Improved Camera Calibration with a Planar Pattern using OpenCV

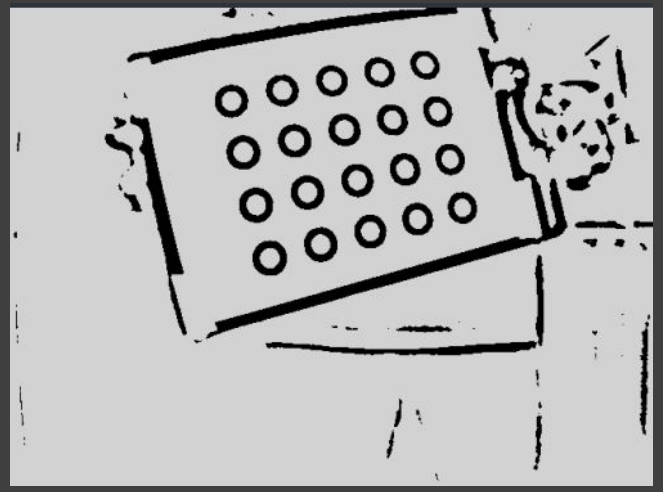
Solange Ramos Cooper

Approach

1. Detection of concentric ring in each frame
2. Filter ellipses and find the center point of each concentric ring
3. Arrangement in a systematic order
4. Calibrate camera and get parameters
5. Fronto-Parallel calibration refinement

1. Detection of concentric ring in each frame

Convert to GrayScale and apply a Blur Filter



Convert to binary image (Adaptative Threshold)

Find contours and fit to ellipses

2. Filter ellipses and find the center point of each ring

- Look for Parent-Child relationships and check distance between center points.

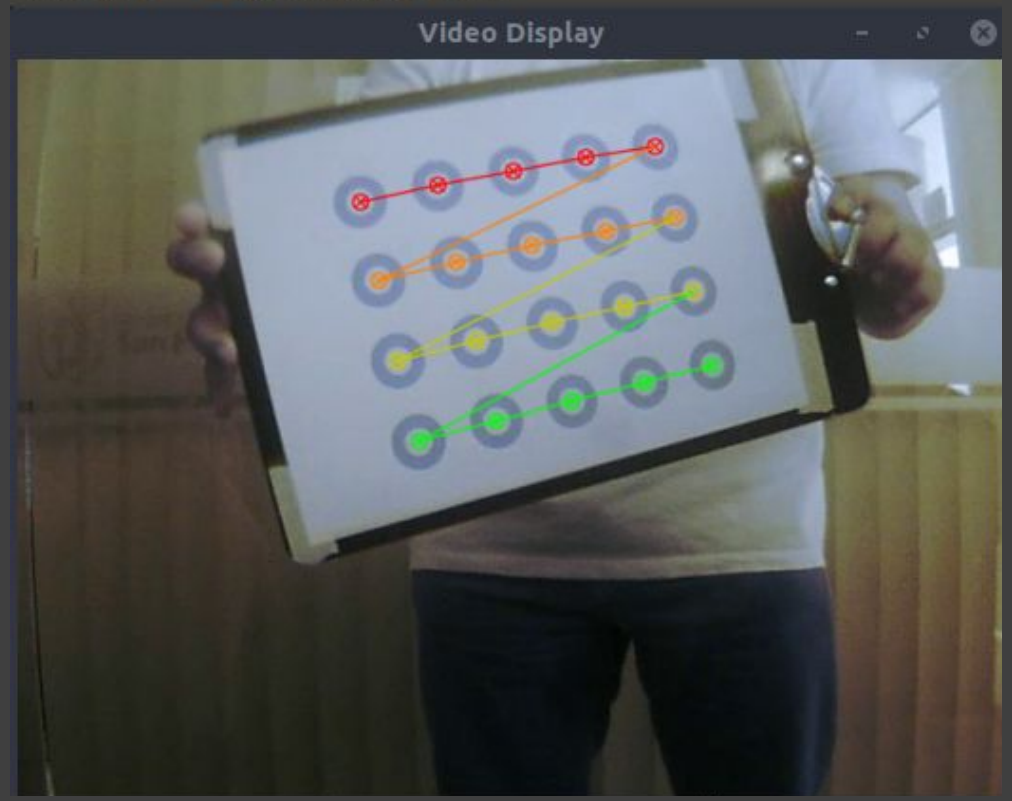
- Compute the average central point and look for a maximum distance that contains at least 20 points. Consider only the points that are in that range.

3. Arrangement in a systematic order

- Group control points by 5 items, then find an line for every group.

- Order every line by Y-axis.

- Order all points in a line by X-axis.



4. Calibrate camera and get parameters

Camera 1

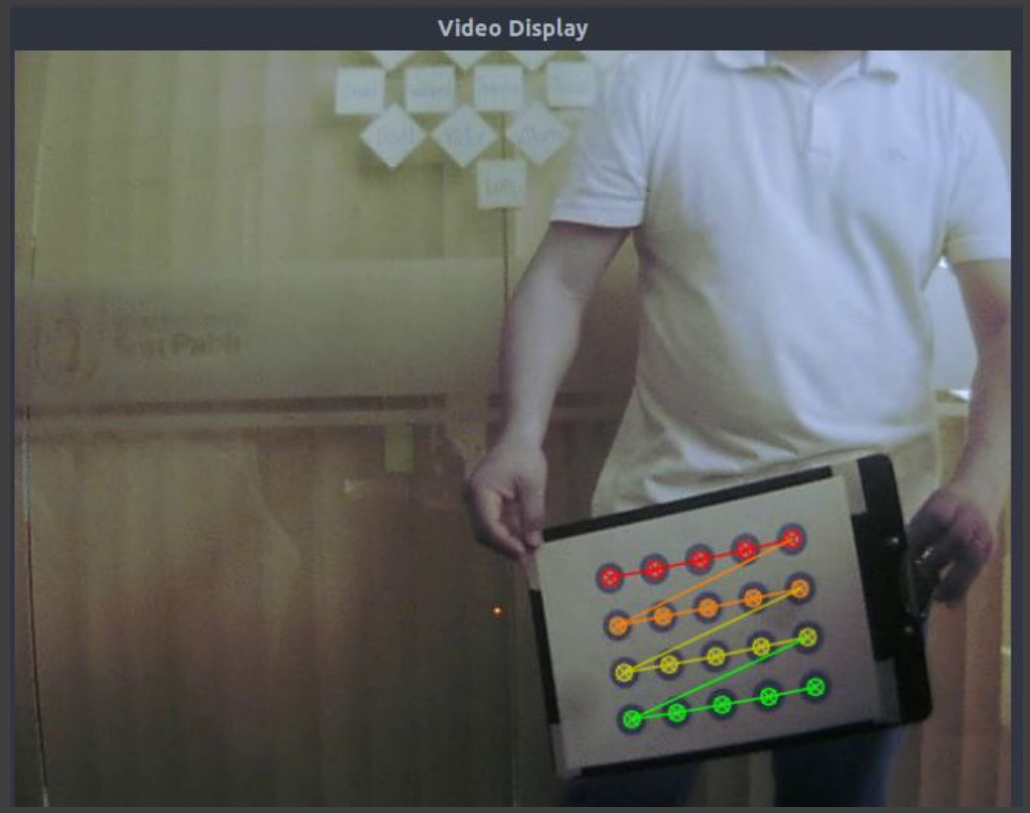
Parameters	Chessboard Pattern	Circle Pattern	Ring Pattern
F_x	726.21	684.63	677.12
F_y	727.24	683.84	674.583
U_0	283.32	324.07	333.52
V_0	272.38	253.37	278.06
K_1	−0.35	−0.40	−0.32
K_2	−0.46	0.17	−0.13
RMS	0.55	0.35	0.20

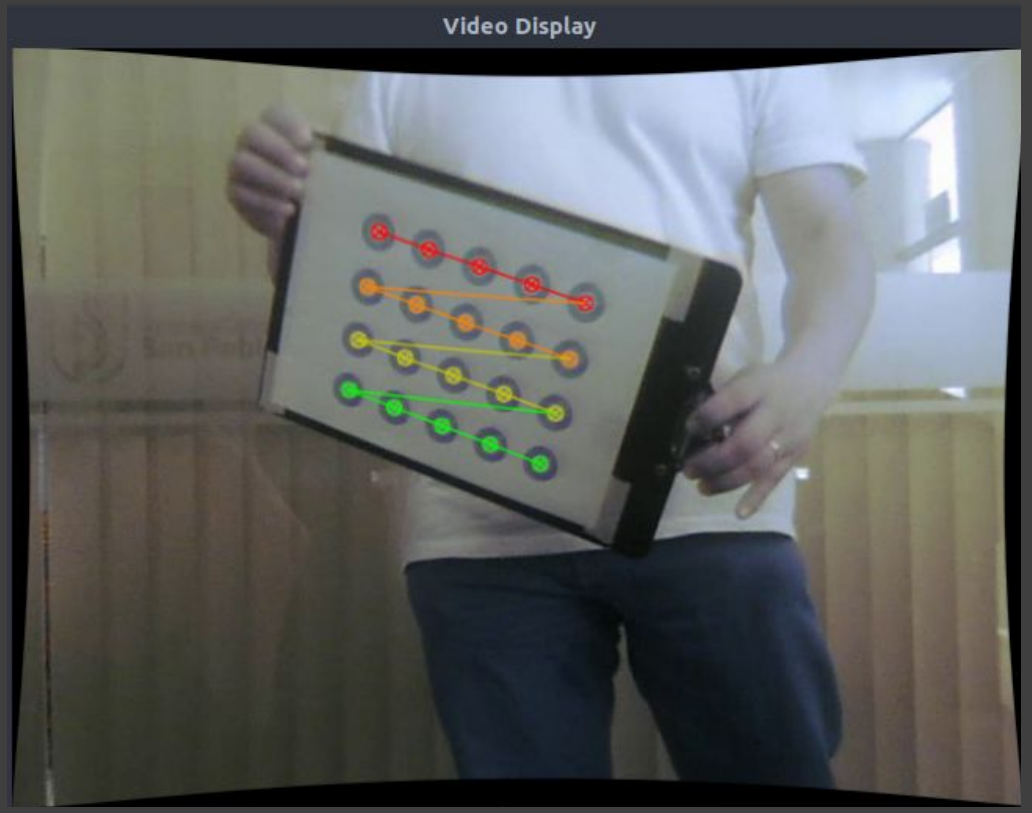
4. Calibrate camera and get parameters

Camera 2

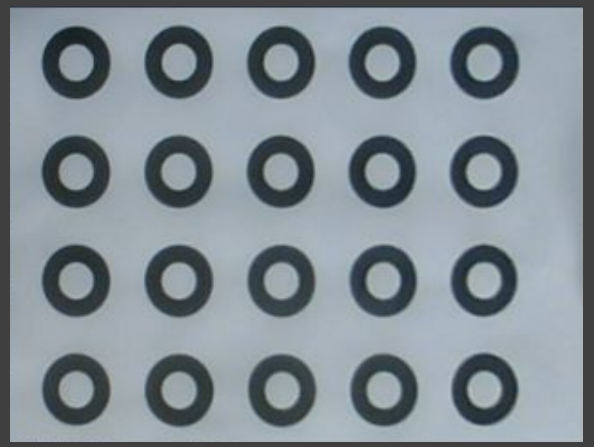
Parameters	Chessboard Pattern	Circle Pattern	Ring Pattern
F_x	499.30	496.03	542.63
F_y	498.82	480.71	537.51
U_0	314.48	319.89	299.97
V_0	173.03	176.06	176.26
K_1	0.02	0.04	0.04
K_2	−0.04	−0.15	0.05
RMS	0.44	0.24	0.23

Applying *undistort*

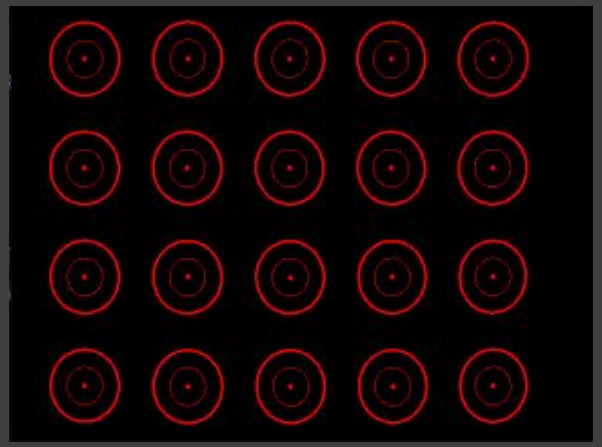




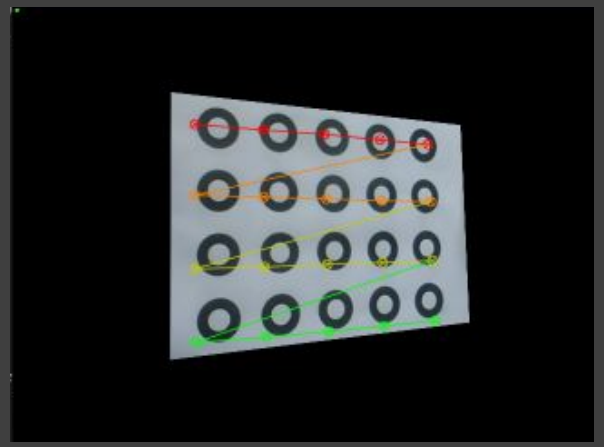
5. Fronto Parallel calibration refinement



Unproject the pattern to a canonical pattern



Localize control points



Reproject control points using estimated camera parameters

Testing Algorithm Accurracy

Pattern Detection

Camera 1

Pattern	Average time (ms)	Total Detected (%)
Chessboard	87.73	25%
Asymmetric circles	91.25	31%
Rings	21.87	93%

Camera 2

Pattern	Average time (ms)	Total Detected (%)
Chessboard	89.43	92%
Asymmetric circles	94.44	95%
Rings	27.70	88%

Fronto parallel refinement

Camera 1

Parameters	Ground Truth	Initial calibration	Iterative refinement
f_x	630	679.45	629.56
f_y	630	674.62	625.79
u_0	320	321.23	324.13
v_0	240	281.69	282.81
RMS	0	0.55	0.51

Camera 2

Parameters	Ground Truth	Initial calibration	Iterative refinement
f_x	500	495.72	492.73
f_y	500	497.05	494.67
u_0	640	313.62	313.15
v_0	360	190.09	193.40
RMS	0	0.46	0.45

MainWindow

Source

Live Video

/videos/cam1/anillc Search

Pattern Size

Width 5 Height 4

Detection Sumary

Total Frame Count	3337
Pattern found (%)	46
Average time (ms)	43.52

Calibration Sumary

RMS	0.161377
Fx	516.18
Fy	515.13
U0	327.56
V0	182.49
K1	-0.01
K2	0.08

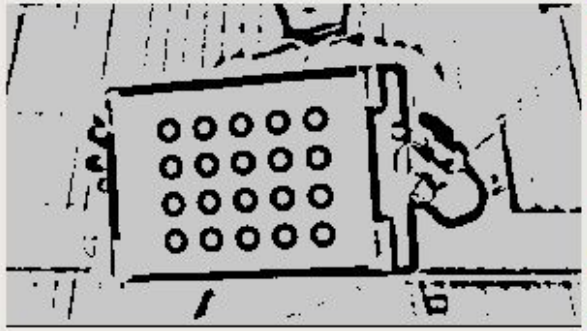
Start

367 1421

PREPROCESS

Grayscale Gaussian Blur

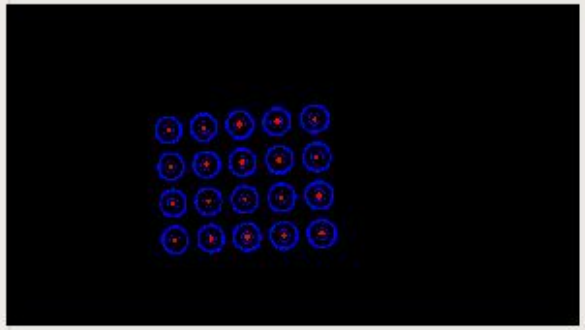
Binary



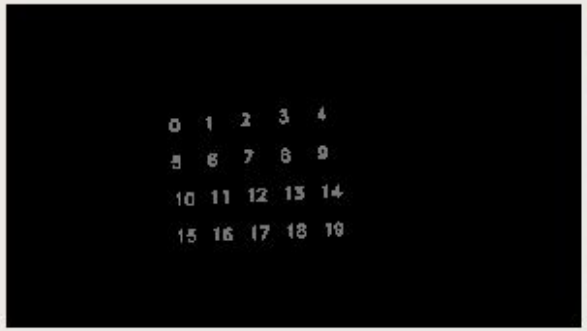
Contour

PATTERN DETECTION

Identify Rings



Find Grid



Tracking