CSE 5524 HW3

**Problem 1**

The original image is of size 319\*567 pixels and I chose Mc = 39 and Mr = 70 to crop the image into 313\*561 pixels with N = 3.

Here is the image after cropping.

A person wearing a hat

Description automatically generated

Here is the image after first blur and sample:

A person wearing a hat

Description automatically generated

Here is the image after second blur and sample:

A picture containing mirror, window, photo, reflection

Description automatically generated

Here is the image after third blur and sample:



Here is the image after 1st interpolation:

A picture containing window

Description automatically generated

And the corresponding error pyramid:

A picture containing sky, star, night, fireworks

Description automatically generated

Here is the image after 2nd interpolation:

A close up of a window

Description automatically generated

And the corresponding error pyramid:

A star in the background

Description automatically generated

Here is the image after 3rd interpolation:

A close up of a window

Description automatically generated

And the corresponding error pyramid:

A dark room

Description automatically generated

The following steps include the recovery of the image:

Here is the copy of the image after 3rd blur and sample:



Interpolate it and adding the third error pyramid we get:

A person standing in front of a mirror

Description automatically generated

Interpolate it and adding the second error pyramid we get:

A picture containing photo, wearing, front, person

Description automatically generated

Interpolate it and adding the first error pyramid we get:

A person wearing a hat

Description automatically generated

Finally, we get back to our original image.

Here is the code for this process

%% Problem 1

%load the image

toumaRGB = im2double(imread("touma.jpg"));

toumaGray = rgb2gray(toumaRGB);

% resize the image from 319 \* 567 to 313\*567 // (8\*39+1)(8\*70+1)

touma = toumaGray(1:313,1:561);

imshow(touma); %original image

pause();

% define the 1-d gaussion mask

a = 0.4;

w = [0.25-0.5\*a,0.25,a,0.25,.25-0.5\*a];

b1 = blur(touma,w);

b11 = subSample(b1);

imshow(b11); % 1st blur and sample

pause();

b2 = blur(b11,w);

b22 = subSample(b2);

imshow(b22); % 2nd blur and sample

pause();

b3 = blur(b22,w);

b33 = subSample(b3); % 3rd blur and sample

imshow(b33);

%% get the error pyramid

b33copy = b33;

ip3 = interpolate(b33);

imshow(ip3);

pause();

e33 = b22 - ip3;

imshow(e33);

pause();

ip2 = interpolate(b22);

imshow(ip2);

pause();

e22 = b11 - ip2;

imshow(e22);

pause();

ip1 = interpolate(b11);

imshow(ip1);

pause();

e11 = touma - ip1;

imshow(e11);

%% recover the image using b33copy,e11,e22,e33

imshow(b33);

pause();

i1 = interpolate(b33copy);

imshow(i1);

pause();

imshow(i1+e33);

pause();

i2 = interpolate(i1+e33);

imshow(i2);

pause();

imshow(i2+e22);

pause();

i3 = interpolate(i2+e22);

imshow(i3);

pause();

origin = i3+e11;

imshow(origin);

%%

function bluredIm = blur(image,w)

bluredIm = image;

[r,c] = size(image);

% blur the rows

for i = 1:r

for j = 3:c-2

bluredIm(i,j) = dot(image(i,j-2:j+2),w);

end

end

% blur the columns

for i = 3:r-2

for j = 1:c

bluredIm(i,j) = dot(image(i-2:i+2,j),w);

end

end

end

function subIm = subSample(image)

[r,c] = size(image);

subIm = ones(ceil(r/2),ceil(c/2));

for i = 1:r/2+1

for j = 1:c/2+1

subIm(i,j) = image(2\*i-1,2\*j-1);

end

end

end

function result = interpolate(image)

[r,c] = size(image);

result = ones(2\*r-1,2\*c-1);

for i = 1:r

for j = 1: c

result(2\*i-1,2\*j-1) = image(i,j);

end

end

end

**Problem 2**

Original image:

A picture containing building, standing, water, person

Description automatically generated

Background extraction when T = 0.3:

A picture containing dark

Description automatically generated

Background extraction when T = 0.5:

A silhouette of a person

Description automatically generated

Background extraction when T = 0.7:

A picture containing fireworks

Description automatically generated

Background extraction with T = 0.5216 (computed with graythresh):

A picture containing fireworks

Description automatically generated

%% Problem 2

%load the object image and background image

object = im2double(imread('walk.bmp'));

background = im2double(imread('bg000.bmp'));

[r,c] = size(object);

result = zeros(r,c);

T = 0.5216; % change this value for experiment

for i = 1:r

for j = 1:c

if abs(background(i,j)-object(i,j)) > T

result(i,j) = 1;

end

end

end

imshow(result);

Discussion: as the threshold value increases, the white part of the image decreases. As you can see from the above subtracts, the leg of the person is almost clarified as the background with threshold greater than 0.3 dues to the light color of her trousers.

**Problem 3**

%% Problem 3

% load all the images

for i = 1:30

filename = sprintf('bg%03d.bmp',i-1);

Im(:,:,i) = im2double(imread(filename));

end

% load the object image

object = im2double(imread('walk.bmp'));

% calculate the mean and std of 30 background images

[r,c] = size(Im(:,:,1));

mu = mean(Im,3);

sigma = std(Im,0,3);

% extract the image

T = 30;

result = zeros(r,c);

for i = 1:r

for j = 1:c

if ((object(i,j) - mu(i,j))/sigma(i,j))^2 > T^2

result(i,j) = 1;

end

end

end

imshow(result);

background extraction with T = 2:

A picture containing water, standing, sitting, flying

Description automatically generated

Background extraction with T = 3:

A picture containing rain

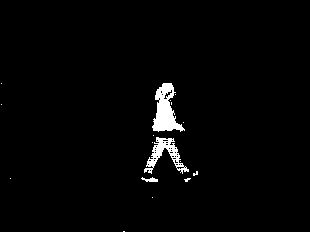
Description automatically generated

Background extraction with T = 10:

A silhouette of a person

Description automatically generated

Background extraction with T = 20:



Background extraction with T = 40:

A close up of a mans face

Description automatically generated

Discussion: As we can see above, when T = 2 or 3, the extracted image looks like a mess where we cannot recognize the contour of the person. However, when we increase the threshold up to 10 or higher, the contour becomes more clear. The reason for this dues to the face that the distribution of the background pixel is not gaussian.

**Problem 4**

A picture containing fireworks, drawing

Description automatically generated

%% Problem 4

d\_bsIm = bwmorph(result, 'dilate');

imshow(d\_bsIm);

Problem 5

A silhouette of a person

Description automatically generated

%% Problem 5

[L, num] = bwlabel(d\_bsIm, 8);

% counting and find the largest region index

max = 1;

for i = 1:12

if sum(L(:) == i) > sum(L(:)== max)

max = i;

end

end

[r,c] = size(L);

for i = 1:r

for j = 1:c

if L(i,j)~= max

L(i,j) = 0;

end

end

end

imshow(L);

**Discussion of the Problems**

In the first problem, I implemented the blur function by myself. One thing I noticed that the change of the image is not very significant comparing with original image, but the value of each pixel (excepted bounded pixel) do changed a little after each smoothing. The reason for this non-obvious may be caused by the pixel of original image which do not differ a lot from its neighbors. Also, the error pyramid is totally black as shown above. The reason for this is the value of each pixel is negative. If I took the absolute value of the error pyramid, for example,

A picture containing photo, person, small, front

Description automatically generated

Then we can see the errors.

In addition, for the final recovered image, the pixel value is not exact the same for each pixel comparing with original image, but they only differ after 4th decimal points, which are caused by precision issues in double.

Problem 2 and 3 have already been discussed in the previous pages. The result of problem 4 just fattens the image and problem 5 labels 12 different connected regions in the image.