COMP 204

Introduction to image analysis with scikit-image (part two)

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Grayscaling

Many image processing algorithms assume a 2D matrix

- not an image with a third dimension of color

To bring the image into two dimensions

- we need to summarize the three colors into a single value
- this process is more commonly know as **grayscaling**
- where the resulting image only holds intensities of gray
  - with values between 0 and 1

skimage submodule **color** has useful functions for this task

- API `http://scikit-image.org/docs/dev/api/skimage.color.html`

Grayscaling

Goal: Create a grayscale version of a color image (see next slide)

```
import skimage.io as io
import skimage.color as color
import matplotlib.pyplot as plt
from skimage.color import rgb2gray

# read image into memory
image = io.imread("monkey.jpg")
# convert to grayscale
gray_image = rgb2gray(image)

print(image[0,0])  # prints [255,255,255]
print(gray_image[0,0])  # prints 1.0
plt.imshow(gray_image)
plt.show()
io.imsave("monkey_grayscale.jpg",gray_image)
```

Binary image

Goal: Produce a black-and-white version of a color image (see next slide).

```python
import skimage.io as io
import skimage.color as color
import matplotlib.pyplot as plt
from skimage.color import rgb2gray
import numpy as np

image = io.imread("monkey.jpg")
gray_image = rgb2gray(image)

# this creates a new array,
# with 1's everywhere gray_image>0.5, and 0 elsewhere
black_and_white = np.where(gray_image>0.5, 255, 0)

plt.imshow(black_and_white)
plt.show()
io.imsave("monkey_black_and_white.jpg",black_and_white)
```

Blurring an image

Goal: Reduce the resolution of an image by blurring it, e.g. to reduce fine-level ”noise” (unwanted details).

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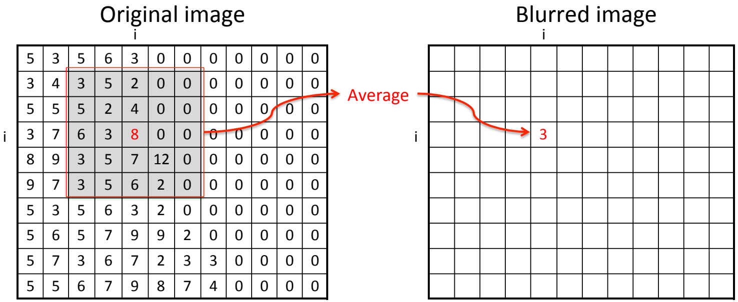
Blurring an image

Blurring is achieved by replacing each pixel by the average value of the pixels in a small window centered on it.
Example, window of size 5:



Original image

5	3	5	6	3	0	0	0	0	0	0	0
3	4	3	5	2	0	0	0	0	0	0	0
5	5	5	2	4	0	0	0	0	0	0	0
3	7	6	3	8	0	0	0	0	0	0	0
8	9	3	5	7	12	0	0	0	0	0	0
9	7	3	5	6	2	0	0	0	0	0	0
5	3	5	6	3	2	0	0	0	0	0	0
5	6	5	7	9	9	2	0	0	0	0	0
5	7	3	6	7	2	3	3	0	0	0	0
5	5	6	7	9	8	7	4	0	0	0	0

Blurred image

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Blurring an image

```
def blur(image, filter_size):
    n_row, n_col, colors = image.shape
    blurred=np.zeros((n_row, n_col, colors),dtype=np.uint8)
    half_size=int(filter_size/2)
    for i in range(n_row):
        for j in range(n_col):
            # define the boundaries of window around (i,j)
            left=max(0,j-half_size)
            right=min(j+half_size,n_row)
            top=max(0,i-half_size)
            bot=min(n_col,i+half_size)
            # calculate average of RGB values in window
            blurred[i,j] = \
                image[bot:top,left:right,:].mean(axis=(0,1))
    return blurred_image
```

- `image[ bottom:top, left:right , ,:]` corresponds to the sub-image ranging from rows bottom to top-1 and columns left to right-1, and all 3 color dimensions.
- `means(axis=(0,1))` states that we want to take an average over dimension 0 (rows) and dimension 1 (columns) but not dimension 2 (RGB). This returns that a 1d ndarray containing the average red, green, and blue values in the subimage.

Original image

Window size $= 5$

Window size = 21

Window size = 101

Running time issues

Note: When our window size is large (say 101), blurring the image is slow (> 1 minute). Why?

- Our image is 674×1200 pixels.
- For each pixel in the image, we need to calculate the average of the 101×101 pixels around it, and for each of the three colors!
- The total number of operations is proportional to $674 \times 1200 \times 101 \times 101 = 25$ Billion operations!

SkImage has many built-in blurring functions (called filters) with faster implementations:
http://scikit-image.org/docs/dev/api/skimage.filters.html

Edge detection

Goal: Identify regions of the image that contain sharp changes in colors/intensities.
Why? Useful for

- delineating objects (image segmentation)
- recognizing them (object recognition)
- etc.

Edge detection

Edge detection

Edge detection

What's an edge in an image?

Horizontal edge at row i: $\mathit{image}(i-1, j)$ is very different from $\mathit{image}(i+1, j)$

Vertical
edge at column j: $\mathit{image}(i, j-1)$ is very different from $\mathit{image}(i, j+1)$

Idea:
For each position (i, j) and each color (RGB), calculate
change_hor = image(i-1,j, color) - image(i+1,j, color)
change_vert = image(i,j-1, color) - image(i,j+1, color)
edge_image(i,j,color) = sqrt(change_hor^2 + change_vert^2)

Edge detection

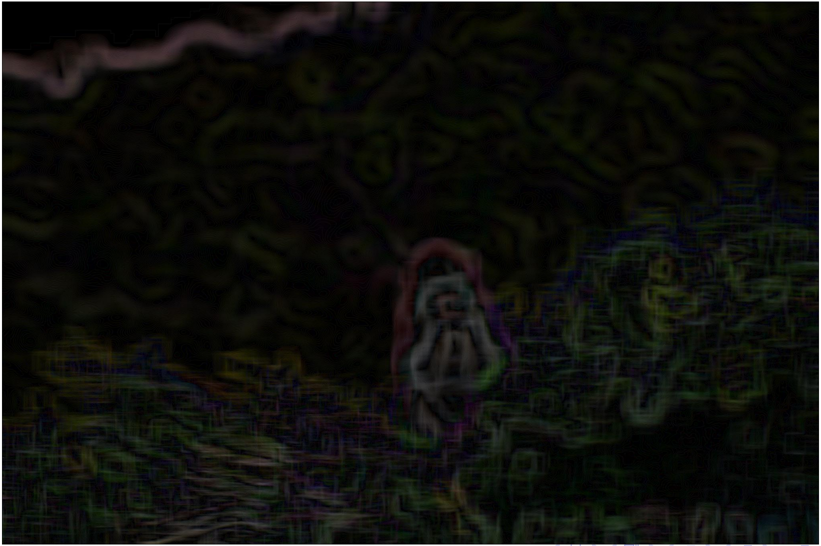
```python
def detect_edges(image):
    n_row, n_col, colors = image.shape
    edge_image = np.zeros( (n_row,n_col,3), dtype=np.uint8)
    for i in range(1,n_row-1):
        for j in range(1,n_col-1):
            for c in range(3):

                # conversion to int needed to accommodate
                # for potentially negative values
                d_r=int(image[i-1,j,c])-int(image[i+1,j,c])
                d_c=int(image[i,j-1,c])-int(image[i,j+1,c])
                grad = math.sqrt(d_r**2+d_c**2)

                # limit value to 255
                edge_image[i,j,c]=np.uint8(min(255,grad))
    return edge_image
```

Edge detection on monkey image

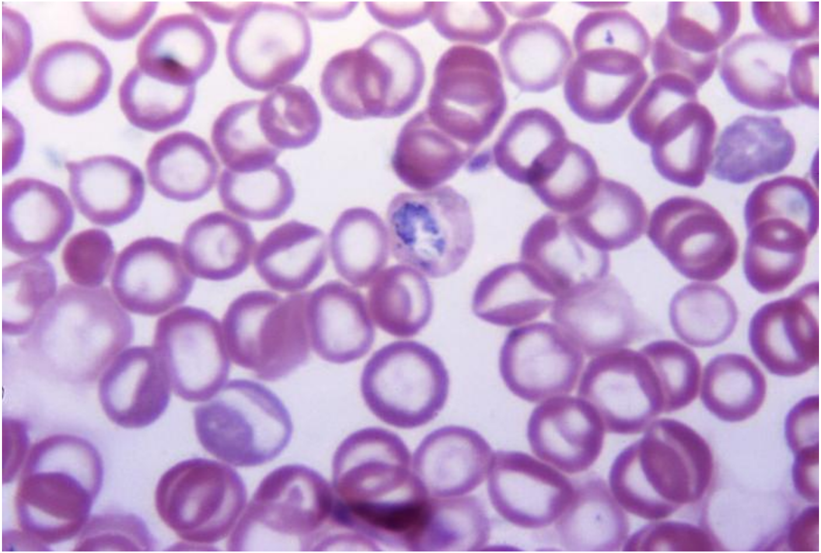
Not so great if our goal is to find the monkey in the image!

Blurring + Edge detection

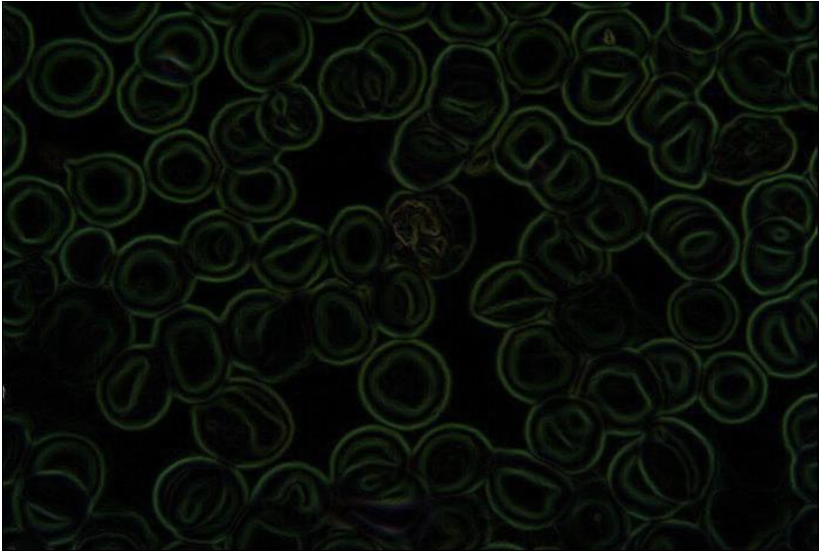
To smooth out fine details like leaves:
Start by blurring the image, then apply edge detection.



Analysis of microscopy images



Edge detection



Edge detection

Skimage has many edge detection algorithms:
`http://scikit-image.org/docs/0.5/auto_examples/plot_canny.html`