

# Stereo calibration in OpenCV

Data structures are: `CvCamera` and `CvStereoCameraq`

Defined in `/usr/include/opencv/cv_aux.h`

The function used to understand the calibration file is `SaveCameraParams()` from file `/usr/src/debug/opencv-1.0.0/cv_aux/src/cvcalibfilter.cpp`

Calibration file `cameras.txt`:

2

1024.0000000000	768.0000000000	1326.3033447266	0.0000000000	535.7369384766
0.0000000000	1325.8737792969	365.6853332520	0.0000000000	0.0000000000
1.0000000000	-0.2039835602	0.1206635684	-0.0025506185	0.0019137006
0.9959881902	-0.0280513112	0.0849746168	-0.0389356464	-0.9908443093
0.1292734593	0.0805703178	-0.1320633739	-0.9879613519	-328.9529418945
36.0187339783	1378.4147949219			

1024.0000000000	768.0000000000	1323.1350097656	0.0000000000	610.5260009766
0.0000000000	1317.4230957031	333.6928710938	0.0000000000	0.0000000000
1.0000000000	-0.1292870939	-0.0738551393	-0.0012181003	0.0096604973
0.9732932448	-0.2022656649	0.1085764170	-0.2118310034	-0.9735853672
0.0852007940	0.0884752125	-0.1059252098	-0.9904301763	-426.6532592773
126.2498397827	1361.8890380859			

-60.7329750061	-95.7486801147	1067.1297607422	5.9503664970	1022.7186279297
790.6403808594	-105.6950454712	764.5604248047		
-90.2963409424	7.2448134422	1034.1735839844	-82.4483566284	1131.7287597656
685.6887207031	11.8106098175	867.5054931641		
1.2017411725	-0.0589985506	-60.7329750060	0.0998748237	1.1234795817
-95.7486801146	0.0000940024	0.0000042972	1.0000000000	
1.2177429285	0.1328555856	-90.2963409424	-0.0971281792	1.1130670402
7.2448134422	0.0001156747	-0.0000081429	1.0000000000	

L1: nb of cams

L2: Cam1 (Left) parameters

- width x height
- intrinsic camera parameters (3x3 matrix,  $[f_u \ 0 \ u_0; \ 0 \ f_v \ v_0; \ 0 \ 0 \ 1]$ )
- distortion coefficients (2 coefs for radial, 2 for tangential  $[k_1 \ k_2 \ p_1 \ p_2]$ )
- rotation matrix (3x3 matrix)
- transition vector (3x1 vector)

L3: Cam2 (Right) parameters

- width x height
- intrinsic camera parameters (3x3 matrix,  $[f_u \ 0 \ u_0; \ 0 \ f_v \ v_0; \ 0 \ 0 \ 1]$ )
- distortion coefficients (2 coefs for radial, 2 for tangential  $[k_1 \ k_2 \ p_1 \ p_2]$ )
- rotation matrix (3x3 matrix)
- transition vector (3x1 vector)

L4: Coordinates of destination quadrangle after epipolar geometry rectification (C1,  $4^*(x,y)$ )

L5: Coordinates of destination quadrangle after epipolar geometry rectification (C2,  $4^*(x,y)$ )

L6: Coefficients for transformation, inverse rectification matrix (C1, 3x3 matrix)

L7: Coefficients for transformation, inverse rectification matrix (C2, 3x3 matrix)

**Note:**

The destination quadrangle refers to the corners of the undistorted and rectified image ((0,0) ; (w,0) ; (w,h) ; (0,h)).

The coordinates of L4 and L5 are the coordinates of the rectified image's corners in the original (distorted and unrectified) image's frame.

**Camera projection matrix:**

$$P = \begin{bmatrix} f_u & 0 & u_0 \\ 0 & f_v & v_0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} R & T \end{bmatrix}$$

**Distortion formula:**

u,v is the undistorted point

u0,v0 is the principal point

f\_u,f\_v are the focal lengths

k1,k2 are radial distortion coefficients

p1,p2 are tangential distortion coefficients

$$x = \frac{u - u_0}{f_u}$$

$$y = \frac{v - v_0}{f_v}$$

$$r_2 = x^2 + y^2$$

$$r_4 = r_2^2$$

$$c_{dist} = 1 + k_1 \cdot r_2 + k_2 \cdot r_4$$

$$x_r = x \cdot c_{dist}$$

$$y_r = y \cdot c_{dist}$$

$$a_1 = 2 \cdot x \cdot y$$

$$a_2 = r_2 + 2 \cdot x^2$$

$$a_3 = r_2 + 2 \cdot y^2$$

$$d_x = a_1 \cdot p_1 + a_2 \cdot p_2$$

$$d_y = a_3 \cdot p_1 + a_1 \cdot p_2$$

$$x_d = x_r + d_x$$

$$y_d = y_r + d_y$$

$$u_d = x_d \cdot f_u + u_0$$

$$v_d = x_d \cdot f_v + v_0$$

**Formula to go from undistorted and rectified pixel coordinates (u\_r, v\_r) to undistorted and unrectified coordinates (u, v):**

$$w = \text{rect}[2][0] \cdot u_r + \text{rect}[2][1] \cdot v_r + \text{rect}[2][2]$$

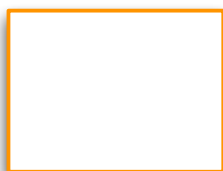
$$u = \frac{\text{rect}[0][0] \cdot u_r + \text{rect}[0][1] \cdot v_r + \text{rect}[0][2]}{w}$$

$$v = \frac{\text{rect}[1][0] \cdot u_r + \text{rect}[1][1] \cdot v_r + \text{rect}[1][2]}{w}$$

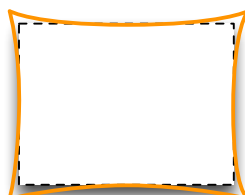
**Rectified projection matrix:**

$$P_r = \text{rect} \cdot P$$

Original  
Distorted and Unrectified



Undistorted and Unrectified



Undistorted and Rectified

