Lens Distortion Software Manual

Original version: March 2013

In this manual function names will look like: eg. distortionLoader()
Function parameters that need to be manually entered are written as: *nameofyourfile*

There are 2 Matlab functions that are explained in this manual:

1. distortionLoader.m
2. distortionProcessor.m

The output from distortionProcessor can be analyzed using fitting software.

Procedure:

Set up the optics bench in the light source, diaphragm, object, lens, screen configuration. The object should be a grid of small squares about 5 mm side length. The lens should be one that causes visible distortion such as the thick lens. The screen should be made of a semitransparent material so that the image can be seen from both in front and behind the screen. A possible material is tissue paper. (**Be careful that the light from the lens does not heat the screen and catch it on fire. Do not leave the light on unattended.**)

Adjust the distances between the object, lens and screen so that a focused image of the distortion is visible on the screen. The image must be magnified enough so that you can see the warped grid lines from the object cast on the screen. The diaphragm may need to be adjusted to allow the image to be visible.

Take a photo of the distortion from behind the screen using a digital camera. Try to keep the front face of the camera parallel to the screen to avoid introducing additional skew. The resolution of the photo should be about 4 megapixels. A too high resolution photo will take long to process without any benefit.

Use a pair of calipers to measure the horizontal distance of the lower horizontal side of the square closest to the optical axis. This square should have a low level of distortion. Record this measurement. This is c_var in the distortionProcessor function.

Use the calipers to measure the length of the sides of the squares in the undistorted object grid. Take several measurements. The program will find the uncertainty.

Download the photo off of the camera and save it in the same directory where you are running the Matlab distortion functions. Add the folder with the photos and distortionLoader.m and distortionProcessor.m to the Matlab path. Type the command clear into the Matlab command window in order to remove old variables that may conflict with the software.

Type distortionLoader('*nameofyourfile.jpg*') into the command window to load the image processing tool . A window with the image will appear.

Use the "measure distance" tool from the toolbar to measure the number of pixels from the optical axis (should be close to the center of the image) to the first, 1.5 and second diagonal radius. The distorted picture should distort squares to diamonds and the measured radius is the diagonal radius of the diamond shape. Record these measurements. The software can accept a maximum of 4 radial measurements for each of the first, 1.5 and 2 diagonal radii. The measurements are always taken from the center outwards. These are the dist_1, dist_1_5 and dist_2 variables.

Use the "measure distance" tool to measure the horizontal distance of the lower horizontal side of the square closest to the optical axis. The same square and place as you measured the c_var variable above. This square should have a low level of distortion. Record this measurement. (This is c_pixels for the distortionProcessor function)

The function distortionProcessor.m takes several input arguments and outputs two variables. The first output variable contains a matrix with the undistorted radius in the first column and the uncertainty in the second. The second variable output is another matrix with the distorted radius in the first column and the uncertainty in the second.

The input variables are as follows:

Input Variable	Explanation	Type
square_side	Measurements of side of undistorted grid (mm)	row vector
dist_1	Radial measurements 1 radius (mm)	row vector
dist_1_5	Radial measurements 1.5 radius (mm)	row vector
dist_2	Radial measurements 2.0 radius (mm)	row vector
c_var	Horizontal distance of the lower horizontal side of the square closest to the optical axis. (mm)	double
c_var_er	Uncertainty in c_var measurement (mm)	double
c_pixels	Pixels measured on photograph for same line segment as c_var (pixels)	double
c_pixels_er	Uncertainty in pixel	double

	measurement for c_pixels (pixels)	
line_width_uncertainty	The uncertainty due to the linewidths in the photograph (pixels)	double

To run the distortion processor, type the following into the command window using the values you measured:

[*a*,*b*] = distortionProcessor(*square_side, dist_1, dist_1_5, dist_2, c_var, c_var_er, c-pixels, c_pixels_er, line_width_uncertainty*)

The results will be returned in the variables a and b. You can then import these into a plotting program to fit the data to a distortion model.