hw2

October 4, 2022

[1]:
```python
import numpy as np
import cv2
# import skimage
import matplotlib.pyplot as plt
import src.cp_hw2
# import src.cp_exr
```

[2]:
```python
# Q1.2) Linearize Rendered Images

# Read images
image_files = ['data/door_stack/exposure'+str(i)+'.jpg' for i in range(1,17)]
images_stack_for_lin = []
for imf in image_files :
    img = plt.imread(imf)
    img = img[::200, ::200]
    images_stack_for_lin.append(img)
images_stack_for_lin = np.array(images_stack_for_lin)
images_stack_for_lin_reshaped = images_stack_for_lin.
 ↪reshape(images_stack_for_lin.shape[0],-1).swapaxes(0,1)
```

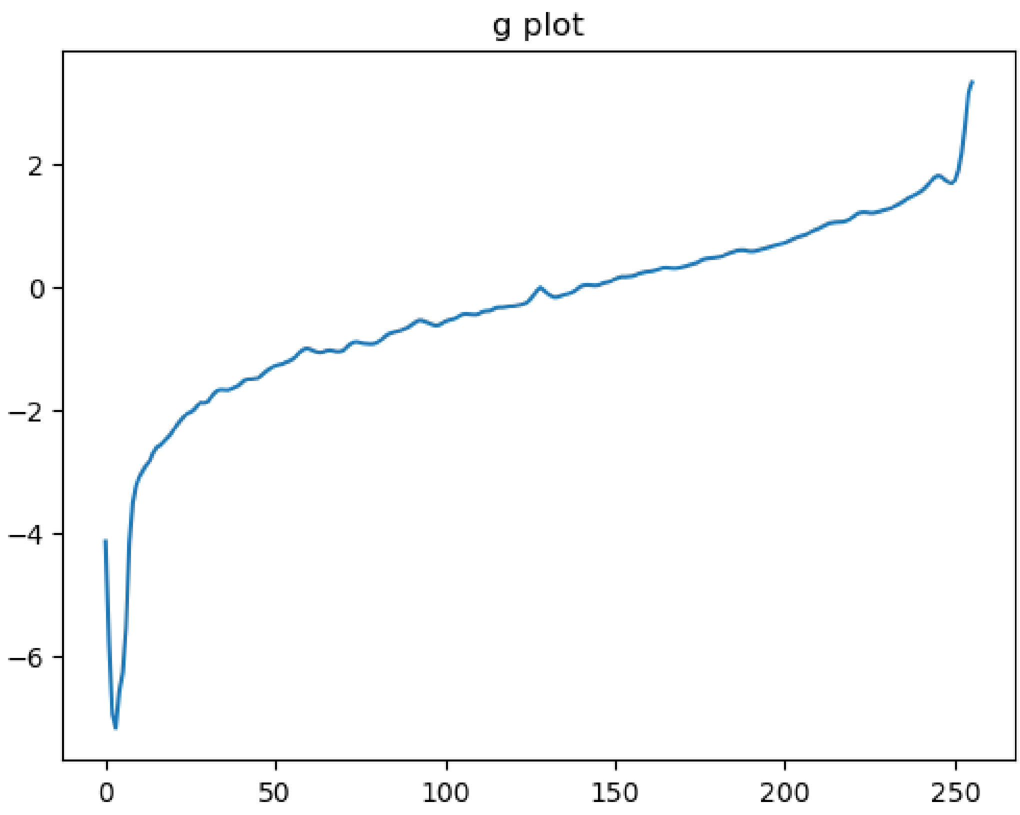
[3]:
```python
t_filler = lambda x : 2.0 ** (x-1-11)
t = [t_filler(i) for i in range(1,17)]
# variable t used in general scope later on in the program
def get_g(images_stack_reshaped, images_stack, w, t, r_l=1, is_w_photon=False) :

    n = 256;
    A = np.zeros((images_stack_reshaped.shape[0]*images_stack_reshaped.
 ↪shape[1]+n+1,
                  n+images_stack_reshaped.shape[0]))
    b = np.zeros((A.shape[0],1))
    cur_row_A = 0
    for i in range(images_stack_reshaped.shape[0]) : # Corresponds to pixel in␣
 ↪image
        for j in range(images_stack_reshaped.shape[1]) : # Corresponds to image␣
 ↪in sequence
    #         wt_ij = 1 # placeholder
            if is_w_photon :
```

```python
                wt_ij = w(images_stack_reshaped[i,j], t[j])
            else :
                wt_ij = w(images_stack_reshaped[i,j])
#             print(wt_ij)
            A[cur_row_A, images_stack_reshaped[i,j]] = wt_ij
            A[cur_row_A, n+i-1] = -wt_ij
            b[cur_row_A, 0] = wt_ij * np.log(t[j])
            cur_row_A = cur_row_A + 1

    # Adding the terms corresponding to the smoothing regularization
    for i in range(n) :
        if is_w_photon :
            wt_i = 1
        else :
            wt_i = w(i)
        A[cur_row_A,i-1] = r_l * wt_i
        A[cur_row_A,i] = -2*r_l*wt_i
        A[cur_row_A,i+1] = r_l*wt_i
        cur_row_A += 1

    # Normalize the curve by setting its middle value to 0
    A[cur_row_A,128] = 1 # Corresponds to g128 in g0-g255

    v = np.linalg.lstsq(A, b, rcond=None)
#     print(v)
    v_sol = v[0]
    g = v_sol[:n]
#     L = v_sol[n:]
#     L = L.reshape(images_stack.shape[1], images_stack.shape[2], images_stack.
 ↪shape[3])

    return g

w = lambda x, zmin=0.05, zmax=0.95 : 0.01
g = get_g(images_stack_for_lin_reshaped, images_stack_for_lin, w, t, 10)
```

[4]:

```python
# Plotting g
plt.plot(np.arange(0,256),g)
plt.title('g plot')
plt.show()
# Linearizing the image
# The other image is too small to make sense of, so looking at a larger image
images_stack = []
for imf in image_files :
    img = plt.imread(imf)
    img = img[::20, ::20]
    images_stack.append(img)
```

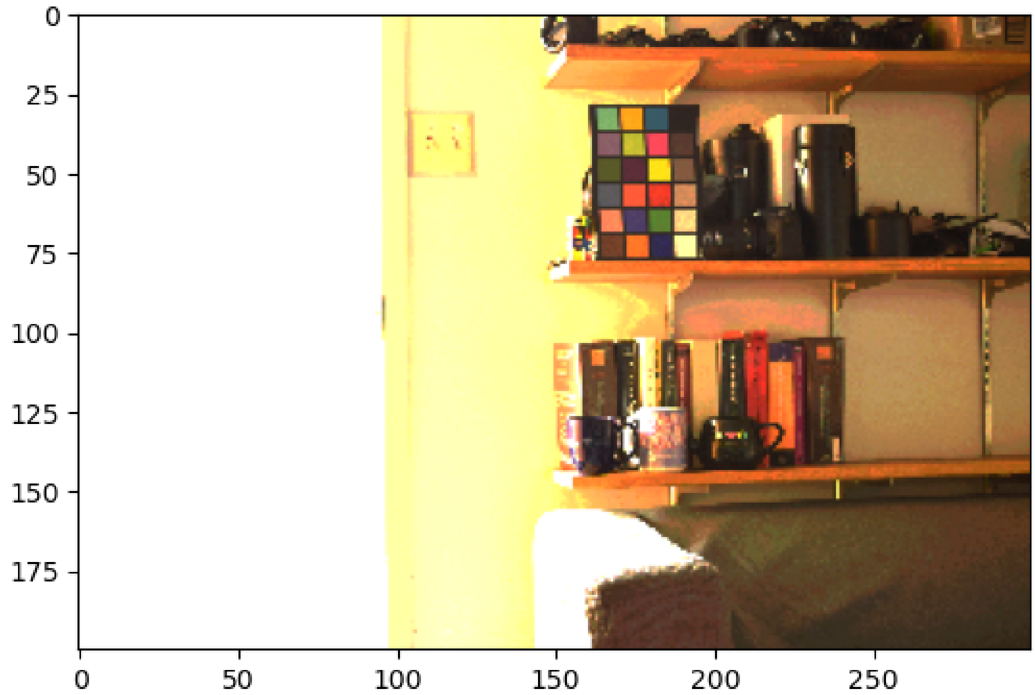
```python
images_stack = np.array(images_stack)

def linearize_image(images_stack, g) :
    lin_images_stack = np.exp(g[images_stack])
    lin_images_stack = lin_images_stack.squeeze(-1)
    return lin_images_stack

lin_images_stack = linearize_image(images_stack, g)
plt.imshow(lin_images_stack[14])
# display_hdr_image(lin_images_stack[8],0.05)
```




```
Clipping input data to the valid range for imshow with RGB data ([0..1] for
floats or [0..255] for integers).
```

[4]:

```
<matplotlib.image.AxesImage at 0x7f319a8b9930>
```



```
[35]: # Q1.3) Merge exposure stack into HDR image (30 points)
      # We've already loaded .jpg images. Lets load .tiff images as well.
      image_files_tiff = ['data/door_stack/exposure'+str(i)+'.tiff' for i in␣
       ↪range(1,17)]
      images_stack_tiff = []
      for imf in image_files_tiff :
      #     img = plt.imread(imf)
          # TO CHANGE TODOOOOO
          img = cv2.imread(imf, -1)
          img = img[...,::-1]
          img = img[::5, ::5]
          images_stack_tiff.append(img)
      images_stack_tiff = np.array(images_stack_tiff)
```

```
[36]: images_stack_normalized = images_stack / 255.0
      images_stack_tiff_normalized = images_stack_tiff / (2**16 - 1)
      #
      # Over-exposure vs under-exposed pixel selection is still off. Fix later!
      def linear_merging(im_s, lin_im_s, t, w_v, is_w_photon=False) :

          I_hdr_num = np.zeros(im_s[0].shape)
          I_hdr_den = np.zeros(im_s[0].shape)
          for k in range(len(im_s)) :
              if is_w_photon :
```

```
            if np.max(lin_im_s) > 256 :
                w_v_imk = w_v(im_s[k],t[k],0.02, 0.98)
            else :
                w_v_imk = w_v(im_s[k],t[k])
        else :
            if np.max(lin_im_s) > 256 :
                w_v_imk = w_v(im_s[k], 0.02, 0.98)
            else :
                w_v_imk = w_v(im_s[k])
        I_hdr_num += (w_v_imk * lin_im_s[k] / t[k] )
        I_hdr_den += (w_v_imk)

    I_hdr = I_hdr_num / I_hdr_den

    # where num is zero, hdr final should also be zero
    I_hdr_num_zero = np.where(I_hdr_num == 0)
    if len(I_hdr_num_zero) == 3 :
        I_hdr_num_zero = np.vstack((np.
↪vstack((I_hdr_num_zero[0],I_hdr_num_zero[1])), I_hdr_num_zero[2])).T
    else :
        I_hdr_num_zero = np.vstack((I_hdr_num_zero[0],I_hdr_num_zero[1])).T


    # where num is not zero, but den is zero, all hdr final values should be␣
↪max val
    I_hdr_den_zero = np.where(I_hdr_den == 0)
    if len(I_hdr_den_zero) == 3 :
        I_hdr_den_zero = np.vstack((np.
↪vstack((I_hdr_den_zero[0],I_hdr_den_zero[1])), I_hdr_den_zero[2])).T
    else :
        I_hdr_den_zero = np.vstack((I_hdr_den_zero[0],I_hdr_den_zero[1])).T

    I_hdr_max_val = []

    if I_hdr_num_zero.size > 0 :
        if len(I_hdr.shape) == 3 :
            I_hdr[I_hdr_num_zero[:,0],I_hdr_num_zero[:,1],I_hdr_num_zero[:,2]]␣
↪= 0
        else :
            I_hdr[I_hdr_num_zero[:,0],I_hdr_num_zero[:,1]] = 0

    if I_hdr_den_zero.size > 0 :
        for index in I_hdr_den_zero :
            if len(I_hdr.shape) == 3 :
                if I_hdr_num[index[0],index[1],index[2]] != 0 :
                    I_hdr_max_val.append(index)
            else :
```

```
                if I_hdr_num[index[0],index[1]] != 0 :
                    I_hdr_max_val.append(index)

        I_hdr_max_val = np.array(I_hdr_max_val).T
        if I_hdr_max_val.size > 0 :
            if len(I_hdr.shape) == 3 :
                I_hdr[I_hdr_max_val[:,0],I_hdr_max_val[:,1],I_hdr_max_val[:,2]] = I_hdr.nanmax()
            else :
                I_hdr[I_hdr_max_val[:,0],I_hdr_max_val[:,1]] = I_hdr.nanmax()

    return I_hdr

def linear_merging_channelwise(im_s, lin_im_s, t, w_v, is_w_photon=False) :

    I_hdr = np.zeros(im_s[0].shape)
    I_hdr[...,0] = linear_merging(im_s[...,0], lin_im_s[...,0], t, w_v, is_w_photon)
    I_hdr[...,1] = linear_merging(im_s[...,1], lin_im_s[...,1], t, w_v, is_w_photon)
    I_hdr[...,2] = linear_merging(im_s[...,2], lin_im_s[...,2], t, w_v, is_w_photon)

    return I_hdr

def log_merging(im_s, lin_im_s, t, w_v, is_w_photon=False) :

    eps = 1e-8
    I_hdr_num = np.zeros(im_s[0].shape)
    I_hdr_den = np.zeros(im_s[0].shape)
    for k in range(len(im_s)) :

        if is_w_photon :
            if np.max(lin_im_s) > 256 :
                w_v_imk = w_v(im_s[k],t[k],0.02, 0.98)
            else :
                w_v_imk = w_v(im_s[k],t[k])
        else :
            if np.max(lin_im_s) > 256 :
                w_v_imk = w_v(im_s[k], 0.02, 0.98)
            else :
                w_v_imk = w_v(im_s[k])
        I_hdr_num += ( w_v_imk * ( np.log(lin_im_s[k] + eps) - np.log(t[k])))
        I_hdr_den += w_v_imk

    I_hdr = I_hdr_num / I_hdr_den
    # where num is zero, hdr final should also be zero (regardless of den)
```

```
    I_hdr_num_zero = np.where(I_hdr_num == 0)
    I_hdr_num_zero = np.vstack((np.
 ↪vstack((I_hdr_num_zero[0],I_hdr_num_zero[1])), I_hdr_num_zero[2])).T

    # where num is not zero, but den is zero, all hdr final values should be␣
 ↪max val
    I_hdr_den_zero = np.where(I_hdr_den == 0)
    I_hdr_den_zero = np.vstack((np.
 ↪vstack((I_hdr_den_zero[0],I_hdr_den_zero[1])), I_hdr_den_zero[2])).T
    I_hdr_max_val = []

    if I_hdr_num_zero.size > 0 :
        I_hdr[I_hdr_num_zero[:,0],I_hdr_num_zero[:,1],I_hdr_num_zero[:,2]] = 0

    if I_hdr_den_zero.size > 0 :
        for index in I_hdr_den_zero :
            if I_hdr_num[index[0],index[1],index[2]] != 0 :
                I_hdr_max_val.append(index)
        I_hdr_max_val = np.array(I_hdr_max_val).T
        if I_hdr_max_val.size > 0 :
            I_hdr[I_hdr_max_val[:,0],I_hdr_max_val[:,1],I_hdr_max_val[:,2]] =␣
 ↪I_hdr.nanmax()

    return np.exp(I_hdr)

# # setting w for merging testing
# w_v = np.vectorize(w)

# I_hdr_lin_merged = linear_merging(images_stack_normalized, lin_images_stack,␣
 ↪t, w_v)
# I_hdr_tiff_lin_merged = linear_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_v)

# I_hdr_log_merged = log_merging(images_stack_normalized, lin_images_stack, t,␣
 ↪w_v)
# I_hdr_tiff_log_merged = log_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_v)

# src.cp_hw2.writeHDR('I_jpg_lin_merged-single-wt.HDR', I_hdr_lin_merged)
# src.cp_hw2.writeHDR('I_tiff_lin_merged-single-wt.HDR', I_hdr_tiff_lin_merged)

# src.cp_hw2.writeHDR('I_jpg_log_merged-single-wt.HDR', I_hdr_log_merged)
# src.cp_hw2.writeHDR('I_tiff_log_merged-single-wt.HDR', I_hdr_tiff_log_merged)
```

[37]:

```
# Weighting Schemes
def w_uniform(z, Z_min = 0.05, Z_max=0.95) :
```

```python
    if isinstance(z,np.uint8) or isinstance(z,int):
        z = z / 255.0
    if Z_min <= z <= Z_max :
        return 1
    return 0

def w_tent(z, Z_min = 0.001, Z_max=0.999) :
    if isinstance(z,np.uint8) or isinstance(z,int) :
        z = z / 255.0
    Z_min = 0.001
    Z_max = 0.999
    if Z_min <= z <= Z_max :
        return np.min([z, 1.0-z])
    return 0

def w_gaussian(z, Z_min = 0.001, Z_max=0.999) :
    if isinstance(z,np.uint8) or isinstance(z,int):
        z = z / 255.0
    Z_min = 0.001
    Z_max = 0.999
    if Z_min <= z <= Z_max :
        return np.exp(-4 * (((z-0.5)**2) / ((0.5)**2)))
    return 0

def w_photon(z, tk, Z_min = 0.05, Z_max=0.95) :
    if isinstance(z,np.uint8) or isinstance(z,int):
        z = z / 255.0
    if Z_min <= z <= Z_max :
        return tk
    return 0
```

[38]:
```python
# HDR display util functions
def linear_scaling(img_cc, scale, should_plot=False):
#     img_scaled = np.clip(skimage.color.rgb2gray(img_cc) * scale, 0, 1)
    img_scaled = np.clip(img_cc * scale, 0, 1)
    if should_plot :
        plt.imshow(img_scaled)
        plt.title('linear scaling')
        plt.show()
    return img_scaled

# Gamma Encoding
def gamma_encoding(val) :
    if val <= 0.0031308 :
        return 12.92 * val
    else :
```

```python
        return (1+0.055) * np.power(val, 1/2.4) - 0.055

def display_hdr_image(img, scale, title='', should_plot=True) :
    img_scaled = linear_scaling(img, scale)
    ge_f = np.vectorize(gamma_encoding)
    image_ge = ge_f(img_scaled)
    if should_plot :
        plt.imshow(image_ge)
        plt.title(title)
        plt.show()
    return image_ge
```

[39]:

```python
w_uniform_vectorized = np.vectorize(w_uniform)
w_tent_vectorized = np.vectorize(w_tent)
w_gaussian_vectorized = np.vectorize(w_gaussian)
w_photon_vectorized = np.vectorize(w_photon)

# Creating all merged raw images
I_hdr_tiff_lin_merged_w_uniform = linear_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_uniform_vectorized)
I_hdr_tiff_lin_merged_w_uniform_channelwise =␣
 ↪linear_merging_channelwise(images_stack_tiff_normalized, images_stack_tiff,␣
 ↪t, w_uniform_vectorized)
I_hdr_tiff_log_merged_w_uniform = log_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_uniform_vectorized)

I_hdr_tiff_lin_merged_w_tent = linear_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_tent_vectorized)
I_hdr_tiff_log_merged_w_tent = log_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_tent_vectorized)

I_hdr_tiff_lin_merged_w_gaussian = linear_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_gaussian_vectorized)
I_hdr_tiff_log_merged_w_gaussian = log_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_gaussian_vectorized)

I_hdr_tiff_lin_merged_w_photon = linear_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_photon_vectorized, is_w_photon=True)
I_hdr_tiff_log_merged_w_photon = log_merging(images_stack_tiff_normalized,␣
 ↪images_stack_tiff, t, w_photon_vectorized, is_w_photon=True)
```

```
/tmp/ipykernel_16623/1946608197.py:23: RuntimeWarning: invalid value encountered
in divide
  I_hdr = I_hdr_num / I_hdr_den
```

[40]:
```
# Creating all merged jpeg images

g_uniform = get_g(images_stack_for_lin_reshaped, images_stack_for_lin,␣
 ↪w_uniform_vectorized,t, 10)
g_tent = get_g(images_stack_for_lin_reshaped, images_stack_for_lin,␣
 ↪w_tent_vectorized,t, 10)
g_gaussian = get_g(images_stack_for_lin_reshaped, images_stack_for_lin,␣
 ↪w_gaussian_vectorized,t, 10)
g_photon = get_g(images_stack_for_lin_reshaped, images_stack_for_lin,␣
 ↪w_photon_vectorized,t, 10, is_w_photon=True)

lin_images_stack_uniform = linearize_image(images_stack, g_uniform)
lin_images_stack_tent = linearize_image(images_stack, g_tent)
lin_images_stack_gaussian = linearize_image(images_stack, g_gaussian)
lin_images_stack_photon = linearize_image(images_stack, g_photon)

I_hdr_jpeg_lin_merged_w_uniform = linear_merging(images_stack_normalized,␣
 ↪lin_images_stack_uniform, t, w_uniform_vectorized)
I_hdr_jpeg_log_merged_w_uniform = log_merging(images_stack_normalized,␣
 ↪lin_images_stack_uniform, t, w_uniform_vectorized)

I_hdr_jpeg_lin_merged_w_tent = linear_merging(images_stack_normalized,␣
 ↪lin_images_stack_tent, t, w_tent_vectorized)
I_hdr_jpeg_log_merged_w_tent = log_merging(images_stack_normalized,␣
 ↪lin_images_stack_tent, t, w_tent_vectorized)

I_hdr_jpeg_lin_merged_w_gaussian = linear_merging(images_stack_normalized,␣
 ↪lin_images_stack_gaussian, t, w_gaussian_vectorized)
I_hdr_jpeg_log_merged_w_gaussian = log_merging(images_stack_normalized,␣
 ↪lin_images_stack_gaussian, t, w_gaussian_vectorized)

I_hdr_jpeg_lin_merged_w_photon = linear_merging(images_stack_normalized,␣
 ↪lin_images_stack_photon, t, w_photon_vectorized, is_w_photon=True)
I_hdr_jpeg_log_merged_w_photon = log_merging(images_stack_normalized,␣
 ↪lin_images_stack_photon, t, w_photon_vectorized, is_w_photon=True)
```

[ ]:
```

```

[41]:
```
# Displaying images
# Displaying RAW source generated images
_ = display_hdr_image(I_hdr_tiff_lin_merged_w_uniform,0.00002,'lin_w_uni_tiff')
_ = display_hdr_image(I_hdr_tiff_lin_merged_w_uniform_channelwise, 0.00002,␣
 ↪'channelwise up')
_ = display_hdr_image(I_hdr_tiff_lin_merged_w_tent,0.00002,'lin_w_tent_tiff')
_ = display_hdr_image(I_hdr_tiff_lin_merged_w_gaussian,0.
 ↪00002,'lin_w_gaussian_tiff')
```

```
_ = display_hdr_image(I_hdr_tiff_lin_merged_w_photon,0.
 ↪00002,'lin_w_photon_tiff')

_ = display_hdr_image(I_hdr_tiff_log_merged_w_uniform,0.00002,'log_w_uni_tiff')
_ = display_hdr_image(I_hdr_tiff_log_merged_w_tent,0.00002,'log_w_tent_tiff')
_ = display_hdr_image(I_hdr_tiff_log_merged_w_gaussian,0.
 ↪00002,'log_w_gaussian_tiff')
_ = display_hdr_image(I_hdr_tiff_log_merged_w_photon,0.
 ↪00002,'log_w_photon_tiff')

# Displaying JPEG source generated images

_ = display_hdr_image(I_hdr_jpeg_lin_merged_w_uniform,0.1,'lin_w_uni_jpeg')
_ = display_hdr_image(I_hdr_jpeg_lin_merged_w_tent,0.1,'lin_w_tent_jpeg')
_ = display_hdr_image(I_hdr_jpeg_lin_merged_w_gaussian,0.
 ↪1,'lin_w_gaussian_jpeg')
_ = display_hdr_image(I_hdr_jpeg_lin_merged_w_photon,0.1,'lin_w_photon_jpeg')

_ = display_hdr_image(I_hdr_jpeg_log_merged_w_uniform,0.1,'log_w_uni_jpeg')
_ = display_hdr_image(I_hdr_jpeg_log_merged_w_tent,0.1,'log_w_tent_jpeg')
_ = display_hdr_image(I_hdr_jpeg_log_merged_w_gaussian,0.
 ↪1,'log_w_gaussian_jpeg')
_ = display_hdr_image(I_hdr_jpeg_log_merged_w_photon,0.1,'log_w_photon_jpeg')

print('lin_w_uni_tiff and lin_w_photon_tiff are the two best images, out of␣
 ↪which the photon weighing scheme image is picked.')
print('lin_w_uni_jpeg and lin_w_photon_jpeg come right after these only because␣
 ↪the colors seem too highlighty near the lights.')
```

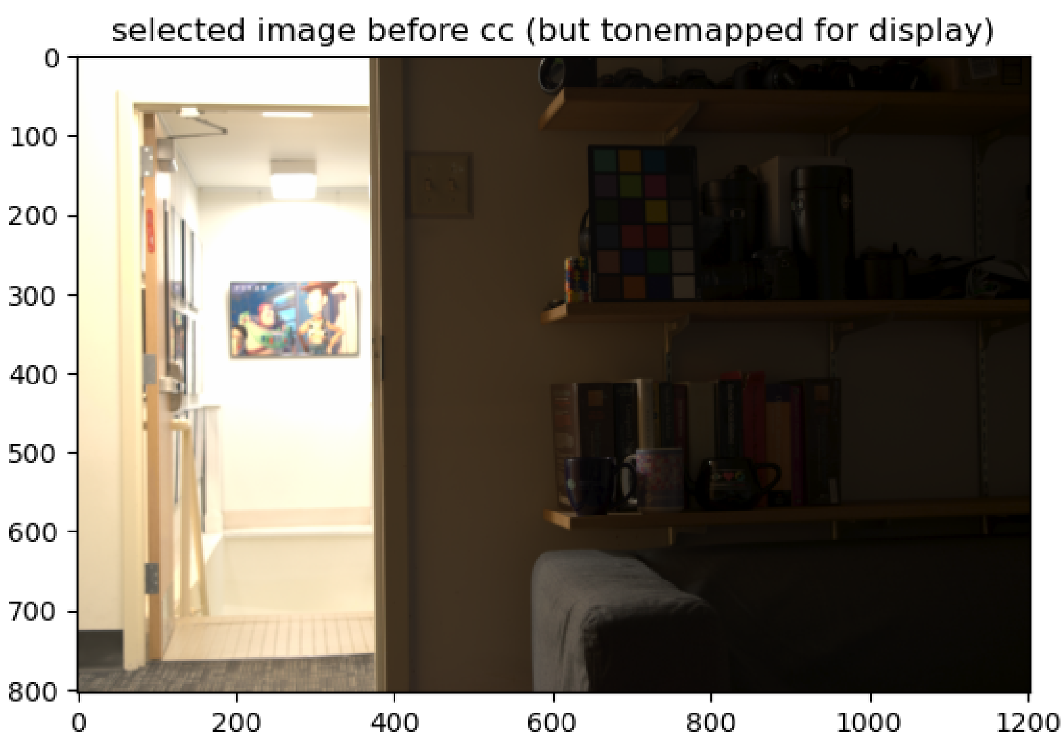
```
lin_w_uni_tiff and lin_w_photon_tiff are the two best images, out of which the
photon weighing scheme image is picked.
lin_w_uni_jpeg and lin_w_photon_jpeg come right after these only because the
colors seem too highlighty near the lights.
```

[42]:
```
# src.cp_hw2.writeHDR('I_hdr_tiff_lin_merged_w_photon-part1-forcolorcorrection.
 ↪HDR', I_hdr_tiff_lin_merged_w_photon)
# src.cp_hw2.writeHDR('I_hdr_tiff_lin_merged_w_uniform-part1-forcolorcorrection.
 ↪HDR', I_hdr_tiff_lin_merged_w_uniform)
```

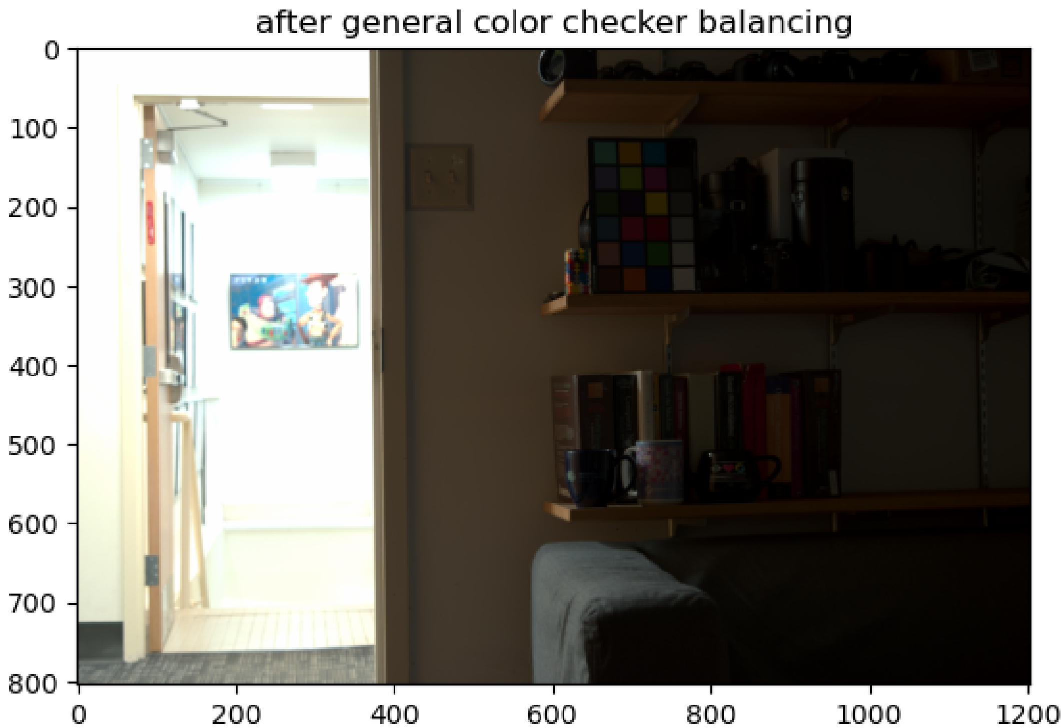
[43]:
```
# Q2) Color Correction and White Mapping
im_hdr_selected = I_hdr_tiff_lin_merged_w_photon.copy()
color_checker_vals = src.cp_hw2.read_colorchecker_gm()

temp = np.stack((color_checker_vals[0],color_checker_vals[1]), axis=2)
color_checker_vals = np.concatenate((temp,np.
 ↪expand_dims(color_checker_vals[2],2)),axis=-1)
```

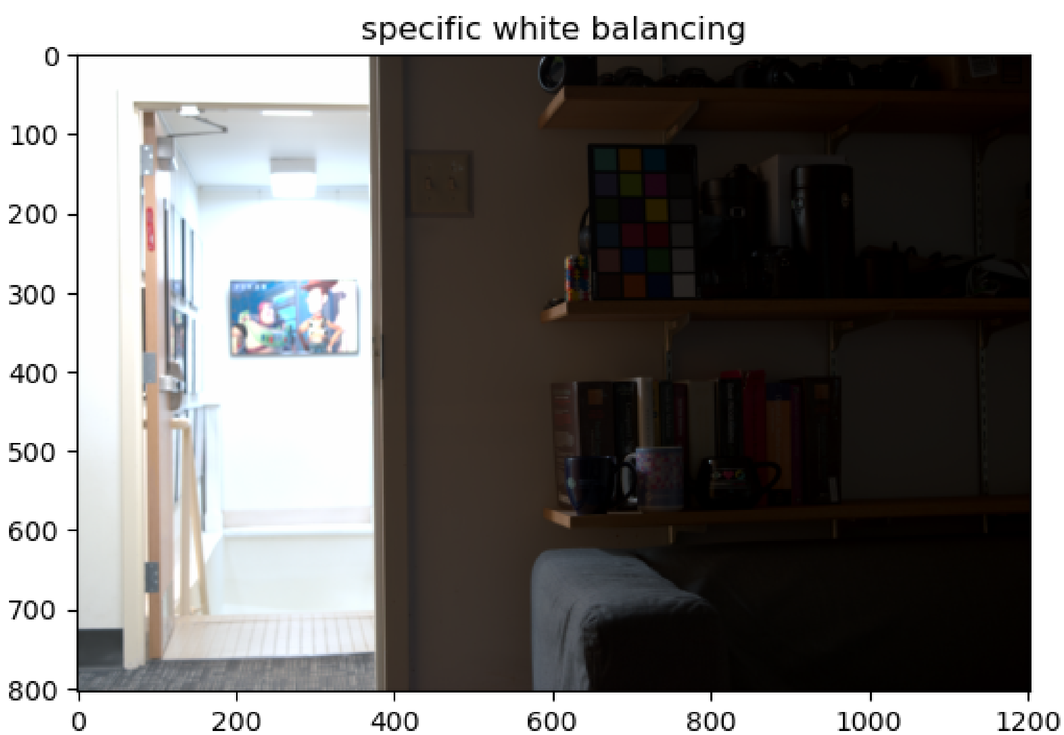
```python
# array above goes from left bottom to right top, column wise

color_checker_vals_vec = []
for ccvs in color_checker_vals : # col
    for ccv in ccvs : # row in col, ie cell
        color_checker_vals_vec.append(ccv)

color_checker_vals_vec = np.array(color_checker_vals_vec)

# %matplotlib qt
im_hdr_selected_tonemapped = display_hdr_image(im_hdr_selected,0.
↪00002,'selected image before cc (but tonemapped for display)')
# coords = plt.ginput(n=24,timeout=10000)
# plt.show()
# %matplotlib inline

# order goes from left bottom to right top, column wise
coords = [(168.31288711288718, 73.79570429570433),
 (168.31288711288718, 65.76373626373629),
 (167.50969030969034, 57.73176823176826),
 (167.50969030969034, 48.89660339660341),
 (167.91128871128873, 41.66783216783219),
 (167.10809190809195, 34.037462537462545),
 (175.5416583416584, 73.3941058941059),
 (175.9432567432568, 65.76373626373629),
 (175.9432567432568, 57.73176823176826),
 (175.5416583416584, 48.89660339660341),
 (174.73846153846156, 40.463036963036984),
 (174.73846153846156, 34.037462537462545),
 (184.77842157842164, 73.3941058941059),
 (183.97522477522486, 64.55894105894109),
 (183.17202797202802, 56.928571428571445),
 (182.77042957042963, 49.29820179820183),
 (182.77042957042963, 40.864635364635376),
 (182.77042957042963, 34.439060939060965),
 (191.60559440559447, 73.79570429570433),
 (191.60559440559447, 64.55894105894109),
 (191.20399600399608, 58.13336663336665),
 (190.80239760239763, 49.29820179820183),
 (190.80239760239763, 40.463036963036984),
 (191.60559440559447, 33.23426573426576)]
coords = np.array(coords).astype('int')

colors_in_img = []
for coord in coords :
    color_avg = im_hdr_selected[coord[1]-2:coord[1]+2,coord[0]-2:coord[0]+2].
↪mean(axis=0).mean(axis=0)
```

```python
    colors_in_img.append(color_avg)
colors_in_img = np.array(colors_in_img)

ones = np.ones((colors_in_img.shape[0],1))
color_checker_vals_vec = np.concatenate((color_checker_vals_vec, ones),-1)
colors_in_img = np.concatenate((colors_in_img, ones),-1)

# The coordinates above have been obtained for a smaller size of the image (skipping 20 pixels).
# For the larger image, we'd need to recount or scale appropriately.
# The correct transform matrix is saved and is loaded in this run, but the commented lines below
# show how we obtained this matrix.
# Solve for X*A = Y. X : Our vals, Y : color checker D65 vals, A : affine transform
# A, _, _, _ = np.linalg.lstsq(colors_in_img, color_checker_vals_vec, rcond=None)
# A[np.abs(A) < 1e-10] = 0
# print(A)
# np.save('color-correction-affine-transform-A',A)
A = np.load('color-correction-affine-transform-A.npy')
```



[45]:
```
ones_image = np.ones([im_hdr_selected.shape[0],im_hdr_selected.shape[1],1])
im_hdr_selected_homogenous = np.concatenate((im_hdr_selected,ones_image),-1)
im_hdr_selected_cc = np.matmul(im_hdr_selected_homogenous,A)
im_hdr_selected_cc = im_hdr_selected_cc[...,:3]
im_hdr_selected_cc_tonemapped = display_hdr_image(im_hdr_selected_cc,0.
↪025,'after general color checker balancing')
# im_hdr_selected_cc = np.clip(im_hdr_selected_cc,0.0,1.0)
# plt.imshow(im_hdr_selected_cc)
# plt.show()
# first layer of tonemapping is done
# second layer below
# all vals at white patch should be white
white_patch = im_hdr_selected_cc[coords[-6][1]-2:
↪coords[-6][1]+2,coords[-6][0]-2:coords[-6][0]+2].mean(axis=0).mean(axis=0)
im_hdr_selected_cc_wb = im_hdr_selected_cc.copy()
im_hdr_selected_cc_wb[...,0] = im_hdr_selected_cc[...,0] * white_patch[0] /
↪white_patch[0]
im_hdr_selected_cc_wb[...,1] = im_hdr_selected_cc[...,1] * white_patch[0] /
↪white_patch[1]
im_hdr_selected_cc_wb[...,2] = im_hdr_selected_cc[...,2] * white_patch[0] /
↪white_patch[2]
im_hdr_selected_cc_wb_tonemapped = display_hdr_image(im_hdr_selected_cc_wb,0.
↪02,'specific white balancing')
# src.cp_hw2.writeHDR('im_hdr_selected_cc_tonemapped.HDR',
↪im_hdr_selected_cc_tonemapped)
# src.cp_hw2.writeHDR('im_hdr_selected_cc.HDR', im_hdr_selected_cc)
src.cp_hw2.writeHDR('im_hdr_selected_cc_wb_tonemapped-part2.HDR',
↪im_hdr_selected_cc_wb_tonemapped)
# src.cp_hw2.writeHDR('im_hdr_selected_cc_wb.HDR', im_hdr_selected_cc_wb)
```


after general color checker balancing
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200


specific white balancing
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200

[34]:

```

```

[34]:

```
array([[ True,  True,  True,  True],
       [ True,  True,  True,  True],
       [ True,  True,  True,  True],
       [ True,  True,  True,  True]])
```

[51]:

```python
# Photographic ToneMapping

# kinda sus, make sure its right
def calc_geometric_mean_log(im) :

    if im.min() < 0 :
        # clipping out negative values and raising them to be over 0
        g_mean = np.exp(np.log(im - (1.00000001) * im.min()).mean())
    else :
        # else
        g_mean = np.exp(np.log(im + 1e5).mean())

    return g_mean

def calc_geometric_mean(im) :
    pass

def place_key(g_mean, im, K) :
    im_keyed= K * (im) / g_mean
    return im_keyed

def set_white(im_keyed, B) :
    im_white = B * np.max(im_keyed)
    return im_white

# Note : don't really understand what the difference
# would be upon applying tonemapping for the 3 channels separately
# in the case mentioned in the hints. That would be same as this right?
def complete_photographic_tonemap(im, K, B) :

    g_mean = calc_geometric_mean_log(im)
    im_keyed = place_key(g_mean, im, K)
    im_white = set_white(im_keyed, B)

    im_tonemapped_num = im_keyed * (1 + im_keyed / (im_white**2))
    im_tonemapped_den = 1 + im_keyed

    im_tonemapped = im_tonemapped_num / im_tonemapped_den

    return im_tonemapped
```

```
def complete_photographic_tonemap_throughxyY(im, K, B) :

    im_XYZ = src.cp_hw2.lRGB2XYZ(im)
    x = im_XYZ[...,0] / im_XYZ.sum(2)
    y = im_XYZ[...,1] / im_XYZ.sum(2)
    Y = im_XYZ[...,1]

    Y_tonemapped = complete_photographic_tonemap(Y, K, B)

    X = (x * Y_tonemapped) / y
    Y = Y_tonemapped
    Z = (1 - x - y) * Y_tonemapped / y

    im_XYZ_tonemapped = np.concatenate((np.stack((X,Y),-1),np.
 ↪expand_dims(Z,-1)),-1)
    im_RGB_tonemapped = src.cp_hw2.XYZ2lRGB(im_XYZ_tonemapped)

    return im_RGB_tonemapped

im_hdr_selected_cc_wb_ptm =␣
 ↪complete_photographic_tonemap(im_hdr_selected_cc_wb, K=0.09, B=0.95)
im_hdr_selected_cc_wb_ptm_tonemapped =␣
 ↪display_hdr_image(im_hdr_selected_cc_wb_ptm, 1, 'image after ptm tonemapped')


im_hdr_selected_cc_wb_ptm_xyY =␣
 ↪complete_photographic_tonemap_throughxyY(im_hdr_selected_cc_wb, K=0.18, B=0.
 ↪01)
im_hdr_selected_cc_wb_ptm_tonemapped =␣
 ↪display_hdr_image(im_hdr_selected_cc_wb_ptm_xyY, 0.5, 'image after ptm␣
 ↪tonemapped-xyY')

src.cp_hw2.writeHDR('im_hdr_selected_cc_wb_ptm-part3.HDR',␣
 ↪im_hdr_selected_cc_wb_ptm)
src.cp_hw2.writeHDR('im_hdr_selected_cc_wb_ptm_xyY-part3.
 ↪HDR',im_hdr_selected_cc_wb_ptm_xyY)
```


image after ptm tonemapped
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200

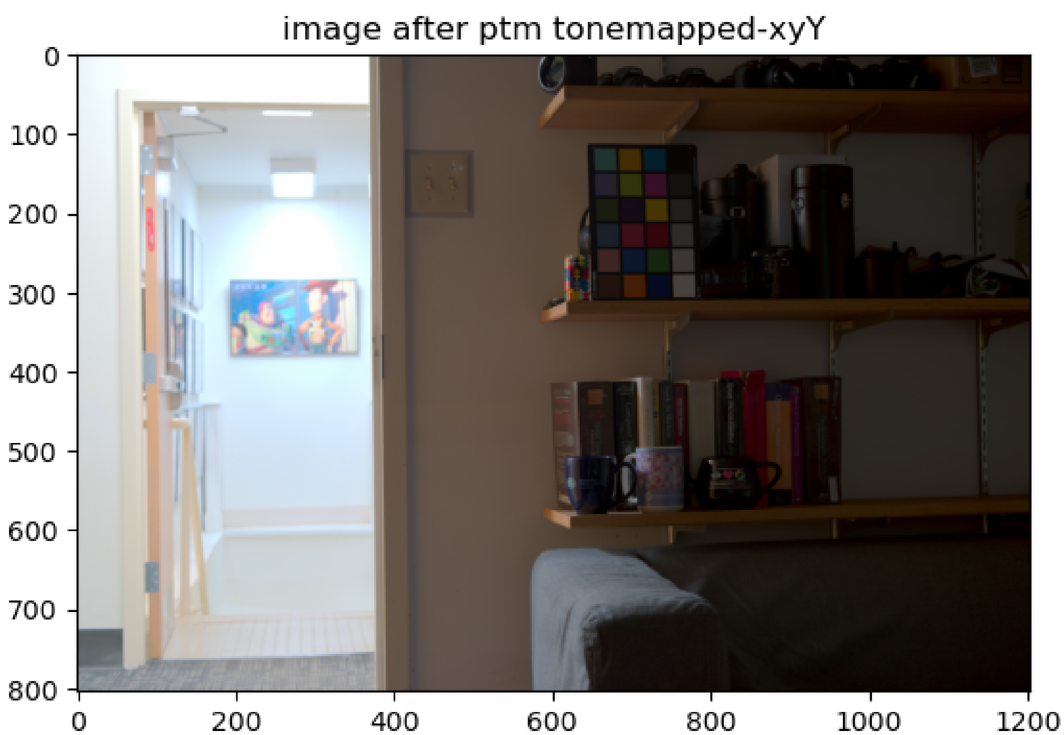


image after ptm tonemapped-xyY
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200

[52]:

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[ ]:

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[ ]:

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[ ]:

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