

Exercises Week #4: Color images and color maps

Solutions should be submitted via moodle before May 11th, 2021 8.00 a.m. (CET)

Exercise 1 – Color mixing (Difficulty level: easy/medium)

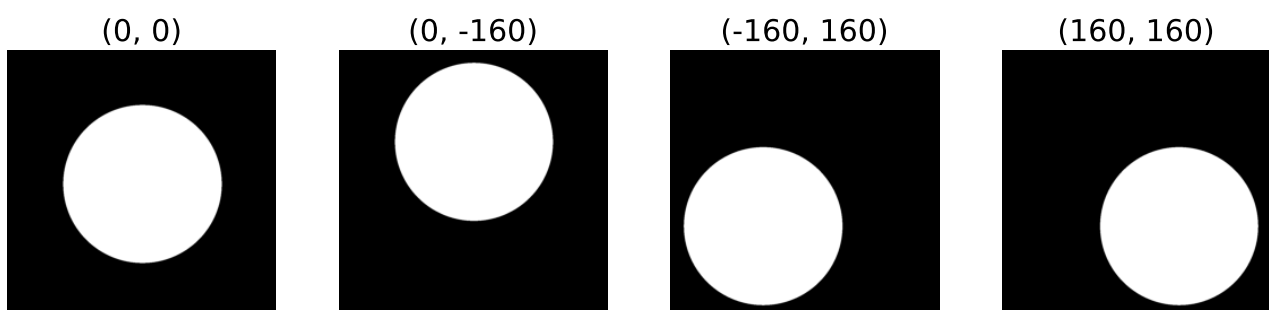
In the exercise, we demonstrate additive and subtractive color mixing. To do so, we create layers with disks at different centers. The template already implements a function to create a disk of desired size, radius and center position (see top of Python template):

```
def make_disk(npix, radius, center=(0, 0)):
    """Creates an (npix, npix) binary image of a disk where `radius` is the
    radius of the disk (in pixels) and `center` is a tuple specifying the center
    of the disk (relative to the origin). """
    x = np.linspace(-0.5*npix, 0.5*npix, npix)
    X, Y = np.meshgrid(x-center[0], x-center[1])
    return np.sqrt(X**2 + Y**2) < radius
```

To create disks of size (1024, 1024), radius 300, at different centers, we can use the following code:

```
npix, radius = 1024, 300
centers = [(0, 0), (0, -160), (-160, 160), (160, 160)]
fig, axes = plt.subplots(1, 4, figsize=(12, 3))
for ax, center in zip(axes, centers):
    ax.axis('off')
    ax.set_title(center)
    ax.imshow(make_disk(npix, radius, center), cmap='gray')
fig.tight_layout()
```

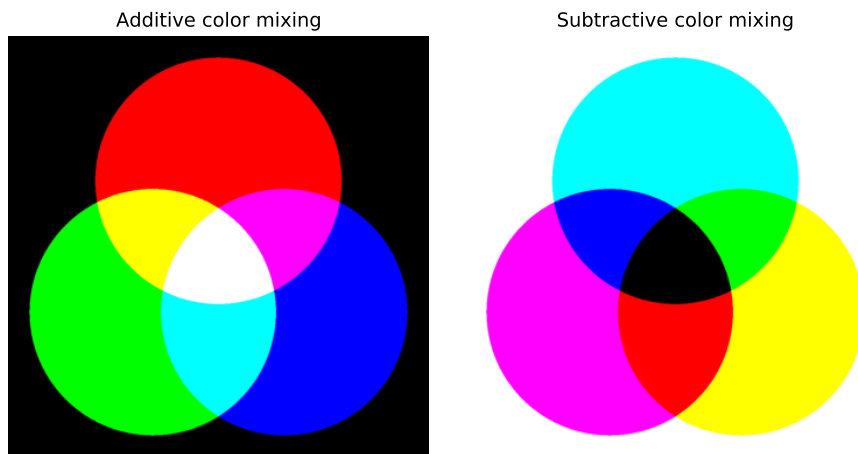
This will create the following figure:



Task 1A. (Difficulty level: easy) To demonstrate additive color mixing, create a (1024, 1024, 3) RGB image with disks of radius 300 in each layer. The center of the disk in the red / green / blue layer is (0, -160) / (-160, 160) / (160, 160), respectively.

Task 1B. (Difficulty level: medium) To demonstrate subtractive color mixing, first create a white RGB image of shape (1024, 1024, 3). Then **subtract** disks of radius 300 in each layer. The centers of the disks that will be subtracted from the red / green / blue layer are (0, -160) / (-160, 160) / (160, 160), respectively.

Task 1C. (Difficulty level: easy) Show both types of color mixing by creating a figure similar to:

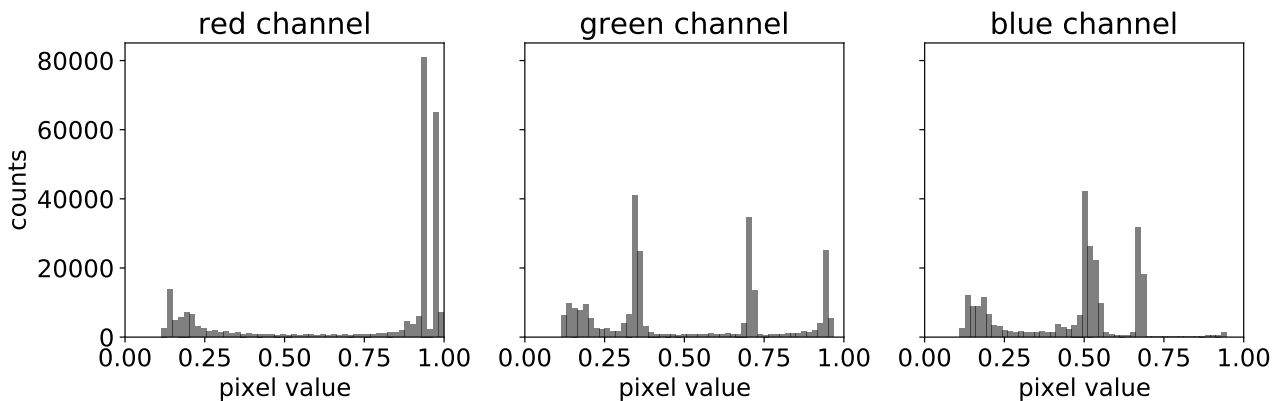


Exercise 2 – Using color maps (Difficulty level: easy/medium)

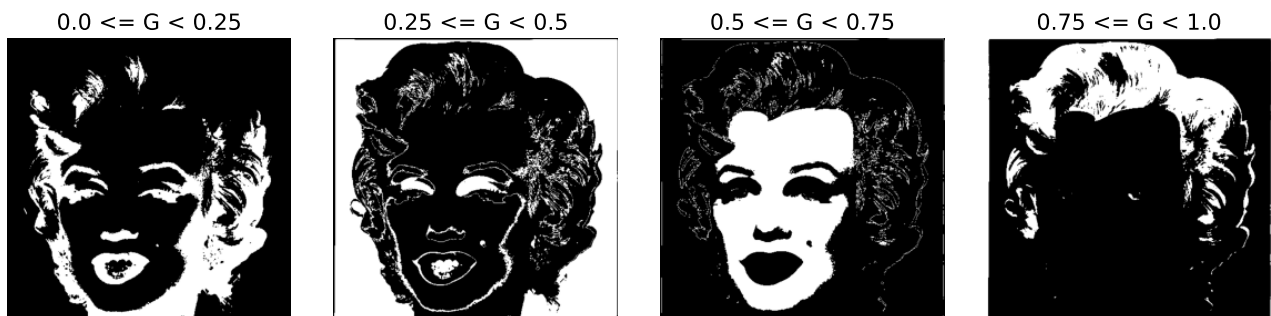
This exercise illustrates the use of color maps by generating alternative versions of the Andy Warhol's iconic portrait of Marilyn Monroe (the original image is available at <https://www.moma.org/collection/works/61240>):



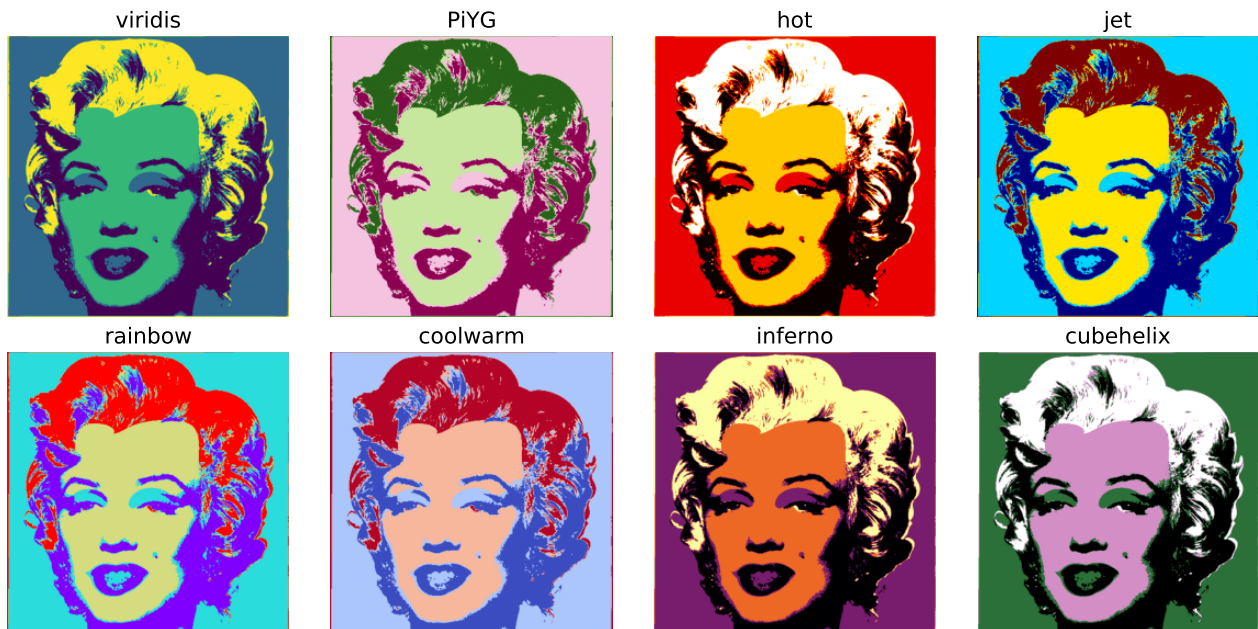
Task 2A. (Difficulty level: easy) Read the image [warhol-marilyn.png](#) (available on the moodle page) and show histograms of the image intensities in each color layer.



Task 2B. (Difficulty level: medium) The pixel values of the green channel show a marked distribution with four well-separated peaks corresponding to large areas of almost constant intensity. So we can segment the image by applying intensity thresholds to the pixel values of the green layer. Suitable thresholds lie somewhere between two peaks. For this particular image, multiples of 0.25 can be used to separate the peaks. Use these thresholds to create four binary images of green pixel values falling into the intervals $[0., 0.25)$, $[0.25, 0.5)$, etc. Show the four binary images that you extracted and create a figure similar to



Task 2C. (Difficulty level: medium) You can now combine the four binary images that you defined in 2B with a color map to create Warhol-like images of Marilyn Monroe. To do so, first create an intensity image with intensities in the interval $[0, 1]$ by adding up the four binary images using weights $[0, 1/3, 2/3, 1]$ for the respective binary images. You can now choose different color maps (indicated in the panel titles) to generate the following image:




Exercise 3 – False colors in thermal imaging (Difficulty level: medium)

Thermal cameras detect infrared radiation and thereby provide a record of the temperature distribution of a scene (more details on thermography can be found [here](#)). During the Image Processing I exam last semester, Christoph Biskup recorded a thermal image of the participants. You can vaguely recognize desks and computer screens.



Task 3A. (Difficulty level: easy) Load the image `thermal_image.jpg` (available on the moodle page). It is a grayscale image where the intensity is directly proportional to the temperature of the scene. Show the temperature distribution using false colors (e.g. the `plasma` color map).



Task 3B. (Difficulty level: medium) Remove the camera logo  in the upper left corner of the image. To do so:

1. Make the image writeable by replacing it with its copy (*Hint: use `np.copy`*).
2. Extract a patch that contains the logo by using the slice `[:80, :160]`.
3. Select the pixels from the patch whose intensity is larger than 100. These pixels are the ones showing the logo.
4. Compute the average intensity of those pixels in the patch that have **not** been selected in the previous step.
5. Set the pixel value of the selected pixels to the average value computed in step 3. (So this is the mean intensity of pixels from the patch whose intensity is smaller than 100.)

The resulting image should look similar to



Task 3C. (Difficulty level: medium) Find and highlight the head of the hardest thinking participant.

To do so:

1. Create a gray RGB image whose color channels are all identical to the intensity image from 3B in which the logo has been removed.¹
2. Select the pixels whose intensity is larger than 93% of the maximum intensity.
3. Color the selected pixels in red. (*Hint:* See task 2B of Homework #3.)

The result should look similar to



¹If you could not solve 3B, you can simply cut away the upper stripe containing the logo by using the slice `[80:, :]`. Note that this changes the shape of the image.