Image Processing SoSe 22 - Assignment - 02

Deadline is 05.05.2022 at 11:55am

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Please solve the assignments together with a partner. I will run every notebook. Make sure the code runs through. Select `Kernel -> Restart & Run All` to test it.

Exercise 1 - 4 Points

Implement the `rgb_to_hsv` and `hsv_to_rgb` functions. Don't use any color conversion functions from a library.

In [ ]:
```
import math

def rgb_to_hsv(image):
    """
    Converts the numpy array `x` from RGB to the HSV.
    """
    return np.array([[rgb_to_hsv_pixel_1(y) for y in x] for x in image])

#there are two ways to calculate this.

def rgb_to_hsv_pixel_1(entry):
    r = entry[0]
    g = entry[1]
    b = entry[2]
    c_max_index =  np.argmax([r,g,b])
    c_min_index = np.argmin([r,g,b])
    delta = max(r,g,b) - min(r,g,b)
    hue = -1
    if delta==0:
        hue = 0
    elif c_max_index==0:
        hue = 60 * (((g-b)/delta)+0)
    elif c_max_index==1:
        hue = 60 * (((b-r)/delta)+2)
    else :
        hue = 60 * (((r-g)/delta)+4)
    if hue < 0 :
        hue += 360
    if max(r,g,b)==0:
        saturation = 0
    else :
        saturation = delta/max(r,g,b)
    value = max(r,g,b)
    return [hue,saturation,value]
```

In [ ]:
```
def hsv_to_rgb_pixel(entry):
    """
    Converts the numpy array `x` from HSV to the RGB.
    We took the idea for our algorithm from here :  https://en.wikipedia.or
```

```
    """
    h = entry[0]
    s = entry[1]
    v = entry[2]
    # chroma
    c = v * s
    h1 = h/60
    rgb = [0,0,0]
    if h1 < 0 or h1 > 6:
        print("not valid value")
    x = c * (1 - abs(h1 % 2 - 1))
    if h1<1 and h1>=0:
        rgb = [c,x,0]
    elif  h1<2 and h1>=1:
        rgb = [x,c,0]
    elif h1<3 and h1>=2:
        rgb = [0,c,x]
    elif h1<4 and h1>=3:
        rgb = [0,x,c]
    elif h1<5 and h1>=4:
        rgb = [x,0,c]
    else :
        rgb = [c,0,x]
    m = v-c
    r = rgb[0]
    g = rgb[1]
    b = rgb[2]
    rgb = [r + m, g+m, b+m]
    return rgb

def hsv_to_rgb(image):
    """
    Converts the numpy array `x` from HSB to the RGB.
    """
    return np.array([[hsv_to_rgb_pixel(y) for y in x] for x in image])
```

Plot the saturation of the astronaut image (see last assignment)

In [ ]:

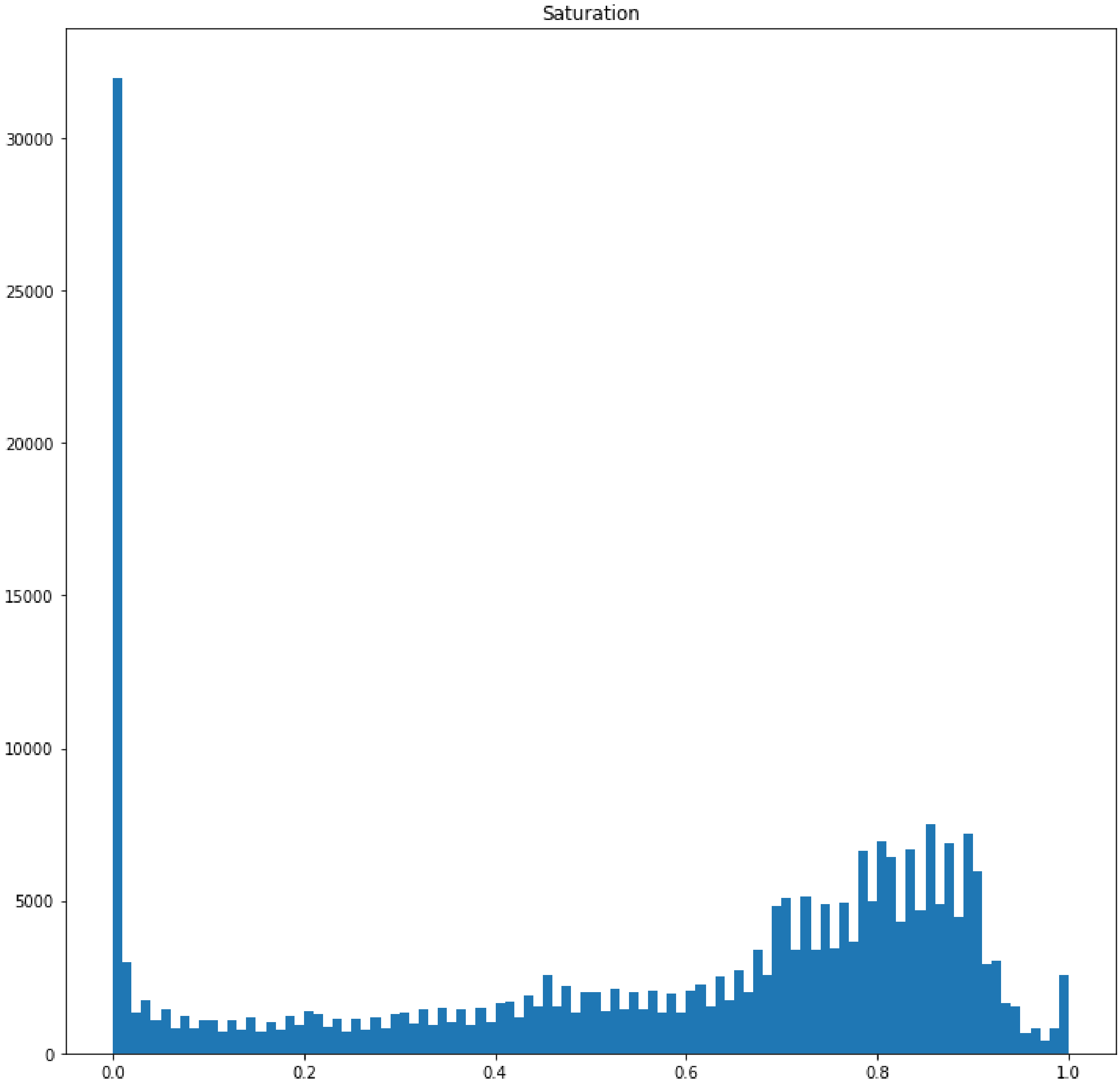
```
# display the plots inside the notebook
%matplotlib inline
from skimage import io, data, color

import numpy as np
import matplotlib.pyplot as plt
from skimage.data import astronaut
import pylab
pylab.rcParams['figure.figsize'] = (12, 12)   # This makes the plot bigger

img = astronaut() / 255.
img_as_hsv = rgb_to_hsv(img)
# your code, saturation is always the first value
sat = img_as_hsv[:,:,-1].flatten()
plt.hist(sat,bins=100)
plt.title("Saturation")
```

Out[ ]:

```
Text(0.5, 1.0, 'Saturation')
```



In [ ]:
```
def mult_2(y):
    if y*2>1:
        return 1
    else :
        return y*2
```

Increase the saturation by a factor of 2, convert it back to RGB and plot the result.

In [ ]:
```
img_as_hsv_sat_inc =  np.array([[[y[0],mult_2(y[1]),y[2]] for y in x] for x
```

In [ ]:
```
img_rgb_back_converted = hsv_to_rgb(img_as_hsv_sat_inc)
io.imshow(img_rgb_back_converted)
```

Out[ ]: <matplotlib.image.AxesImage at 0x7f4ff7dd60d0>

Exercise 2 - 6 Points

Implement affine transformation with [linear interpolation]. Implement the functions `affine_transformation` and `bilinear_interpolation` . Apply some affine transformation of your choice and smooth the output using your bilinear interpolation.

The skimage library comes with multiple useful test images. Let's start with an image of an astronaut.

In [ ]:
```
from skimage.data import astronaut
from skimage.color import rgb2gray
```

In [ ]:
```
# We use a gray image. All the algorithms should work with color images too
img = rgb2gray(astronaut() / 255.)
plt.imshow(img, cmap='gray')
plt.show()
```

In [ ]:

```
def derive_y(image):
    """Computes the derivative of the image w.r.t the y coordinate"""
    derived_image = np.zeros_like(image)
    for x in range(image.shape[0]):
        for y in range(image.shape[1]):
            if y + 1 < image.shape[1] and y - 1 > 0:
                derived_image[x,y] = (image[x, y + 1] - image[x, y - 1]) /
    return derived_image

def derive_x(image):
    """Computes the derivative of the image w.r.t the x coordinate"""
    derived_image = np.zeros_like(image)
    for x in range(image.shape[0]):
        for y in range(image.shape[1]):
            if x + 1 < image.shape[1] and x - 1 > 0:
                derived_image[x,y] = (image[x + 1, y] - image[x - 1, y]) /
    return derived_image
```

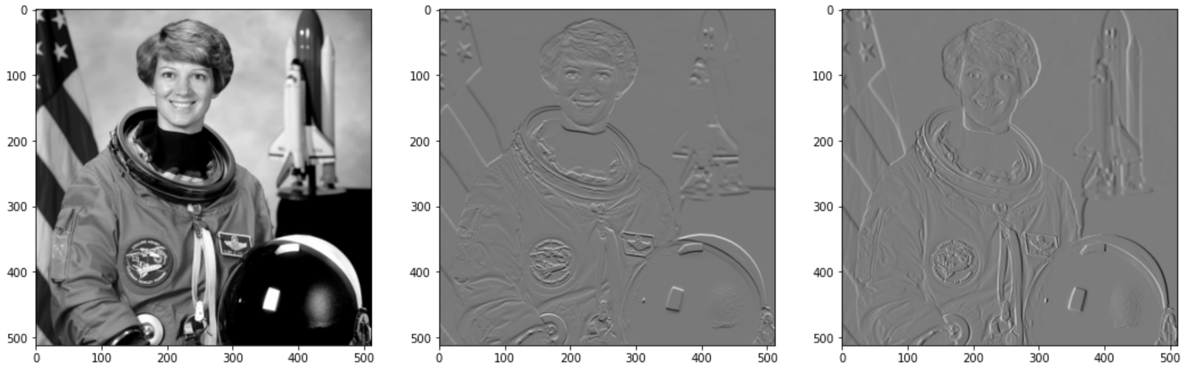
In [ ]:

```
dx_img = derive_x(img)
dy_img = derive_y(img)
```

In [ ]:

```
plt.figure(figsize=(18, 12))
plt.subplot(131)
plt.imshow(img, cmap='gray')
plt.subplot(132)
plt.imshow(dx_img, cmap='gray')
```

```
plt.subplot(133)
plt.imshow(dy_img, cmap='gray')
plt.show()
```



Here are some sample affine transformations to be used later on

In [ ]:
```
T_scale = np.array([
    [0.75, 0, 0],
    [0, 0.75, 0],
    [0, 0, 1],
])
```

In [ ]:
```
T_shear = np.array([
    [1, 0.3, 0],
    [0, 1, 0],
    [0, 0, 1],
])
```

In [ ]:
```
# you can use this function to invert the matricies
np.linalg.inv(T_scale)
```

Out[ ]:
```
array([[1.33333333, 0.        , 0.        ],
       [0.        , 1.33333333, 0.        ],
       [0.        , 0.        , 1.        ]])
```

In [ ]:
```
def affine_transformation(img, matrix):
    output = np.zeros(img.shape)
    #do it here, to make the loop run faster
    inverted_matrix = np.linalg.inv(matrix)
    for x in range(output.shape[0]):
        for y in range(output.shape[1]):
            helper = np.zeros(3)
            helper = inverted_matrix.dot([x,y,1])
            output[x,y] = bilinear_interpolation(img,helper)
    return output
```

In [ ]:
```
import bisect

def bilinear_interpolation(img, indicies):
    x = np.asarray(indicies[0])
    y = np.asarray(indicies[1])

    x_0 = np.floor(x).astype(int)
    y_0 = np.floor(y).astype(int)

    x_1 = x_0 + 1
    y_1 = y_0 + 1

    #make sure the intervals do not exceed the image boundaries
    x_0 = np.clip(x_0, 0, img.shape[1]-1)
```

```
    x_1 = np.clip(x_1, 0, img.shape[1]-1)
    y_0 = np.clip(y_0, 0, img.shape[0]-1)
    y_1 = np.clip(y_1, 0, img.shape[0]-1)

    #take the four points as described in the lecture
    Q11 = img[x_1,y_0]
    Q12 = img[x_0,y_0]
    Q21 = img[x_1,y_1]
    Q22 = img[x_0,y_1]

    #calculate helper values
    w_1 = (x_1 - x)/(x_1 - x_0)
    w_2 = (x-x_0)/(x_1-x_0)
    w_3 = (y_1 - y)/(y_1-y_0)
    w_4 = (y - y_0)/(y_1-y_0)

    #calculate the value of the new pixels in both directions
    f_R1 = (w_1*Q11 + w_2*Q21)
    f_R2 = (w_1 *Q12 + w_2*Q22)
    f_P = w_3*f_R1 + w_4*f_R2
    return f_P
```

In [ ]:

```
#input [[x1,x2],[y1,y2]]
img_scale = affine_transformation(img, T_shear)
plt.imshow(img_scale, cmap='gray')
plt.show()
```

```
/tmp/ipykernel_16/173973473.py:26: RuntimeWarning: divide by zero encounter
ed in double_scalars
  w_1 = (x_1 - x)/(x_1 - x_0)
/tmp/ipykernel_16/173973473.py:27: RuntimeWarning: divide by zero encounter
ed in double_scalars
  w_2 = (x-x_0)/(x_1-x_0)
/tmp/ipykernel_16/173973473.py:32: RuntimeWarning: invalid value encountere
d in double_scalars
  f_R1 = (w_1*Q11 + w_2*Q21)
/tmp/ipykernel_16/173973473.py:33: RuntimeWarning: invalid value encountere
d in double_scalars
  f_R2 = (w_1 *Q12 + w_2*Q22)
/tmp/ipykernel_16/173973473.py:28: RuntimeWarning: invalid value encountere
d in double_scalars
  w_3 = (y_1 - y)/(y_1-y_0)
/tmp/ipykernel_16/173973473.py:29: RuntimeWarning: invalid value encountere
d in double_scalars
  w_4 = (y - y_0)/(y_1-y_0)
/tmp/ipykernel_16/173973473.py:26: RuntimeWarning: invalid value encountere
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d in double_scalars
  w_2 = (x-x_0)/(x_1-x_0)
```

In [ ]:
```
img_scale = affine_transformation(img, T_scale)
plt.imshow(img_scale, cmap='gray')
plt.show()
```

```
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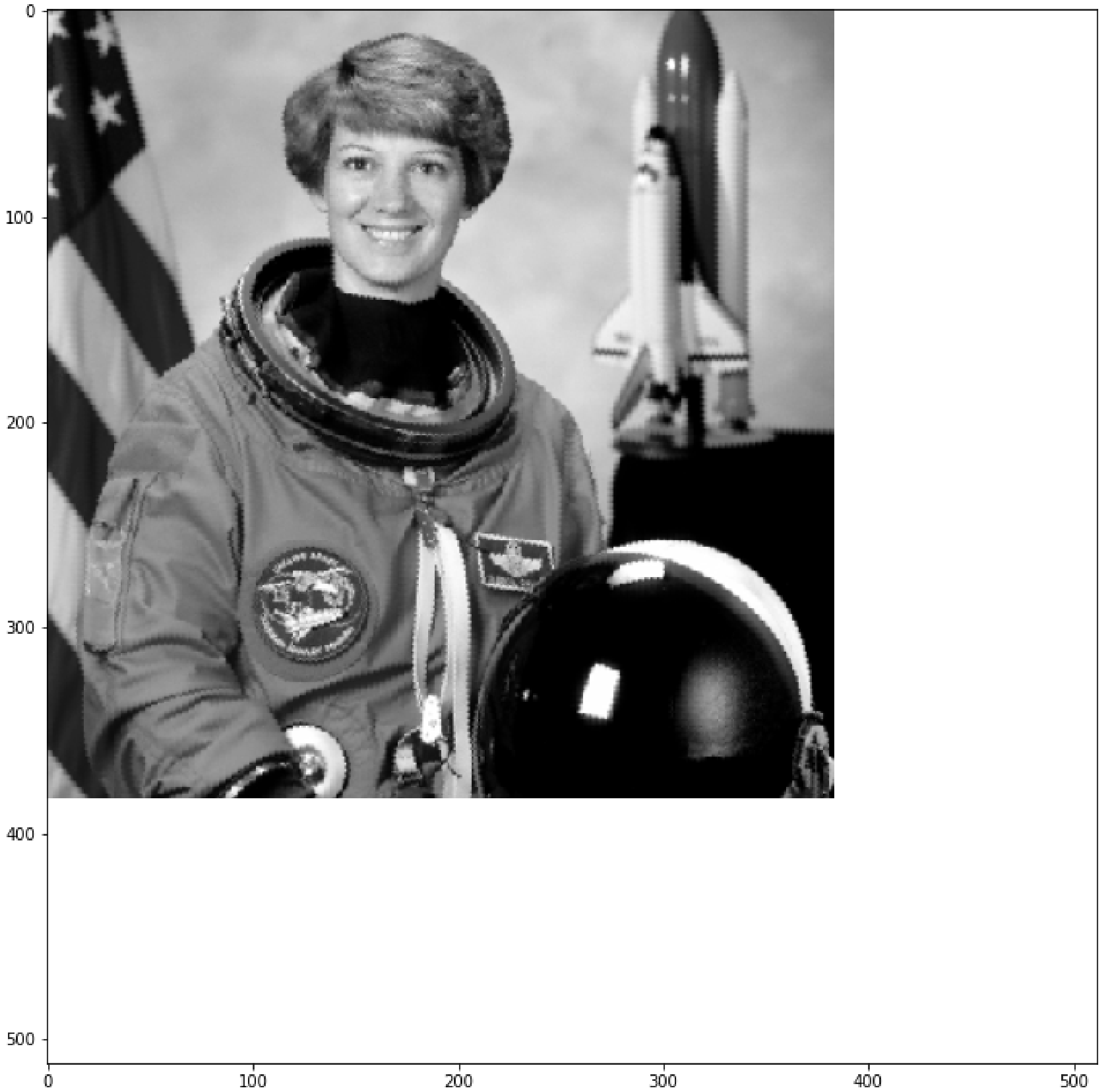

In [ ]:

In [ ]: