Final Project – Stereo Correspondence

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Abstract

Stereo Correspondence is a matching method to find corresponding points in two or more images from difference different viewpoints. In this report, we will show some of the stereo correspondence algorithm that use to establish a correspondence points in the left and right image such as: sum of square difference (SSD), graph cut / dynamic programming (DP). We will discuss the result from those methods and compare them with the ground truth and see what's the cons and pros for those methods.

Introduction

For the project that outputs the disparity map between left image and right image. First way to do that is compare pixel at corresponding locations in 2 images known as Sum of Square Difference (SSD). The second way to do is using the graph-cut method which a separation of the graph into two disjoint sets of nodes and chosen the minimize total weight of the edges. Let's introduce those 2 methods in the next section.

Method

1. Sum of Square Difference

SSD method is a technique used in computer vision/Image Processing for matching corresponding points in 2 images. The idea of this method is compare pixel values at corresponding location in 2 images and calculate the sum of squared differences between them. Below is the formula for SSD

Formula:

$$\mathrm{SSD} = \sum_{i,j} \left(I_1(i,j) - I_2(i+d,j)\right)^2$$

If we transfer the formula to code, we would be have the below pseudo code:

Algorithm 1: SSD method

```
for d in range(0, D) do
    Calculate difference images between I' and I
     shifted by d
    Calculate squared difference images
    Convolve squared difference image with a box
     filter of size k to obtain SSD images
end
for p(x,y) in I do
    Find the SSD image with the smallest value at
     location (x,y)
    The corresponding d for that image is the disparity
     at p(x,y)
end
```

2. Minimum-Cut/Max-Flow

Minimum-Cut in a network (flow network) is a partition of the nodes into 2 disjoint sets: the source and the sink. The capacity of a cut is the sum of the capacities of the edges crossing the cut from the source to the sink. Max-Flow is similar to the Minimum-Cut but it representing the maximum amount of flow it can carry.

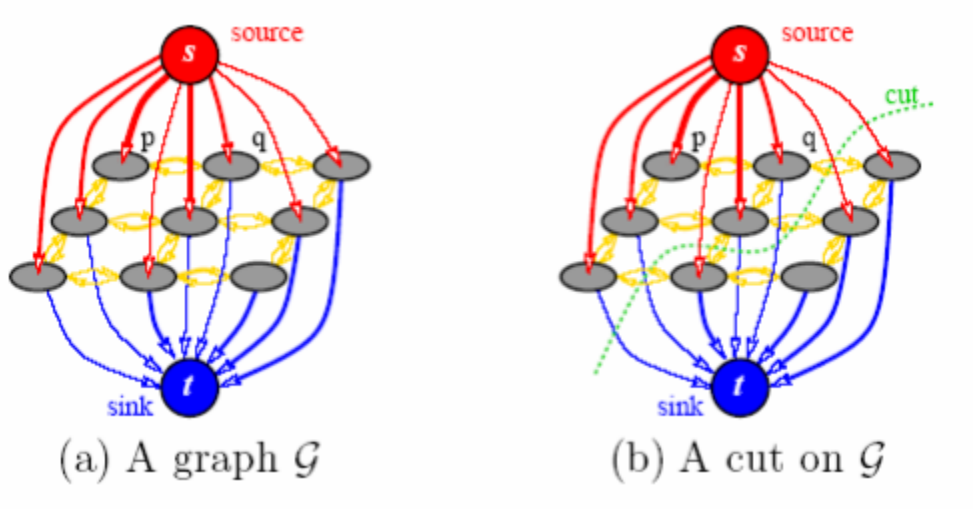

Figure 1. graph cut process

The Minimum-Cut also can be said as the s-t Cut and the flow defined as:

$$f(S,T)=\sum_{x\in S}\sum_{y\in T} f(x,y)$$

And the cut defined as:

$$c(S,T) = \sum_{x \notin S} \sum_{y \in T} c(x,y)$$

The Minimum-Cut process in a graph as below:

1. Initialize the cut.
2. Find the augmenting paths.
3. Augment the flow.
4. Update the residual graph.
5. Repeat 2-4.
6. Identify the Minimum Cut

3. Result and discussion

Below are the results run by 2 methods and with the ground truth:

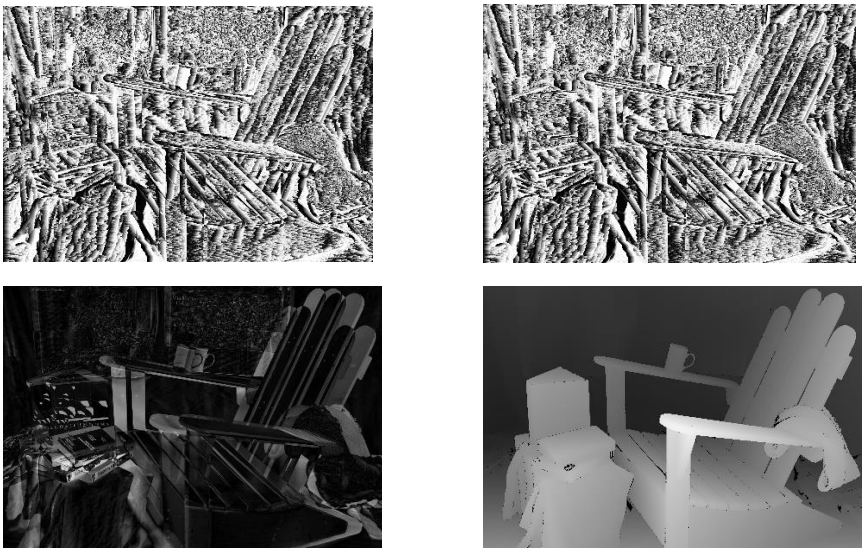

Figure 2-5. Top left: SSD from left to right; Top right: SSD from right to left; Bottom left: Minimum-Cut; Bottom right: ground truth

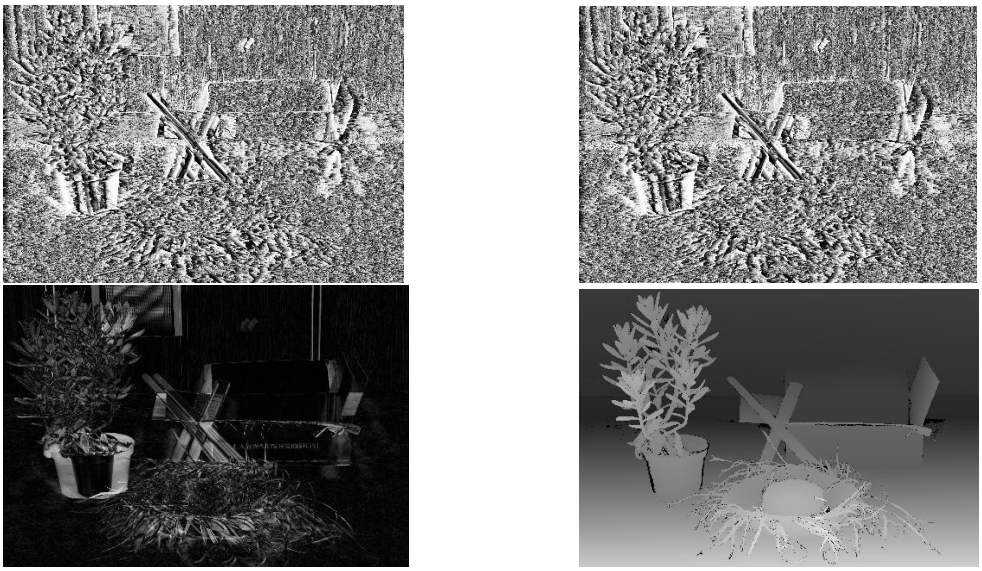

Figure 6-9. Top left: SSD from left to right; Top right: SSD from right to left;
Bottom left: Minimum-Cut; Bottom right: ground truth

After compare both result, we can see that the disparity map for SSD has noisy for left-to-right and right-to-left. The detail on disparity map for SSD lose more than the graph-cut method. The disparity map for SSD from for left-to-right and right-to-left are same, hard to tell difference, but is not clear after compare to ground truth. The graph-cut method can see the detail of object in the images, but the disparity map also does not close to ground truth and there has the shallow around the objects, should be cause by the algorithm or the value for cost weight or smoothness.

After compare all the results with ground truth, we find out that the algorithm for minimum cut might be not strong enough because it should be much better than the SSD and very close to the ground truth. For further improvement, we should be improve the minimum cut and remove the shallow part and make sure the object detection can be match on left and right images.

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