Prj02_Enhancement_S025235

February 27, 2024

0.0.1 EE 421/521 Image Processing

0.1 Project 2 - Image Enhancement

Submission deadline: 26 February 2024 In this project, you will implement the following:

1. Histogram calculation
2. Histrogram equalization for image enhancement
3. Histogram matching

Make sure to submit both .ipynb and .html files.

This project will be graded for both EE 421 (HW1) and EE 521 (HW1) students.

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[42]:
```
# STEP 0 Import the necessary packages

# reading/writing image files
from skimage import io
from skimage import color

# histogram calculation
from skimage import exposure

# displaying images and plots
import matplotlib.pyplot as plt

# array operations
import numpy as np

# Mount Google Drive folder to Colab
from google.colab import drive
drive.mount('/content/drive',force_remount = True)
```

```
Mounted at /content/drive
```

[43]:
```
# my function to convert to lumincance, round to nearest integer,
# truncate to range [0, 255], and then set data type to uint8

def my_imgLuminance(imgRGB):

    # make sure it is a color image
    assert imgRGB.shape[2] == 3

    # get the luminance data
    imgLum = color.rgb2gray(imgRGB)

    imgLum = np.round(imgLum * 255, 0)
    imgLum = np.minimum(imgLum, 255)
    imgLum = np.maximum(imgLum, 0)
    imgLum = imgLum.astype('uint8')

    return imgLum

# end of function
```

[44]:
```
# my function to convert float image data from range [0, 1] to range [0, 255],
# and then set data type to uint8

def my_float2int(img):

    img = np.round(img * 255, 0)
    img = np.minimum(img, 255)
    img = np.maximum(img, 0)
    img = img.astype('uint8')

    return img

# end of function
```

[45]:
```
# STEP 1 Pick two different images, one with low exposure (i.e., a dark image)
# and one with high exposure (i.e., a bright image). Find and display their␣
 ↪luminance.

# set YOUR image folder
image_folder = r'/content/drive/MyDrive/EE421/Project2'

# read YOUR under exposed image
image_file = r'/under_exposed.jpg'
image_path = image_folder + image_file
imgRGB_low = io.imread(image_path)

# read YOUR over exposed image
```

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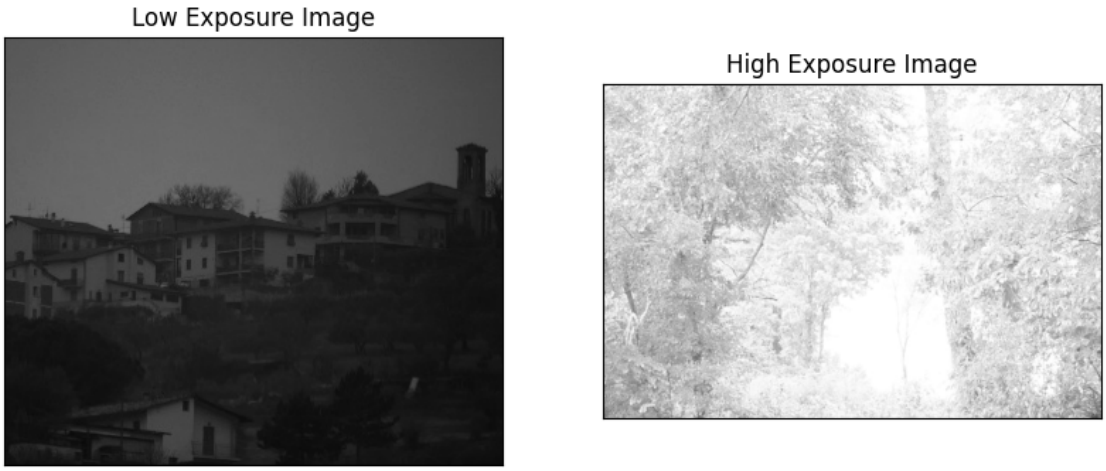
image_file = r'/over_exposed.jpg'
image_path = image_folder + image_file
imgRGB_high = io.imread(image_path)

# calculate the luminance image
img_low = my_imgLuminance(imgRGB_low)
img_high = my_imgLuminance(imgRGB_high)

# display both images
plt.figure(figsize=(10,10))
plt.subplot(121), plt.imshow(img_low, cmap = 'gray', vmin=0, vmax=255)
plt.title('Low Exposure Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122), plt.imshow(img_high, cmap = 'gray', vmin=0, vmax=255)
plt.title('High Exposure Image'), plt.xticks([]), plt.yticks([])
plt.show()
plt.close()
```



[46]:
```
# ==================================
# (1) Histogram calculation
# ==================================

# ADD YOUR CODE HERE

# 1.1 write a function to calculate the histogram of an image
def calcHistogram( img):

    # calculate histogram here
    assert img.ndim == 2
    histogram = np.zeros(256)
    for p in img.reshape(-1):
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        histogram[p] += 1

    return histogram

# end of function

# 1.2 calculate the histograms using the above function
histLow = calcHistogram(img_low)
histHigh = calcHistogram(img_high)

# 1.3 calculate the pdf's
pdfLow = histLow/histLow.sum()
pdfHigh = histHigh/histHigh.sum()

# 1.4 display the histograms and pdf's
plt.figure(figsize=(10,8))

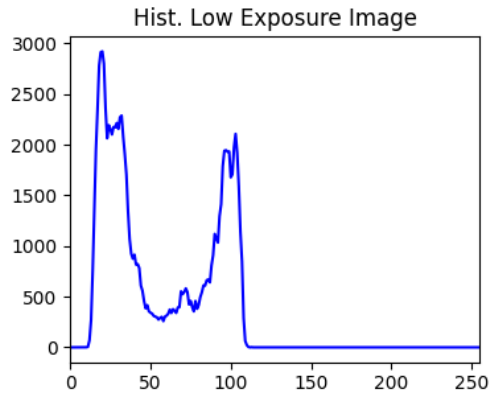
plt.subplot(221), plt.plot(histLow,'blue')
plt.xlim(0, 255)
plt.title('Hist. Low Exposure Image')

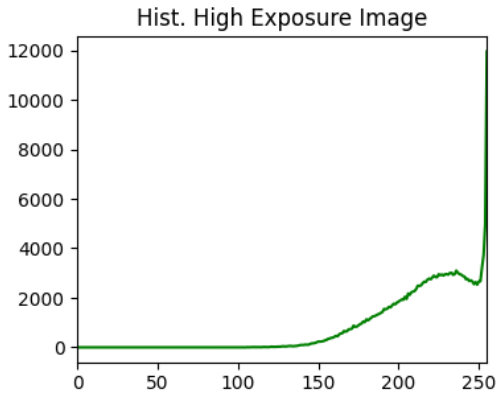
plt.subplot(223), plt.plot(pdfLow,'blue')
plt.xlim(0, 255)
plt.title('PDF Low Exposure Image')

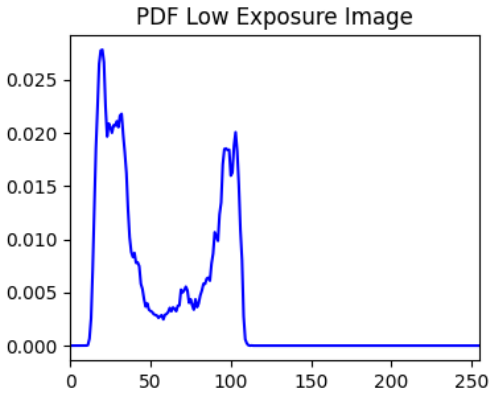
plt.subplot(222), plt.plot(histHigh,'green')
plt.xlim(0, 255)
plt.title('Hist. High Exposure Image')

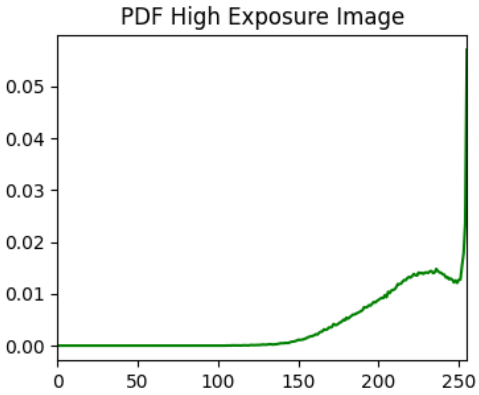
plt.subplot(224), plt.plot(pdfHigh,'green')
plt.xlim(0, 255)
plt.title('PDF High Exposure Image')

plt.subplots_adjust(hspace=0.5,wspace=0.5)
plt.show()
plt.close()
```









[47]:
```python
# ================================
# (2) Histrogram equalization
# ================================

# ADD YOUR CODE HERE

# 2.1 write a function to equalize the histogram of an image
def equalizeHistogram( img):

    # calculate histogram equalized image here
    histogram=calcHistogram(img)
    cdf = np.cumsum(histogram)

    # Normalize the CDF to the range [0, 255]
    cdfNormalized= (cdf-cdf.min())*255/(cdf.max()-cdf.min())
    mappingFunc= np.interp(img.flatten(), range(256), cdfNormalized)
    imgEqualized= np.reshape(mappingFunc,img.shape).astype('uint8')
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    return imgEqualized



# end of function

# 2.2 obtain the histogram equalized images using the above function
imgLow_eq = equalizeHistogram(img_low)
imgHigh_eq = equalizeHistogram(img_high)

plt.figure(figsize=(11,11))
plt.subplot(121), plt.imshow(imgLow_eq, cmap = 'gray', vmin=0, vmax=255)
plt.title('Equalized Low Exposure Image'), plt.xticks([]), plt.yticks([])
plt.subplot(122), plt.imshow(imgHigh_eq, cmap = 'gray', vmin=0, vmax=255)
plt.title('Equalized High Exposure Image'), plt.xticks([]), plt.yticks([])
plt.show()
plt.close()

# 2.3 calculate the pdf's of the histogram equalized images
hist_low_eq = calcHistogram(imgLow_eq)
hist_high_eq = calcHistogram(imgHigh_eq)
pdf_low_eq = hist_low_eq/ hist_low_eq.sum()
pdf_high_eq = hist_high_eq/hist_high_eq.sum()


# 2.4 display the histogram equalized images and their pdf's
plt.figure(figsize=(10,8))


plt.subplot(221), plt.plot(hist_low_eq, 'blue')
plt.xlim(0,255)
plt.title('Hist. equalized low exposure image ')

plt.subplot(223), plt.plot(pdf_low_eq, 'blue')
plt.xlim(0,255)
plt.title('PDF equalzied low exposure image')

plt.subplot(222), plt.plot(hist_high_eq, 'green')
plt.xlim(0,255)
plt.title('Hist. equalized high exposure image')

plt.subplot(224), plt.plot(pdf_high_eq, 'green')
plt.xlim(0,255)
plt.title('PDF equalized high exposure image')
```
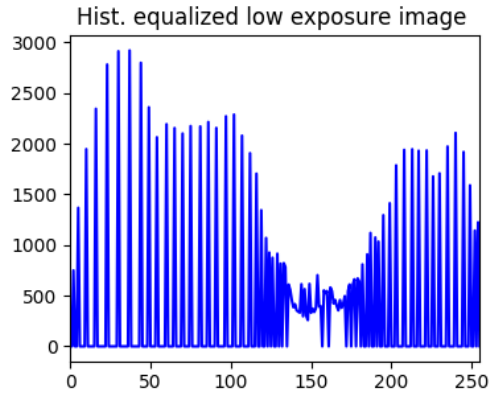
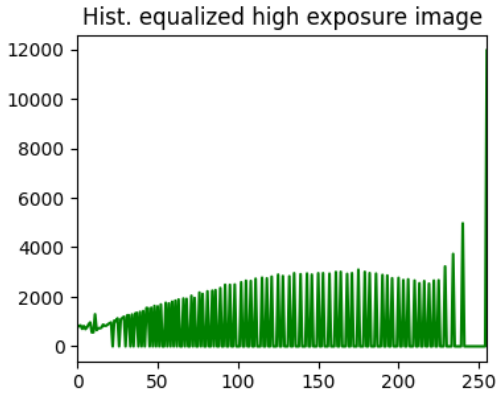
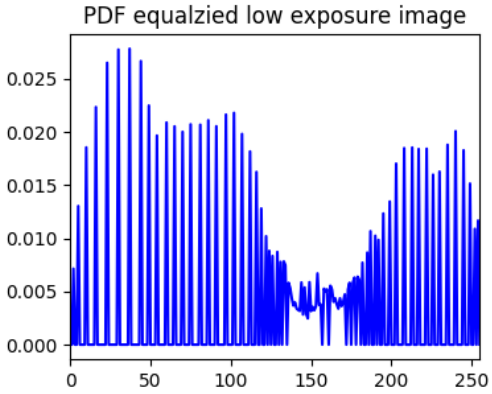
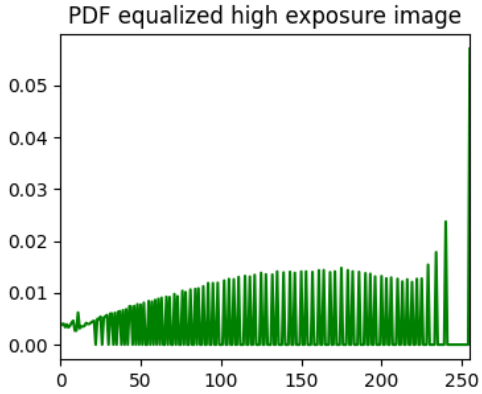

```
plt.subplots_adjust(hspace=0.5,wspace=0.5)
plt.show()
plt.close()
```



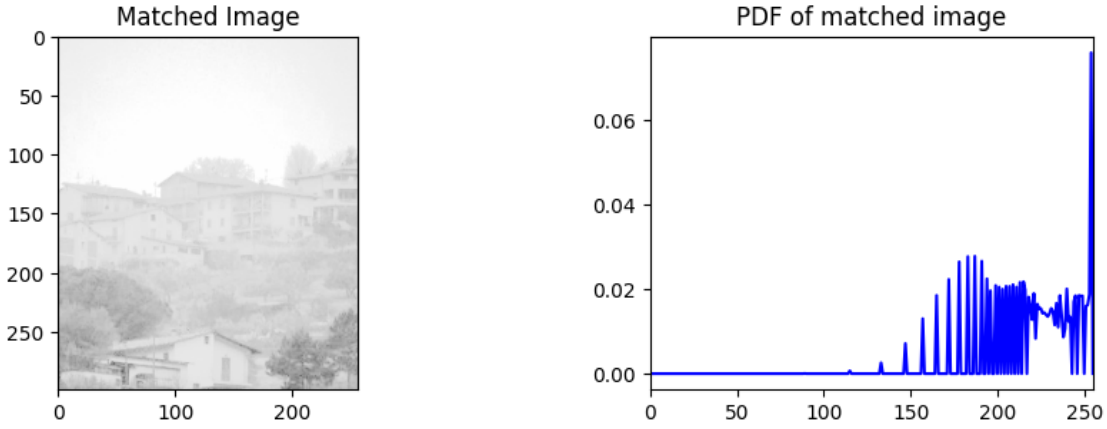






[48]:
```
# ================================
# (3) Histogram matching
# ================================

# ADD YOUR CODE HERE

# 3.1 write a function to match the histogram of one image to that of another␣
 ↪image
def matchHistogram( imgSource, imgTarget):

    # calculate the histogram matched image here
    histTarget= calcHistogram(imgTarget)
    histSource= calcHistogram(imgSource)
    pdfTarget= histTarget/histTarget.sum()
    pdfSource= histSource/histSource.sum()

    cdfTarget= np.cumsum(pdfTarget)
    cdfSource= np.cumsum(pdfSource)

    mappingFunc= np.interp(cdfSource, cdfTarget, np.arange(256))

    # Apply the mapping to the source image
    matched= mappingFunc[imgSource]

    imgMatched= matched.astype('uint8')

    return imgMatched

# end of function

# 3.2 obtain the histogram matched image using the above function
my_img_matched= matchHistogram(img_low, img_high)

# 3.3 calculate the pdf of the histogram matched image
histMatched = calcHistogram(my_img_matched)
pdfMatched = histMatched / histMatched.sum()

# 3.4 display the histogram matched image and its pdf
plt.figure(figsize=(10, 8))

plt.subplot(221), plt.imshow(my_img_matched,cmap='gray',vmin=0,vmax=255)
plt.xlim(0, 255)
plt.title('Matched Image')

plt.subplot(222), plt.plot(pdfMatched, 'blue')
plt.xlim(0, 255)
```

```
plt.title('PDF of matched image')


plt.subplots_adjust(hspace=0.5,wspace=0.5)
plt.show()
plt.close()
```



STEP 4 Comments on the results

ADD YOUR COMMENTS HERE

(a) Compare the histogram equalized images obtained in Step 2 with the original images in Step 1. Comment on any improvements in the visual quality.

In step 1, images have low or high exposure. In other words, have low contrast (short range color band). Therefore, they are hard to observe. We equalized the number of pixel for each color band. This way we managed to increase the contrast of images.

(b) Comment on the appearance of the histogram matched image obtained in Step 3. Why would one use histogram matching?

Image in step 3 has high exposure. We converted the image from low exposure to high exposure since we determined the high exposure image as target. By using histogram matching method, we can obtain a different version of the image which looks like the target image.

[ ]:
```
!sudo apt-get install texlive-xetex texlive-fonts-recommended␣
↪texlive-plain-generic
```

[52]:
```
!jupyter nbconvert--to pdf '/content/drive/My Drive/Colab Notebooks/
↪Prj02_Enhancement_S025235.ipynb'
```

```
usage: jupyter [-h] [--version] [--config-dir] [--data-dir] [--runtime-dir]
[--paths] [--json]
               [--debug]
               [subcommand]
```

```
Jupyter: Interactive Computing

positional arguments:
  subcommand     the subcommand to launch

options:
  -h, --help     show this help message and exit
  --version      show the versions of core jupyter packages and exit
  --config-dir   show Jupyter config dir
  --data-dir     show Jupyter data dir
  --runtime-dir  show Jupyter runtime dir
  --paths        show all Jupyter paths. Add --json for machine-readable format.
  --json         output paths as machine-readable json
  --debug        output debug information about paths

Available subcommands: bundlerextension console dejavu execute kernel kernelspec
migrate nbclassic
nbconvert nbextension notebook run server serverextension troubleshoot trust

Jupyter command `jupyter-nbconvert--to` not found.
```

[ ]: