The Damped Bundle Adjustment Toolbox v0.2 for Matlab

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Contents

1 Introduction

1.1 Purpose

Matlab toolbox with freely available code for bundle adjustment. Intention to be state-of-the-art.

1.2 Limitations

What it can do.

What it cannot do.

1.3 Legal

1.4 Scientific publications

Refer to any of the papers...

Börlin and Grussenmeyer (2013a) Börlin and Grussenmeyer (2013b)

2 Installation

1. Download the package file `dbat_0.2.zip`.
2. Unpack the package into a directory *dbat*.
3. Inside Matlab, do the following initialization:
   ```
   cd dbat % the directory where you installed the files.
   dbatSetup % set paths, etc.
   ```
4. Test the installation by executing `loadplotdemo`.
5. If `loadplotdemo` runs without errors and generates a figure with a camera network, the installation is ok.

3 Usage

3.1 Demos

3.1.1 loadplotdemo

The `loadplotdemo` demo loads a modified Photomodeler text export file of the 60-camera, 26000-point project used in Börlin and Grussenmeyer (2013a). The camera network, as computed by Photomodeler, is plotted with camera 1 aligned to the cardinal axes. The result should look like Figure 1. The figure is a standard Matlab 3D figure and may e.g. be rotated or zoomed using the camera toolbar.

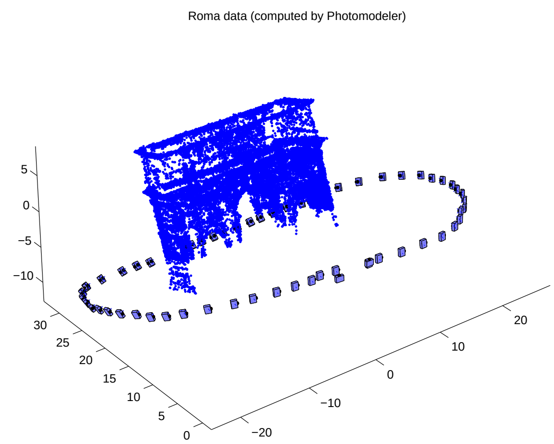


Figure 1: The figure generated by the `loadplotdemo` demo.

3.1.2 loadplotdemo2

The `loadplotdemo2` demo loads a modified Photomodeler text export file of a 21-camera, 100-point camera calibration project. The camera network, as computed by Photomodeler, is plotted and should look like Figure 2. The figure is a standard Matlab 3D figure and may e.g. be rotated or zoomed using the camera toolbar.

3.1.3 romabundledemo

3.1.4 camcaldemo

The `loadplotdemo2` demo loads the camera calibration export file from Section 3.1.2 and runs a camera calibration. The true focal length is used as initial value. The other values are set to "default" values, e.g. the principal point is the center of the sensor and all lens distortion parameters are zero.

The bundle adjustment is run with Gauss-Newton-Armijo damping. The result is given in a number of plots and a Photomodeler-style result text file. The result file is listed in Appendix B.

The result plots are of two kinds: Plots that show the evolution of the iterations and plots that show the quality of the input or output data. The former plots may be useful to understand how the bundle adjustment works but also to "debug" a difficult network that has convergence difficulties. The latter plots give information about the quality of the result and may also provide clues to how to improve a network where the bundle did converge.

Figure 4 contains three figures showing the evolution of the internal orientation (IO), external orientation (EO), and object point (OP), respectively, during the iterations. The EO and OP plots are interactive. Lines in the plots or legends may be selected and all corresponding lines will be highlighted. In

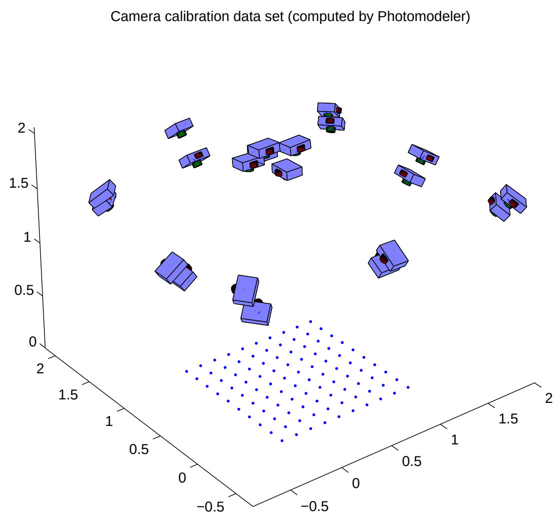
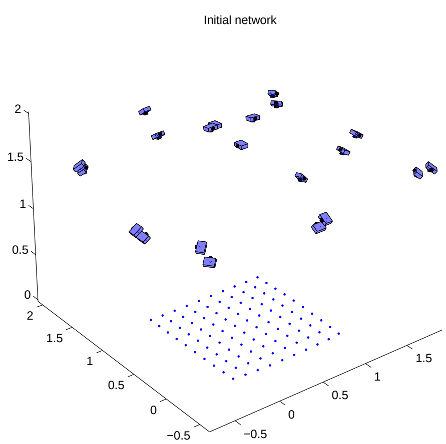
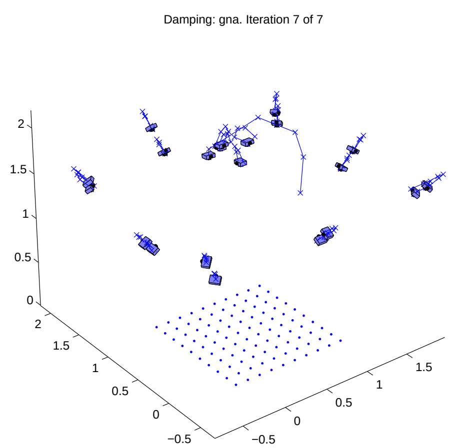


Figure 2: The figure generated by the `loadplotdemo2` demo.

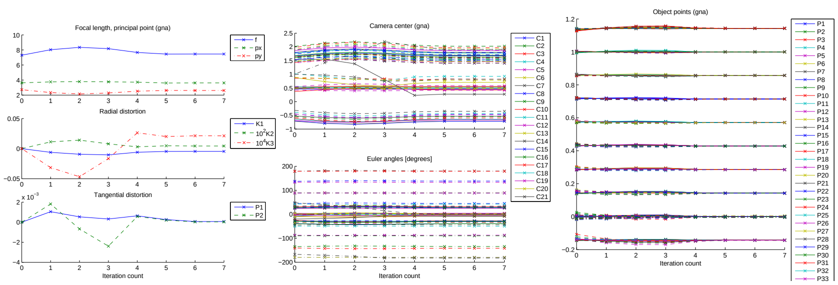


(a) Initial network configuration.



(b) Network configuration after convergence, with camera center trace lines.

Figure 3: 3D network evolution during the iterations. The evolution of the IO parameters are not visible.



(a) IO parameters (b) EO parameters (c) OP parameters

Figure 4: Evolution of all parameters of the network during the iteration sequence.

Figure 4b, it is clear that

3.2 Using your own data

3.2.1 Enabling text export from Photomodeler

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Some versions of Photomodeler do not have the text file export option enabled by default. In that case, follow the following steps to enable it:

1. Right-click on the main window toolbar, select *Customize toolbar...*.
2. In the *Commands* tab, select the *File* category.
3. Drag the *Export Text File...* command to a toolbar of your choice.
4. Now you should be able to export your project as a text file by clicking on the *Export Text File* button.

3.2.2 Export from Photomodeler

To import a Photomodeler project into the toolbox, the following steps are valid in Photomodeler Scanner 2012:

1. Export the project using *Export Text File*. If the *Export Text File* command is not available, follow the instructions in Section 3.2.1.
2. After export, open the *Project/Cameras...* dialog and select the camera that was used in your project.
3. Open the generated text file in a text editor.
   (a) On the 2nd line (usually reading `0.00005 20`), append the width and height in pixels of your images, e.g. to `0.000500 20 5616 3744`.

(b) Inspect the 4th line. For instance, the original data in `roma.txt` was (some trailing zeros removed):

`24.3581 18.1143 12.0 35.96404 24.0 0.00022 -0.0 0.0 0.0 0.0`

The values correspond to the following camera parameters:

`focal pp_x pp_y format_w format_h K1 K2 K3 P1 P2`.

Notice that most of the significant digits of K1–K3 were lost in the text export.

(c) Update the parameter values on the 4th line with values from the camera dialog *for each parameter with a larger number of significant digits in the dialog*. This usually means all parameters except `format_w`. In the `roma.txt` test case, the 4th line was modified to:

`24.3581 18.1143 12 35.96404 24 2.174e-4 -1.518e-7 0 0 0`.

3.2.3 Loading into Matlab

1. In matlab, run step 3 from Section 2 if not already done.
2. Set the variable `fName` to the text export file name `fName='c:/path/to/exported/file.txt';`, or select it using `[f,p]=uigetfile('*.txt'); fName=[f,p];`
3. Run the `loadplotdemo` script. A figure with your camera network, aligned with the first camera and rotated to have +Z 'up', should now have been generated.

References

N. Börlin and P. Grussenmeyer. Bundle adjustment with and without damping. *Photogrammetric Record*, 28(144):396–415, Dec. 2013a. doi: 10.1111/phor.12037.

N. Börlin and P. Grussenmeyer. Experiments with metadata-derived initial values and linesearch bundle adjustment in architectural photogrammetry. *ISPRS Annals of the Photogrammetry, Remote Sensing, and Spatial Information Sciences*, II-5/W1:43–48, Sept. 2013b.

A Camera model

B Result file example

```
Damped Bundle Adjustment Toolbox result file
   Project Name: Bundle Soln PhotoModeler Calibration Project
   Problems and suggestions:
      Project Problems: Not evaluated
      Problems related to the processing: (1)
         One or more of the camera parameter deviations has a high correlation (see below).
   Information from last bundle
      Last Bundle Run: 05-Feb-2014 07:47:15
      DBAT version: 0.2.0.136 (2014-02-04 12:25:53)
      Status: OK (0)
      Sigma0 (pixels): 0.15106
      Sigma0 (mm): 0.000482148
      Processing options:
         Orientation: on
         Global optimization: on
         Calibration: on
         Constraints: off
         Maximum # of iterations: 20
         Convergence tolerance: 0.001
         Singular test: off
         Chirality veto: off
         Damping: gna
      Total error:
         Initial value comment: Camera calibration
         Number of stages: 1
         Number of iterations: 7
         First error: 9.28313
         Last error: 0.029411
      Precisions / Standard Deviations:
         Camera Calibration Standard Deviations:
            Camera1:
               Focal Length:
                   Value: 7.45885 mm
                   Deviation: 0.001 mm
               Xp - principal point x:
                   Value: 3.61622 mm
                   Deviation: 0.0008 mm
               Yp - principal point y:
                   Value: 2.60928 mm
                   Deviation: 0.0009 mm
               Fw - format width:
                   Value: 7.25319 mm
               Fh - format height:
                   Value: 5.43764 mm
```

```
      K1 - radial distortion 1:
          Value: 0.0045807 mm^(-2)
          Deviation: 2e-05 mm^(-2)
      K2 - radial distortion 2:
          Value: -4.34359e-05 mm^(-4)
          Deviation: 2e-06 mm^(-4)
          Correlations over 95.0%: K3:-97.9%.
      K3 - radial distortion 3:
          Value: -2.12972e-06 mm^(-6)
          Deviation: 9e-08 mm^(-6)
          Correlations over 95.0%: K2:-97.9%.
      P1 - decentering distortion 1:
          Value: -6.54637e-05 mm^(-2)
          Deviation: 3e-06 mm^(-2)
      P2 - decentering distortion 2:
          Value: -3.13246e-05 mm^(-2)
          Deviation: 4e-06 mm^(-2)
Photograph Standard Deviations:
   Photo 1: P8250021.JPG
      Omega:
         Value: -39.351215 deg
         Deviation: 0.008 deg
      Phi:
         Value: -1.118308 deg
         Deviation: 0.008 deg
      Kappa:
         Value: -179.789856 deg
         Deviation: 0.004 deg
      Xc:
         Value: 0.457102
         Deviation: 0.0002
      Yc:
         Value: 1.791883
         Deviation: 0.0002
      Zc:
         Value: 1.470536
         Deviation: 0.0002
   .
   .
   .
   Photo 21: P8250041.JPG
      Omega:
         Value: -8.620606 deg
         Deviation: 0.009 deg
      Phi:
         Value: 1.135801 deg
```

```
            Deviation: 0.01 deg
         Kappa:
            Value: -182.602049 deg
            Deviation: 0.003 deg
         Xc:
            Value: 0.271704
            Deviation: 0.0003
         Yc:
            Value: 0.818510
            Deviation: 0.0003
         Zc:
            Value: 1.906171
            Deviation: 0.0002
Quality
   Photographs
      Total number: 21
      Numbers used: 21
   Cameras
      Total number: 1
      Camera1:
         Calibration: yes
         Number of photos using camera: 21
         Photo point coverage:
            Rectangular: 41%-83% (61% average, 92% union)
            Convex hull: 31%-62% (46% average, 87% union)
   Photo Coverage
      References points outside calibrated region:
   Point Marking Residuals
      Overall point RMS: 0.202 pixels
      Mark point residuals:
         Maximum: 0.793 pixels (OP 8 on photo 19)
      Object point residuals (RMS over all images of a point):
         Minimum: 0.097 pixels (OP 67 over 21 images)
         Maximum: 0.392 pixels (OP 90 over 16 images)
      Photo residuals (RMS over all points in an image):
         Minimum: 0.131 pixels (photo 8 over 98 points)
         Maximum: 0.281 pixels (photo 6 over 93 points)
   Point Precision
      Total standard deviation (RMS of X/Y/Z std):
         Minimum: 8.1e-05 (OP 22)
         Maximum: 0.00016 (OP 88)
      Maximum X standard deviation: 7.2e-05 (OP 90)
      Maximum Y standard deviation: 7.7e-05 (OP 90)
      Maximum Z standard deviation: 0.00012 (OP 88)
   Point Angles
      Minimum: 79.6 degrees (OP 90)
```

```
Maximum: 90.0 degrees (OP 43)
Average: 86.4 degrees
```