Exercise 1: Camera models

Test every model, whether the result of un-projection of the projection matched the original vector (which is a 3D point ($x, y \in \{-10, -9, ..., 0, 1, ..9, 10\}$, $z = 5$) after normalized to unit vector).

Exercise 2: Optimization

Robust curve fitting can also deal with outliers. Outliers can have strong influence on the cost function and let the result shift from the ground truth. The robust curve fitting reduce this influence.

Exercise 3: Camera calibration

Command line parameters

The command line parameters passed the user chosen functionalities to the program. For example, the GUI can be showed, one of the 4 possible camera models can be set. Also, the data path is needed.

Summary and analysis

As we can see from the screen shots of the result of calibration (at frame 42), all camera models except "pinhole" model have produced good results. The calibrated projections are perfectly aligned with the detected corners (with sub-pixel error), while pinhole model has visible mis-alignment without scaling the image. Frame 42 represents a typical situation, the distortions of cameras are clearly showed.

When looking at the quantified massured performance, we can conclude:

1. Double sphere, extended unified, Kannala-Brandt models have better initialization
2. Double sphere, extended unified, Kannala-Brandt models lead to better calibration result of this camera set than pinhole
3. Extended unified, Kannala-Brandt models use less iterartions and time to converge

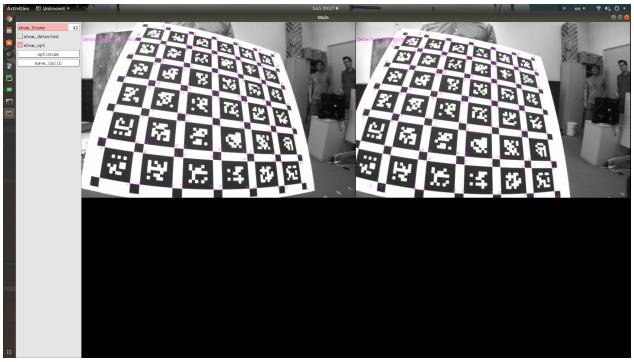

Figure 1: Pinhole camera model

Figure 2: Double sphere camera model

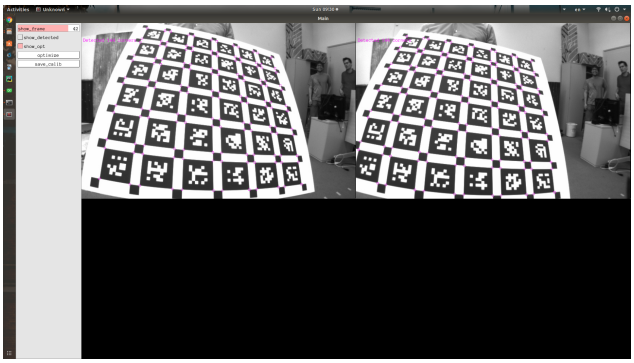

Figure 3: Extended uniffied camera model

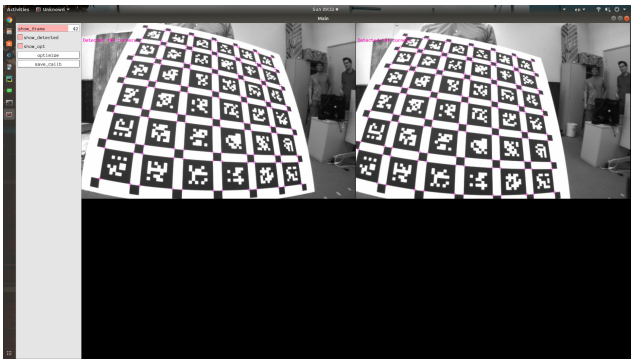

Figure 4: Kannala-Brandt camera model

1		Pinhole	Ds	Eucm	Kb4
2	Initial	1.795667e+07	5.353282e+06	5.353182e+06	5.788049e+06
3	final	1.565735e+05	1.627482e+02	1.627604e+02	1.619844e+02
4	Change	1.780009e+07	5.353019e+06	5.353019e+06	5.787887e+06
5	Iterations	16	15	7	8
6	Time(sec)	1.383261	1.154401	0.621915	0.731877
7					

Figure 5: Calibration outputs of 4 camera models from ceres solver