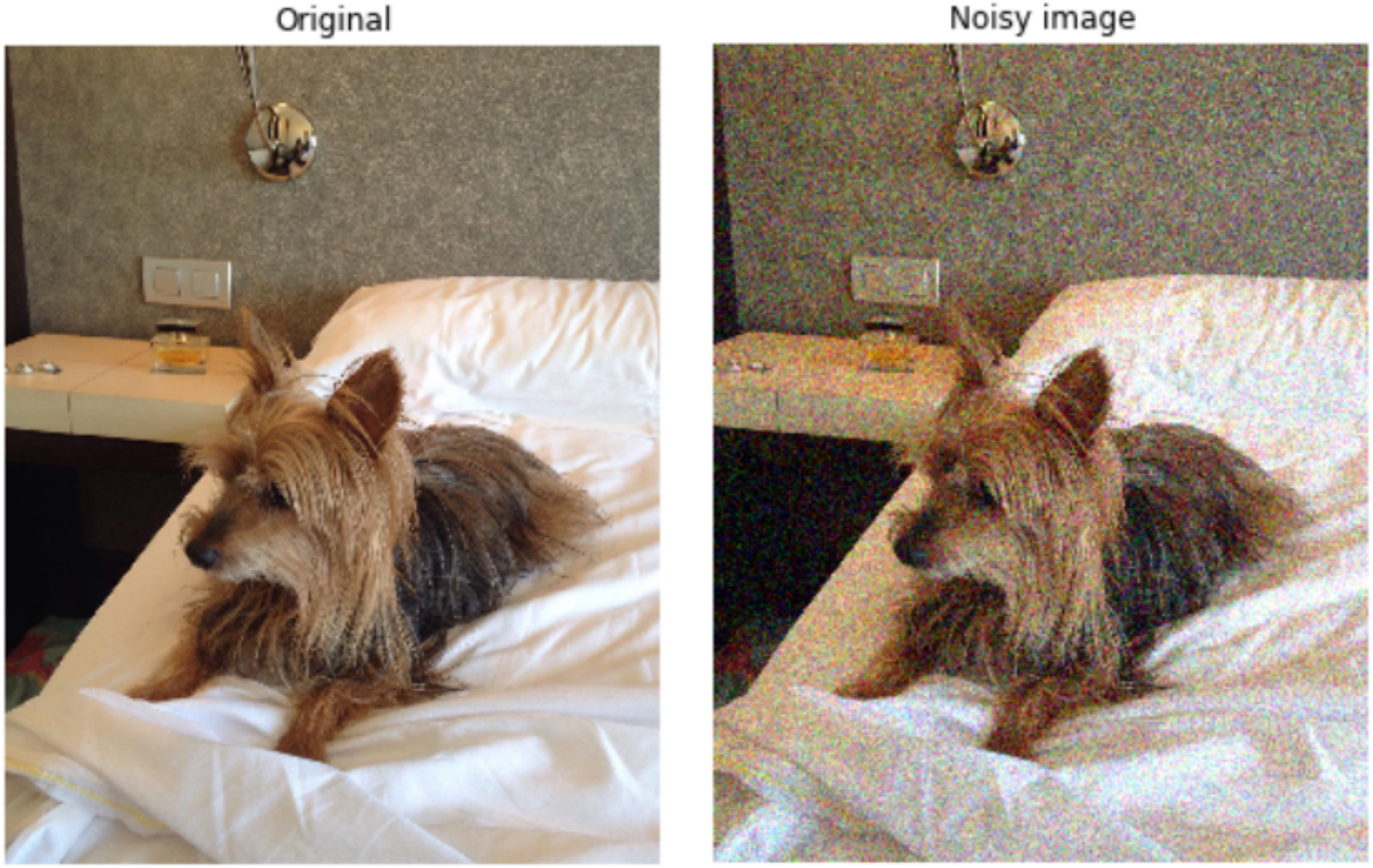
Apply noise in scikit-image

```
# Import the module and function
from skimage.util import random_noise

# Add noise to the image
noisy_image = random_noise(dog_image)

# Show original and resulting image
show_image(dog_image)
show_image(noisy_image, 'Noisy image')
```

Apply noise in scikit-image



Reducing noise

Noisy image

Denoised

Denoising types

- Total variation (TV)
- Bilateral
- Wavelet denoising
- Non-local means denoising

Denoising

Using total variation filter denoising

```
from skimage.restoration import denoise_tv_chambolle

# Apply total variation filter denoising
denoised_image = denoise_tv_chambolle(noisy_image,
                                      weight=0.1,
                                      multichannel=True)

# Show denoised image
show_image(noisy_image, 'Noisy image')
show_image(denoised_image, 'Denoised image')
```

Denoising

Total variation filter

Noisy image

Denoised image

Denoising

Bilateral filter

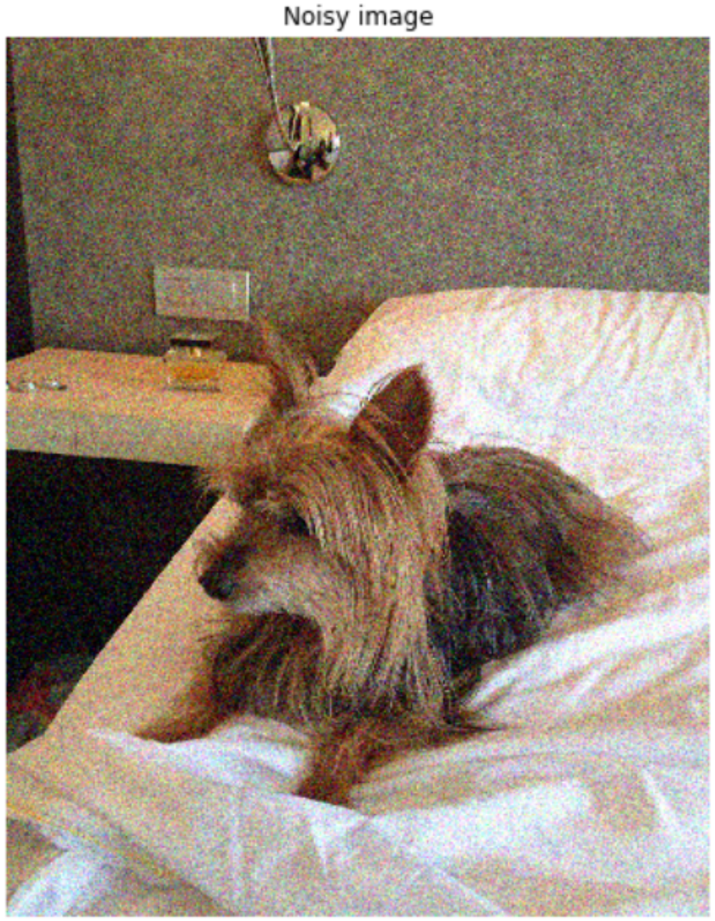
```
from skimage.restoration import denoise_bilateral

# Apply bilateral filter denoising
denoised_image = denoise_bilateral(noisy_image, multichannel=True)

# Show original and resulting images
show_image(noisy_image, 'Noisy image')
show_image(denoised_image, 'Denoised image')
```

Denoising

Bilateral filter



Let's practice!

IMAGE PROCESSING IN PYTHON

Superpixels & segmentation

IMAGE PROCESSING IN PYTHON

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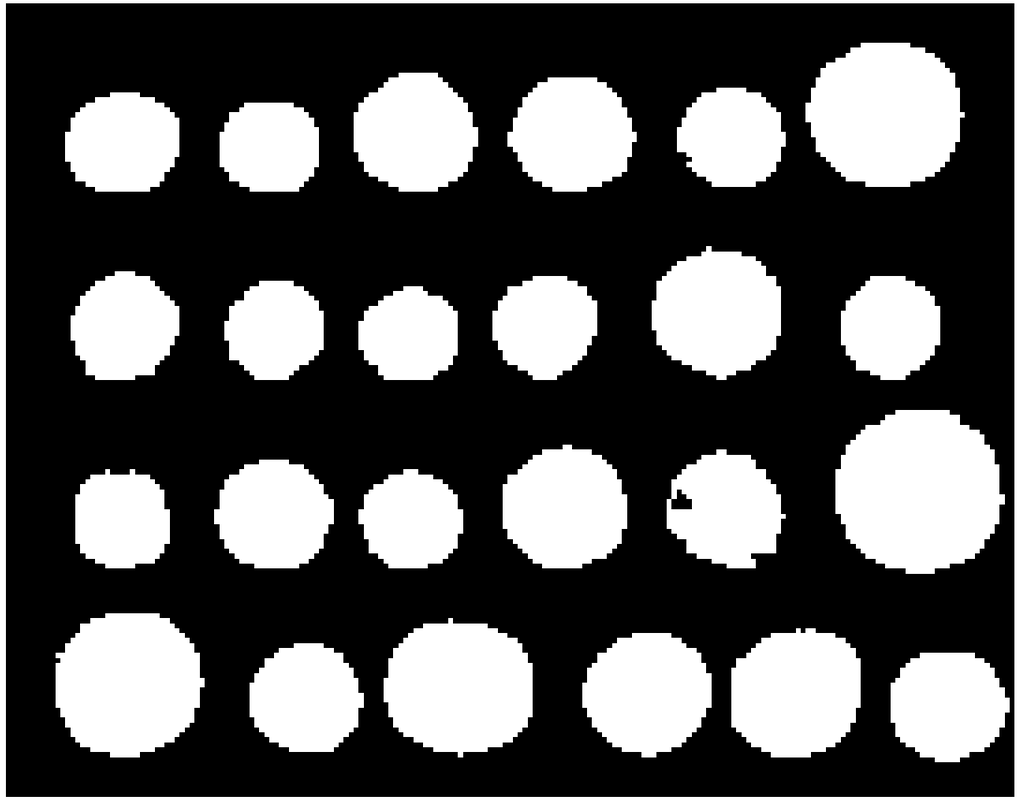
Segmentation

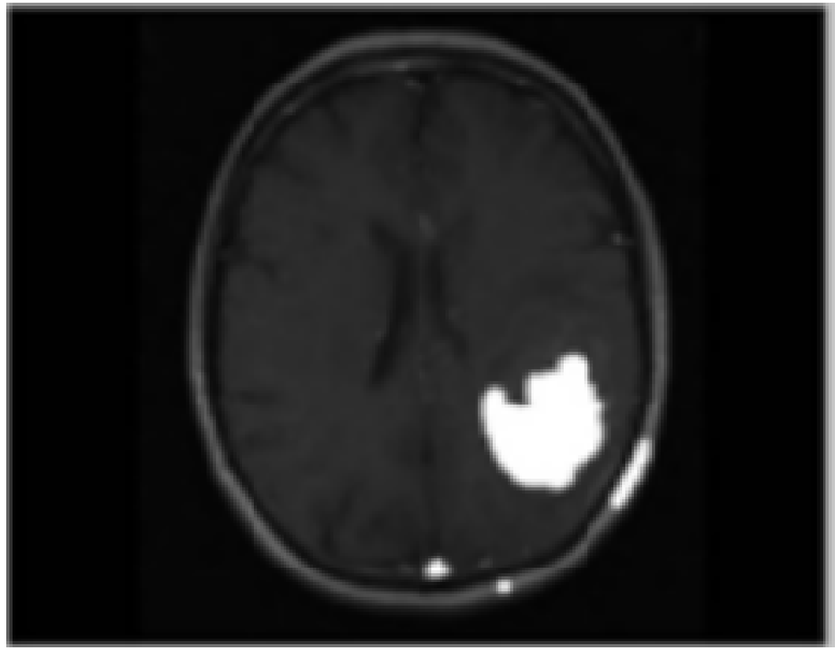
Original

Segmentated image



Segmentation

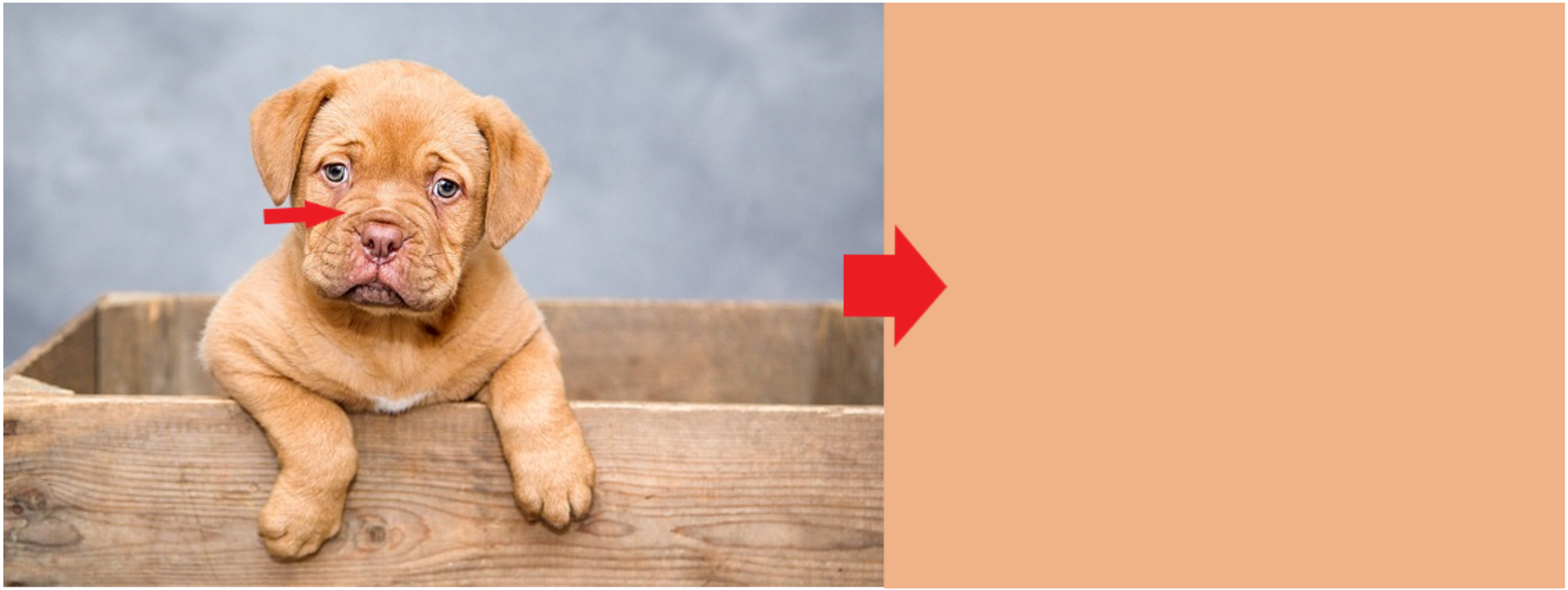
Segmented



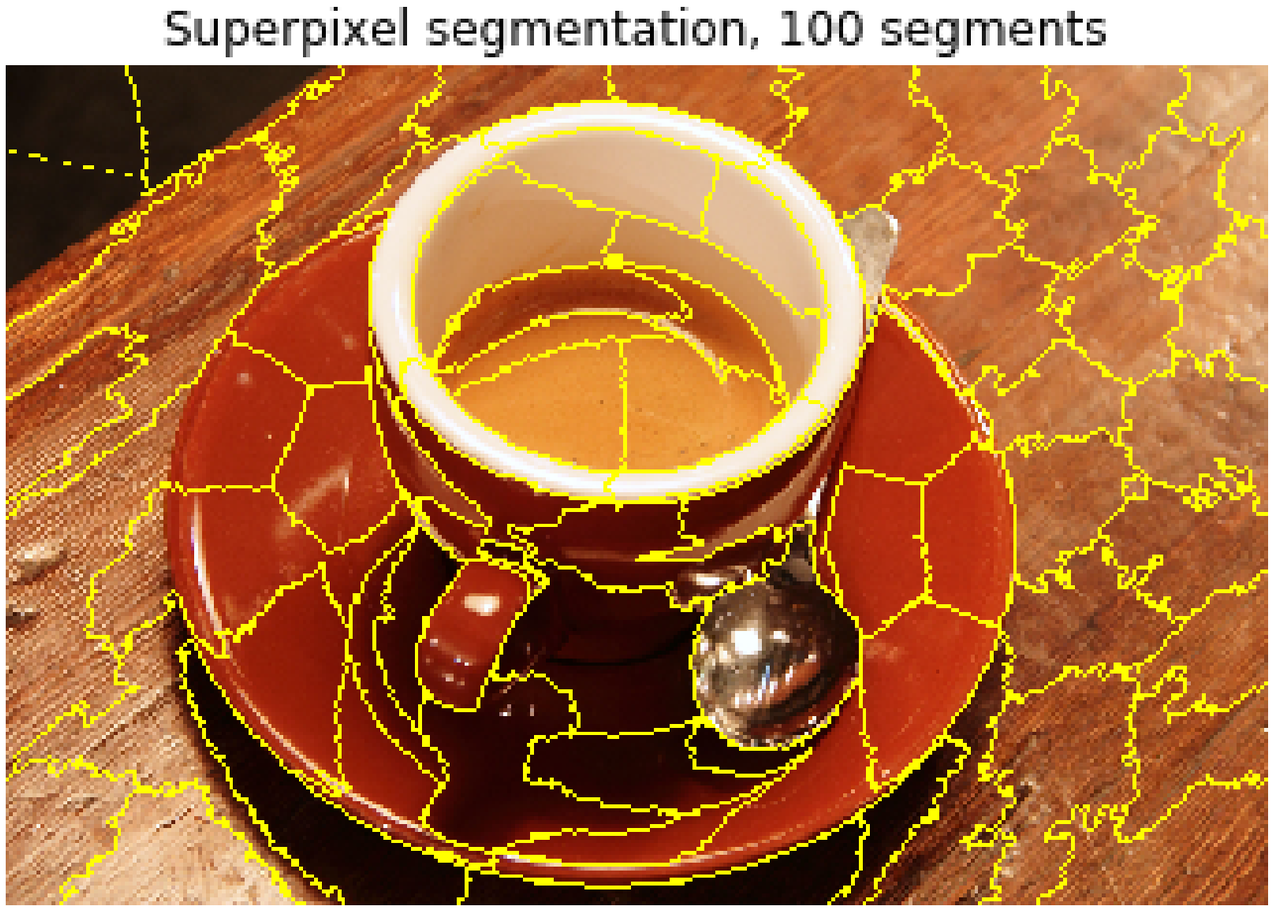
Original

Segmented

Image representation



Superpixels



Benefits of superpixels

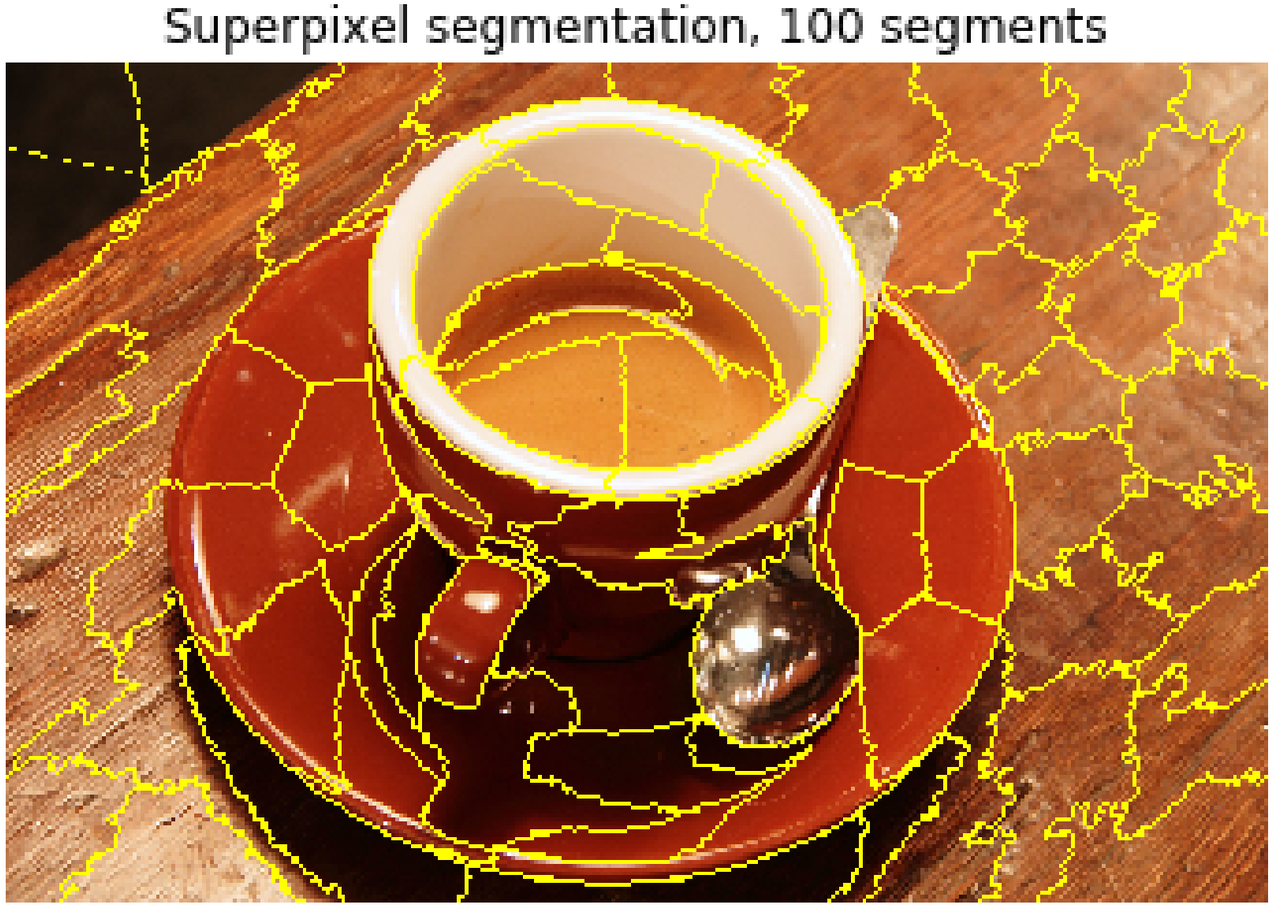
- More meaningful regions
- Computational efficiency

Segmentation

- Supervised
- Unsupervised

Unsupervised segmentation

Simple Linear Iterative Clustering (SLIC)



Unsupervised segmentation (SLIC)

```
# Import the modules
from skimage.segmentation import slic
from skimage.color import label2rgb

# Obtain the segments
segments = segmentation.slic(image)

# Put segments on top of original image to compare
segmented_image = label2rgb(segments, image, kind='avg')

show_image(image)
show_image(segmented_image, "Segmented image")
```

Unsupervised segmentation (SLIC)

Original

Segmented image

More segments

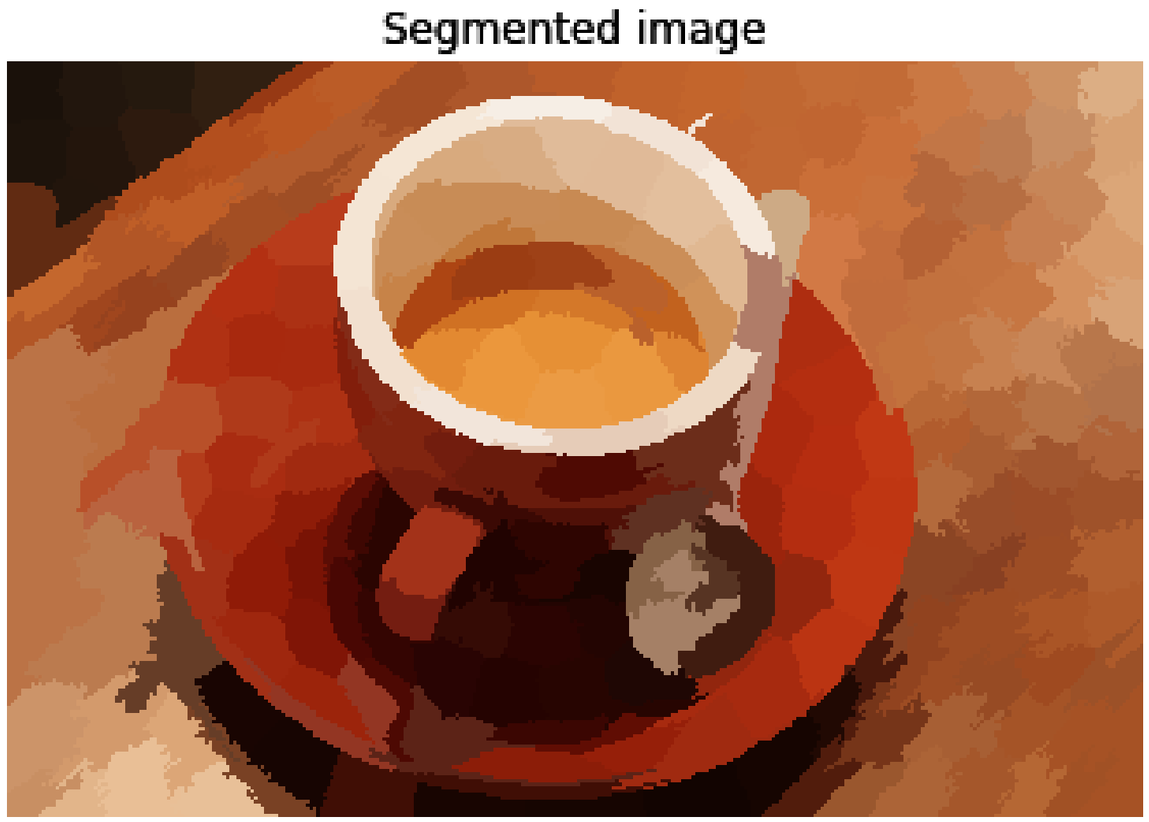
```
# Import the modules
from skimage.segmentation import slic
from skimage.color import label2rgb

# Obtain the segmentation with 300 regions
segments = slic(image, n_segments= 300)

# Put segments on top of original image to compare
segmented_image = label2rgb(segments, image, kind='avg')

show_image(segmented_image)
```

More segments



Let's practice!

IMAGE PROCESSING IN PYTHON

Finding contours

IMAGE PROCESSING IN PYTHON

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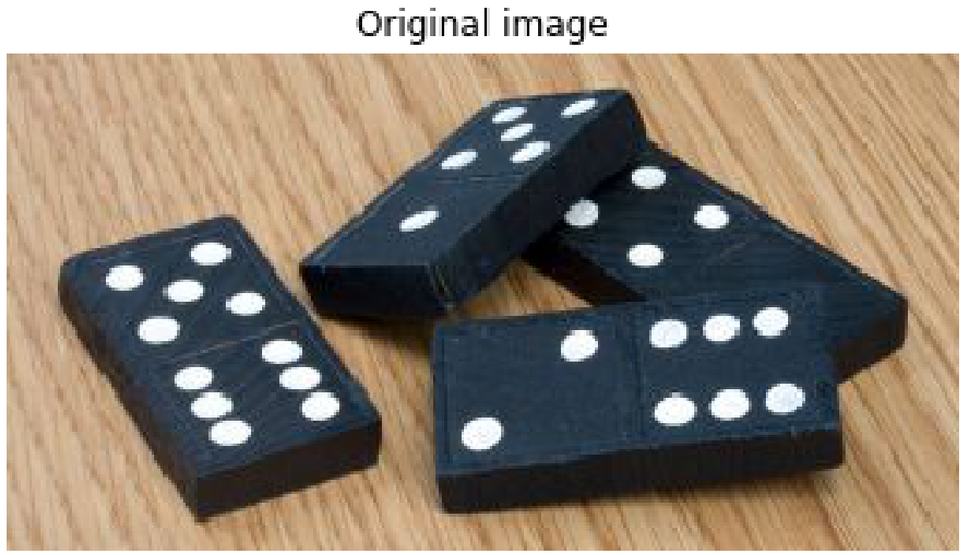
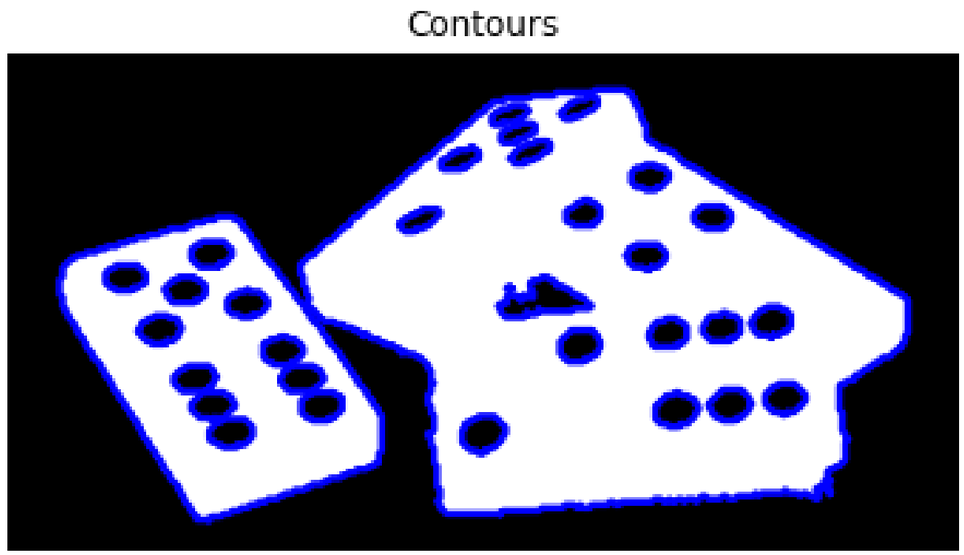
Data Engineer

datacamp

Finding contours

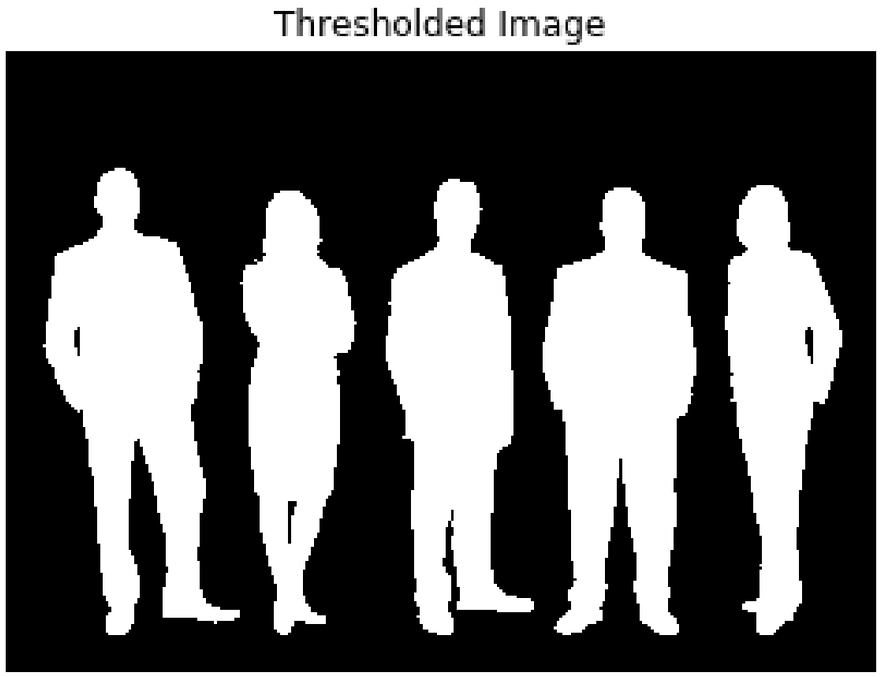


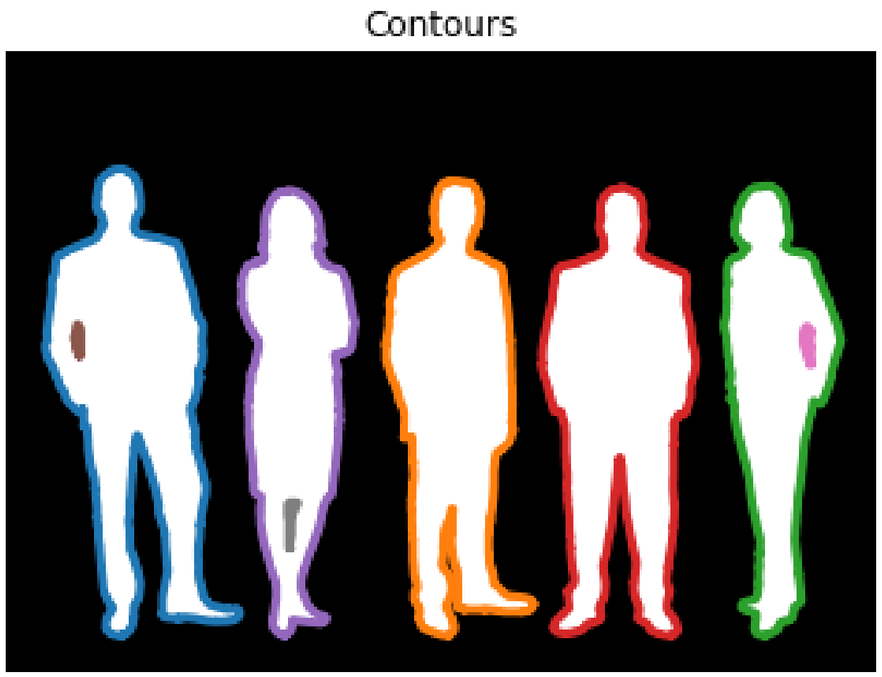


- Measure size
- Classify shapes
- Determine the number of objects

Total points in domino tokens: 29.

Binary images





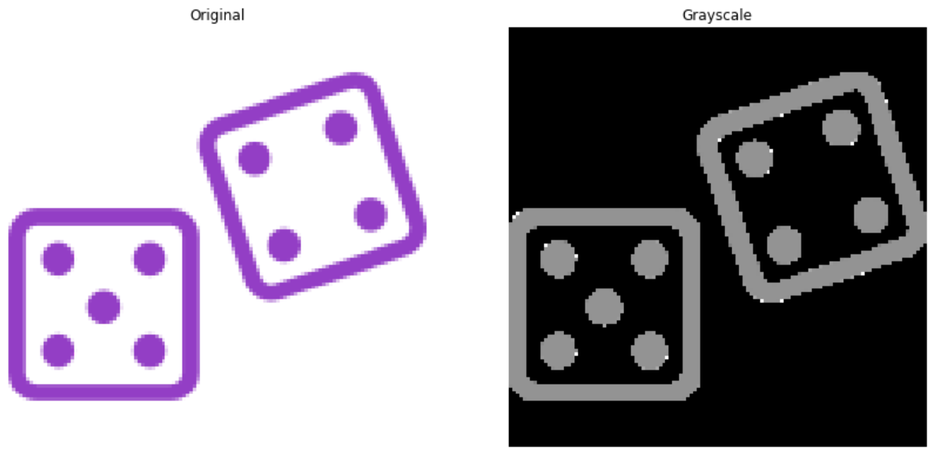
We can obtain a binary image applying **thresholding** or using **edge detection**

Find contours using scikit-image

PREPARING THE IMAGE

Transform the image to 2D grayscale.

```
# Make the image grayscale
image = color.rgb2gray(image)
```

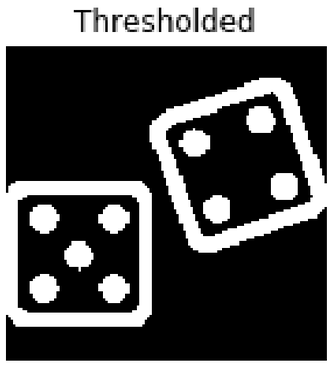


Find contours using scikit-image

PREPARING THE IMAGE

Binarize the image

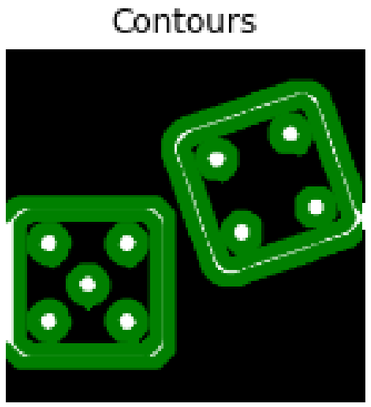
```
# Obtain the thresh value
thresh = threshold_otsu(image)

# Apply thresholding
thresholded_image = image > thresh
```



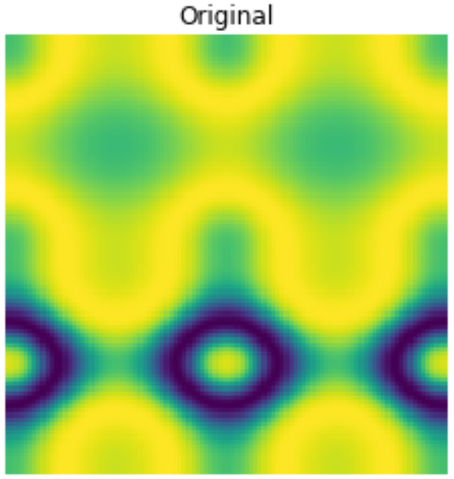
Find contours using scikit-image

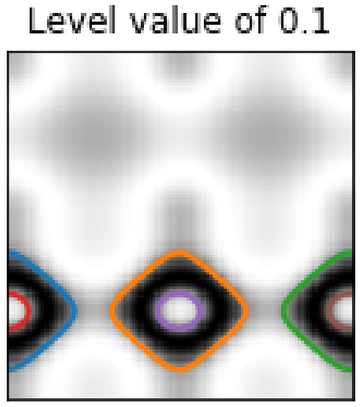
And then use `find_contours()`.

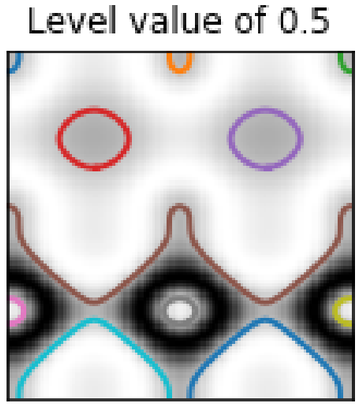
```
# Import the measure module
from skimage import measure

# Find contours at a constant value of 0.8
contours = measure.find_contours(thresholded_image, 0.8)
```

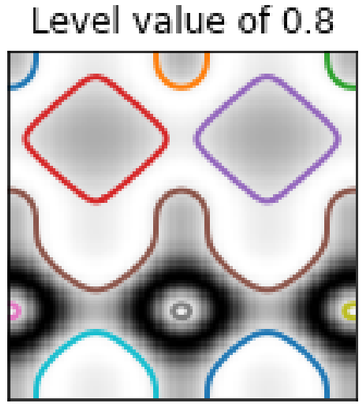


Constant level value







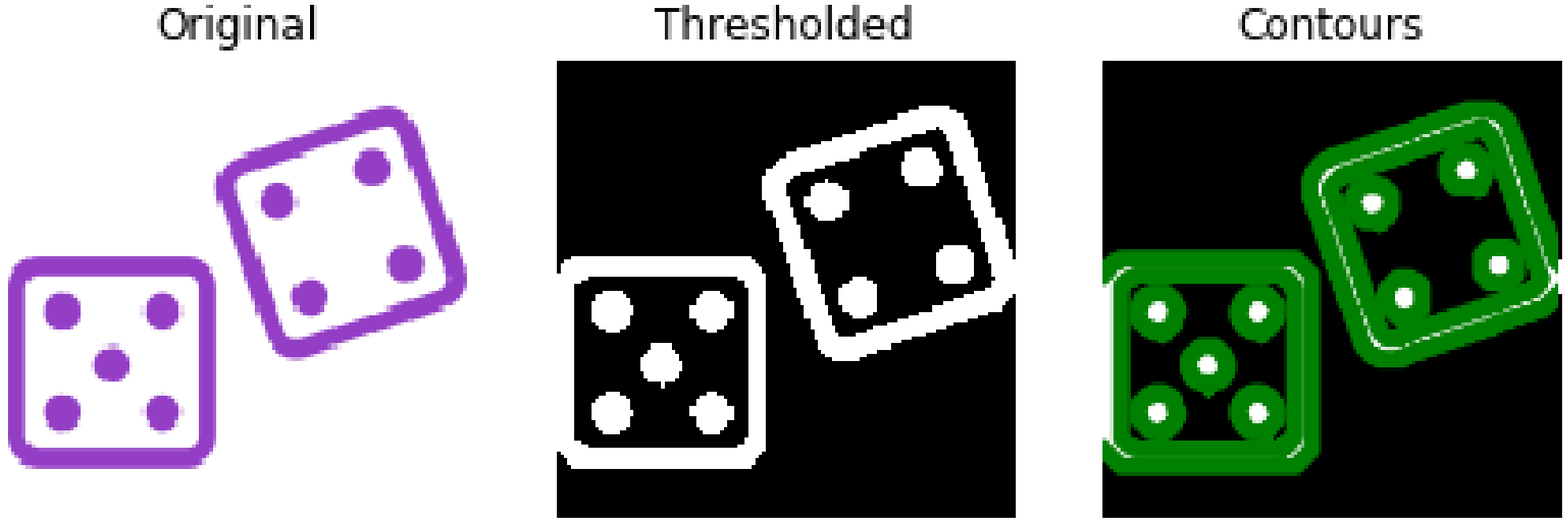


The steps to spotting contours

```
from skimage import measure
from skimage.filters import threshold_otsu

# Make the image grayscale
image = color.rgb2gray(image)
# Obtain the optimal thresh value of the image
thresh = threshold_otsu(image)

# Apply thresholding and obtain binary image
thresholded_image = image > thresh

# Find contours at a constant value of 0.8
contours = measure.find_contours(thresholded_image, 0.8)
```

The steps to spotting contours

Resulting in



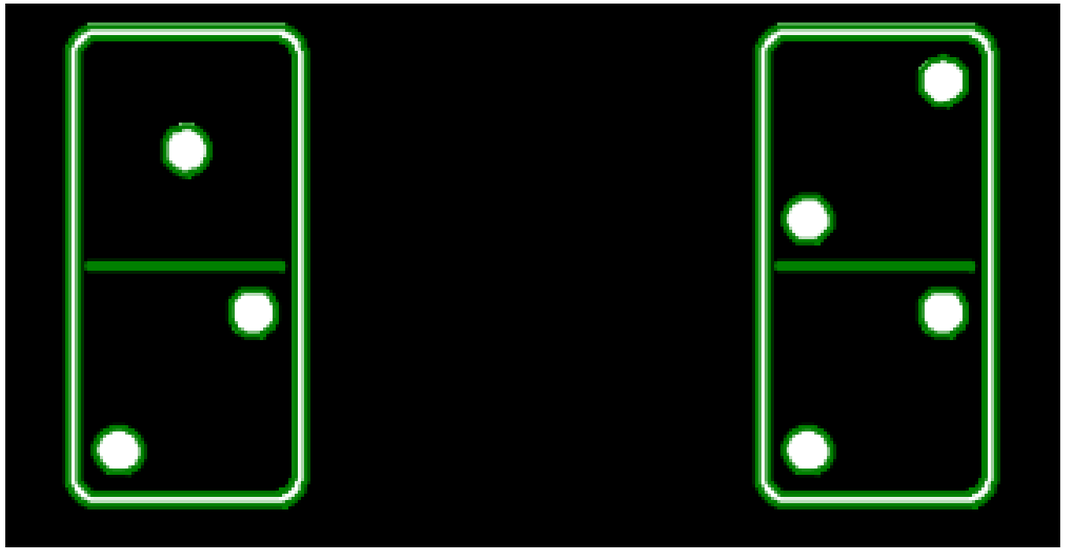
A contour's shape

Contours: list of (n,2) - ndarrays.

```
for contour in contours:
    print(contour.shape)
```

```
(433, 2)
(433, 2)
(401, 2)
(401, 2)
(123, 2)
(123, 2)
(59, 2)
(59, 2)
(59, 2)
(57, 2)
(57, 2)
(59, 2)
```

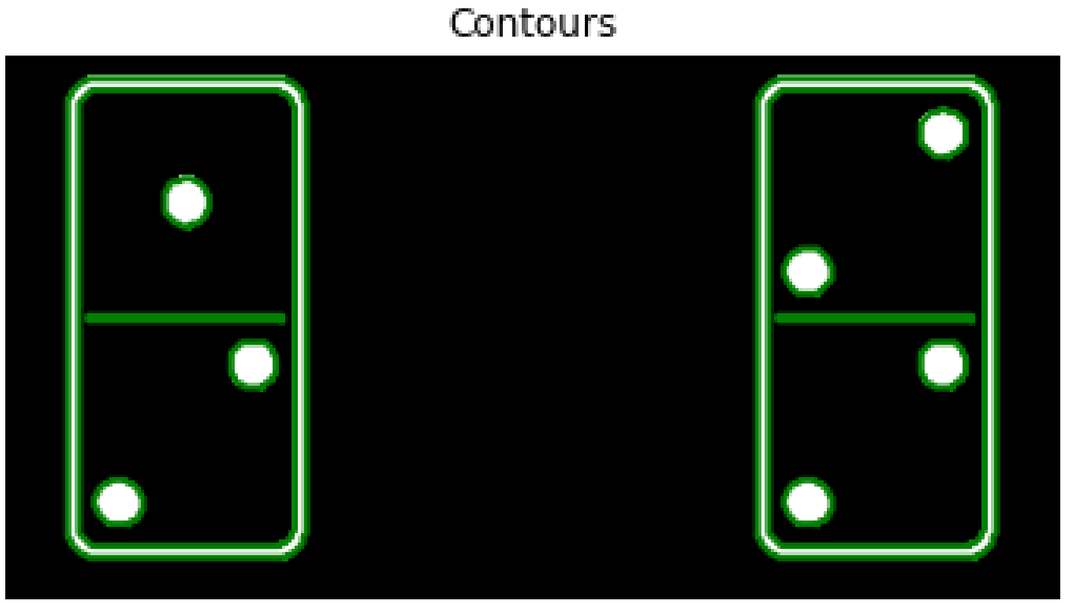
Contours



A contour's shape

```
for contour in contours:
    print(contour.shape)
```

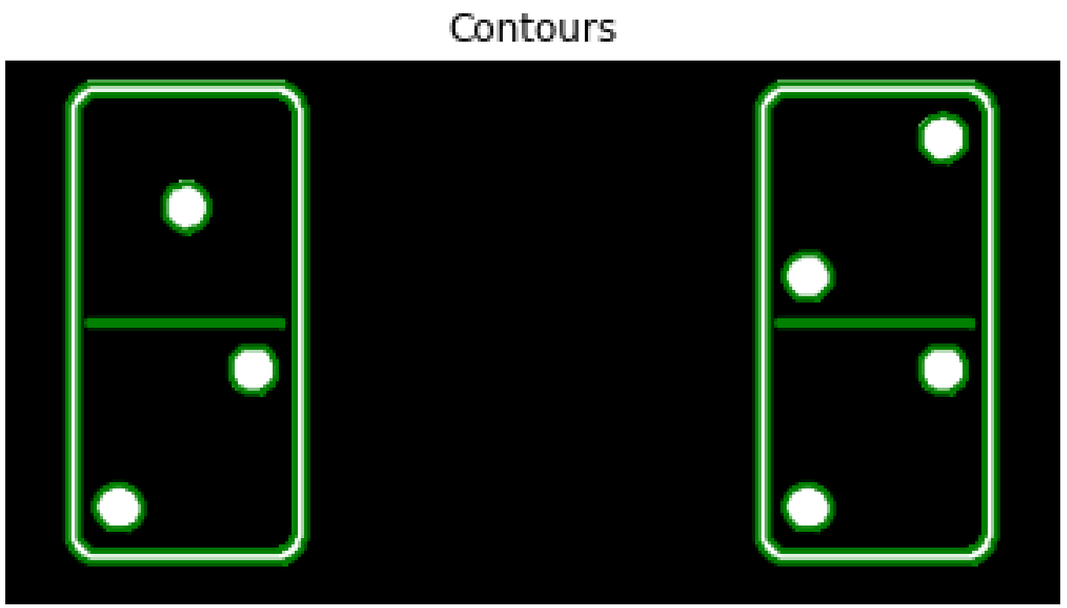
```
(433, 2)
(433, 2) --> Outer border
(401, 2)
(401, 2)
(123, 2)
(123, 2)
(59, 2)
(59, 2)
(59, 2)
(57, 2)
(57, 2)
(59, 2)
(59, 2)
```



A contour's shape

```
for contour in contours:
    print(contour.shape)
```

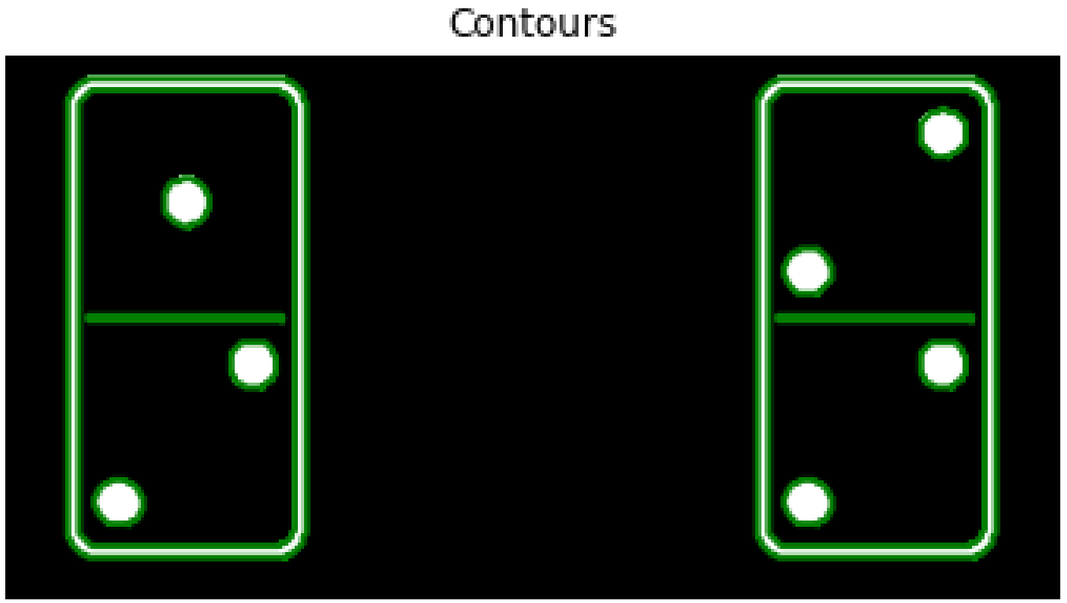
```
(433, 2)
(433, 2) --> Outer border
(401, 2)
(401, 2) --> Inner border
(123, 2)
(123, 2)
(59, 2)
(59, 2)
(59, 2)
(57, 2)
(57, 2)
(59, 2)
(59, 2)
```



A contour's shape

```
for contour in contours:
    print(contour.shape)
```

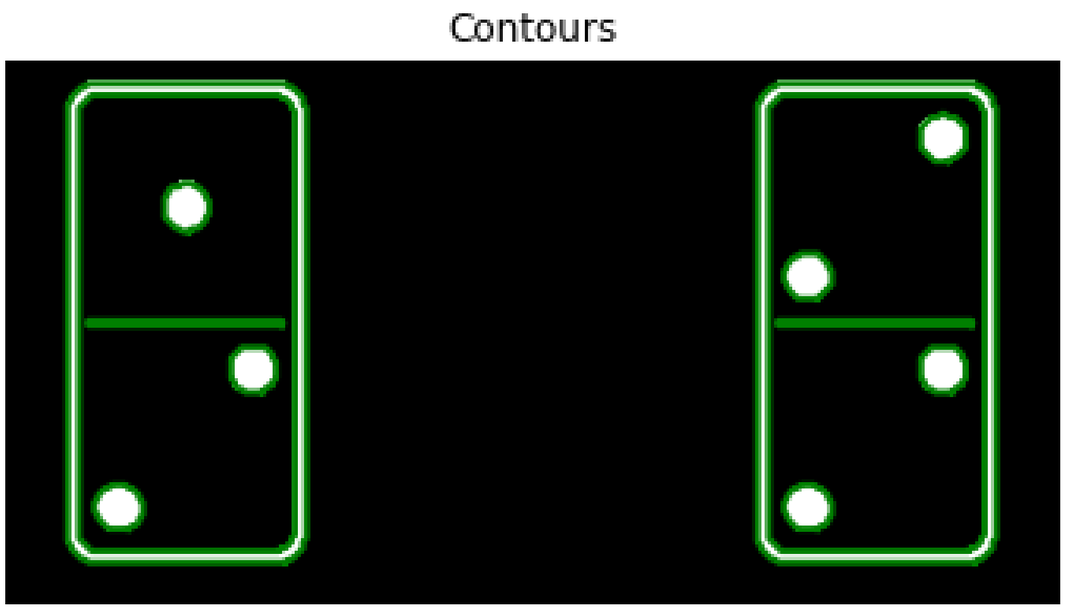
```
(433, 2)
(433, 2) --> Outer border
(401, 2)
(401, 2) --> Inner border
(123, 2)
(123, 2) --> Divisory line of tokens
(59, 2)
(59, 2)
(59, 2)
(57, 2)
(57, 2)
(59, 2)
(59, 2)
```



A contour's shape

```
for contour in contours:
    print(contour.shape)
```

```
(433, 2)
(433, 2) --> Outer border
(401, 2)
(401, 2) --> Inner border
(123, 2)
(123, 2) --> Divisory line of tokens
(59, 2)
(59, 2)
(59, 2)
(57, 2)
(57, 2)
(59, 2)
(59, 2) --> Dots
```



Number of dots: 7.

Let's practice!

IMAGE PROCESSING IN PYTHON

Finding the edges with Canny

IMAGE PROCESSING IN PYTHON

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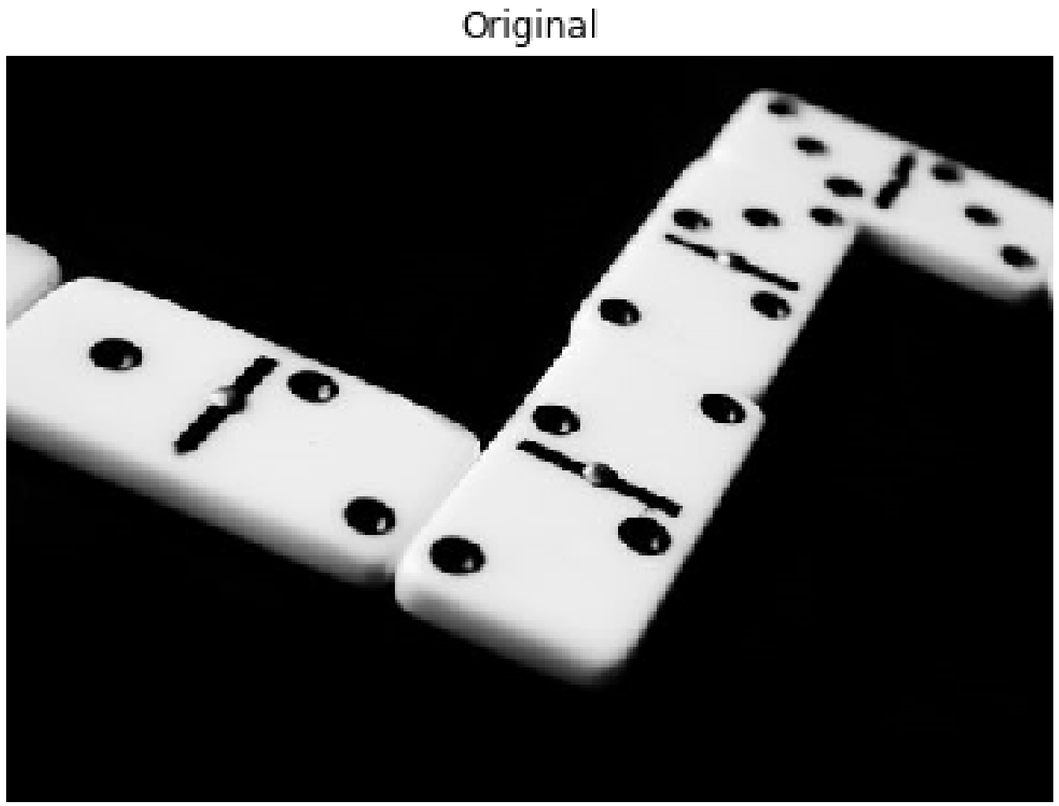
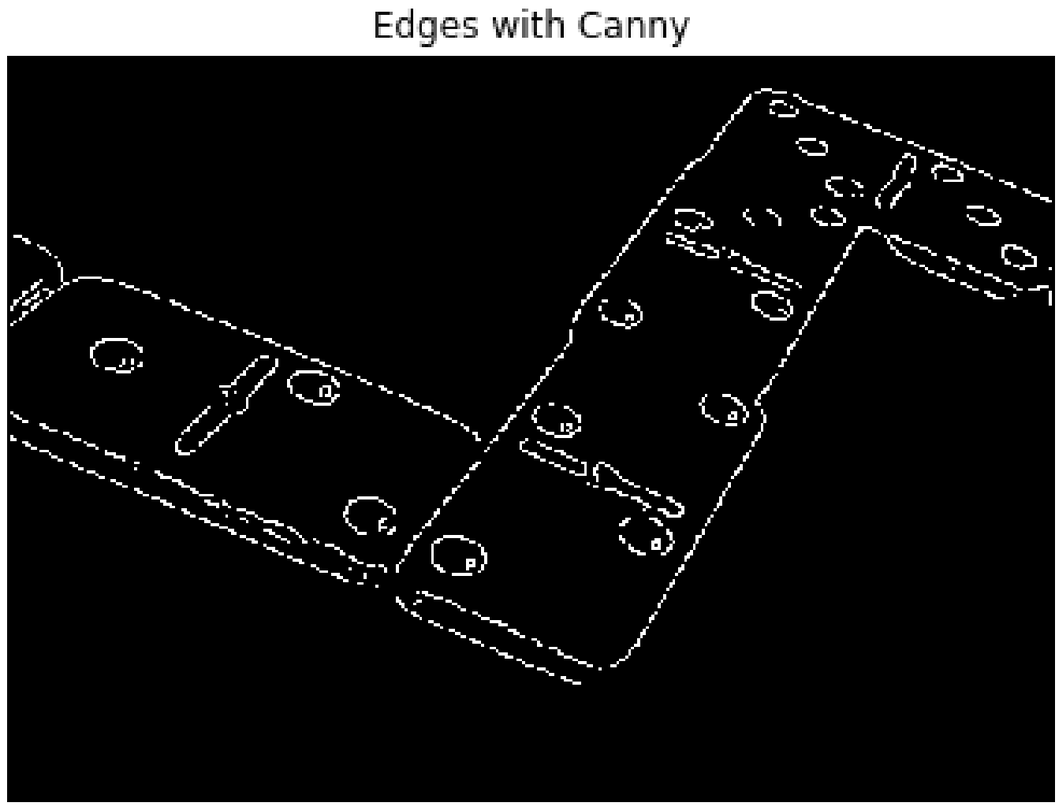
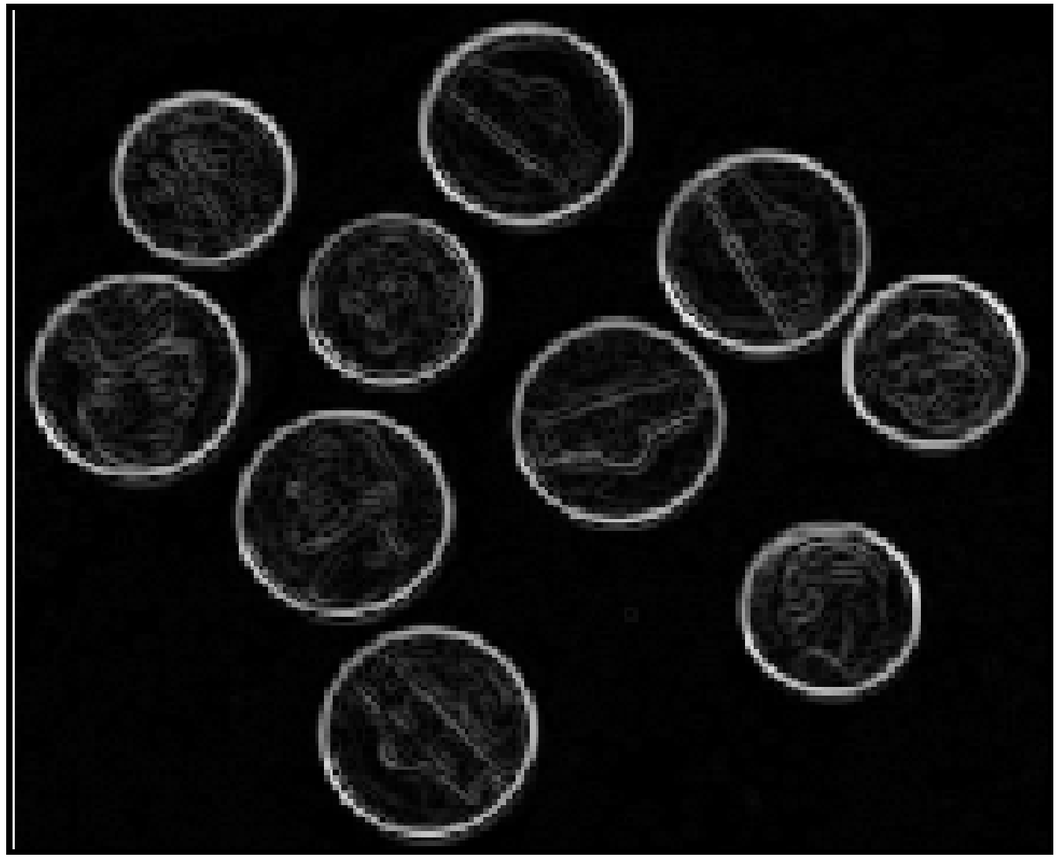
Detecting edges



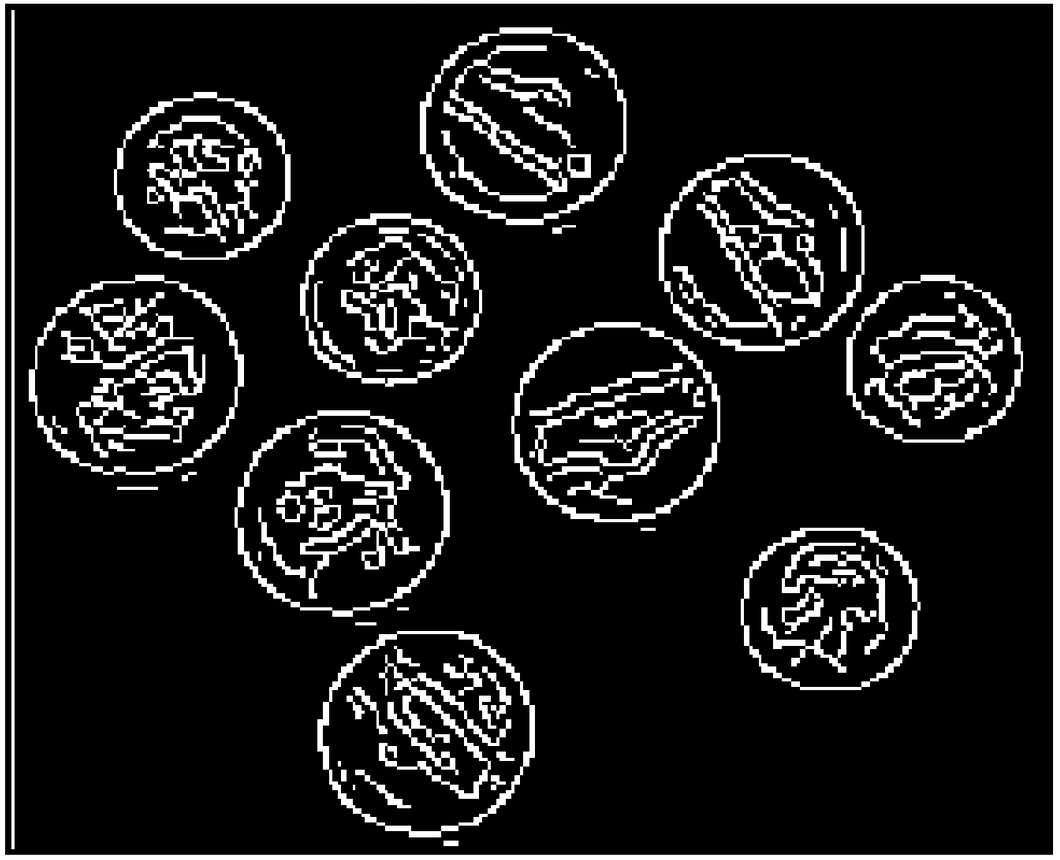


Edge detection

Edges with Sobel



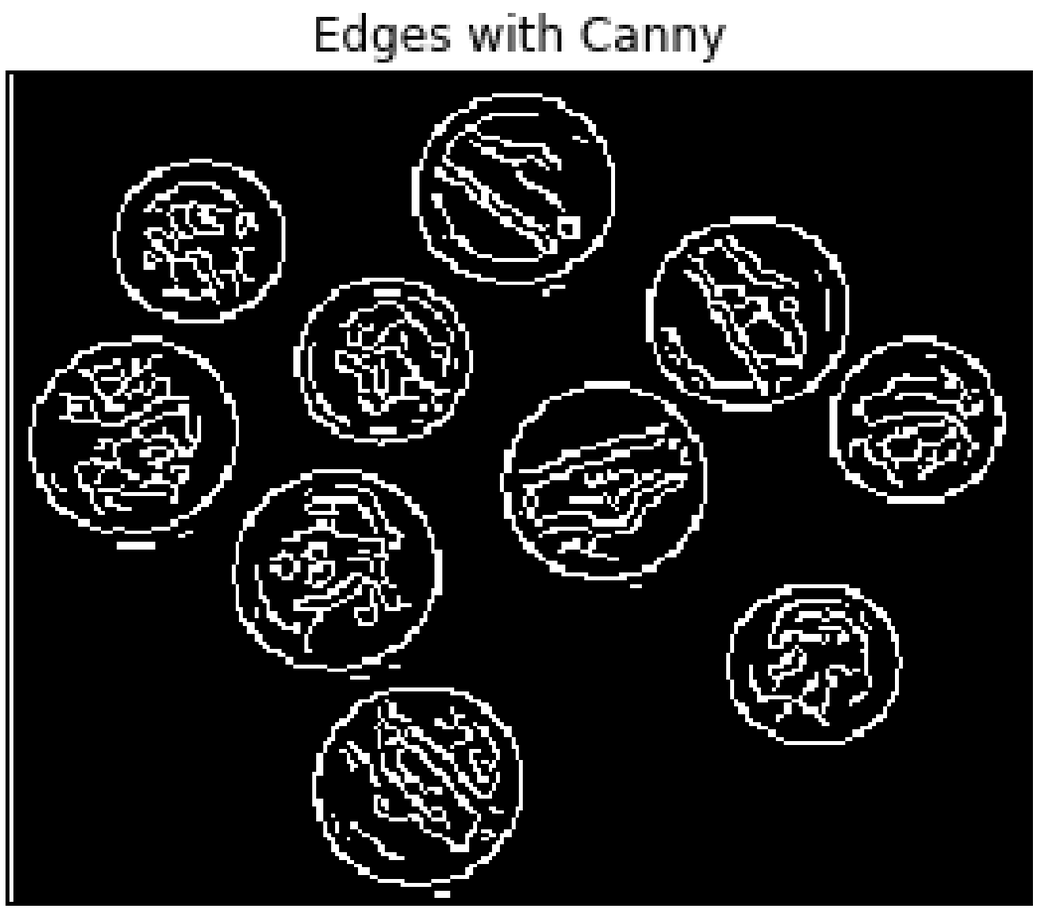
Edges with Canny



Edge detection

```
from skimage.feature import canny

# Convert image to grayscale
coins = color.rgb2gray(coins)

# Apply Canny detector
canny_edges = canny(coins)

# Show resulted image with edges
show_image(canny_edges, "Edges with Canny")
```

Edge detection

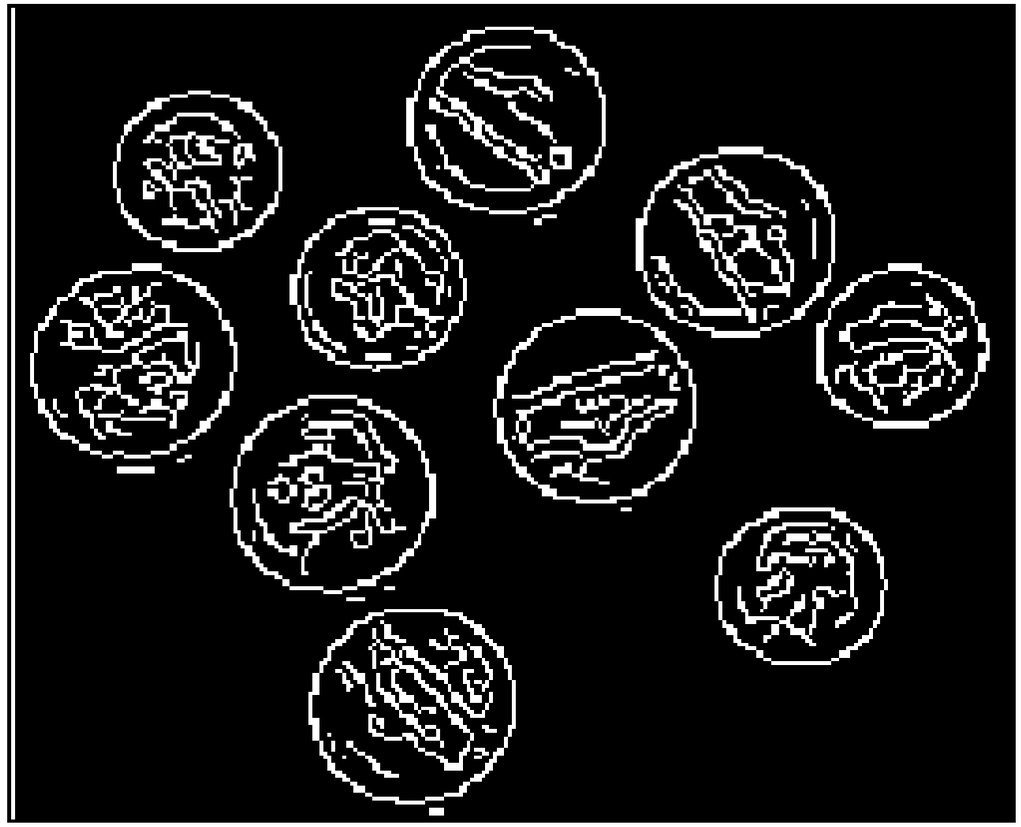


Canny edge detector

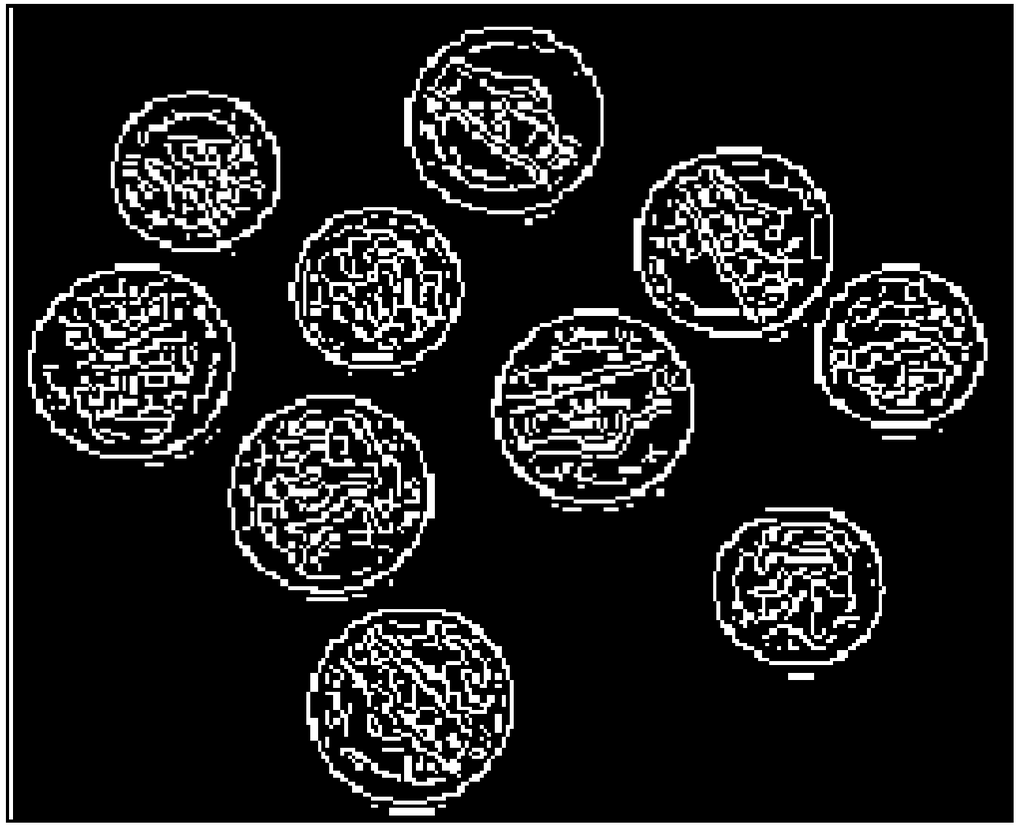
```
# Apply Canny detector with a sigma of 0.5
canny_edges_0_5 = canny(coins, sigma=0.5)


# Show resulted images with edges
show_image(canny_edges, "Sigma of 1")
show_image(canny_edges_0_5, "Sigma of 0.5")
```

Canny edge detector

Sigma of 1



Sigma of 0.5



Let's practice!

IMAGE PROCESSING IN PYTHON

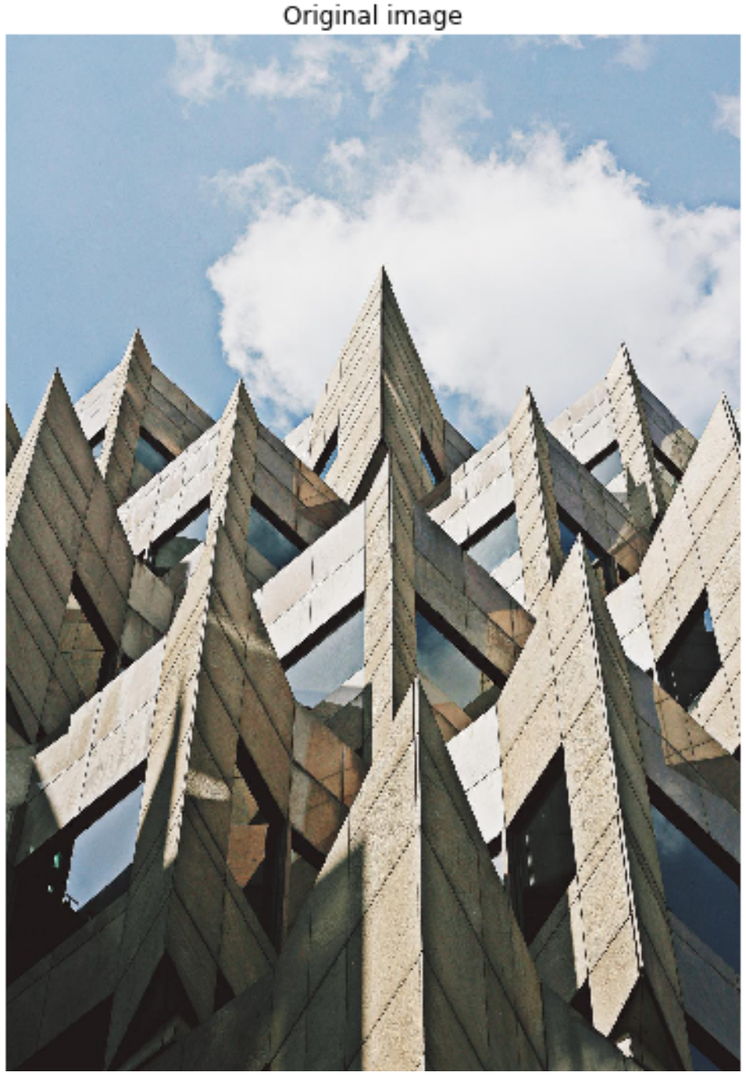
Right around the corner

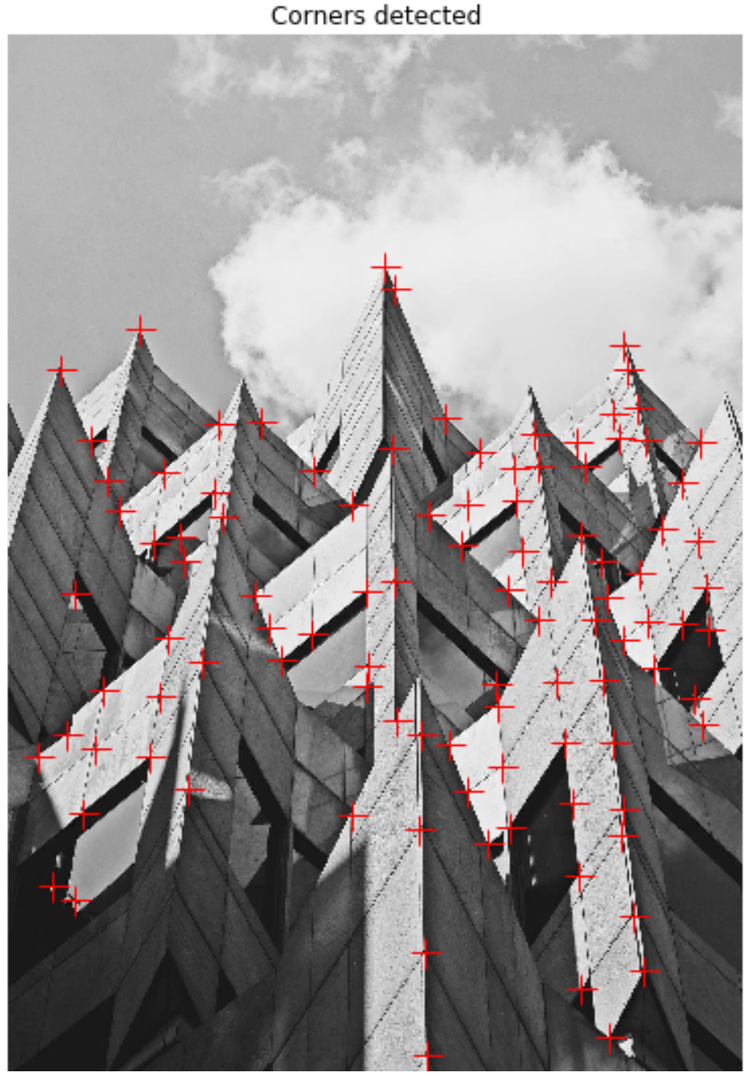
IMAGE PROCESSING IN PYTHON

Rebeca Gonzalez
Data Engineer

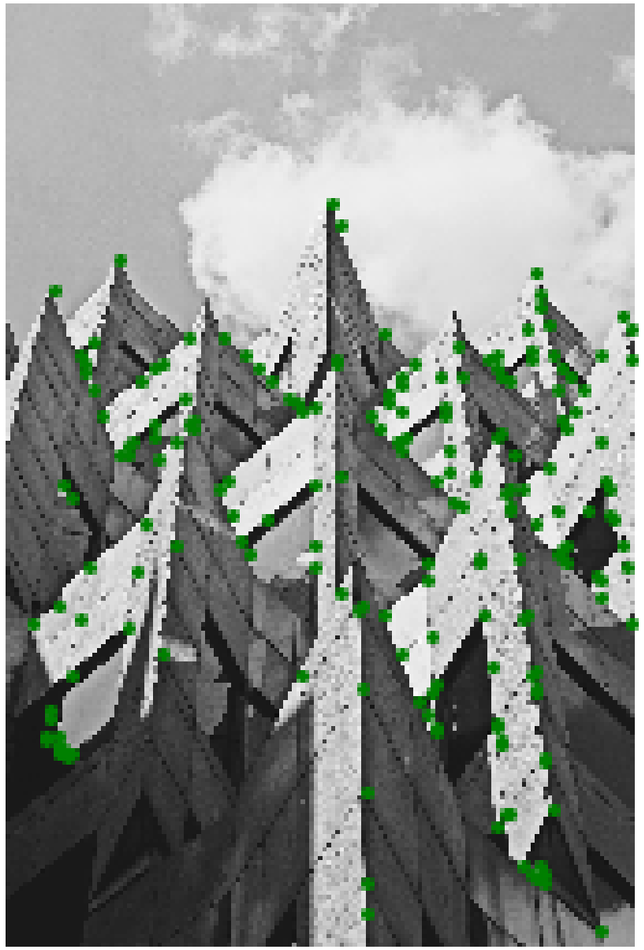
datacamp

Corner detection

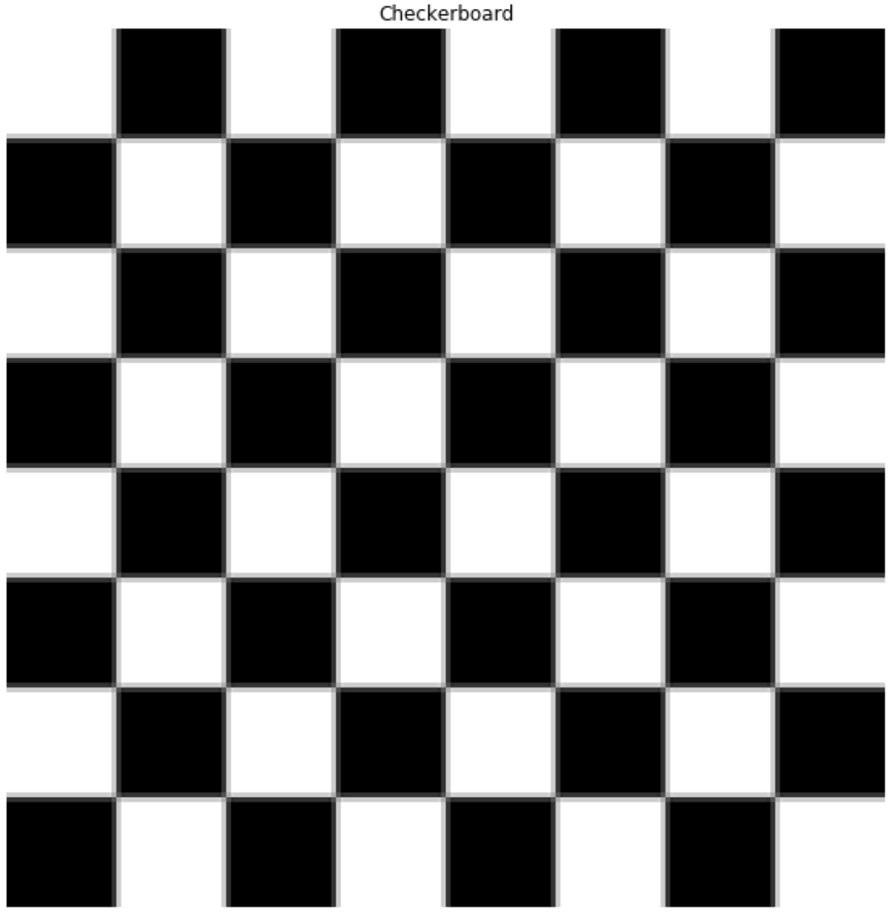


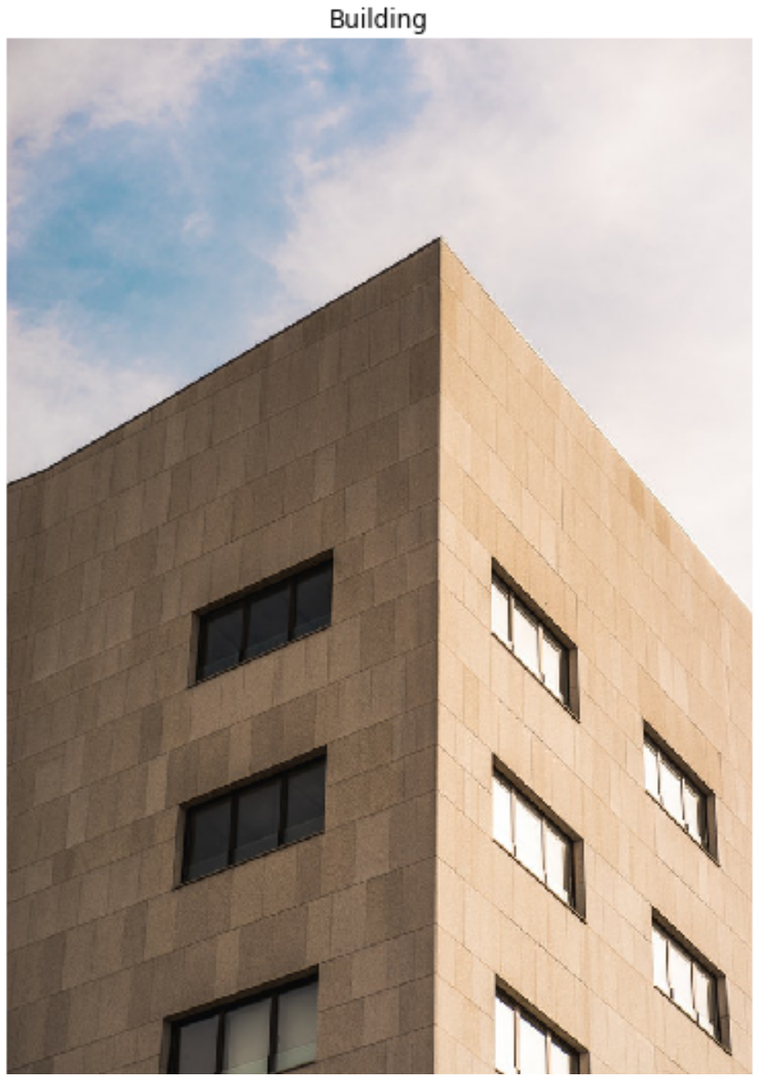


Points of interest

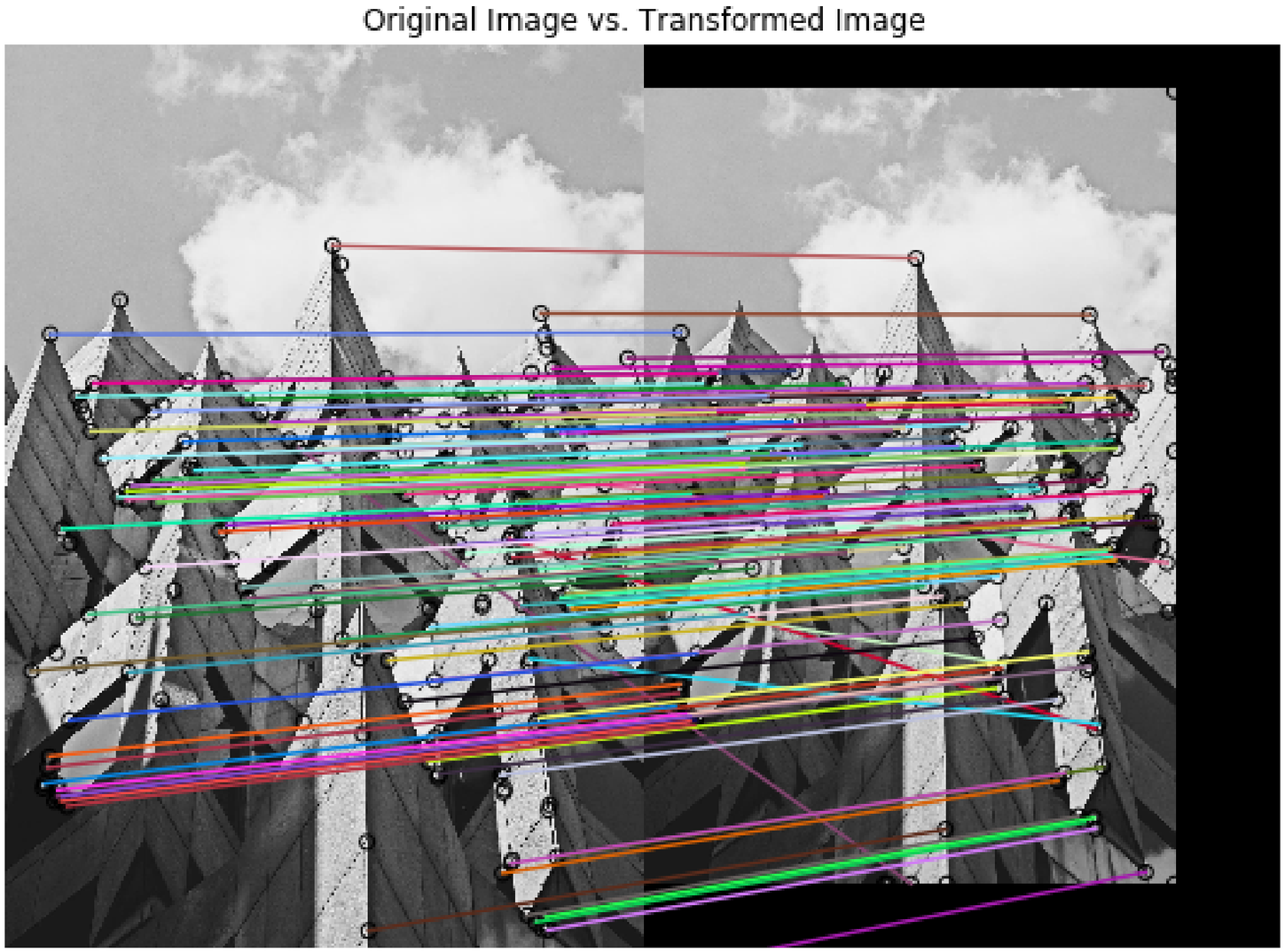


Corners

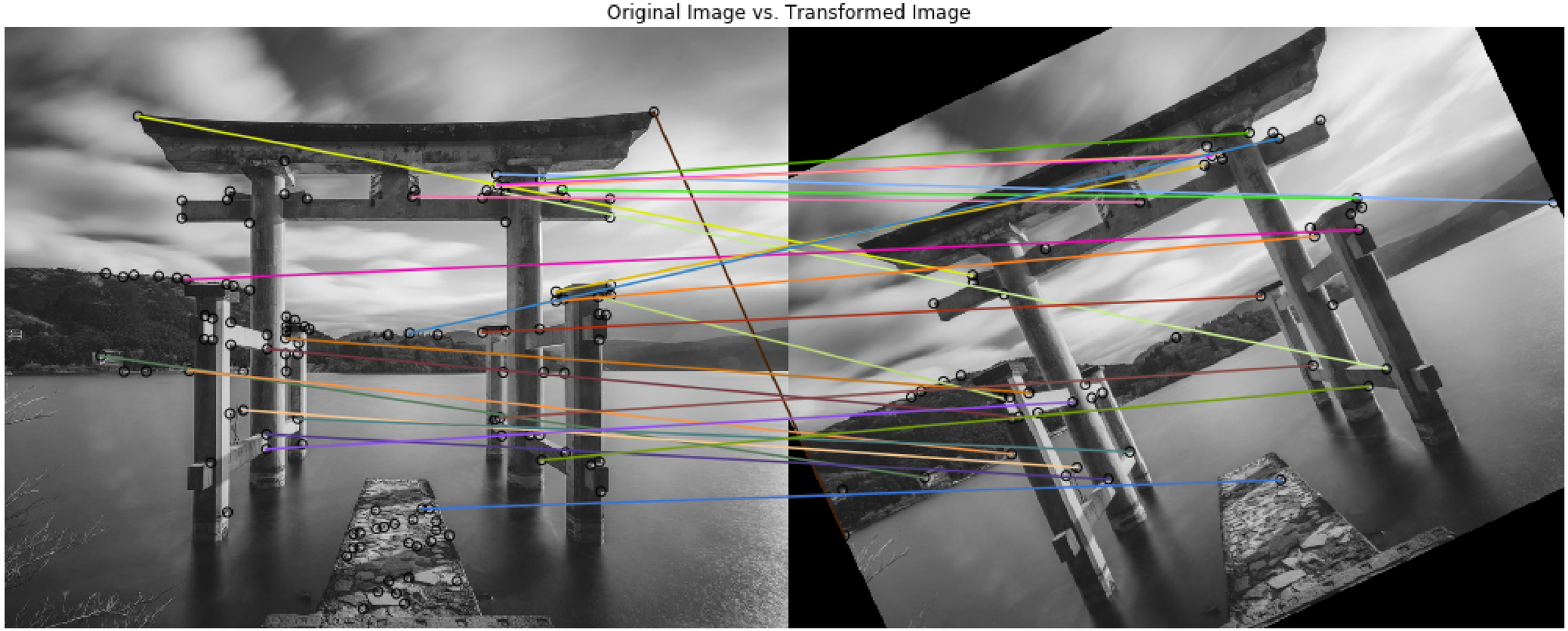




Matching corners

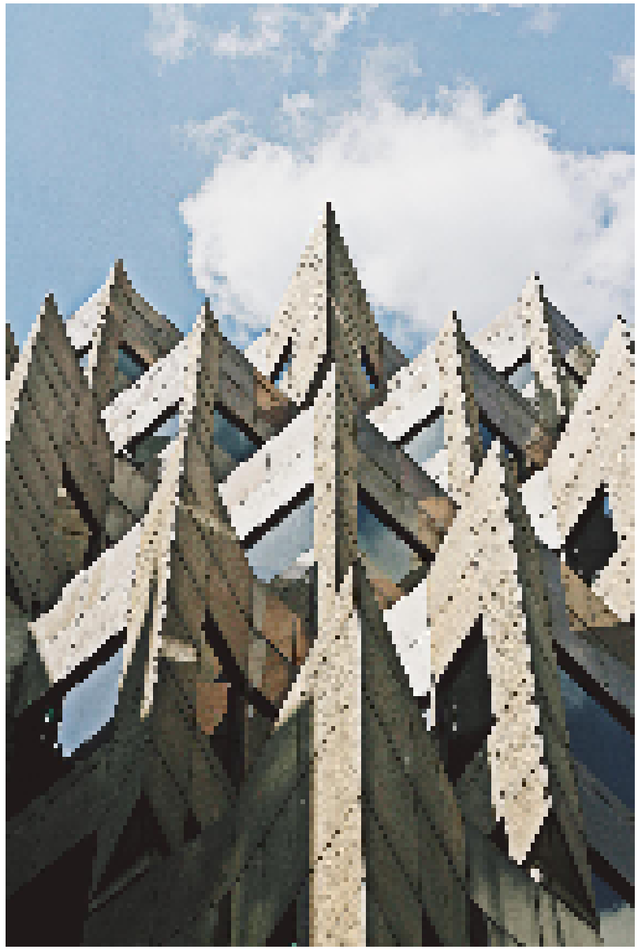


Matching corners

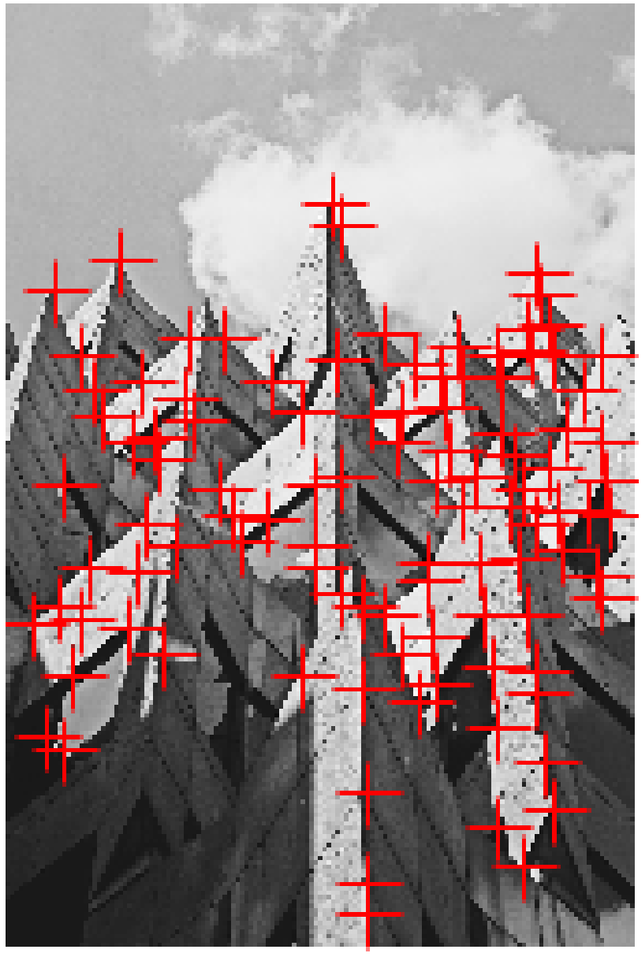


Harris corner detector

Original image



Corners detected

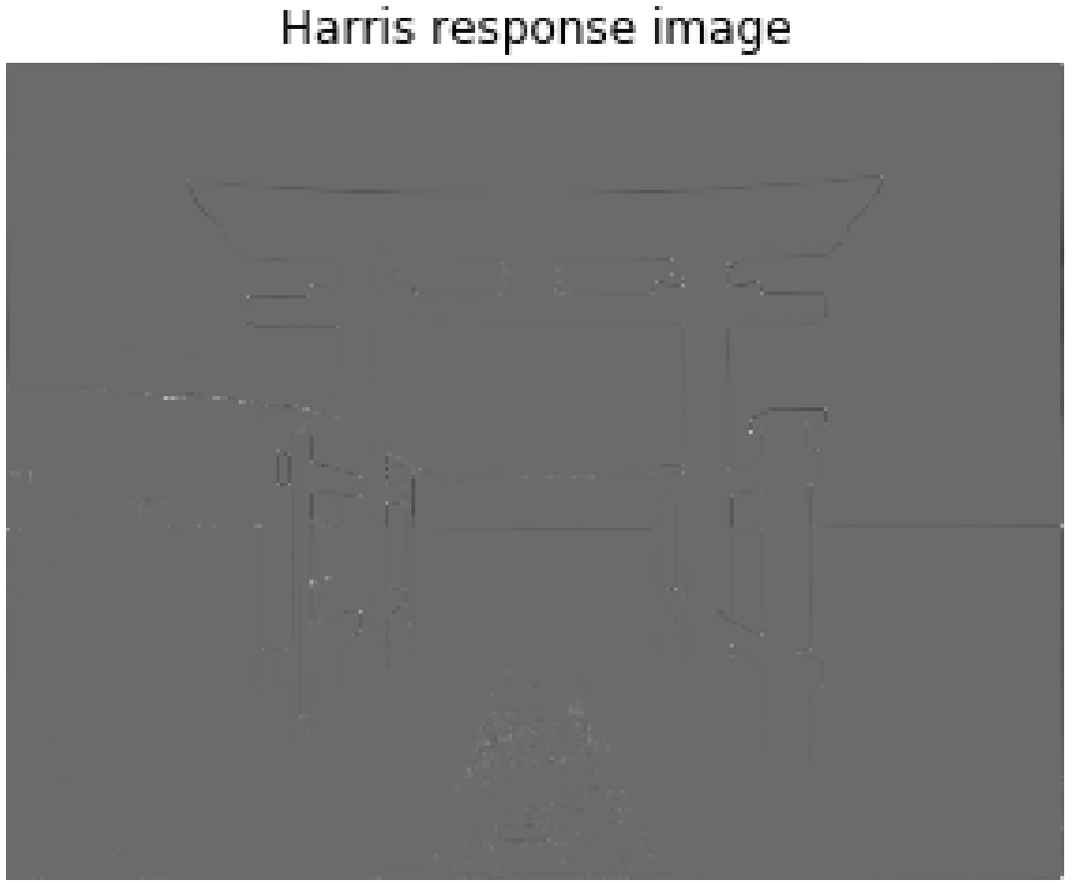


Harris corner detector

Harris corner detector

```
from skimage.feature import corner_harris

# Convert image to grayscale
image = rgb2gray(image)

# Apply the Harris corner detector on the image
measure_image = corner_harris(image)

# Show the Harris response image
show_image(measure_image)
```

Harris corner detector



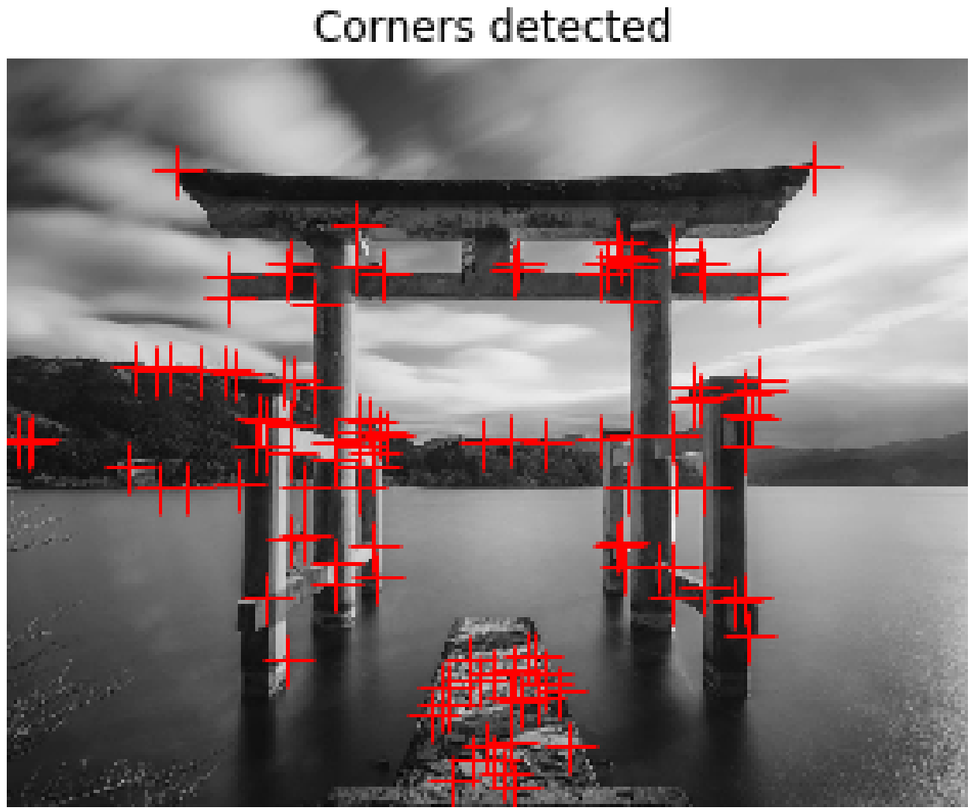
Harris corner detector

```
# Finds the coordinates of the corners
coords = corner_peaks(corner_harris(image), min_distance=5)


print("A total of", len(coords), "corners were detected.")
```

```
A total of 122 corners were found from measure response image.
```

Corners detected

```
# Show image with marks in detected corners
show_image_with_detected_corners(image, coords)
```



Show image with contours

```
def show_image_with_corners(image, coords, title="Corners detected"):
    plt.imshow(image, interpolation='nearest', cmap='gray')
    plt.title(title)
    plt.plot(coords[:, 1], coords[:, 0], '+r', markersize=15)
    plt.axis('off')
    plt.show()
```

Let's practice!

IMAGE PROCESSING IN PYTHON

Face detection

IMAGE PROCESSING IN PYTHON

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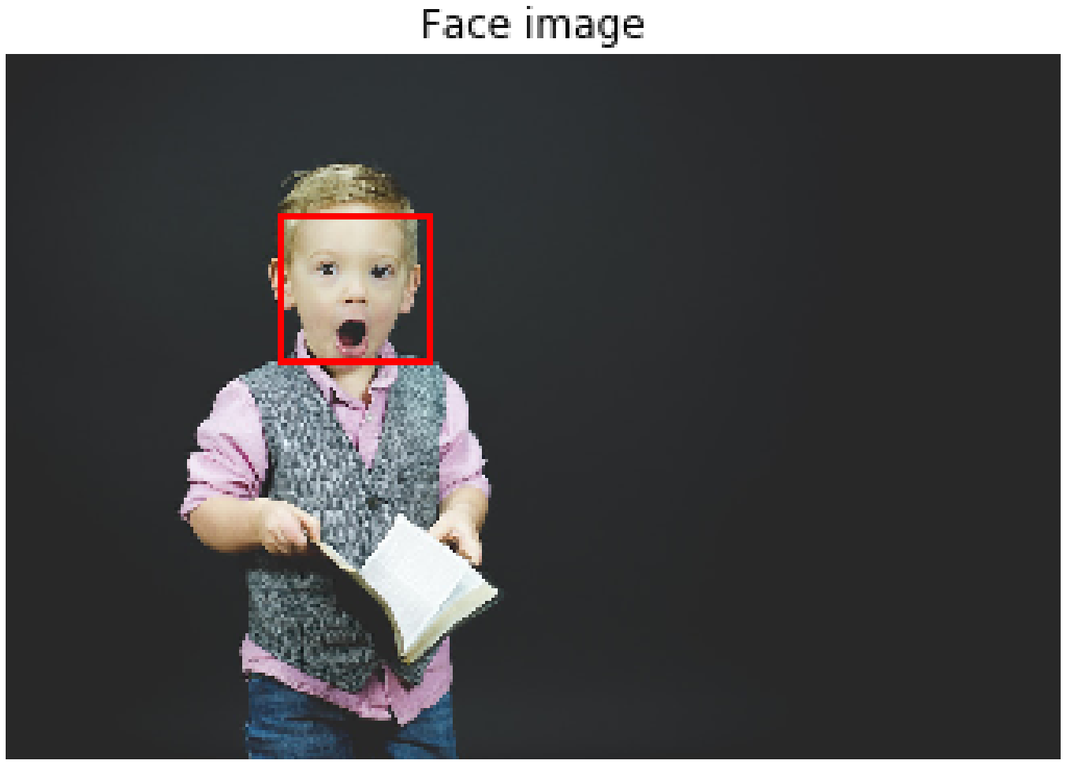
Data Engineer

datacamp

Face detection use cases

- Filters
- Auto focus
- Recommendations
- Blur for privacy protection
- To recognize emotions later on

Detecting faces with scikit-image

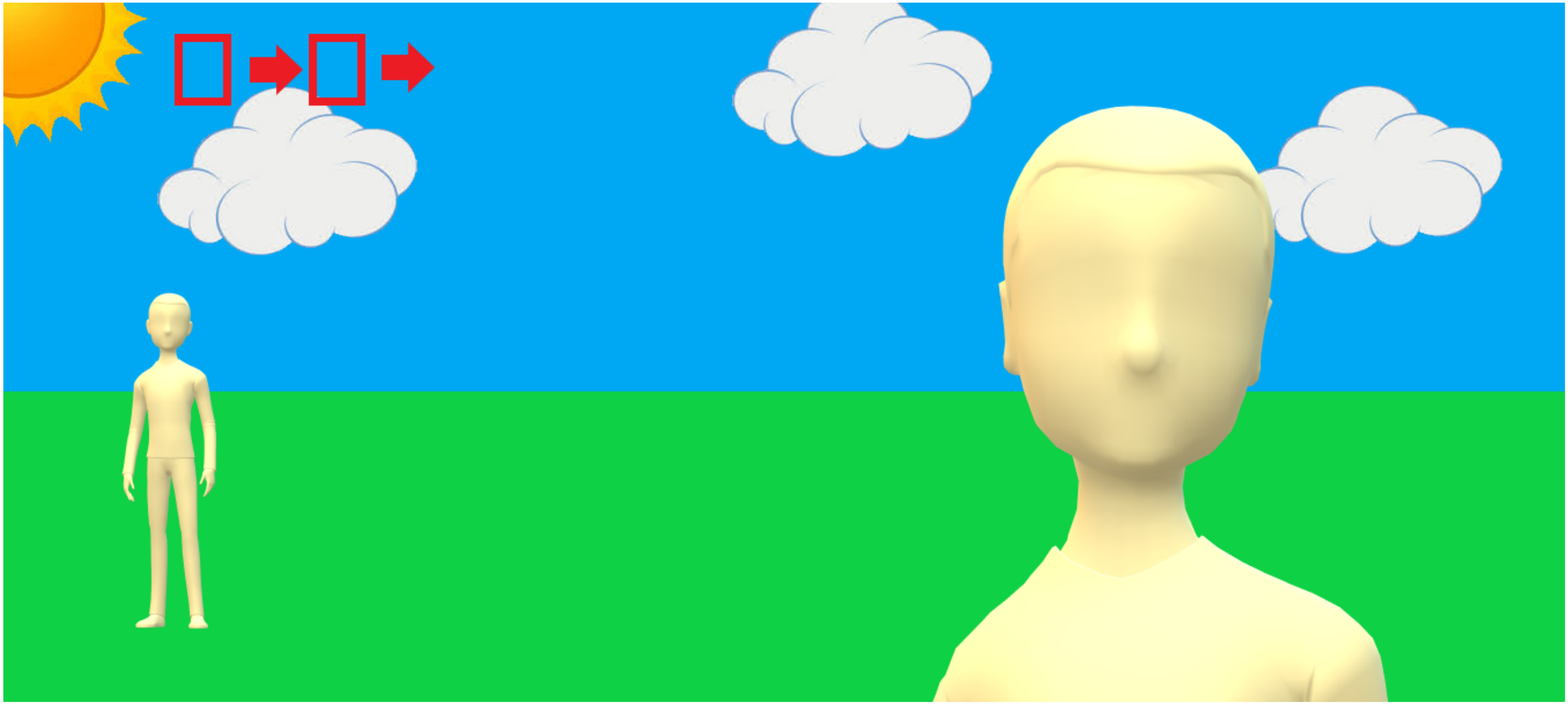


Detecting faces with scikit-image

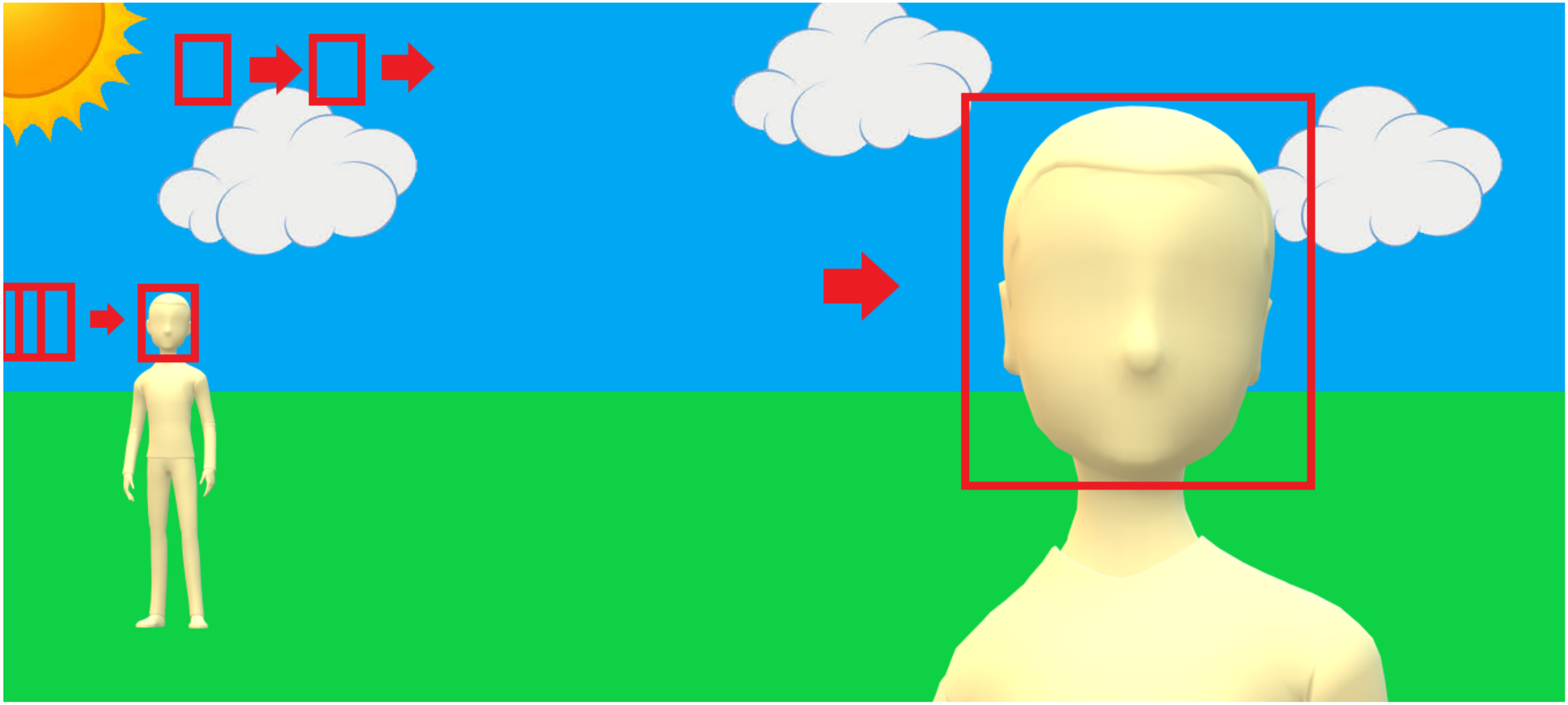
```
# Import the classifier class
from skimage.feature import Cascade

# Load the trained file from the module root.
trained_file = data.lbp_frontal_face_cascade_filename()

# Initialize the detector cascade.
detector = Cascade(trained_file)
```

Let's try it

Detecting faces



Detecting faces



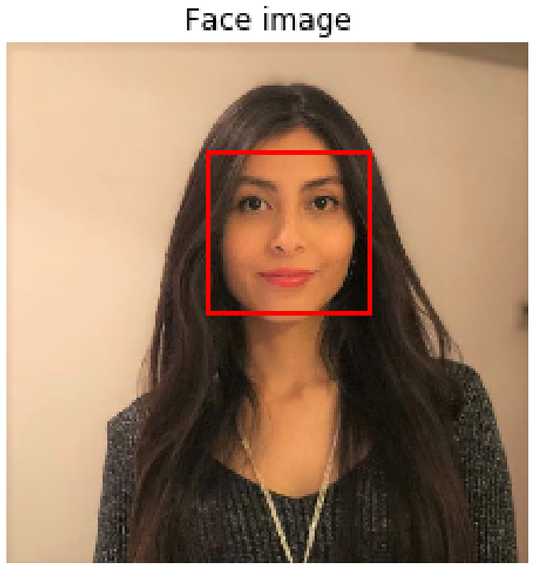
Detecting faces

```
# Apply detector on the image
detected = detector.detect_multi_scale(img=image,
                                       scale_factor=1.2,
                                       step_ratio=1,
                                       min_size=(10, 10),
                                       max_size=(200, 200))
```

Detected faces

```
print(detected)
# Show image with detected face marked
show_detected_face(image, detected)
```

```
Detected face: [{'r': 115, 'c': 210, 'width': 167, 'height': 167}]
```



Show detected faces

```
def show_detected_face(result, detected, title="Face image"):
    plt.imshow(result)
    img_desc = plt.gca()
    plt.set_cmap('gray')
    plt.title(title)
    plt.axis('off')

    for patch in detected:
        img_desc.add_patch(
            patches.Rectangle(
                (patch['c'], patch['r']),
                patch['width'],
                patch['height'],
                fill=False,color='r',linewidth=2)
        )
    plt.show()
```

Let's practice!

IMAGE PROCESSING IN PYTHON

Real-world applications

IMAGE PROCESSING IN PYTHON

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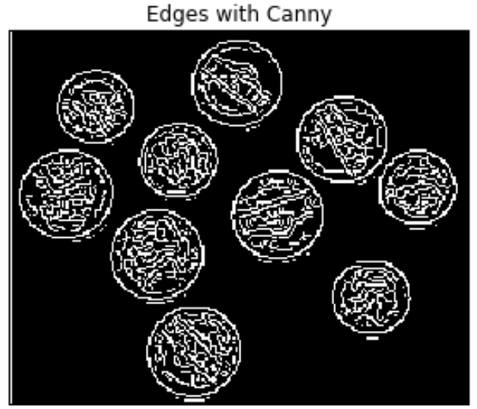
Data engineer

datacamp

Applications

- Turning to grayscale before detecting edges/corners
- Reducing noise and restoring images
- Blurring faces detected
- Approximation of objects' sizes



Privacy protection

Privacy protection

```
# Import Cascade of classifiers and gaussian filter
from skimage.feature import Cascade
from skimage.filters import gaussian
```

Privacy protection

```
# Detect the faces
detected = detector.detect_multi_scale(img=image,
                                       scale_factor=1.2, step_ratio=1,
                                       min_size=(50, 50), max_size=(100, 100))
# For each detected face
for d in detected:
    # Obtain the face cropped from detected coordinates
    face = getFace(d)
```

Privacy protection

```
def getFace(d):
    ''' Extracts the face rectangle from the image using the
    coordinates of the detected.'''
    # X and Y starting points of the face rectangle
    x, y  = d['r'], d['c']

    # The width and height of the face rectangle
    width, height = d['r'] + d['width'],  d['c'] + d['height']

    # Extract the detected face
    face= image[x:width, y:height]
    return face
```

Privacy protection

```
# Detect the faces
detected = detector.detect_multi_scale(img=image,
                                       scale_factor=1.2, step_ratio=1,
                                       min_size=(50, 50), max_size=(100, 100))
# For each detected face
for d in detected:
    # Obtain the face cropped from detected coordinates
    face = getFace(d)

    # Apply gaussian filter to extracted face
    gaussian_face = gaussian(face, multichannel=True, sigma = 10)

    # Merge this blurry face to our final image and show it
    resulting_image = mergeBlurryFace(image, gaussian_face)
```

Privacy protection

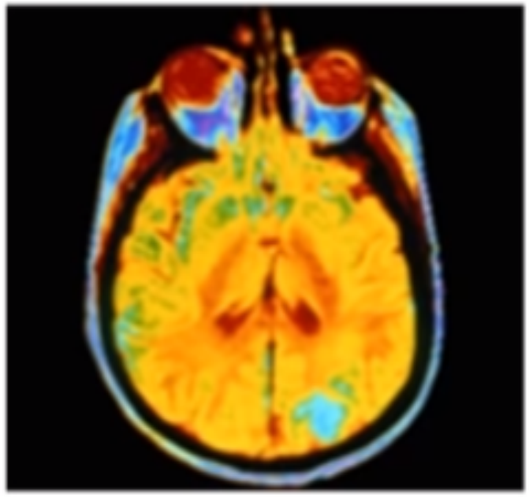
```
def mergeBlurryFace(original, gaussian_image):
    # X and Y starting points of the face rectangle
    x, y  = d['r'], d['c']
    # The width and height of the face rectangle
    width, height = d['r'] + d['width'],  d['c'] + d['height']

    original[ x:width, y:height] =  gaussian_image
    return original
```

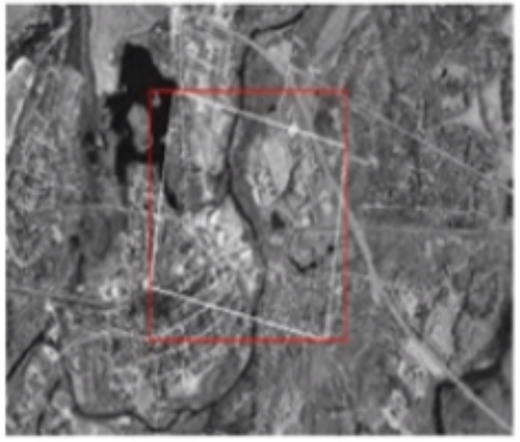
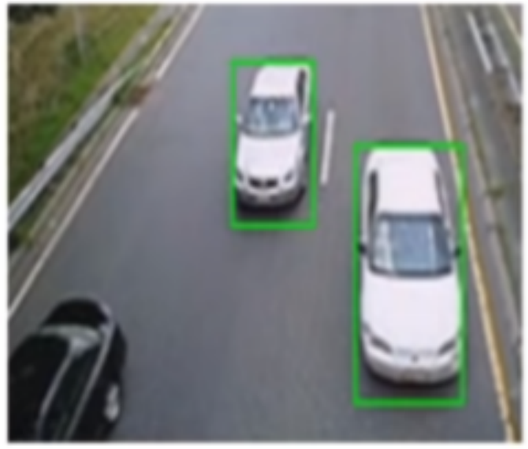
Privacy protection

Blurred faces

More cases





Let's practice!

IMAGE PROCESSING IN PYTHON

Amazing work!

IMAGE PROCESSING IN PYTHON

Rebeca Gonzalez
Data Engineer

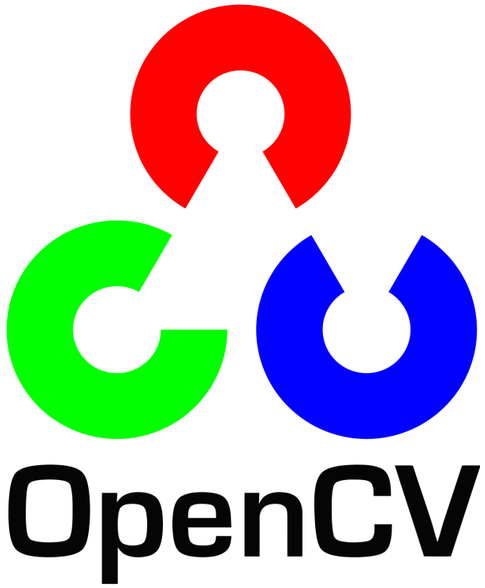
datacamp

Recap: What you have learned

- Improved contrast
- Restored images
- Applied filters
- Rotated, flipped and resized!
- Segmented: supervised and unsupervised
- Applied morphological operators
- Created and reduced noise
- Detected edges, corners and faces
- And mixed them up to solve problems!

What's next?

- Tinting gray scale images
- Matching
- Approximation
- Many others!



Congrats!

IMAGE PROCESSING IN PYTHON