Ana San Román Gaitero and José Luis (Pepe) Cano-Manuel Claver

Assignment 1: Camera Geometric Calibration

The aim of the project is to calibrate the camera using different datasets. For each one (run), the images are segmented automatically, or manually if not detected.

Methods

Apart from the camera calibration and cube plotting, three other tasks are done. Real-time performance with webcam in online phase for Run 1 (see video), iterative detection and rejection of low-quality inputs, and implementation of an edge enhancement (Canny) filter to reduce the number of input images that are not correctly processed by findChessboardCorners.

The Canny filter is applied on all the images/frames of both the offline and online phase.

For the detection of low-quality images, an error corresponding to the normalize difference between the detected points from the offline phase and the detected after the calibration is calculated, for each image. The outlier images are rejected.

Results and Discussion

For each Run, the corresponding K intrinsic matrices are:

$$K_1 = \begin{bmatrix} 943{,}85 & 0 & 612{,}57 \\ 0 & 943{,}76 & 405{,}20 \\ 0 & 0 & 1 \end{bmatrix}$$

$$K_2 = \begin{bmatrix} 938{,}14 & 0 & 607{,}95 \\ 0 & 939{,}29 & 403{,}65 \\ 0 & 0 & 1 \end{bmatrix}$$

$$K_3 = \begin{bmatrix} 935{,}26 & 0 & 608{,}94 \\ 0 & 932{,}61 & 405{,}75 \\ 0 & 0 & 1 \end{bmatrix}$$

For all of them, the focal length (mm) is similar on both the x and y direction. The central point x_0 and y_0 is also similar between the images, and the s coefficient is 1, meaning that the pixels are perfectly squared (and matches with the fact that $f_x = f_y$).

In Table 1, the results for Run 1, where all images are used, are shown. Without applying any optimization 5 images were not automatically detected, and the calibration error was of 0,37. When applying the Canny filter, the error downs to 0,22 and 2 more images are automatically detected. If using only the outliers correction, one image is detected as low quality (and rejected) and the error also decreases to 0,23. Applying both the error obtained is 0,076.

Therefore, the Canny filter is proven to work efficiently on helping the automatic detection of the corners. Also, the outliers correction is able to discard low quality input images. Using both can reduce the error from 0,37 to 0,076.

Run 1	Canny and Outliers correction			Canny		
Error	0,076			0,22		
# Images	Auto	Manual	Outliers	Auto	Manual	Outliers
	22	3	1	22	3	
Run 1	Outliers correction			No improvement		
Error	0,23			0,37		
# Images	Auto	Manual	Outliers	Auto	Manual	Outliers
	20	5	1	20	5	

Table 1: Run 1 error of the calibration and number of images on the dataset. Outliers correspond to the images rejected.

In Table 2, the calibration errors per Run can be seen. The best set is that of Run 2 (0,052), closely followed by Run 3 (0,055), and Run 1 (0,076).

In this sense, either the linear interpolation or the corners allocation used in Run 1 is proven to increase the error of the calibration (0,076), from those Runs where all the images are automatically detected. For the Run 2 the error is lower than for Run 3, thus using more images help on improving the calibration.

	Run 1	Run 2	Run 3
Error calibration	0,076	0,052	0,055

Table 2: Calibration error per Run.

Github link

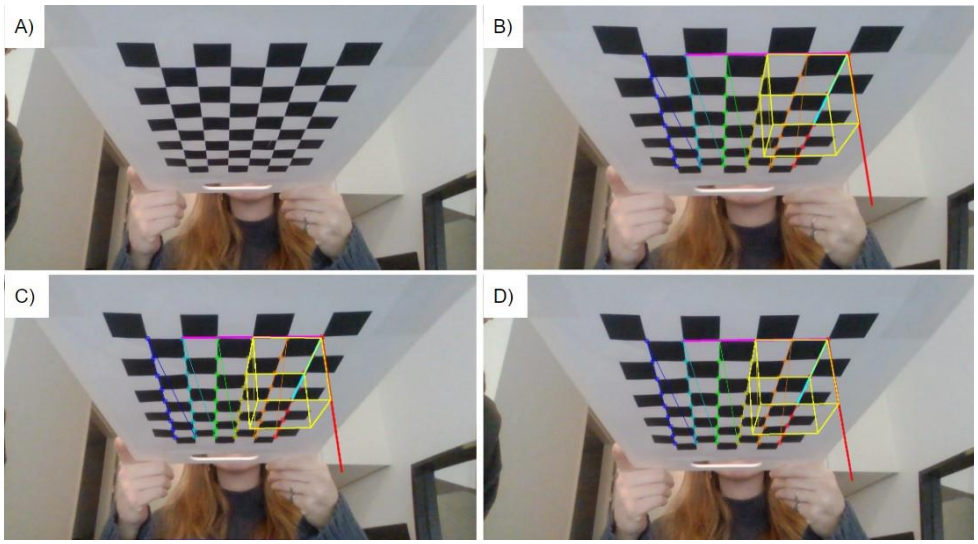

Figure 1: chessboard images tilted, with a width of 22mm per square (6x9 squares). Cube (yellow) and axis (red, pink, blue) plotted in the distorted images after calibration, A) Original image. B) Run 1. C) Run 2. D) Run 3.