Project 3 Writeup

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Introduction

Image segmentation is usually done by K-means or mean-shift. The project requires us to do image segmentation using mean-shift method.

Implementation Details

The mean-shift image segmentation algorithm usually performs the following procedures:

- Iteration through every pixel in the image, and place the center of a window (usually circle window, but for the convience we use square window) with a certain bandwidth on this pixel.
- Caculate using the following formula, sum up and devide, then get the shift vector.
- Move the center through shift vector to a new center UNTIL reaching $max\_iteration$ or $norm(shift\ vector)$ is smaller than a threshold.
- Use the current center's pixel to fill the original place's pixel.
- Go through every pixel until the picture is finished.
  Function used:

$$m(x) = \frac{\sum x_i g(\frac{||\vec{x}-\vec{x}_i||^2}{h})}{\sum g(\frac{||\vec{x}-\vec{x}_i||^2}{h})} \tag{1}$$

$$g(x) = \frac{1}{\sqrt{2}\pi} e^{-\frac{(\vec{x}-\vec{x}_i)^2}{2h^2}} (Gaussian\ Kernel) \tag{2}$$

  Every pixel is evaluated as a vector$[x, y, r, g, b]$, representing it's x-coordinate, y-coordinate, red value, green value and blue value.
  Parameters used in my code is listed in Table 1. Bandwidth is half of windows size, if it goes larger then the picture will be more smooth and if it is smaller, the result will look more like the original one. max_iteration is the maximum iteration times of mean shifting, preventing irrational result or long running time. Threshold means if the shift vector is small enough, we don need to carry on mean shifting because the pixels around are very likely already.

Name	Value
Bandwidth	15
threshold	0.3
max_iteration	5

Table 1: Recommended parameters values.

```
for i1 = max(1,round(data(1))-bandwidth):min(round(
   data(1))+bandwidth,height)
for j1 = max(1,round(data(2))-bandwidth):min(round(
   data(2))+bandwidth,length)
    ...
end
end
```

This is the interesting code I want to mention. This is a flexible window size, we use max and min function to prevent overflow or underflow.

Experiments & Results

Figure 1: This is the comparasion set 1

As you can see, the shade of two objects on the snow is regarded as one segmentation. This result uses bandwidth 10, a little smaller than my default number. So the snow on the trees are not completely merged, but overall it seems good.

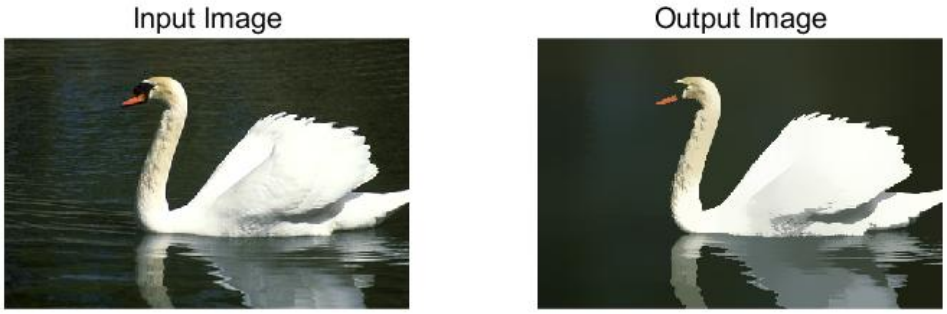

Figure 2: This is the comparasion set 2

Figure 2 is a result with segmentation bandwidth 25, you can see the swan's black face is merged with the dark water, so it is a little over segmentation.

After changing parameters several times, we get relatively good results.
Figure 3 is performed with bandwidth 15. And is better compared to the last one for we saved his face hhh.

Another example:(figure 4,bandwidth 15)

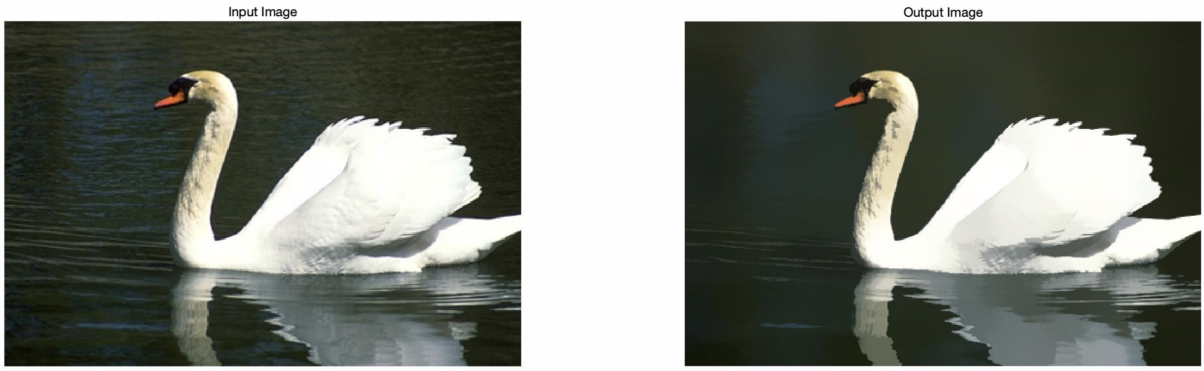

Figure 3: This is the comparasion set 2

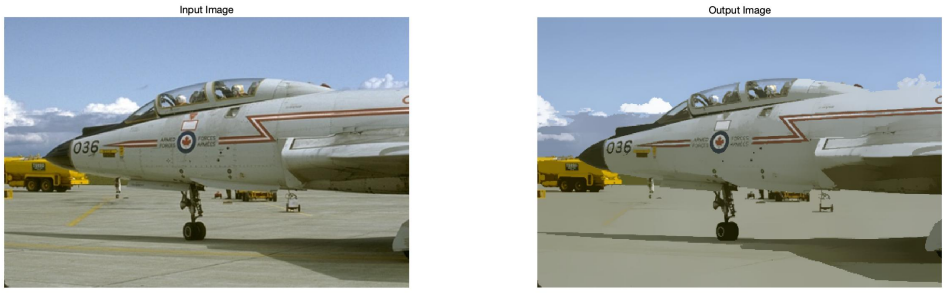

Figure 4: This is the comparasion set 2