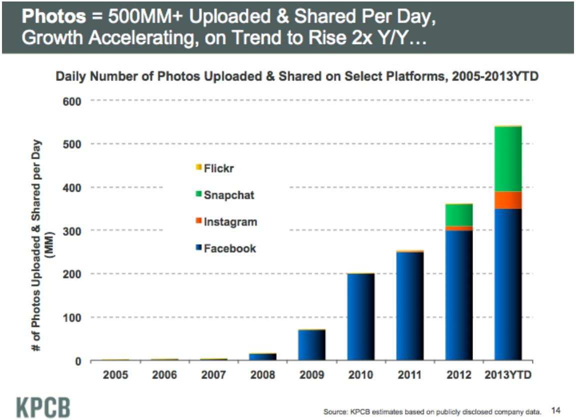
Image processing with `scikit-image`

Emmanuelle Gouillart
Surface, Glass and Interfaces, CNRS/Saint-Gobain

Paris-Saclay Center for Data Science

The world is getting more and more visual

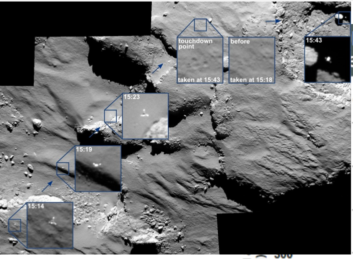


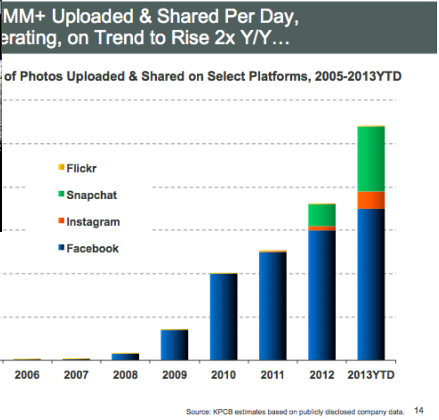
Photos = 500MM+ Uploaded & Shared Per Day,
Growth Accelerating, on Trend to Rise 2x Y/Y…

Daily Number of Photos Uploaded & Shared on Select Platforms, 2005-2013YTD

Source: KPCB estimates based on publicly disclosed company data. 14

The world is getting more and more visual





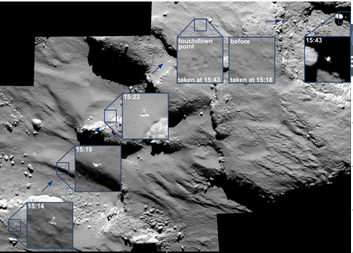
MM+ Uploaded & Shared Per Day,
erating, on Trend to Rise 2x Y/Y…

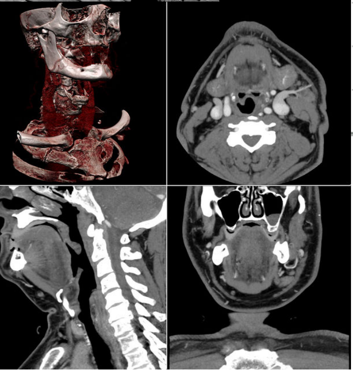
of Photos Uploaded & Shared on Select Platforms, 2005-2013YTD

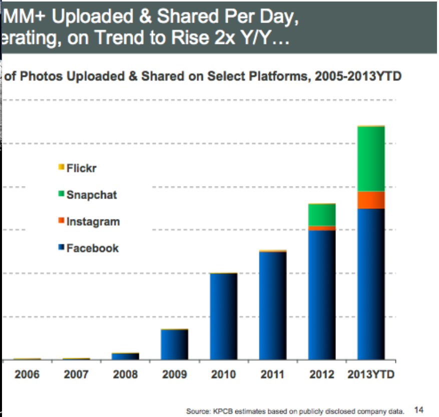
KPCB

Source: KPCB estimates based on publicly disclosed company data.

The world is getting more and more visual







MM+ Uploaded & Shared Per Day,
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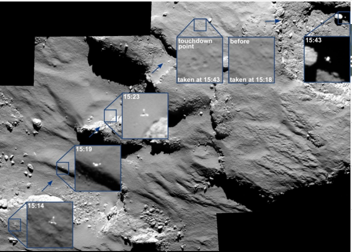

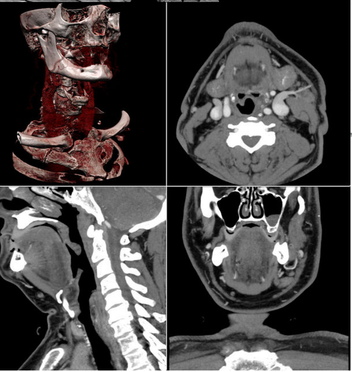

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of Photos Uploade
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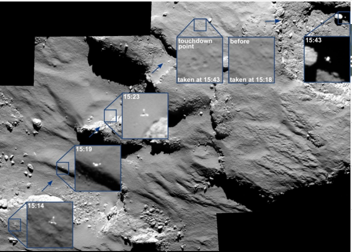
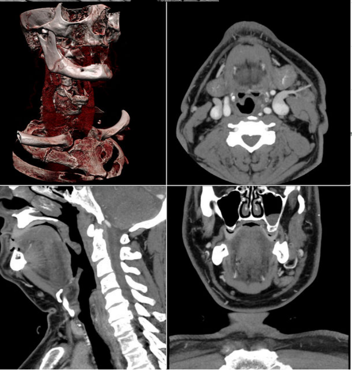
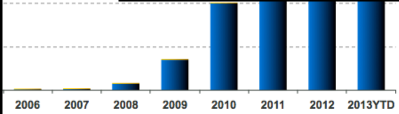
Snapchat
Instagram
Facebook
2006
2007
2008
2009
2010
2011
2012
2013YTD
Russian → English
PARKING SERVICE VEHICLES
Russian → English
СТОЯНКА СЛУЖЕБНОГО АВТОТРАНСПОРТА

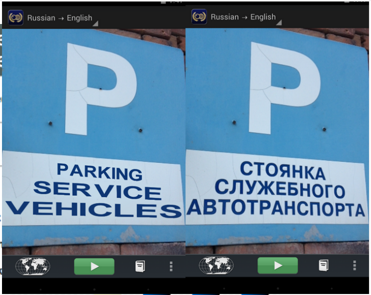
Source: KPCB estimates based on publicly disclosed company data. 14

The world is getting more and more visual









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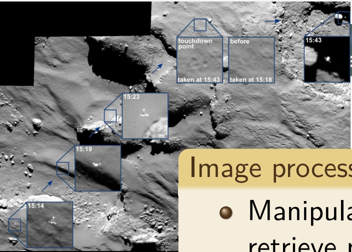
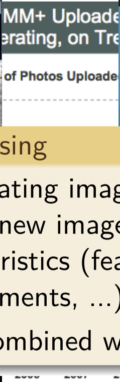




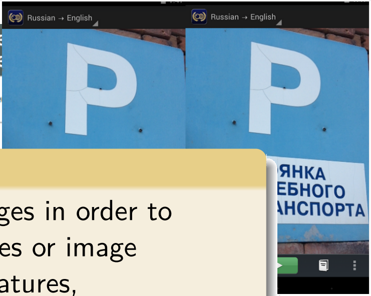
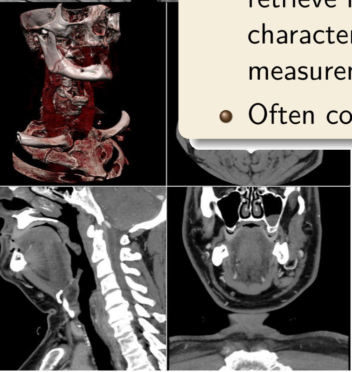


Image processing

- Manipulating images in order to retrieve new images or image characteristics (features, measurements, ...)
- Often combined with machine learning



scikit-image

http://scikit-image.org/

A module of the Scientific Python stack

- Language: Python
    - Core modules: NumPy, SciPy, matplotlib
        - Application modules: scikit-learn, scikit-image, pandas, ...

A general-purpose image processing library

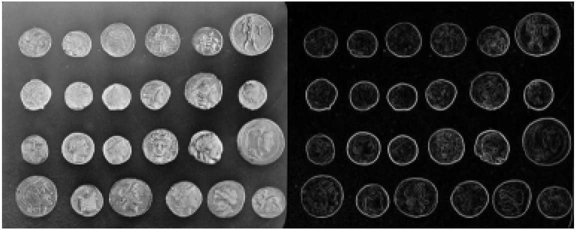
- open-source (BSD)
- not an application (ImageJ)
- less specialized than other libraries (e.g. OpenCV for computer vision)

1 Principle

1 First steps

```python
from skimage import data, io, filter

image = data.coins() # or any NumPy array!
edges = filter.sobel(image)
io.imshow(edges)
io.show()
```

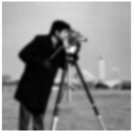


My environment: IPython interpreter + text editor
Ipython notebook nice for demos/trial and error

1 Manipulating images as numpy arrays

- numpy arrays as arguments and outputs

```
>>> from skimage import io, filter
>>> camera_array = io.imread('camera_image.png')
>>> type(camera_array)
<type 'numpy.ndarray'>
>>> camera_array.dtype
dtype('uint8')
>>> filtered_array = filter.gaussian_filter(
    camera_array, sigma=5)
>>> type(filtered_array)
<type 'numpy.ndarray'>
>>> filtered_array.dtype
dtype('float64')
```

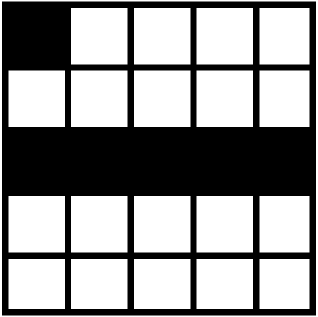


http://www.numpy.org/
scipy-lectures.github.io/intro/numpy/index.html

1 Manipulating images as numerical (numpy) arrays

- Pixels are arrays elements

```
import numpy as np
image = np.ones((5, 5))
image[0, 0] = 0
image[2, :] = 0
```



(use matplotlib for visualization: matplotlib.pyplot.imshow)

1 Manipulating images as numerical (numpy) arrays

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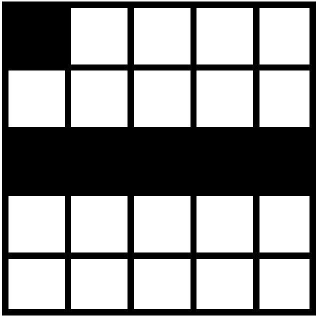


(use matplotlib for visualization: matplotlib.pyplot.imshow)

1 Some magics inside

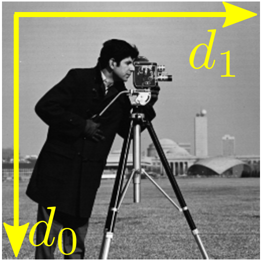
Don't let yourself be tricked by integer / float conversion!

```
>>> from skimage import data, filter
>>> camera_array = data.camera()
>>> camera_array.dtype
dtype('uint8')
>>> filtered_array = filter.gaussian_filter(
    camera_array, sigma=5)
>>> filtered_array.dtype
dtype('float64')
>>> camera_array.min(), camera_array.max()
(0, 255)
>>> filtered_array.min(), filtered_array.max()
(0.031287384322526979, 0.85609948978467 72)
```

1 An API relying mostly on functions

```
skimage.filter.gaussian_filter(image, sigma, output=
    None, mode='nearest', cval=0, multichannel=None)

Multi-dimensional Gaussian filter

Parameters
----------

image : array-like
    input image (grayscale or color) to filter.
sigma : scalar or sequence of scalars
    standard deviation for Gaussian kernel. The
        standard
    deviations of the Gaussian filter are given for
        each axis as a
    sequence, or as a single number, in which case it
        is equal for
    all axes.
output : array, optional
    The ``output`` parameter passes an array in which
        to store the
    filter output.
```

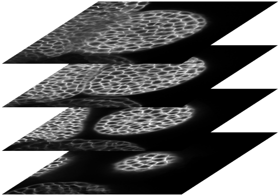
1 Images and dimensions



```
>>> data.camera().shape
(512, 512)
```

- Most functions suitable for 2-D gray- or color-scale images
- Some functions work with 3D images as well
- Check out `scipy.ndimage` for n-d functionnality.

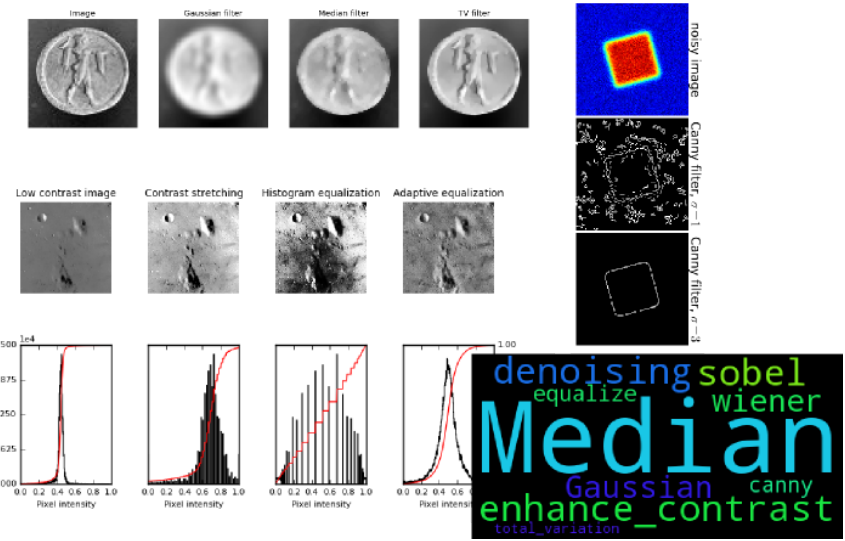
```
>>> coffee.shape
(400, 600, 3)
>>> red_channel =
coffee[..., 0]
```



(d_0, d_1, d_2)

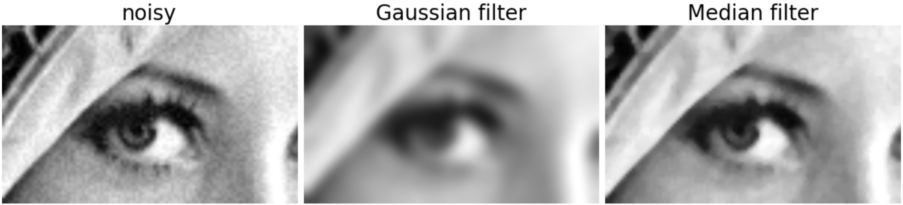
2 Some features

2 Filtering: transforming image data



skimage.filter, skimage.exposure, skimage.restoration

2 From very simple/classical algorithms



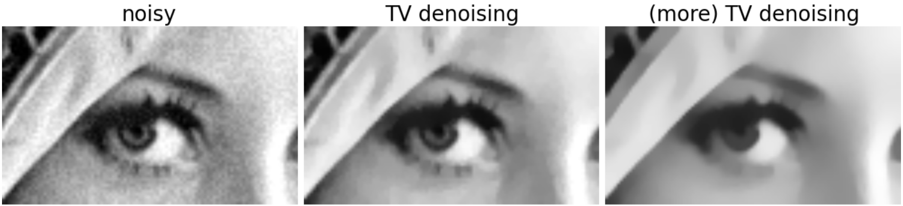
noisy

Gaussian filter

Median filter

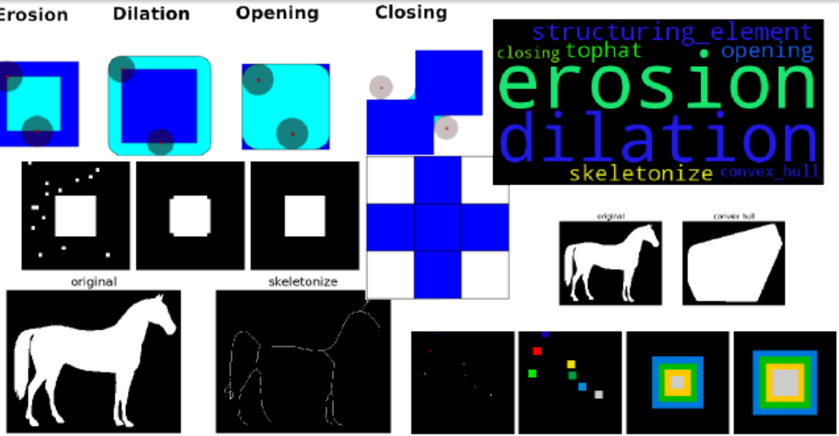
```
from skimage import data, filter, color
from skimage.morphology import disk

I = data.lena()
I = color.rgb2grey(I)
I = I[230:290, 220:320]

noisy = I + 0.4 * I.std() * np.random.random(I.shape)

gaussian_denoised = filter.gaussian_filter(noisy,
    sigma=2)
median_denoised = filter.rank.median(noisy, disk(3))
```

2 To more advanced/recent algorithms



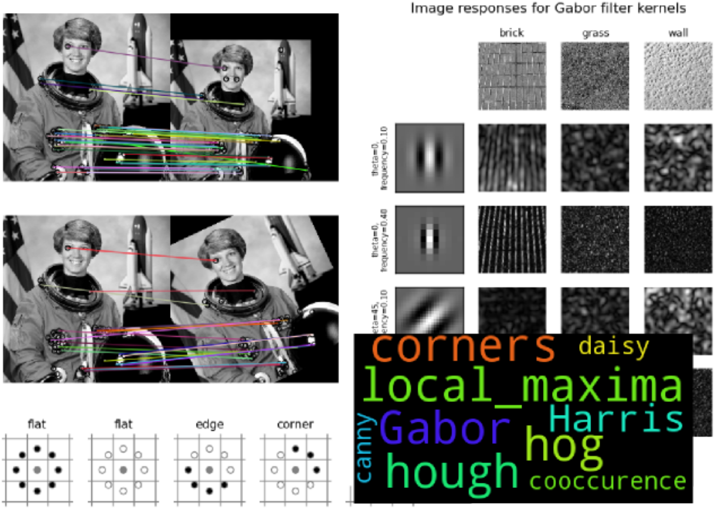
```
from skimage.filter import tv_denoise
from skimage import data

l = data.lena()
l = l[230:290, 220:320]
noisy = l + 0.4*l.std()*np.random.random(l.shape)

tv_denoised = tv_denoise(noisy, weight=10)
```

2 Mathematical morphology



skimage.morphology

2 Extracting features



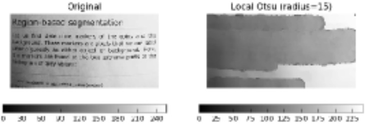
skimage.feature, skimage.filter

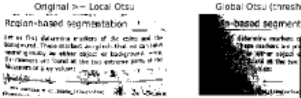
2 Geometrical transformations

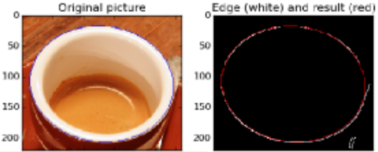
`skimage.transform`

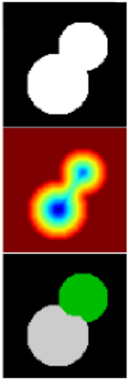
scale, zoom, rotate, swirl, warp, ...

2 Segmentation: labelling regions









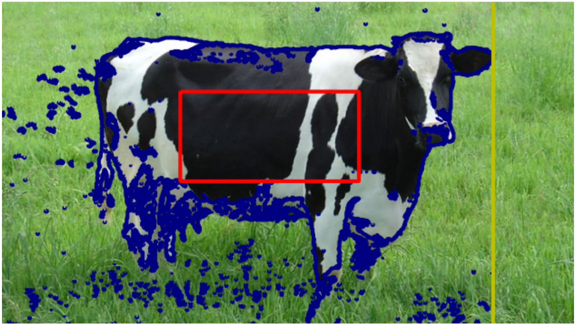
Felzenszwalbs's method

`skimage.segmentation`

2 Feature extraction followed by classification

Combining `scikit-image` and `scikit-learn`

- Extract features (`skimage.feature`)
  - Pixels intensity values (R, G, B)
  - Local gradients
  - More advanced descriptors: HOGs, Gabor, ...
- Train classifier with known regions
  - here, random forest classifier
- Classify pixels



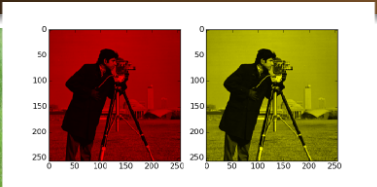
2 Measures on images

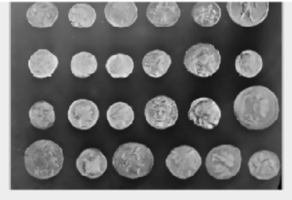
size
label
measure
histogram
regionprops
0
50
100
150
200
250
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300

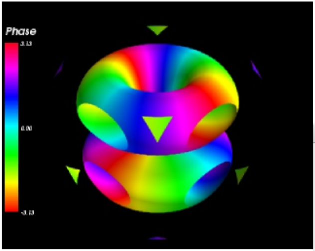
skimage.measure

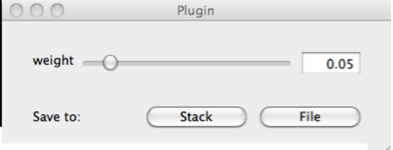
2 Visualizing images and more

matplotlib, mayavi

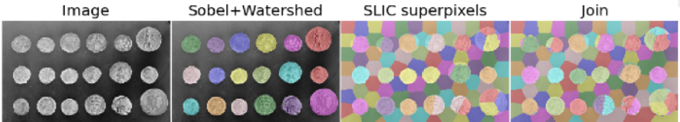








weight 0.05



Image

Sobel+Watershed

SLIC superpixels

Join

2 Development of `scikit-image`

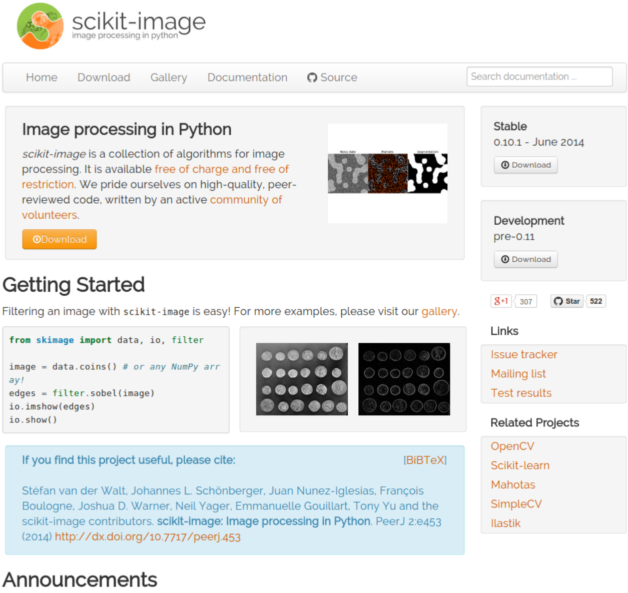
- Mature algorithms
- Only `Python` + `Cython` code for easier maintainability
- Hosted on GitHub
- Thorough code review by others: readability, PEP8, efficiency, ...
- 1-2 releases per year
- Core team of 5 persons (+ GSoc students)

2 Getting started: installing `scikit-image`

http://scikit-image.org/docs/dev/install.html

- Packaged on Ubuntu/Debian
- Shipped with all major Scientific Python distributions: Enthought Canopy, Anaconda, Python(x,y)

2 Getting started: finding documentation



scikit-image
image processing in python

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Image processing in Python

scikit-image is a collection of algorithms for image processing. It is available free of charge and free of restriction. We pride ourselves on high-quality, peer-reviewed code, written by an active community of volunteers.

Download

Stable
0.10.1 - June 2014
Download

Development
pre-0.11
Download

8+1 307 | Star 522

Getting Started

Filtering an image with `scikit-image` is easy! For more examples, please visit our gallery.

```
from skimage import data, io, filter

image = data.coins() # or any NumPy arr
ay!
edges = filter.sobel(image)
io.imshow(edges)
io.show()
```

If you find this project useful, please cite: [BiBTeX]

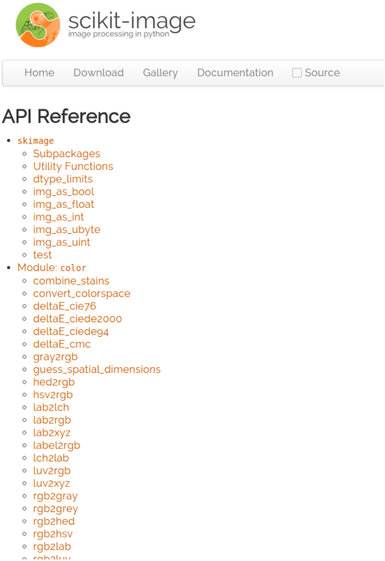
Stéfan van der Walt, Johannes L. Schönberger, Juan Nunez-Iglesias, François Boulogne, Joshua D. Warner, Neil Yager, Emmanuelle Gouillart, Tony Yu and the scikit-image contributors. **scikit-image: Image processing in Python**. PeerJ 2:e453 (2014) http://dx.doi.org/10.7717/peerj.453

Links
- Issue tracker
- Mailing list
- Test results

Related Projects
- OpenCV
- Scikit-learn
- Mahotas
- SimpleCV
- Ilastik

Announcements

2 Getting started: finding documentation



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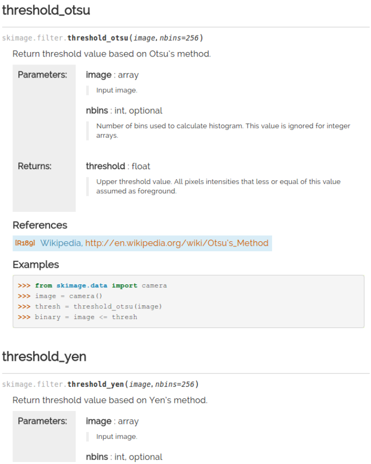
API Reference

- skimage
  - Subpackages
  - Utility Functions
  - dtype_limits
  - img_as_bool
  - img_as_float
  - img_as_int
  - img_as_ubyte
  - img_as_uint
  - test
- Module: color
  - combine_stains
  - convert_colorspace
  - deltaE_cie76
  - deltaE_ciede2000
  - deltaE_ciede94
  - deltaE_cmc
  - gray2rgb
  - guess_spatial_dimensions
  - hed2rgb
  - hsv2rgb
  - lab2lch
  - lab2rgb
  - lab2xyz
  - label2rgb
  - lch2lab
  - luv2rgb
  - luv2xyz
  - rgb2gray
  - rgb2grey
  - rgb2hed
  - rgb2hsv
  - rgb2lab
  - rgb2luv



threshold_otsu

`skimage.filter.threshold_otsu(image, nbins=256)`

Return threshold value based on Otsu's method.

Parameters:	**image** : array Input image. **nbins** : int, optional Number of bins used to calculate histogram. This value is ignored for integer arrays.
Returns:	**threshold** : float Upper threshold value. All pixels intensities that less or equal of this value assumed as foreground.

References

[R189] Wikipedia, http://en.wikipedia.org/wiki/Otsu's_Method

Examples

```
>>> from skimage.data import camera
>>> image = camera()
>>> thresh = threshold_otsu(image)
>>> binary = image <= thresh
```

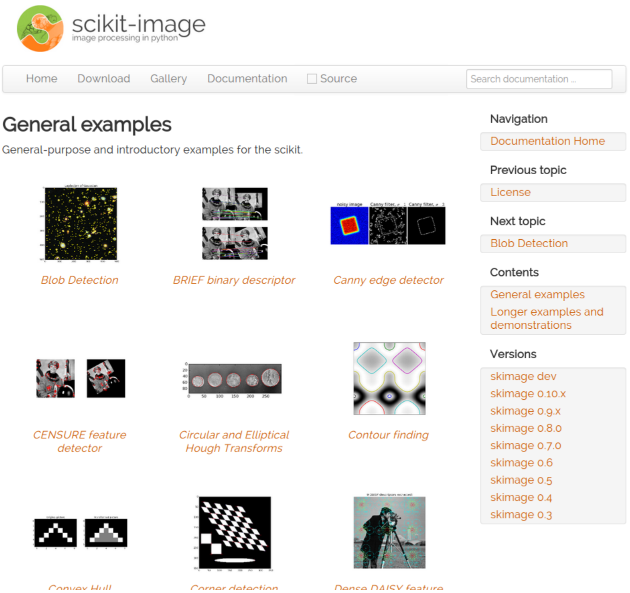
threshold_yen

`skimage.filter.threshold_yen(image, nbins=256)`

Return threshold value based on Yen's method.

Parameters:	**image** : array Input image. **nbins** : int, optional

2 Gallery of examples



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General examples

General-purpose and introductory examples for the scikit.

Blob Detection

BRIEF binary descriptor

Canny edge detector

CENSURE feature detector

Circular and Elliptical Hough Transforms

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Convex Hull

Corner detection

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Blob Detection

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Longer examples and demonstrations

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skimage 0.10.x

skimage 0.9.x

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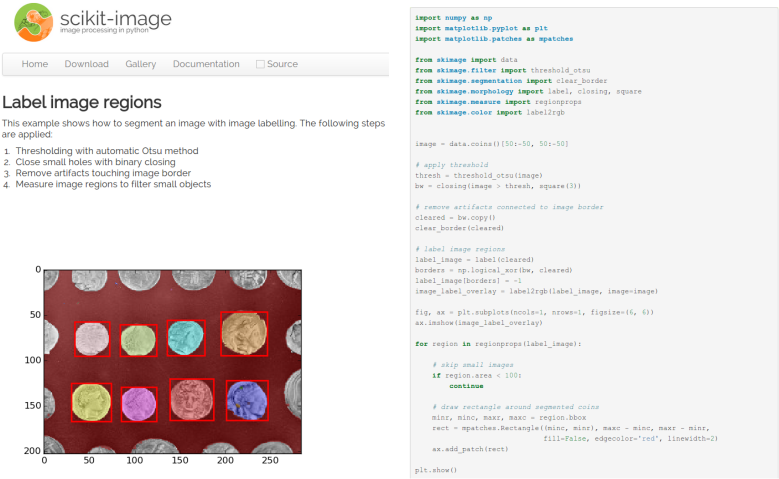
skimage 0.6

skimage 0.5

skimage 0.4

skimage 0.3

2 Getting started: finding documentation



Label image regions

This example shows how to segment an image with image labelling. The following steps are applied:

1. Thresholding with automatic Otsu method
2. Close small holes with binary closing
3. Remove artifacts touching image border
4. Measure image regions to filter small objects

```
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.patches as mpatches

from skimage import data
from skimage.filter import threshold_otsu
from skimage.segmentation import clear_border
from skimage.morphology import label, closing, square
from skimage.measure import regionprops
from skimage.color import label2rgb


image = data.coins()[50:-50, 50:-50]

# apply threshold
thresh = threshold_otsu(image)
bw = closing(image > thresh, square(3))

# remove artifacts connected to image border
cleared = bw.copy()
clear_border(cleared)

# label image regions
label_image = label(cleared)
borders = np.logical_xor(bw, cleared)
label_image[borders] = -1
image_label_overlay = label2rgb(label_image, image=image)

fig, ax = plt.subplots(ncols=1, nrows=1, figsize=(6, 6))
ax.imshow(image_label_overlay)

for region in regionprops(label_image):

    # skip small images
    if region.area < 100:
        continue

    # draw rectangle around segmented coins
    minr, minc, maxr, maxc = region.bbox
    rect = mpatches.Rectangle((minc, minr), maxc - minc, maxr - minr,
                              fill=False, edgecolor='red', linewidth=2)
    ax.add_patch(rect)

plt.show()
```

2 Conclusions

scikit-image

- An image processing Python module relying on NumPy arrays
- Trade-off between performance and usability
- More and more features
- Try it out!
  - http://scikit-image.org/
  - https://www.youtube.com/watch?v=SE7h0IWD93Y (and others)
  - http://scipy-lectures.github.io/packages/scikit-image/