Manual for Epipolar Rectification 9c (ER9c)

Ugo Capeto*

December 3, 2016

ER9c is an implementation of the epipolar rectification method described in [2] and [5]. Unlike ER9, this is my own implementation which includes SIFT [3] for feature detection and optimized RANSAC aka ORSA [4] for outlier rejection. Unlike ER9b which minimizes the Sampson error, ER9c directly minimizes the mean vertical disparity error using either the Powell method or the simplex method. Also, unlike ER9b which considers the focal length a variable, ER9c considers the focal length as fixed and given by the user.

Proper epipolar rectification of a stereo pair is crucial prior to applying any depth map automatic generator that assumes that stereo matches occur along the same horizontal line (matching pixels have the same ordinate). Most two view (left and right) automatic depth map generators make that assumption.

Assuming you have two images to rectify stored in a directory somewhere on your computer, the files `er9c.bat` and `er9c_input.txt` must be copied to that directory. These two files are provided in the directory `er9c_test` along with a set of sample input files. The file `er9c.bat` must be modified so that the path to `er9c.exe` is the correct one for your computer. To run ER9c, you simply double-click on `er9c.bat`.

The format of `er9c_input.txt` is as follows:

```
Name of first image (input)
Name of second image (input)
Name of rectified first image (output)
Name of rectified second image (output)
Number of trials
Maximum allowed mean vertical disparity error
Focal length
Minimization method
```

The file names cannot have spaces in them. I would not use a full path format like `C:\this_dir\that_dir\image.png` but simply `image.png`. I also wouldn't use a point in the body of the name (`image_ref.png` is ok but `image.ref.png` is not). The supported image file formats are png, tiff, and jpeg.

The number of trials determines how hard the program is gonna try to eliminate the outliers among the matches between the two views. The higher the number, the better the result is likely to be although it will take longer.

*e-mail: `ugocapetodifrancia3d@gmail.com`

If the mean vertical disparity error in the rectified images is above the maximum allowed mean vertical disparity error, the program stops and gives an error message. This parameter is set to some large value (`10000.0` for example) in order for the program to always produce rectified images. The program prints out the mean vertical disparity error, which can be used to evaluate the quality of the rectification process. It is usually accepted that a value below 0.5 is excellent. In practice, a value below 1.0 can be considered as very good. Caution should be exercised for larger values as the rectification process may not have been optimal. It is not a bad idea to load the left and right rectified images as layers into Gimp and switch between the two layers to make sure the images are shifting horizontally or very close to it.

The focal length does not have to be the actual focal length that was used to take the pictures. On the contrary, it is recommended to use various focal lengths and see which rectification process gives the smallest mean vertical disparity error. Typically, if `w` is the width of the images and the images are landscape oriented, it is a good idea to run ER9c with a focal length equal to `w` times 0.5, 1.0, 2.0 etc.

The method to minimize the mean vertical disparity error can be either `powell` (Powell's method) or `simplex` (simplex method). There really should not be much difference between the two. To be perfectly clear, I did not write the code for these two methods. The code comes from the most excellent Numerical Recipes book.

Beside the rectified images, ER9c also outputs the features (keypoints) detected by SIFT in `feat1.tiff` and `feat2.tiff`, the matches determined by SIFT in `match1.tiff` and `match2.tiff`, and the (good) matches determined by ORSA in `good_match1.tiff` and `good_match2.tiff`. The matches are displayed as small rectangles of the same color.

ER9c also outputs the min and max disparity on two lines in the console window. This min and max disparity can be used as input to the various automatic depth map generators in the DMAG family instead of [1]. The first line shows the min and max disparity as is. The second line shows the min and max disparity taking into account possible outliers. If the min and max disparity on the first line don't make sense (are way too far apart), the second line should be considered for min and max disparity.

At this point in time (this may change as the code is improved upon), it is not recommended to use images that are too big. I personally recommend images that are in the one to two megapixels range although one can certainly try with larger images and see what happens.

If you cannot scroll to the beginning of the command window (ER9c prints out useful info as it runs), you need to increase the screen buffer size of the command window by doing the following: Right-click on the icon in the upper left and then click on Properties; Click on the Layout tab; Increase the Screen Buffer Size Height to the maximum, which is 9999; Click OK. You should now be able to get to the beginning of the printouts next time you run ER9c.

References

[1] Ugo Capeto. Disparity finder 2 (df2). `http://3dstereophoto.blogspot.com/2013/06/disparity-finder-2-df2.html`. Accessed June 11, 2016.

[2] Andrea Fusiello and Luca Irsara. Quasi-euclidean uncalibrated epipolar rectification. In *Pattern Recognition, 2008. ICPR 2008. 19th International Conference on*, pages 1–4. IEEE, 2008.

[3] David G Lowe. Distinctive image features from scale-invariant keypoints. *International journal of computer vision*, 60(2):91–110, 2004.

[4] Lionel Moisan, Pierre Moulon, and Pascal Monasse. Automatic homographic registration of a pair of images, with a contrario elimination of outliers. *Image Processing On Line*, 2:56–73, 2012.

[5] Pascal Monasse. Quasi-Euclidean Epipolar Rectification. *Image Processing On Line*, 1, 2011. `http://dx.doi.org/10.5201/ipol.2011.m_qer`.