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# A camera calibration method for long distance 3D image measurement

Huan Fan　　Cunwei Lu

Dept. of Information Electronics, Graduate School of Engineering, Fukuoka Institute of Technology

## 1. Introduction

To achieve tsunami forecasts, our lab has designed a long-distance sea wave measurement system based on the stereo vision method. Camera calibration is a necessary step of sea wave measurement. Because the range of distance measurement of the system is 3 kilometers to 20 kilometers, considering the size, materials and other factors of the calibration target, the existing templates are not suitable for this research. Consequently, we need to establish a target which can satisfy the demand for this research and design the feature point extraction algorithm.

In this paper, we used a cylindrical hollow metal bar as a calibration target and based on the distribution of the feature points of the bar, designed an algorithm which includes three parts concerning edge detection, center axis of target detection and feature point extraction. Afterwards, according to the requirement of the experiment to select the feature points, and complete camera calibration.

## 2. Method and Principle

(1)Selection of calibration target

A suitable target should satisfy these conditions: ①It can be seen clearly from 3 kilometers. ② The corresponding points on the left and right graphs are easily judged. ③ Feature points are easily extracted. Considering all the above conditions, as shown in Figure 1, we chose a cylindrical hollow metal bar as a target and select the red and white boundary points on the center axis of the target as feature points.

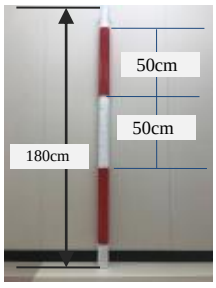


Fig. 1 Image of the calibration target

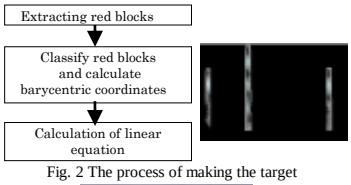


Fig. 2 The process of making the target


Fig. 3 Image of calibration experimental

(2)Extracting feature point

Firstly, as shown in Figure 2, we took a block from each metal cylinder bar as a template, where the width is one pixel and the height equals the bar`s height. Secondly, calculated the covariance value between the template and the tested block to determine whether the distribution of gray values is similar or not, so we can find the left side and right side of the bar. The average value of the x axis value of the left and right boundary is the center axis of the bar. Finally, we calculated the average value of gray value for all points on the center axis of the metal cylinder bar, and the difference between the average value and the gray value of each point. We found the points where the sign is changing and recorded their coordinates and these points are feature points we were looking for. Then ,we used these points to calculate the paramaters of the cameras[1] .

## 3. Experiment results

In this experiment, three bars are used for camera calibration, and the position of the three bars is shown in Figure 3. The bars are placed at 3 kilometers from the camera and the horizontal distance between the two cameras is 27 meters. The camera calibration result is shown in Table 1.

Table 1 the result of camera calibration

| Parameter | Result |
|---|---|
| $\theta\_lz$ | -2.23° |
| $f\_l$ | 1806.95mm |
| $\theta\_rz$ | -1.63° |
| $f\_r$ | 1806.95mm |
| $b$ | 27.1m |

$\theta\_lz$: The angle between the left camera optical axis and the Z axis.
$\theta\_rz$: The angle between the right camera optical axis and the Z axis.
$f\_l$, $f\_r$: The focal length of left camera and right camera
b: The length of baseline. shown in Table 1.

We adjusted the camera around the X axis and the Y axis rotation angle is zero in the experiment, and only considering the existing Z axis rotation, so the result, as shown in table 1 was able to be obtained. Using these paraments to measure objects in the visual field of cameras and the results show that the calibration target and feature point extraction method in this paper can be used for camera calibration at long distance.

## 4. Conclusion

In this paper, a calibration target suitable for long distance calibration is designed, and a feature point detection orientation algorithm is proposed. Use the calibration result to calculate the location information of multiple objects, and the results show that the calibration precision can satisfy the system.

## 5. References

[1] H. Yi, et al. "A long-distance sea wave height measurement based on 3D image measurement technique." Progress in Electromagnetic Research Symposium IEEE, 2016:4774-4779.