COMPSCI 527 Homework 6

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1 Introduction

Our goal in this paper is to investigate the following questions:

First, which types of error fail first when enough noise is added for the shape to be unrecognizable?

Second, what happens when we change the image resolution but keep `sigma` fixed?

2 Progression of failure with increasing levels of noise

2.1 Introduction

The software provided creates a simulated world with a square object (with multiple colored squares on each side) and two cameras, adds Gaussian noise to the image coordinates, and runs the eight-point algorithm for 3-d reconstruction. Because reconstruction is a ill-conditioned/ill-posed problem (due to its inverse nature), small errors in the data will often result in large errors in the 3D reconstruction.

We investigate the effect of pseudo-random Gaussian noise on different types of errors, especially as the image become so distorted that the reconstructed shape becomes unrecognizable.

We have three broad categories of errors:

1. Motion error: the difference between true and computed motion, for both translation and rotation, measured in degrees

2. Structure error: the difference between true and computed structure, measured in RMS average percentage error of the overall size of the object

3. Reprojection error: the difference between the image of the original object and reprojected image of the reconstructed object, measured in RMS pixels per point

We pose the question: at the point where enough noise has been added so that the reconstructed object is unrecognizable, what types of errors fail first?

2.2 Methods

The experiment we ran was to run the following procedure, in which a subroutine was applied on a range of `sigma`s from `0:.25:5`, with n = 150 for each `sigma`; we recorded the average errors for each, as shown in Figures 1-3.

Procedure

1. Create a 3D world, with object (Gaussian noise `sigma` = 0), two cameras, and the resulting images

2. Compute the true transformation between the camera reference frames

3. Compute the true structure

4. Subroutine for each sigma `0:.25:4`

   - Add noise to the original image with `sigma`
   - Compute the resulting transformation figure
   - Measure and record motion, structure, and reprojection errors

After this, we also drew the reconstructed figures for choice `sigma` (Figures 4-9), to demonstrate the effects of noise on the resulting reconstruction and to find out when the reconstructed object became unrecognizable.

2.3 Data

Figure 1. Motion error

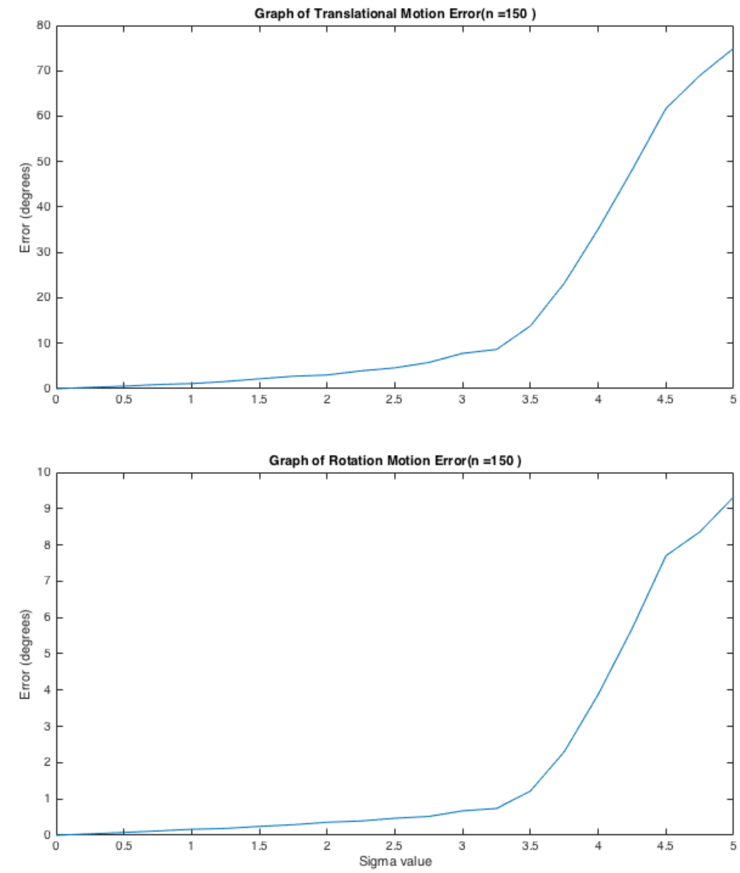

Figure 2. Structure error

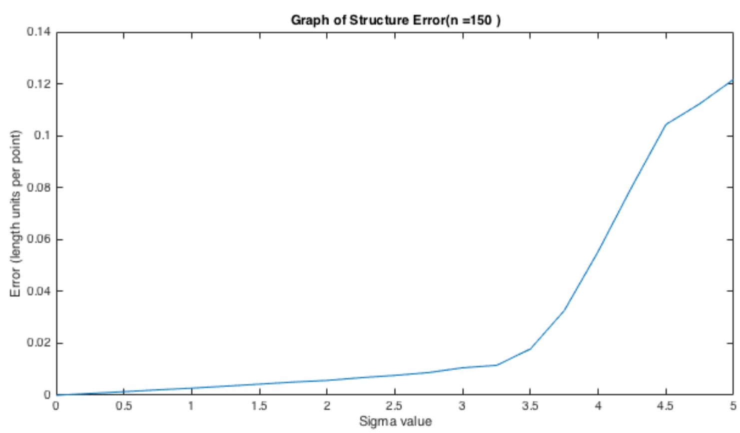

Figure 3. Reprojection error

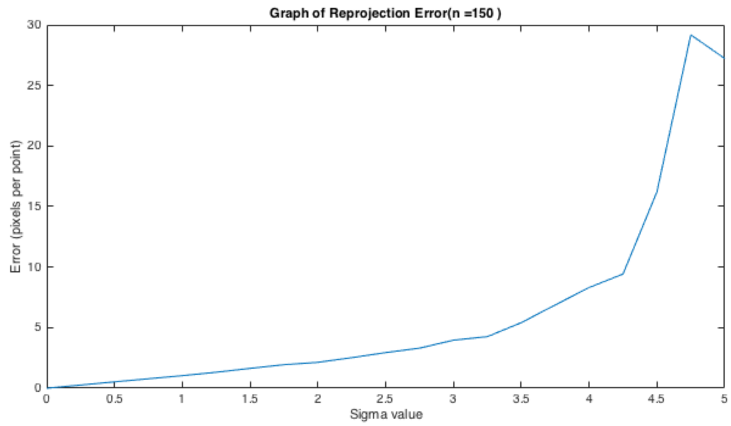

Figure 4. Reconstructed objects for `sigma`=0

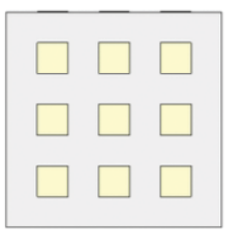

Figure 5. Reconstructed objects for `sigma`=1

Figure 6. Reconstructed objects for `sigma`=2

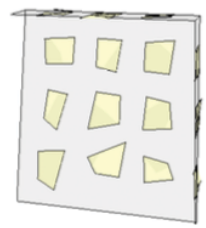

Figure 7. Reconstructed objects for `sigma`=3

Figure 8. Reconstructed objects for `sigma`=4

Figure 9. Reconstructed objects for `sigma`=5

2.4 Conclusions

Clearly, there is a severe drop in quality of the reconstructed object after `sigma` reaches around 3.25, and the reconstructed object for `sigma`=4 (Figure 8) is completely unrecognizable.

As we can see from the error plots, there is an inflection point around 3.25 where motion error (especially translation error) begins to climb drastically. This is followed immediately by structure error, which also has a similar inflection point. Finally, there is a slight inflection point in reprojection error, which is relatively delayed compared to the other errors (around `sigma`=4.25).

Interestingly, all of the error rates drop at around `sigma`=2.7, which is especially pronounced in translation motion and reprojection errors.

3 Effects of modifying image resolution

4 Conclusion

References

[1] Hartley, Richard. "In defense of the eight-point algorithm." Pattern Analysis and Machine Intelligence, IEEE Transactions on 19, no. 6 (1997): 580-593.

[2] Chojnacki, Wojciech, and Michael J. Brooks. "On the consistency of the normalized eight-point algorithm." Journal of Mathematical Imaging and Vision 28, no. 1 (2007): 19-27.