Optional Projects

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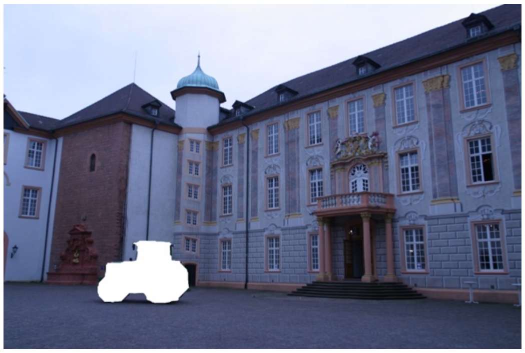
1. Project 1

For project 1, the code name is project 1, I download all picture that needed and store all images in the folder “project1”. I was planning to do this project as same as the homework 4. I assert three classes for those pictures, they are building, sculpture, door. And I want to use histograms to classifier those pictures. But I meet some problems to implement the mean shift algorithm. So this project is not finished.

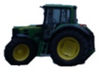
2. Project 2

For this project, I want to do it as the homework 4. The code name is “project 3”. First, I store all images in the folder “castle_dense”, including the input images and output images. I use the image “0008.jpg” as the train image and the mask image is showing below.

Mask1:



mask2:

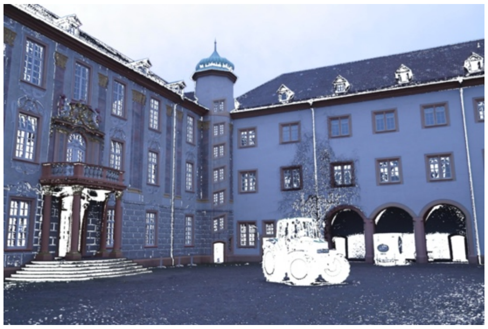


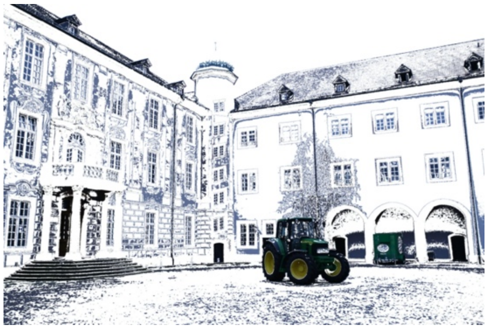
I resize the image first, because they are so large, then as the homework, I use k-means to separate the different part and obtain 10 visual words for them. And classify those parts by finding the nearest word.

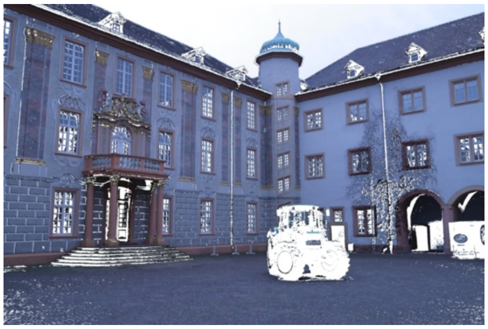
Here are the sample output images for those two mask, you can see all the results in the “castle_dense” folder.

Mask1:

mask2:







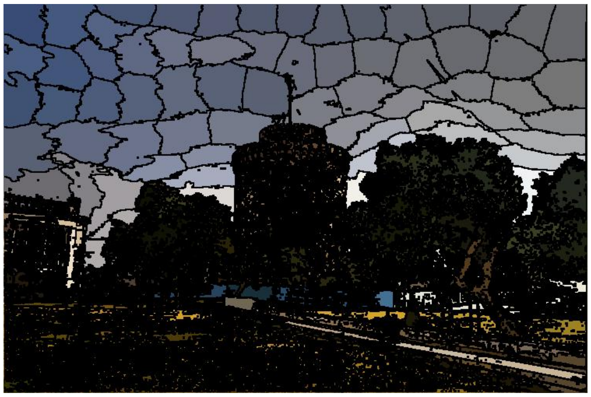
3. Project 3

For project 3, I searched some code, and look how they implement it and trying to implement it myself, but I'm not sure I understand it.

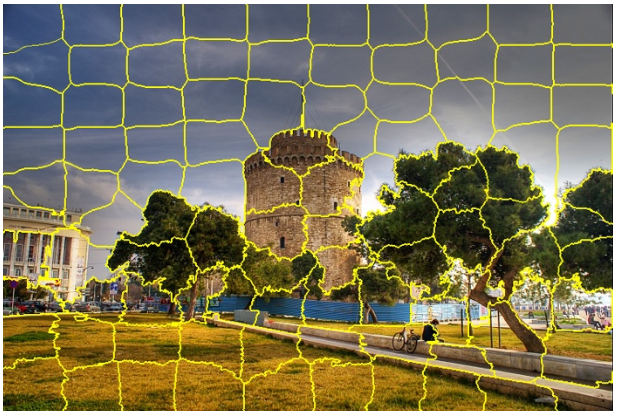
4. Project 4

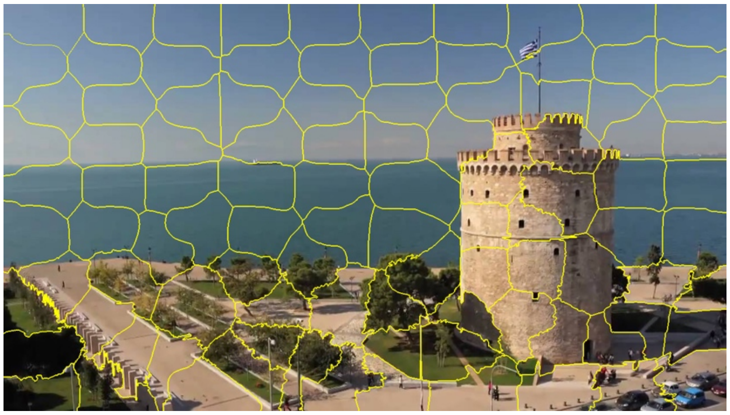
For project 4, I implement the SLIC with matlab which is "SLIC.m", and implement the SNIC and the original SLIC with python, and their name are "SNIC.py" and "project4.py". I use the homework 3 images as the input images.

First is my SLIC's output:

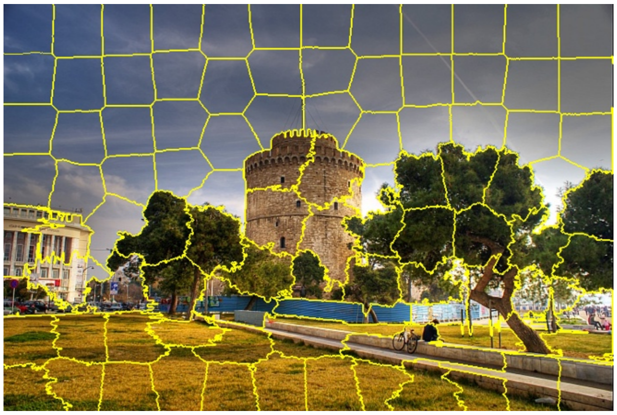


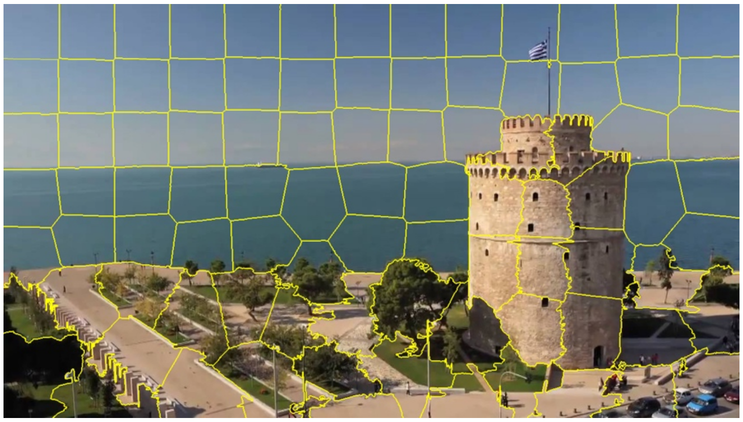
Then is the SNIC's output:





Those are the output of the SLIC in the package skimage:





For the result, SNIC use more time to process than the SLIC package. Both of them are better than my implement. And the SNIC has more unregular selection than the SLIC, such as the tree area in the image, it could handle more details than SLIC, but it is slower than SLIC, I think it is better than the SLIC.

5. Code

Project 1

```
clear all;

folder = 'project1/superset1/';
bin=4;
trainl=zeros(12,1);
trainh=zeros(12,bin*3);
testl=zeros(12,1);
testh=zeros(12,bin*3);
class={'building','sculpture','door'};
count=1;

for i=1:29
    for j=1:length(class)
        % training
        train=imread([folder num2str(i) '.jpg']);
        trainl(count) = j;
        trainh(count,:) = [Histograms(train(:,:,1),bin),
Histograms(train(:,:,2),bin), Histograms(train(:,:,3),bin)];
        % testing
%         test=imread([folder num2str(i) '.jpg']);
%         testl(count) = j;
%         testh(count,:) = [Histograms(test(:,:,1),bin),
Histograms(test(:,:,2),bin), Histograms(test(:,:,3),bin)];
%         count=count+1;
%     end
end
```

```
% index2=MeanShift(trainh,testh,'k',1,'Distance','euclidean');

count=0;
for i=1:size(testh,1)
    if testl(i)==trainl(index2(i))
        count=count+1;
    end
%     disp(['Test image ' num2str(i) ' of class ' num2str(testl(i)) ' has
been assigned to class ' num2str(testl(index2(i))) '.']);
end
```

Project 2

```
clear all;

folder = 'castle_dense/';
traini=double(imread([folder '0008.jpg']));
maski=double(imread([folder 'mask2.jpg']));

trainimage = imresize(traini, 0.125);
maskimage = imresize(maski, 0.125);

car=[];
noncar=[];
carcolor = [];
carcolor(1,1,1) = 255;
carcolor(1,1,2) = 255;
carcolor(1,1,3) = 255;

paintcolor = [];
paintcolor(1,1,1) = 255;
paintcolor(1,1,2) = 255;
paintcolor(1,1,3) = 255;
skyindex=1;
nonskyindex=1;

for i=1:size(trainimage,1)
    for j=1:size(trainimage,2)
        if maskimage(i,j,:)== carcolor
            car(skyindex,:)=trainimage(i,j,:);
            skyindex=skyindex+1;
        else
            noncar(nonskyindex,:)=trainimage(i,j,:);
            nonskyindex=nonskyindex+1;
        end
    end
end

% k-means
k=8;
[~,sw]=kmeans(car,k,'EmptyAction','singleton');
[~,nsw]=kmeans(noncar,k,'EmptyAction','singleton');
words=[ones(k,1) sw;zeros(k,1) nsw];

% testing
for n=1:9
```

```
    test1=imread([folder '000' num2str(n) '.jpg']);
    [s1,s2,s3] = size(test1);
    test2=double(reshape(test1,s1*s2,s3,1));
    index3=knnsearch(words(:,2:end),test2,'k',1,'Distance','euclidean');
    test3=words(index3,1);
    [x,y]=ind2sub([s1 s2],1:s1*s2);

%     painting sky
    for i=1:s1*s2
        if test3(i)==1
            test1(x(i),y(i),:)= paintcolor;
        end
    end

    figure,imshow(test1);
    imwrite(test1, [folder 'nocar' num2str(n) '.jpg']);
end

for n=10:18
    test1=imread([folder '00' num2str(n) '.jpg']);
    [s1,s2,s3] = size(test1);
    test2=double(reshape(test1,s1*s2,s3,1));
    index3=knnsearch(words(:,2:end),test2,'k',1,'Distance','euclidean');
    test3=words(index3,1);
    [x,y]=ind2sub([s1 s2],1:s1*s2);

%     painting sky
    for i=1:s1*s2
        if test3(i)==1
            test1(x(i),y(i),:)= paintcolor;
        end
    end

    figure,imshow(test1);
    imwrite(test1, [folder 'nocar' num2str(n) '.jpg']);
end
```

k-means

```
function image2=kmeans(image1,center,k)

h=size(image1,1);%height
w=size(image1,2);%width
m=size(image1,3);

% get RGB
center1=zeros(k,m);
center2=zeros(k,m);
for i=1:k
    center1(i,1:m)=image1(center(i,1),center(i,2),:);
end

% initialize distance
distance=inf(h,w,k);
```

```
%calculate the distance
flag=0;
while ~flag
    for i=1:k
        for d=1:m
            temp(:,:,d)=repmat(center1(i,d),h,w);
        end

        distance(:,:,i)=sqrt(sum(power(image1-temp,2),3));
    end

    % find out which closest center
    [~,d] = min(distance,[],3);

    % find the centroid of these points in each cluster
    for i=1:k
        index=d==i;
        rgb=reshape(image1(repmat(index,1,1,m)),sum(index(:)),m);
        center2(i,:)=round(mean(rgb));
    end

    if abs(norm(center1-center2))<0.1
        flag=1;
    end

    center1=center2;
end

image2=zeros(h,w,m);
for i=1:h
    for j=1:w
        image2(i,j,:)=center1(d(i,j),:);
    end
end
```

Filter

```
function image_filter = f(image,filter)
%image info
iw = size(image,2);%image width
ih = size (image,1);%image height

%filter info
fw = size(filter,2);%filter width
fh = size(filter,1);%filter height
fhw = (fw - 1)/2;%filter half width
fhh = (fh - 1)/2;%filter half height

image1 = zeros(iw+fhw*2, ih+fhh*2);
for i = 1:iw
    for j = 1:ih
        image1(j+fhh, i+fhw) = image(j, i);
    end
end
```

```
%replicate boundary
for i = 1:iw + fhw * 2
    for j = 1:ih + fhh *2
        if i<=fhw && j>=fhh && j<=ih+fhh
            image1(j,i)=image1(j,fhw+1);
        elseif i>=iw+fhw+1 && j>=fhh+1 && j<=ih+fhh
            image1(j,i)=image1(j,fhw+iw);
        elseif j<=fhh && i>=fhw+1 && i<=iw+fhw
            image1(j,i)=image1(fhh,i);
        elseif j>=ih+fhh+1 && i>=fhw+1 && i<=iw+fhw
            image1(j,i)=image1(ih+fhh,i);
        elseif i<=fhw && j<=fhh
            image1(j,i)=image1(1+fhh,1+fhw);
        elseif i<=fhw && j>=ih+fhh+1
            image1(j,i)=image1(ih+fhh,1+fhw);
        elseif j<=fhh && i>=iw+fhw+1
            image1(j,i)=image1(1+fhh,iw+fhw);
        elseif i>=iw+fhw+1 && j>=ih+fhh+1
            image1(j,i)=image1(iw+fhh,iw+fhw);
        end
    end
end

%filter
image2 = image1;
for i = 1+fhw:iw+fhw
    for j = 1+fhh:ih+fhh
        image2(j,i)=sum(sum(filter.*image1(j-fhh:j+fhh, i-fhw:i+fhw)));
    end
end

image_filter=zeros(ih,iw);
for i=1:iw
    for j=1:ih
        image_filter(j,i)=image2(j+fhh,i+fhw);
    end
end
```

Project 4

```
clear all;

% SLIC
folder = 'project4/';
image=imread([folder 'white-tower.png']);
h2=size(image,1);
w2=size(image,2);
image=double(image);

% parameter
s=50;

% slic
image1=SLIC(image,s);

image1=uint8(image1(:,:,1:3));
```

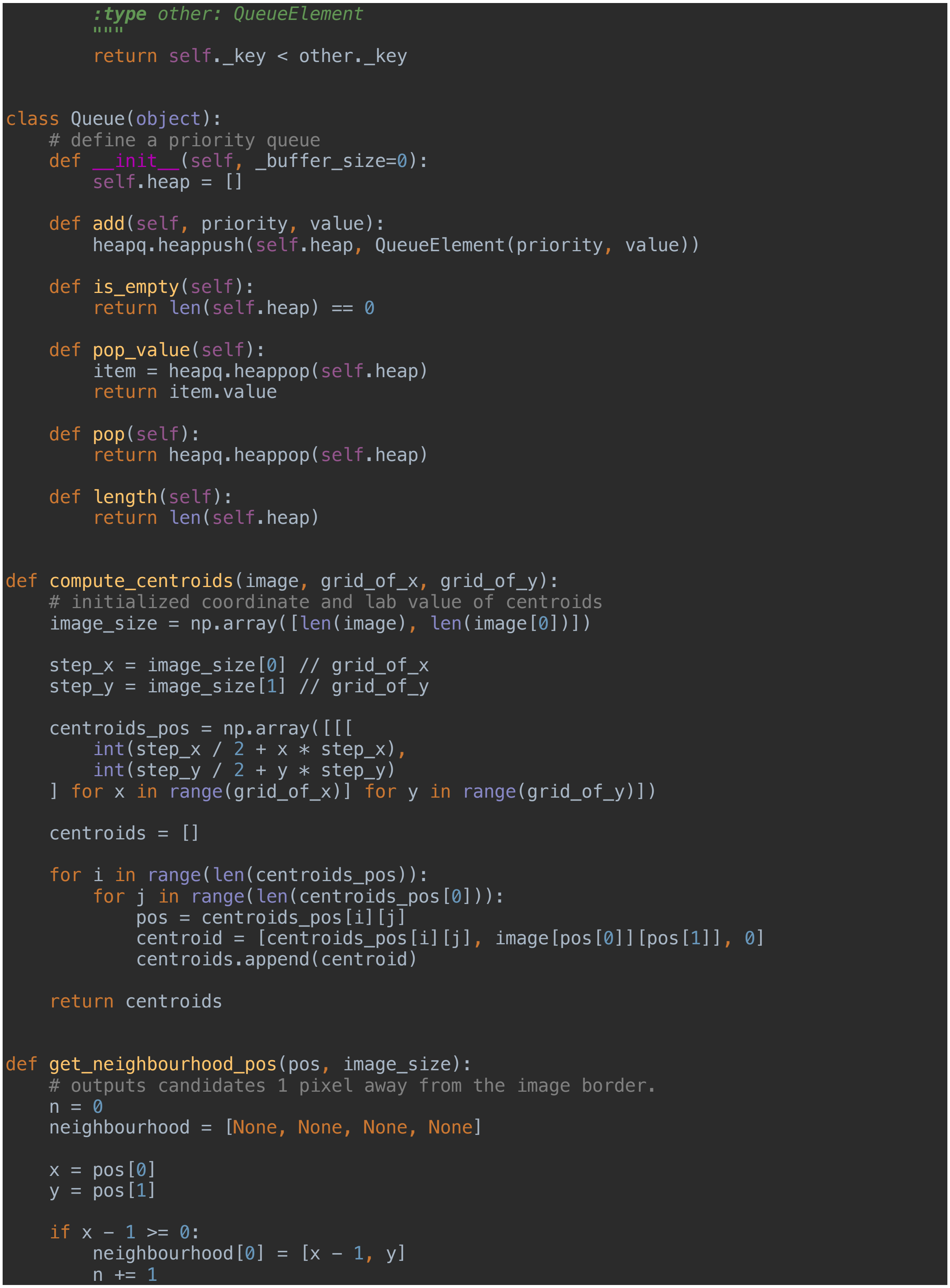
```
figure,imshow(image1);
imwrite(image1,[folder 'tower_SLIC1.jpg']);

% color the pixel that touch two different clusters black
simage=image1;
for i=2:h2-1
    for j=2:w2-1
        flag=0;
        for t=1:3
            if image1(i,j,t)~=image1(i+1,j,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i,j+1,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i-1,j,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i,j-1,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i+1,j+1,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i-1,j-1,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i+1,j-1,t)
                flag=1;
            end
            if image1(i,j,t)~=image1(i-1,j+1,t)
                flag=1;
            end
        end
        if flag==1
            simage(i,j,:)=[0 0 0];
        end
    end
end

figure,imshow(simage);
imwrite(simage,[folder 'tower_SLIC2.jpg']);
```

SLIC.m

```
function image2=SLIC(image1,s)

h=size(image1,1); % image height
w=size(image1,2); % image width

% gradient magnitude
sobel_x=[-1,0,1;-2,0,2;-1,0,1];
sobel_y=[1,2,1;0,0,0;-1,-2,-1];
gradient(:,:,1)=f(image1(:,:,1),sobel_x);
gradient(:,:,2)=f(image1(:,:,2),sobel_x);
gradient(:,:,3)=f(image1(:,:,3),sobel_x);
gradient(:,:,4)=f(image1(:,:,1),sobel_y);
gradient(:,:,5)=f(image1(:,:,2),sobel_y);
gradient(:,:,6)=f(image1(:,:,3),sobel_y);
gradient=sqrt(sum(power(gradient,2),3));

% initialize the centroids and move it to the position
% with the smallest gradient magnitude
count=1;
centroids=zeros(h,w);
for i=round((s+1)/2):s:h
    for j=round((s+1)/2):s:w
        window=gradient(i-1:i+1,j-1:j+1);
        [~,small]=min(window(:));
        [i2,j2]=ind2sub(size(window),small);
        centroids(i+i2-2,j+j2-2)=1;
        center(count,:)=[i+i2-2,j+j2-2];
        count=count+1;
    end
end

% divide x and y by 2
[x,y]=meshgrid(1:h,1:w);
x=x';
y=y';
image3(:,:,1:3)=image1;
image3(:,:,4)= x./2;
image3(:,:,5)= y./2;

% image3(:,:,4)= x.*2;
% image3(:,:,5)= y.*2;

% k-means
image2=kmeans(image3,center,count-1);

end
```

SNIC.py

```
from math import sqrt

"""
    Computes superpixels from a given image.
    > reference = {Achanta, Radhakrishna, and Sabine Süsstrunk.
    "Superpixels and polygons using simple non-iterative clustering."
    Computer Vision and Pattern Recognition (CVPR), 2017 IEEE Conference on. Ieee,
2017.}
    {https://github.com/MoritzWillig/pysnic}
    """

class QueueElement(object):
    __sub_index = 0

    def __init__(self, dist, value):
        self._key = dist
        self.value = value

    def __lt__(self, other):
        """
```

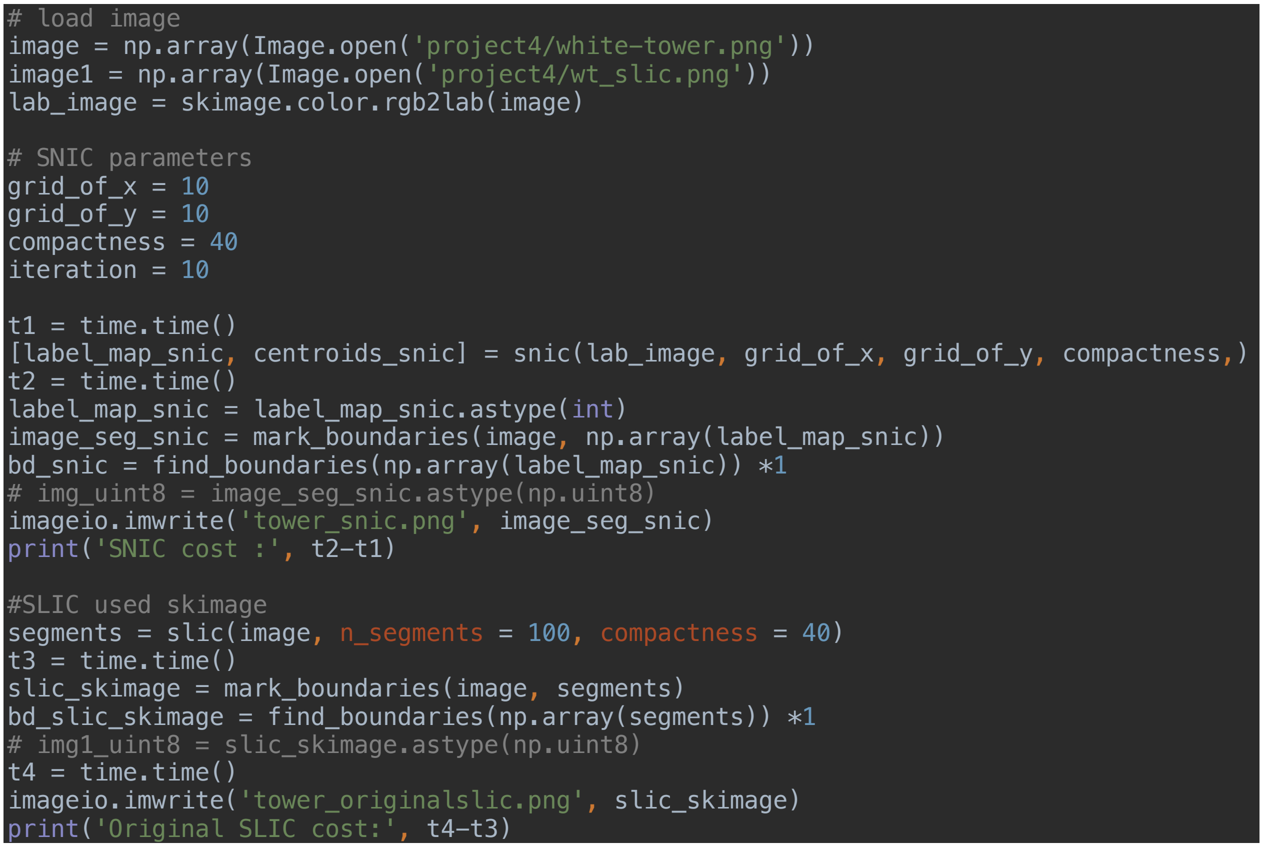


```
        :type other: QueueElement
        """
        return self._key < other._key


class Queue(object):
    # define a priority queue
    def __init__(self, _buffer_size=0):
        self.heap = []

    def add(self, priority, value):
        heapq.heappush(self.heap, QueueElement(priority, value))

    def is_empty(self):
        return len(self.heap) == 0

    def pop_value(self):
        item = heapq.heappop(self.heap)
        return item.value

    def pop(self):
        return heapq.heappop(self.heap)

    def length(self):
        return len(self.heap)


def compute_centroids(image, grid_of_x, grid_of_y):
    # initialized coordinate and lab value of centroids
    image_size = np.array([len(image), len(image[0])])

    step_x = image_size[0] // grid_of_x
    step_y = image_size[1] // grid_of_y

    centroids_pos = np.array([[[
        int(step_x / 2 + x * step_x),
        int(step_y / 2 + y * step_y)
    ] for x in range(grid_of_x)] for y in range(grid_of_y)])

    centroids = []

    for i in range(len(centroids_pos)):
        for j in range(len(centroids_pos[0])):
            pos = centroids_pos[i][j]
            centroid = [centroids_pos[i][j], image[pos[0]][pos[1]], 0]
            centroids.append(centroid)

    return centroids


def get_neighbourhood_pos(pos, image_size):
    # outputs candidates 1 pixel away from the image border.
    n = 0
    neighbourhood = [None, None, None, None]

    x = pos[0]
    y = pos[1]

    if x - 1 >= 0:
        neighbourhood[0] = [x - 1, y]
        n += 1
    if y - 1 >= 0:
        neighbourhood[n] = [x, y - 1]
        n += 1

    if x + 1 < image_size[0]:
        neighbourhood[n] = [x + 1, y]
        n += 1

    if y + 1 < image_size[1]:
        neighbourhood[n] = [x, y + 1]
        n += 1

    return neighbourhood, n


def update(centroid, candidate, num_pixel):
    # online update centroids value with candidates
    return (centroid * (num_pixel - 1) + candidate) / num_pixel


def snic_distance_mod(pos_i, pos_j, col_i, col_j, s, m):
    # Computes the SNIC pixel distance between i and j
    # param s: normalization factor = 1 /
np.sqrt(num_pixels_in_image/num_super_pixels)
    # param m: user provided, higher m leads to more compact superpixels and poorer
boundary adherence

    pos_d = ((pos_i[0] - pos_j[0]) ** 2 + (pos_i[1] - pos_j[1]) ** 2) / s
    col_d = ((col_i[0] - col_j[0]) ** 2 + (col_i[1] - col_j[1]) ** 2 + (col_i[1] -
col_j[1]) ** 2) / m
    distance = pos_d + col_d
    return distance


def snic(
        image,
        grid_of_x,
        grid_of_y,
        compactness):

    # initializa basic parameters
    image_size = np.array([len(image), len(image[0])])
    label_map = np.ones(image_size) * -1
    s = sqrt(image_size[0] * image_size[1] / (grid_of_x * grid_of_y))  # normalization
factor
    m = compactness
    centroids = compute_centroids(image, grid_of_x, grid_of_y)  # [position, color at
position]

    # create priority queue
    queue = Queue(image_size[0] * image_size[1] * 4)  # [position, color,
centroid_idx]
    q_add = queue.add
    q_pop = queue.pop

    # create a priority queue first filled with the centroids itself.
    for k in range(len(centroids)):
        init_centroid = centroids[k]
        q_add(-k, [init_centroid[0], init_centroid[1], k])
```

```python
    try:
        # process until the queue is empty
        while True:

            # pop current processing pixels
            item = q_pop()
            candidate = item.value
            candidate_pos = candidate[0]
            candidate_color = candidate[1]

            # test if pixel is not already labeled
            # since the key of first element in queue is 0, we set key of unlabeled pixel to be -1
            if label_map[candidate_pos[0]][candidate_pos[1]] == -1:
                centroid_idx = candidate[2]

                # label new pixel
                label_map[candidate_pos[0]][candidate_pos[1]] = centroid_idx

                # online update of centroid
                centroid = centroids[centroid_idx]
                num_pixels = centroid[2] + 1

                # update centroid position and color and the number of pixels corresponding to this superpixel
                centroid[0] = update(centroid[0], candidate_pos, num_pixels)
                centroid[1] = update(centroid[1], candidate_color, num_pixels)
                centroid[2] = num_pixels
                centroids[centroid_idx] = [centroid[0], centroid[1], centroid[2]]

                # get four neighbour candidates to current processing pixel to queue
                neighbours_pos, neighbour_num = get_neighbourhood_pos(candidate_pos, image_size)

                # process neighbour pixels and add unlabeled ones into priority queue
                for i in range(neighbour_num):
                    neighbour_pos = neighbours_pos[i]
                    neighbour_color = image[neighbour_pos[0]][neighbour_pos[1]]
                    if label_map[neighbour_pos[0]][neighbour_pos[1]] == -1:
                        distance = snic_distance_mod(neighbour_pos, centroid[0], neighbour_color, centroid[1], s, m)
                        q_add(distance, [neighbour_pos, neighbour_color, centroid_idx])

    except IndexError:
        pass

    return label_map, centroids
```

Project4.py

```python
from PIL import Image
import numpy as np
import time
import skimage.color
from skimage.segmentation import mark_boundaries, find_boundaries
from skimage.segmentation import slic
import imageio
from SNIC import snic
```



```
# load image
image = np.array(Image.open('project4/white-tower.png'))
image1 = np.array(Image.open('project4/wt_slic.png'))
lab_image = skimage.color.rgb2lab(image)

# SNIC parameters
grid_of_x = 10
grid_of_y = 10
compactness = 40
iteration = 10

t1 = time.time()
[label_map_snic, centroids_snic] = snic(lab_image, grid_of_x, grid_of_y, compactness,)
t2 = time.time()
label_map_snic = label_map_snic.astype(int)
image_seg_snic = mark_boundaries(image, np.array(label_map_snic))
bd_snic = find_boundaries(np.array(label_map_snic)) *1
# img_uint8 = image_seg_snic.astype(np.uint8)
imageio.imwrite('tower_snic.png', image_seg_snic)
print('SNIC cost :', t2-t1)

#SLIC used skimage
segments = slic(image, n_segments = 100, compactness = 40)
t3 = time.time()
slic_skimage = mark_boundaries(image, segments)
bd_slic_skimage = find_boundaries(np.array(segments)) *1
# img1_uint8 = slic_skimage.astype(np.uint8)
t4 = time.time()
imageio.imwrite('tower_originalslic.png', slic_skimage)
print('Original SLIC cost:', t4-t3)
```