A Practical Calibration Method for Top View Image Generation

Yohei Ishii, Keisuke Asari, Hitoshi Hongo, Hiroshi Kano
Digital Systems Research Center, R&D H.Q., SANYO Electric Co., Ltd.
Daito, Osaka, JAPAN

***Abstract*—This paper describes a practical calibration method to generate a top view image from an image of a rear view camera for automobile. The geometric relation between the input and output images is described by a 3x3 homography matrix. Conventional methods have to use a large planar pattern to achieve precise calibration. The proposed method uses much smaller patterns, and enables to place those patterns on arbitrary positions within the view of the camera. The experimental results show that the method has equivalent calibration precision with much easier setting than the conventional methods.**

I. INTRODUCTION

The number of rear view backup camera installed to automobile is increased. The major application of the camera is to show the blind spots of a vehicle. However, it is difficult to have correct feeling of distance from the image, because of the perspective effect of the camera. Top view image transformation as shown in Fig. 1 was proposed to alleviate the false feeling and to assist parking [1]. It was also applied to lane detection effectively [2].

Camera calibration is necessary for top view image generation. In general, calibration obtains the camera parameters such as the focal length, pixel size, mounting location and angle, etc. In the case of the top view image transformation, it is well known that these parameters are involved in a homography matrix [3]. It is a 3x3 planar projective transformation matrix that transforms the input image to the top view image. In order to compute the matrix, at least four sets of corresponding points between input and the transformed image are required. In general, many accurately aligned points on a calibration surface bring precise results. The area becomes very large such as 10m x 10m, because the field of view is wide and deep. The all aligned points must have 2D absolute coordinates. As a result of this, the calibration pattern must be large and precise in a conventional calibration. It is a big problem for practical use.

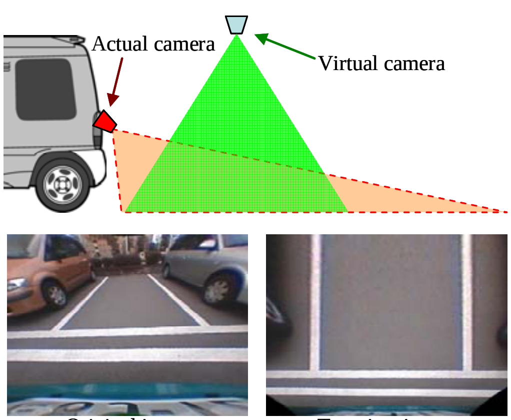

Fig. 1. Top view camera image conversion

In this paper, a practical calibration method is proposed to solve the problem. It does not require a global 2D coordinate in the calibration area. It uses a several smaller square patterns. The proposed method computes the homography matrix using the shape information of the patterns.

II. PROPOSED METHOD

A. Basic idea

It is believed that the pattern must cover major part of input image for precise calibration. Therefore, the conventional method uses a large printed pattern, such as checkerboard. The proposed method uses smaller elemental patterns and places them on a road surface (Fig. 2). It is same to the conventional method in that the patterns cover the major part of input image as a whole. However it is different in that each pattern is not aligned precisely each other.

Each elemental pattern must have at least four feature points for extracting coordinate information. In this paper, square shape is used in order to compute the matrix for each pattern. They are placed evenly but not necessary aligned precisely on a road surface. If all homography matrixes corresponding to all patterns are optimized to one unique matrix, it is considered that the matrix is as precise as the one obtained by the conventional method using a large pattern.

B. Procedure

The calibration procedure is shown in Fig. 3. In the first step, one of the patterns is selected. In the second step, a homograhy matrix that transforms the selected pattern, which is a quadrangle in the input image, to a square is computed. This matrix is used as an initial value of an iteration process in the third step. In the step, the matrix is modified iteratively by using an evaluation value obtained from all patterns and a temporary homography matrix.

C. Optimization of projective matrix

In the optimization, parameters of projective matrix are

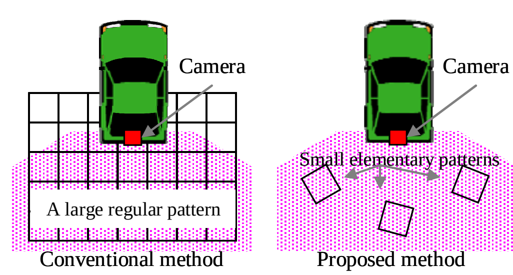

Fig. 2. Difference of calibration patterns

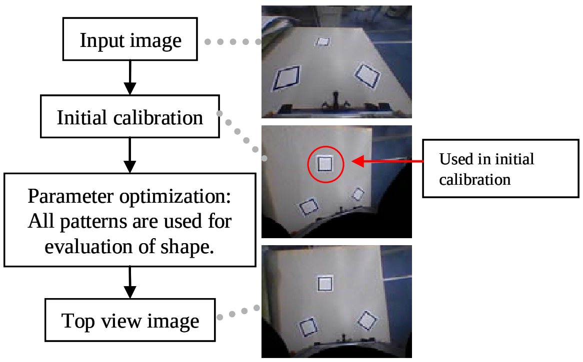

Fig. 3. Calibration procedure

adjusted in order to minimize deformation of all patterns in the transformed image. All corner points of patterns are projected by temporary matrix. The deformation of shape is evaluated by relative locations of corner points in the output image coordinate. In next iteration, adjusted matrix is used and evaluated with the shape transformed points.

III. EXPERIMENTS

A. Experimental Conditions

Experiments are intended to evaluate the accuracy of proposed method. A checkerboard pattern is used to compare the conventional and proposed methods (Fig. 4). However the position information of each square pattern in the checkerboard is not used in the proposed method. Image distortion caused by lens distortion is corrected beforehand.

B. Accuracy evaluation

Ten intersecting points selected from the checkerboard were used for the conventional calibration (Fig. 4-a). Ten pairs of input and transformed image coordinate are obtained. In the proposed method, some squares on the checkerboard are used. In the experiment, number of used squares was varied to one, two and four for discussing accuracy.

The results of calibration are shown in Fig. 4 and TABLE I. In the TABLE, labels (e.g. CV, PM1…) are same as Fig. 4. The points used in the conventional method are shown by bold circle (Fig. 4-a). The squares used in proposed methods are shown by bold rectangle (Fig. 4-b, c, d). The ideal lines in projected images are shown in horizontal and vertical solid lines. The 74 intersecting points are used for evaluation. The error is defined as difference between ideal and projected points. The results showed that large number of squares brings low error rate. In case of PM4, the proposed method showed equivalent performance to the conventional method. In PM2, the difference of intersecting points is large in right top and bottom left. It shows that the errors become large in the far from used squares due to extrapolation. It is considered that the many patterns and alignment of major part of input image are important to obtain accurate calibration results as it same in conventional method.

C. Application to image of actual rear view camera

The proposed method using two patterns was applied to a rear view camera attached to a vehicle. The pattern size was 1.5m x 1.5m. The result is shown in Fig. 5. The result shows that practical top view image was obtained with two patterns. The procedure of calibration is just placing patterns and calculating via a computer. The procedure was easier and more practical than conventional method.

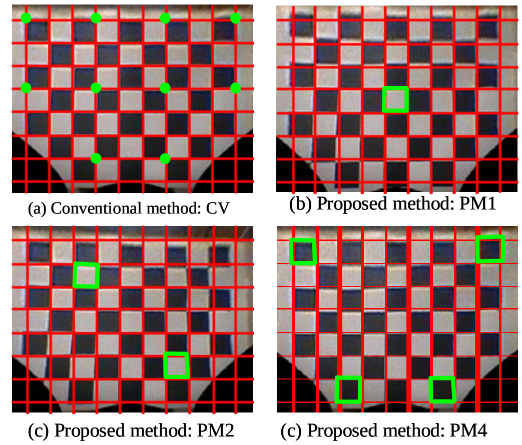

Fig. 4. Calibration results

TABLE I Errors between ideal and output points [pixel]

	CV	PM1	PM2	PM4
Max.	13.98	39.48	33.81	14.09
Min.	0.45	0.70	1.10	0.37
Av.	3.94	14.41	13.23	4.73
Variance	2.92	8.11	8.79	3.10

Input image Top view image

Fig. 5. A result using camera mounted on a vehicle

IV. CONCLUSIONS

In this paper, a practical calibration method based on the homography is proposed for top view image generation. In this method, several small square patterns are placed evenly but not necessary aligned precisely. The experimental results showed that the procedure of proposed method is more practical than conventional method with equivalent precision.

As the future work, computation cost of the proposed method should be reduced for the embedded implementation in automobile.

REFERENCES

[1] H. Shimizu, “Overhead View Parking Support System,” *Proc. of 11th World Congress on ITS*, 2004.

[2] A. Takahashi, Y. Ninomiya, M. Ohta, M. Nishida, and N. Yoshikawa, “Image Processing Techinology for Rear View Camera (1): Development of Lane Detection System,” *R&D Review of Toyota CRDL*, Vol. 38, No. 2, pp. 31-36, 2003.

[3] R. Hartley and A. Zisserman, *Multiple View Geometry in computer vision second edition*, Cambridge University Press, pp. 87-93, 2003.