An Effective Pedestrian Detection Method for Driver Assistance System

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***Abstract*— A driver assistance system typically adopts the wide-angle camera to obtain a wide-view image. However, the wide-angle camera often produces radial distortion. Since the conventional training-based pedestrian detection method uses distortion-free training samples, it is not suitable for distorted images. In this paper, we propose an effective pedestrian detection method that divides pedestrian training samples into several classes according to the amount of radial distortion, and trains each class separately. Likewise, a test image is divided into sub-regions and detection is performed for each sub-region separately. Experimental results show that our approach provides better performance compared to the conventional method.**

I. INTRODUCTION

Due to the rise in the car accidents, the driver assistance system (DAS) becomes an important technology in the automobile industry [1]. In the DAS, various sensors such as radar, laser, or image sensor are mounted at the front, side, and rear parts of the vehicle for sensing pedestrians or obstacles around the vehicle. Among these sensors, the image sensor is widely used in the DAS because it provides visual information to the driver. Like vision-based surveillance systems, many automobiles adopt the wide-angle cameras to capture objects and avoid the collision from obstacles. However, this type of cameras produces the image with undesirable radial distortion. Thus, the distorted image needs to be processed before detection and/or recognition.

In the past few decades, numerous solutions for compensating camera distortion have been proposed [2], [3]. These algorithms typically estimate intrinsic or extrinsic properties of the lens by using a specific calibration diagram [2]. Although the automatic calibration method does not require a specific calibration diagram, it still measures the amount of straightness from the distorted image to extract camera parameters [3]. The estimation of exact intrinsic/extrinsic parameters is challenging because even the small estimation error of the parameters can result in unsatisfactory calibration, especially at the boundary regions of the image. Fig. 1 shows the compensation error by the pre-processing [4]. As a result, the resultant compensated image can lead to performance degradation of pedestrian detection.

In this paper we propose a simple method to detect pedestrians in the radially distorted image obtained from the wide-angle camera. Instead of the camera distortion calibration, the proposed method separates the pedestrian training samples into N classes according to the amount of the radial distortion and trains each class separately. A test image is also divided into N regions and pedestrians are found in each region using the corresponding trained data.

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(a) (b)

Fig. 1. (a) Radial distorted image. (b) Compensated image.

II. PROPOSED METHOD

The proposed method uses Haar-like feature and AdaBoost classifier [5] for the pedestrian detection algorithm. For the simplicity of the algorithm, we set the number of overlapped regions of the test image to three. The procedure details are described below.

A. Training step

The radial distortion bends an object of the input image to both the horizontal and vertical directions according to the position of the object. However, the significance of the bending direction depends on the object's shape. Fig. 2 illustrates the relationship between the direction of the distortion and the shape of the object. Since pedestrians are vertically long objects, they are sensitive to the horizontal bending, while a horizontally long parking assistance line is

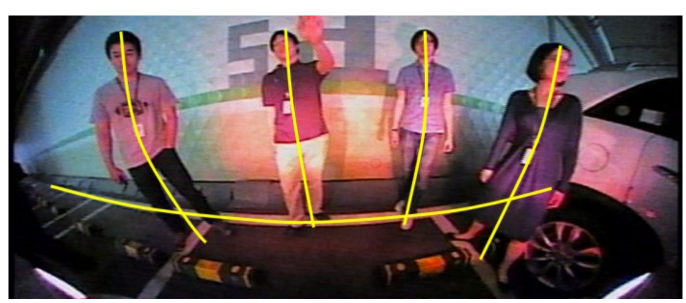

Fig. 2. The significance of the radial distortion relates with the shapes of the object.

(a) (b) (c)

Fig. 3. The classified training samples; (a) left, (b) right, and (c) center training set, respectively.

more sensitive to the vertical bending. To reflect the above relation, we classify training samples into three classes according to the horizontal bending directions; left, right, and center, as shown in Fig. 3.

B. Detection step

Since the training samples are classified into three classes at the training stage, an input image which contains the human body to be detected is also divided into three regions. In addition, we set three regions to be overlapped to get rid of the miss alarms around the boundary of regions. Three kinds of trained results then are applied to these three regions respectively according to the direction of radial distortion. In our experiments, we set each overlapping region to 72x300 for 720x300 image as shown in Fig. 4.

Fig. 4. A test image is divided into three regions, and pedestrians are found in each region, respectively.

III. EXPERIMENTAL RESULT

To evaluate the performance of the proposed method, we use a set of test image captured by the wide-angle camera. For the training, we used 3,900 positive samples; 1,300 representing the number of the left, center, and right positive samples, respectively, and 12,092 representing negative samples from the distorted images. To compare the performance with conventional method, we employed Zhang's

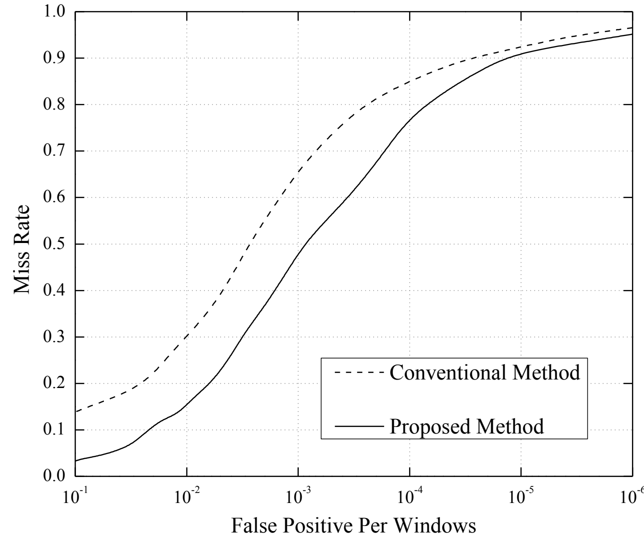

Fig. 5. ROC curves of two classifiers.

calibration algorithm [4] to compensate distorted test images. And test images are independent of the training data. Then three kinds of the trained data, left, center, and right, were applied to the distorted test images and the center trained data to the compensated test images. The ROC curve shown in Fig. 5 proves that the proposed method provides better performance.

IV. CONCLUSION

This paper introduces a simple but effective method for detecting pedestrians from radially distorted images. By dividing the image samples according to the amount of radial distortion without camera calibration at the training and detection stages, the proposed method can reduce computational complexity. Experimental results support that the proposed method can achieve better detection ratio compared to the conventional method.

REFERENCES

[1] D. Geronimo, A. M. Lopez, A. D. Sappa, and T. Graf, "Survey of pedestrian detection for advanced driver assistance systems," *IEEE Trans. Pattern Anal. Mach. Intell.,* vol. 32, no. 7, pp. 1239-1258, Jul. 2010.

[2] F. Devernay and O. D. Faugeras, "Straight lines have to be straight," *Mach. Vis. Appl.,* vol. 13, no. 1, pp. 14-24, Aug. 2001.

[3] M. Friel, C. Hughes, P. Denny, E. Jones, and M. Glavin, "Automatic calibration of fish-eye cameras from automotive video sequences," *IET Intell. Transp. Syst.,* vol. 4, no. 2, pp. 136-148, Jun. 2010.

[4] Z. Zhang, "A flexible new technique for camera calibration," *IEEE Trans. Pattern Anal. Mach. Intell.,* vol. 22, no. 11, pp. 1330-1334, Nov. 2000.

[5] P. Viola and M. Jones, "Rapid objet detection using a boosted cascade of simple features," in *Proc. IEEE Conf. Computer Vision and Pattern Recognition,* Kauai, USA, 2001, vol. 1, pp. I-511-I-518.