CSC320 A1

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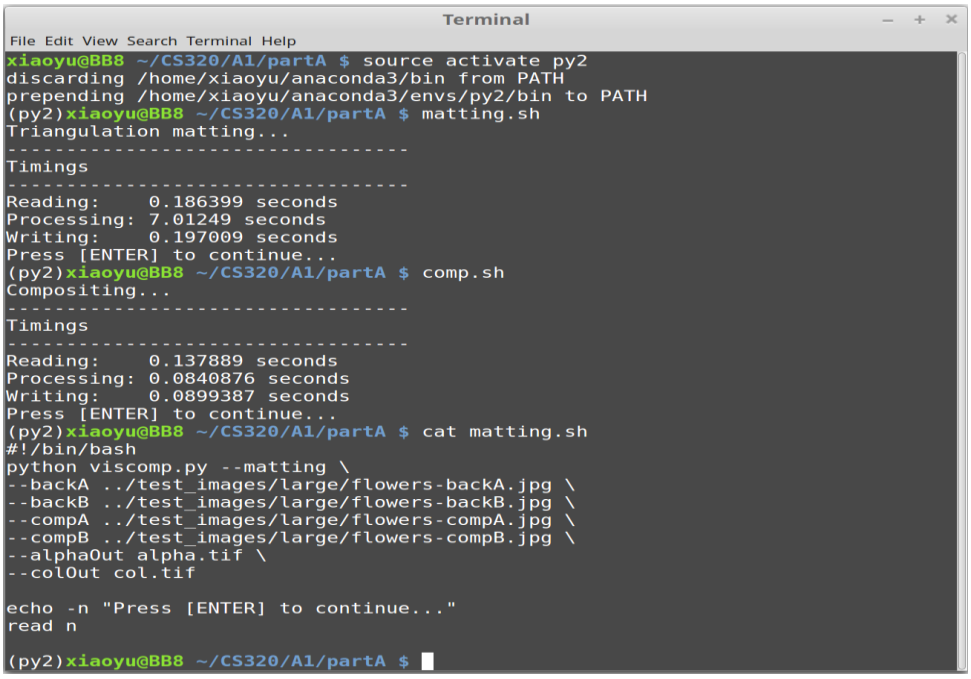
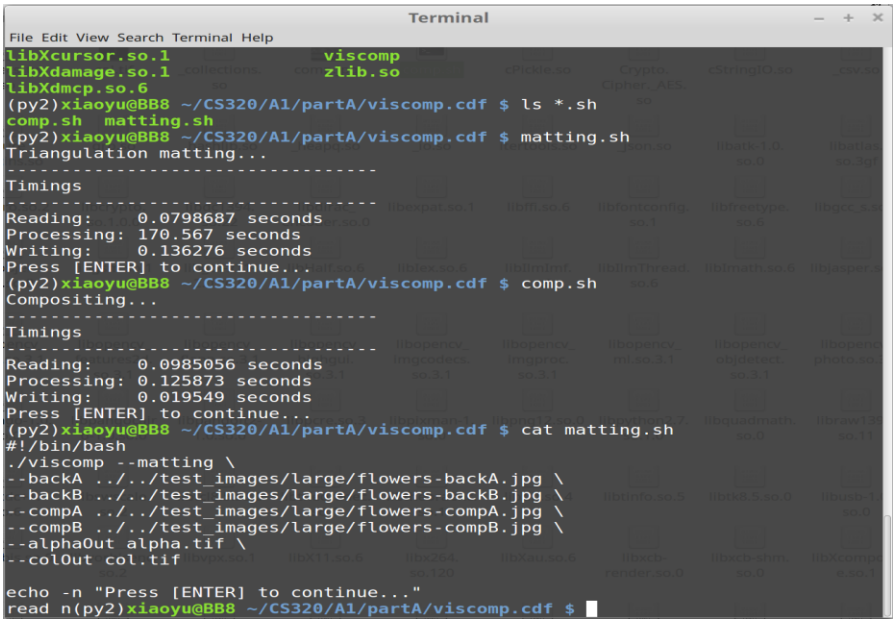
Part 2

My solution: Processing (large): 7.01249 seconds



Reference solution: Processing (large): 170.567 seconds



1. Using the feature of numpy's ndarray datatype, trying to avoid creating temp array in the computation.
2. To speed up the solving procedure, I tried to avoid using the for loops, instead I took advantage of the Numpy's broadcast feature to do iteration works:

```
# Construct matrix A
E = np.tile(np.eye(3), (M,N,1,1))
aa = backA.reshape(M,N,3,1) * -1
ab = backB.reshape(M,N,3,1) * -1
aa = np.concatenate((E, aa), axis=3).astype(np.int64)
ab = np.concatenate((E, ab), axis=3).astype(np.int64)
A = np.concatenate((aa,ab), axis=2)
```

3. Building square matrix to solve the equations. In this way, creating the transpose of a matrix will not create a new array using Numpy. It is also much faster than computing the inverse of a matrix.
4. Finally, by building a square matrix, we can use the optimized numpy.linalg.solve() function to solve all equations at the same time.

Part 3

Procedures

Step 1: Putting the camera on a stable table and facing it to a wall.

Step 2: Putting the background A against the wall, taking a photo of A and saving it as *backA.jpg*

Step 3: Putting the background B against A, taking a photo of B and saving it as backB.jpg

Step 4: Putting the foreground object between the camera and the wall, taking a photo and saving it as compB.jpg

Step 5: Taking out background B, taking a photo of the object against background A, saving as compA.jpg

Experiments and Analysis

Camera info:

Maker: Intel Corporation

Model: OV8865

F-Stop: f/2

Image info:

backC.jpg: 1/24 s, ISO 1097, Focal Length (FL) 254m

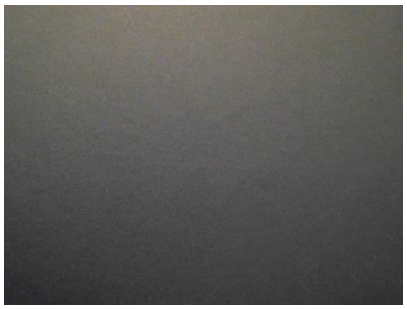
Image size: 816 x 612 pixels

Light intensity

In different experiments, using the same foreground object and backgrounds, but different light intensities.

Normal-Experiment 1

backA.jpg (1/50 s, ISO 352, FL 100mm)



backB.jpg (1/24 sec, ISO 1331, FL 319mm)

compA.jpg (1/41 s, ISO 419, FL 365mm)

compB.jpg (1/30 s, ISO 759, FL 350mm)

Alpha.tif

col.tif

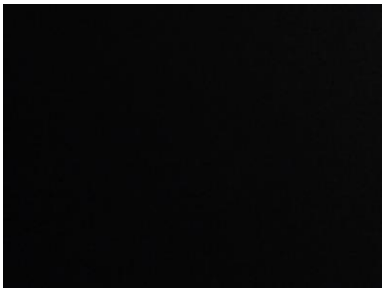
backC.jpg (1/24 s, ISO 1097, FL 254m)

comp.jpg

Dark environment - Experiment 2

Turn off one light to make the environment dark.

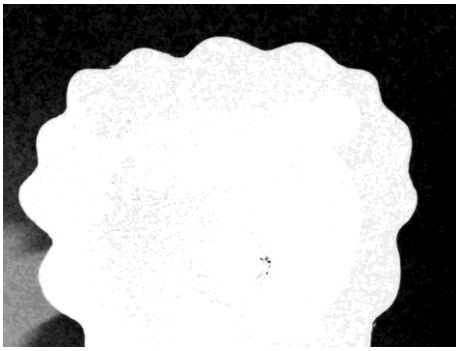
backA.jpg (1/25 s, ISO 1399, 300mm)



backB.jpg (1/25 s, ISO 1399, 300mm)

compA.jpg (1/25 s, ISO 1399, 348mm)

compB.jpg (1/25 s, ISO 1399, 350mm)



Alpha.tif

col.tif

backC.jpg (1/24 s, ISO 1097, FL 254m)

comp.jpg

In dark environment, this method also can extract the object accurately but may add more noise to the new background.

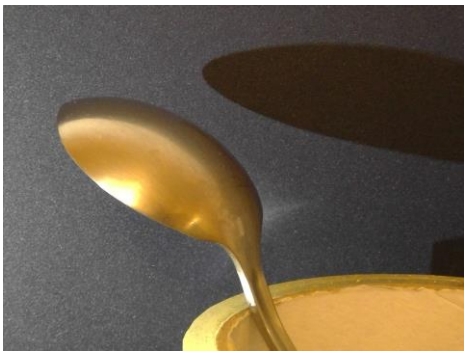
Shadow and reflection - Experiment 3

Using a metallic spoon to experiment the object's reflection effect and changing light source position to make a large shaded area.

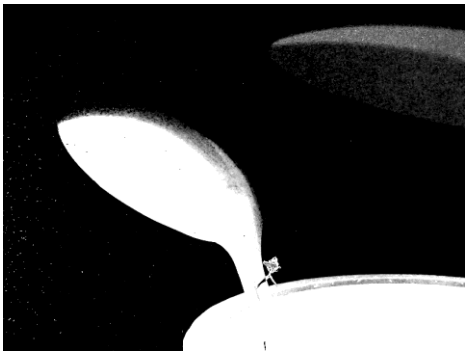
backA.jpg (1/50s, 289mm, ISO 82)

backB.jpg (1/30 s, 309mm, ISO 630)

compA.jpg (1/50 s, 339mm, ISO 114)



compB.jpg (1/40s, 327mm, ISO 469)



Alpha.tif

col.tif

backC.jpg

comp.jpg

The performance of triangulation method is relative weak to extract objects with high reflection effect. As we can see from the comp.jpg, there are a lot noise on the foreground spoon object. This method is also not idea to handle shadows in the environment. On the top right corner, the spoon's shadow information was incorrectly.

Foreground object shape - Experiment 4

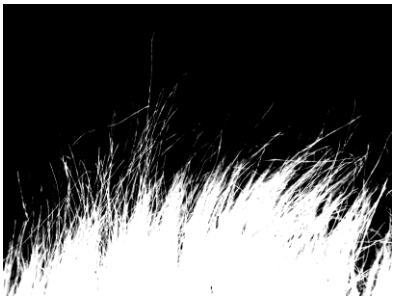
Experiment on different foreground objects with different shape (fluffy edge, sharp edge).

backA.jpg (1/50 s, 301mm, ISO 352)

backB.jpg (1/25 s, 313mm, ISO 1361)

compA.jpg (1/40 s, 380mm, ISO 408)

compB.jpg (1/25 s, 380mm, ISO 1089)



Alpha.tif

col.tif

BackC.jpg

comp.jpg

The previous experiments have shown that the triangulation method can extract objects with sharp edges perfectly. In this experiment, it also shows us that this method can extract fluffy objects ideally when the object is not moving.

Background material - Experiment 5

Using a shining metallic background to experiment the background's reflection effect.

backA.jpg (1/30 s, 274mm, ISO 1303)

backB.jpg (1/60 s, 271mm, ISO 163)

compA.jpg (1/30 s, 307mm, ISO 1119)

compB.jpg (1/30 s, 307mm, ISO 1119)

Alpha.tif

col.tif

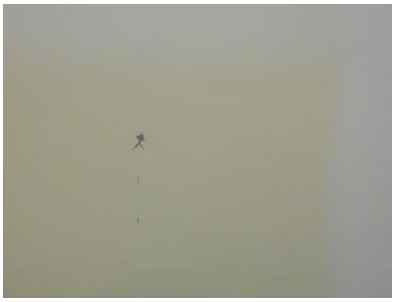
backC.jpg

comp.jpg

The triangulation method performed badly on the background that has strong reflection ability. In the comp.jpg image, the reflective part in the background was treated as foreground objects and also the reflective spoon in the foreground was treated as transparent object which was totally wrong.

Background pattern - Experiment 6

Using a green board with horizontal stripes as the background, a glass as foreground object.



backA.jpg (1/60 s, 261mm, ISO 366)

backB.jpg (1/30 s, 287mm, ISO 1040)

compA.jpg (1/60 s, 300mm, ISO 363)

compB.jpg (1/30 s, 293mm, ISO 972)

Alpha.tif

col.tif

backC.jpg

comp.jpg

In the comp.jpg, the green stripes appeared. The reason is the glass distorted the stripes on the green background, which was treated as part of the glass in this method. Therefore, when the foreground object may distort the background pattern, this method is not ideal enough.

Conclusion

This method can extract the foreground object with a high accuracy from most backgrounds and environments. The backgrounds do not have to be constant color and the foreground can be any shape.

It can be easily implemented without strict requirements of equipment or working environment.

However, this method requires the four input images and the foreground object must be non-motion.

In certain specific conditions (reflection, refraction, shadows, light intensity consistency etc.), this method cannot extract the foreground object with satisfying accuracy.

Part 4

It resulted from the vase shadow. The light was coming from the right side of the vase, which made a shaded area on the left side of the background. Since the triangulation method comparing the same pixel at the same position in four input images, the shadow appeared in the same area when taking photo of vase. In the computation of this method, the shadow area mainly shown the backgrounds color with slightly dark, so it would be treated as transparent part of the foreground. Therefore, the alpha value in this area is a small value instead of 0. In Experiment 3, the spoon's shadow area was also treated as transparent part in the comp.jpg output.