bonus-flash-reflection-removal

October 26, 2022

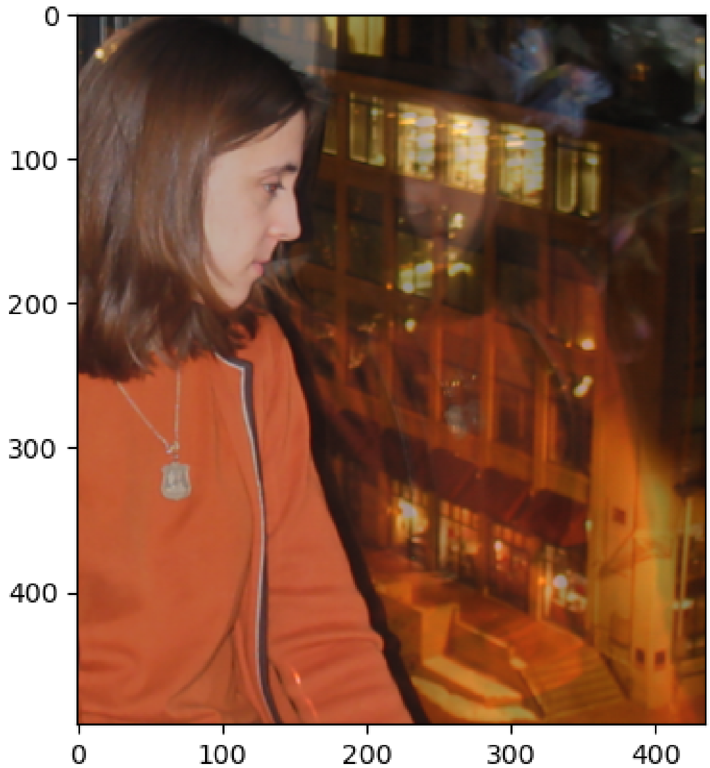
[10]:
```
import numpy as np
import matplotlib.pyplot as plt
import cv2
from scipy.interpolate import interpn
from scipy.signal import convolve2d
from tqdm import tqdm
```

[11]:
```
# load images
museum_amb = './data/custom_bonus_1/paper_ambient.png'
museum_flash = './data/custom_bonus_1/paper-reflection.png'
# museum_amb = './data/custom_part1/DSC_1080.JPG'
# museum_flash = './data/custom_part1/DSC_1081.JPG'
skip = 1
museum_amb = cv2.imread(museum_amb,-1)[::skip,::skip,:3][:-50,:,::-1]
museum_flash = cv2.imread(museum_flash,-1)[::skip,::skip,:3][:-50,:,::-1]

# normalize to 0-1
# museum_amb_norm = (museum_amb - np.min(museum_amb)) / (np.max(museum_amb) -␣
↪np.min(museum_amb))
# museum_flash_norm = (museum_flash - np.min(museum_flash)) / (np.
↪max(museum_flash) - np.min(museum_flash))
museum_amb_norm = museum_amb / 255
museum_flash_norm = museum_flash / 255
# museum_flash_norm_shifted = np.zeros(museum_flash_norm.shape)
# museum_flash_norm_shifted[76//skip:] = museum_flash_norm[:-76//skip]
# museum_flash_norm = museum_flash_norm_shifted
H = museum_amb_norm*2/4  + museum_flash_norm*3/4
plt.imshow(H)
```

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

[11]: `<matplotlib.image.AxesImage at 0x7fcca44d2830>`



[12]:
```
def gradient(img) :

    temp = img[:,:].copy()
    row = np.zeros((1,temp.shape[1]))
    col = np.zeros((temp.shape[0]+2,1))
    temp2 = np.vstack((row,np.vstack((temp, row))))
    temp2 = np.hstack((col,np.hstack((temp2, col))))
    img = temp2.copy()

    # we remove the last row and the last column corresponding to img_x at the
 ↪end
    # we remove the last col and the last column corresponding to img_y at the
 ↪end

    img_x = np.diff(img,n=1,axis=1) # change along row (i.e. diff bw columns)
    img_y = np.diff(img,n=1,axis=0) # change along column (i.e. diff bw rows)
#     print(img_x.shape, img_y.shape)
#     img_x, img_y = img_x[:-1,:], img_y[:,:-1]
#     print(img_x.shape, img_y.shape)
    return img_x, img_y # vector field

def divergence(u,v) :
```

```
    u_x = np.diff(u,n=1,axis=1) # change along row (i.e. diff bw columns)
    v_y = np.diff(v,n=1,axis=0) # change along column (i.e. diff bw rows)
    u_x, v_y = u_x[1:-1,:], v_y[:,1:-1]

    out = u_x + v_y
    return out # scalar field

def laplacian(img) :
    kernel = np.array([[0,1,0],[1,-4,1],[0,1,0]])
    out = convolve2d(img, kernel, mode='same', boundary='fill', fillvalue=0)
    return out # scalar field
```

[13]:

```
# Differentiate then re-integrate an image

# Poisson Solver

def conjugate_gradient_descent(I_init, B, I_star_boundary, eps, N, D) :

    I_star = B * I_init + (1-B) * I_star_boundary
    r = B * (D - laplacian(I_star))
    d = r.copy()
    delta_new = np.sum(r*r) # <r,r>
    n = 0

    while np.sqrt(np.sum(r*r)) > eps and n < N :

        if n % 200 == 0 : print(n,np.sqrt(np.sum(r*r)))
        q = laplacian(d)
        eta = delta_new / np.sum(d*q) # n = delta_new / <d,q>

        I_star = I_star + B * (eta * d)
        r = B * (r - eta * q)

        delta_old = delta_new.copy()
        delta_new = np.sum(r*r)

        beta = delta_new / delta_old
        d = r + beta * d

        n = n + 1

    return I_star

def poisson_solver(lap_img, img, N = 1000, eps = 0.001) :

    I_init = np.zeros(img.shape)
```

```
    boundary_size = 10
    B = np.ones(img.shape)
    B[0:boundary_size,:], B[-boundary_size:-1,:], B[:,0:boundary_size], B[:
 ↪,-boundary_size:-1] = 0,0,0,0

    I_star_boundary = np.zeros(img.shape)
    I_star_boundary[0:boundary_size,:] = img[0:boundary_size,:].copy()
    I_star_boundary[-boundary_size:-1,:] = img[-boundary_size:-1,:].copy()
    I_star_boundary[:,0:boundary_size] = img[:,0:boundary_size].copy()
    I_star_boundary[:,-boundary_size:-1] = img[:,-boundary_size:-1].copy()

    I_star = conjugate_gradient_descent(I_init, B, I_star_boundary, eps, N,␣
 ↪lap_img)

    return I_star
```

[14]:
```
# Creating fused gradient field

def fuse_gradient_field(img_amb_norm, img_flash_norm, H) :

    a_grad_x, a_grad_y = gradient(img_amb_norm)
    phi_dash_grad_x, phi_dash_grad_y = gradient(img_flash_norm)
    h_grad_x, h_grad_y = gradient(H)

    a_grad_x_org = a_grad_x.copy()
    a_grad_y_org = a_grad_y.copy()
    phi_dash_grad_x_org = phi_dash_grad_x.copy()
    phi_dash_grad_y_org = phi_dash_grad_y.copy()
    h_grad_x_org = h_grad_x.copy()
    h_grad_y_org = h_grad_y.copy()

    a_grad_x, phi_dash_grad_x, h_grad_x = a_grad_x[1:,:], phi_dash_grad_x[1:,:
 ↪], h_grad_x[1:,:]
    a_grad_y, phi_dash_grad_y, h_grad_y = a_grad_y[:,1:], phi_dash_grad_y[:,1:
 ↪], h_grad_y[:,1:]

    h_proj_alpha = lambda h_grad,a_grad : a_grad * (h_grad * a_grad) / np.
 ↪sqrt(np.sum(a_grad**2))

    sigma = 0.01
    tau_ue = 0.1
    wue = np.zeros(a_grad_x.shape)
    wue[:-1,:-1] = 1 - np.tanh(sigma * (img_flash_norm-tau_ue))
    wue = (wue - np.min(wue)) / (np.max(wue) - np.min(wue))
#     print(ws.shape, a_grad_x.shape, M.shape, phi_dash_grad_x.shape, a_grad_y.
 ↪shape, phi_dash_grad_y.shape)
```

```
    phi_star_grad_x = np.zeros(a_grad_x_org.shape)
    phi_star_grad_y = np.zeros(a_grad_y_org.shape)
    phi_star_grad_x[1:,:] = wue * a_grad_x + (1-wue) * (h_proj_alpha(h_grad_x,␣
↪a_grad_x))
    phi_star_grad_y[:,1:] = wue * a_grad_y + (1-wue) * (h_proj_alpha(h_grad_y,␣
↪a_grad_y))
    plt.imshow(phi_star_grad_x)
    div = divergence(phi_star_grad_x,phi_star_grad_y)

    return div

fused_image_r_div = fuse_gradient_field(museum_amb_norm[:,:,0],␣
↪museum_flash_norm[:,:,0], H[:,:,0])
fused_image_g_div = fuse_gradient_field(museum_amb_norm[:,:,1],␣
↪museum_flash_norm[:,:,1], H[:,:,0])
fused_image_b_div = fuse_gradient_field(museum_amb_norm[:,:,2],␣
↪museum_flash_norm[:,:,2], H[:,:,0])

I_star_r = poisson_solver(fused_image_r_div, H[:,:,0], N=5000, eps=0.0001)
I_star_g = poisson_solver(fused_image_g_div, H[:,:,1], N=5000, eps=0.0001)
I_star_b = poisson_solver(fused_image_b_div, H[:,:,2], N=5000, eps=0.0001)

I_star = np.concatenate((np.expand_dims(I_star_r,2),np.
↪stack((I_star_g,I_star_b),axis=-1)),axis=2)

fig, ax = plt.subplots(2, figsize = (20,20))

ax[0].imshow(museum_amb_norm)
ax[1].imshow(I_star)

plt.show()
```

```
0 31.84426646509108
200 0.18217253005695647
400 0.0704343601452927
600 0.0076339061194579646
800 0.0010530636841693238
0 20.875489673044942
200 0.10351062478934817
400 0.04289114240389554
600 0.002880652265953053
800 0.00046533325298821275
0 21.534055060107413
200 0.06001455299345685
400 0.024193333498329687
600 0.003232640287154867
800 0.00037635856977812353
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for
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```
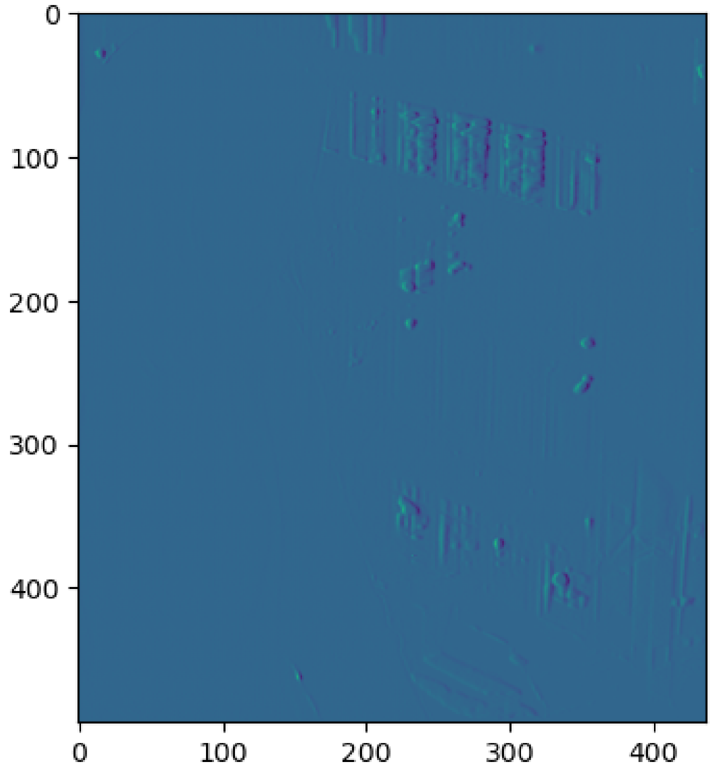
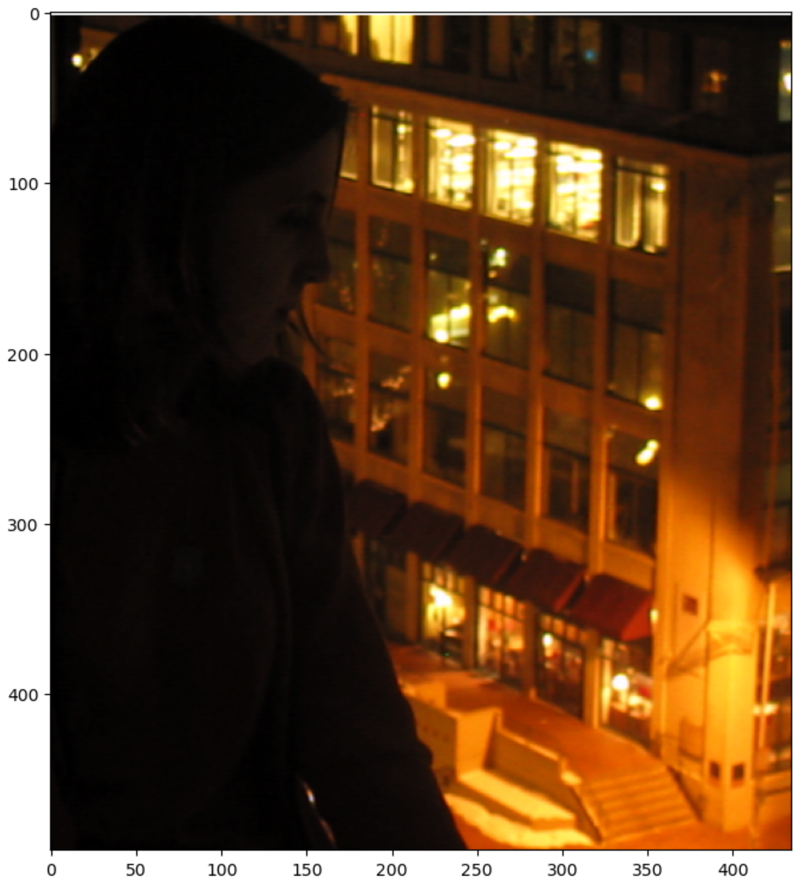
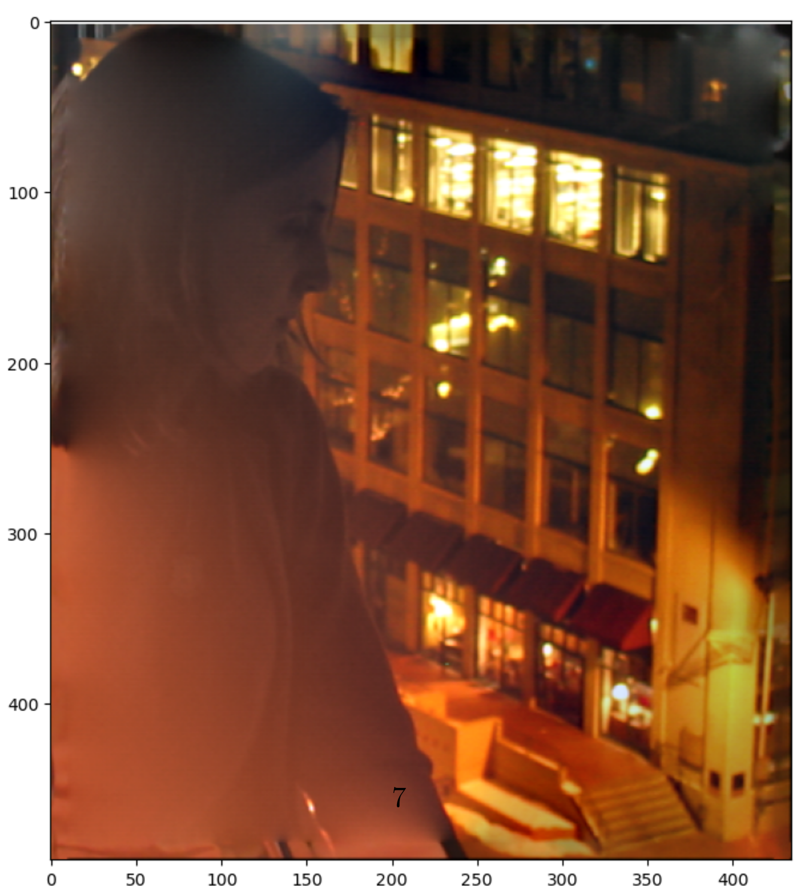
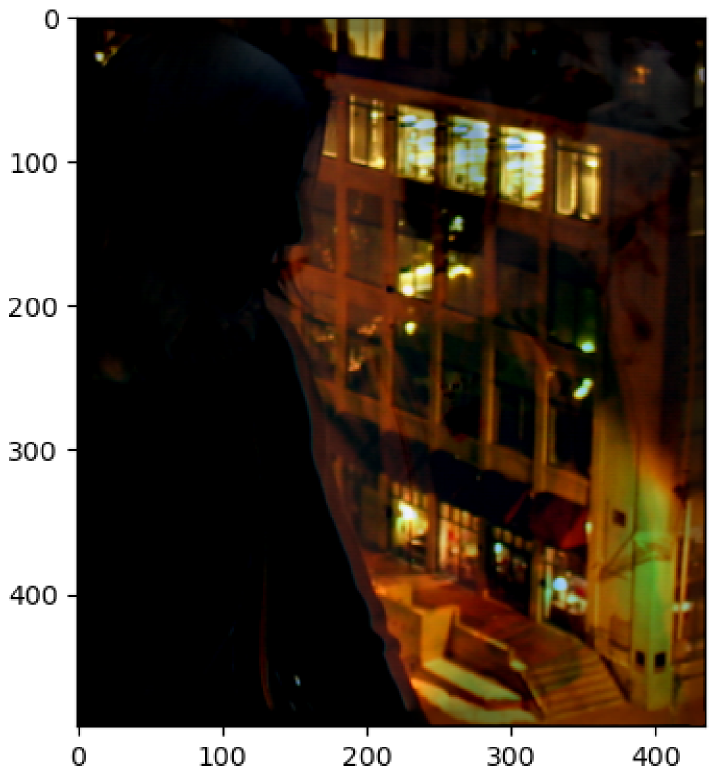



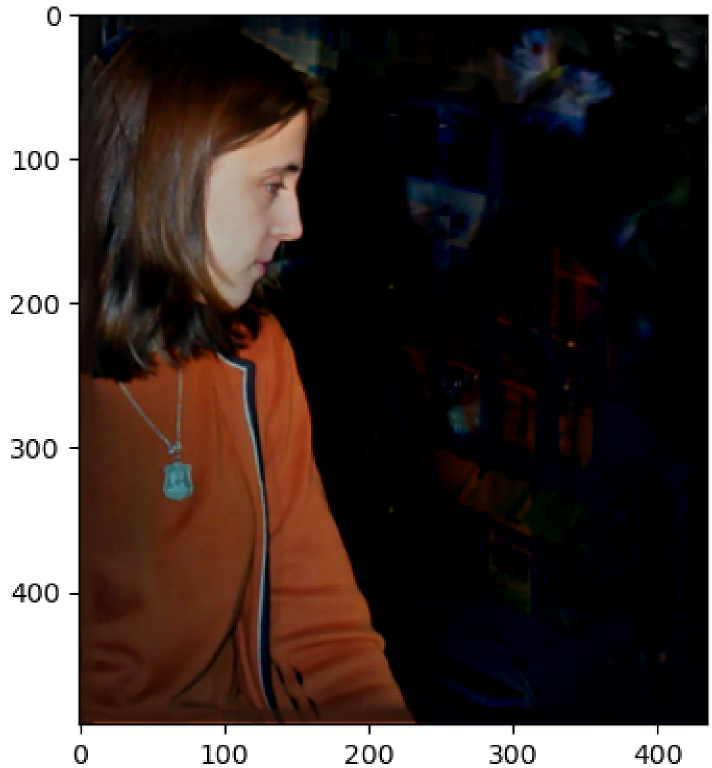

0
100
200
300
400
0 50 100 150 200 250 300 350 400


0
100
200
300
400
0 50 100 150 200 250 300 350 400

[8]:
```
plt.imsave('outputs/reflection_sigma{}_tau{}_5by4.png'.format(0.01,0.1),np.
 ↪clip(I_star,0,1))
```

[15]:
```
plt.imshow(np.clip(I_star-museum_flash_norm,0,1))
plt.show()
plt.imshow(np.clip(museum_flash_norm-I_star,0,1))
plt.show()
```





[ ]:
```
museum_amb_norm_gradient_x.shape
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[ ]:
```
museum_amb_norm_gradient_y.shape
```

[ ]:
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```