

An Image Processing Based Pedestrian Detection System for Driver Assistance

Sandeep A. K.*, Nithin S.** and K. I. Ramachandran***

ABSTRACT

Advanced Driver Assistance System (ADAS) has developed further from just improving traffic safety to an area to help the driver to anticipate accidents. The Pedestrian Protection System (PPS) is a part of ADAS that alerts the driver once the pedestrian is detected. This paper suggests an approach for detecting pedestrians from a real time video and performing braking action once detected. Real time video is captured and the moving background is first modeled. Foreground segmentation is performed on a modeled background. Blob analysis is performed on the foreground pixels to detect the presence of pedestrian. As a control action an alert is given acoustically and braking is performed by actuating the brake pedals using a controller and actuator as a further measure.

Keywords: Advanced Driver Assistance System(ADAS), Pedestrian Protection system(PPS), Pedestrian Size Constraints(PSC), Background Modeling.

1 INTRODUCTION

Automotive industry has gained swift growth over the last decade. The increase in traffic density has ensued more number of road accidents. There has been several researches over the years to improve road safety and their outcomes were technologies such as Airbags[12], Seatbelt tensioning[13], Electronic stability Program (ESP) Antilock Braking System (ABS)[14] etc. Now research has moved towards a new focus area as to anticipate an accident before it even happens and such intelligent systems are called as Advanced Driver Assistance System (ADAS)[15].

Pedestrian Protection System (PPS) is one such system belonging to ADAS. The main objective of PPS is to detect pedestrians in front of an approaching vehicle and to anticipate the possibility of collision. The system provides a warning to the driver acoustically and if the likelihoods of collision are more, braking is performed. PPS are highly significant now a days as the chances of a driver getting distracted by mobile phones have increased. Pedestrian detection is challenging as the posture of individuals differ and they could be carrying objects, both resulting in the variation of the normal shape of pedestrian. The variations in the colour of clothes worn by the pedestrian make it difficult for a detection algorithm based on colour. The system should satisfy the reaction time constraints for real time applications and must be robust to work without fail.

Several techniques for PPS have been proposed by researchers, a survey of various techniques for pedestrian detection was carried out by David Gero´ nimohor *et.al* [9] and it was observed that most of the techniques uses learning algorithms in combination with classification algorithms. An example of such a system is the use of HAAR features with Adaboost [8] or Histogram of oriented Gradients (HOG) with Support Vector

* PG Research Scholar , Dept. of Electrical and Electronics Engineering, Amrita School of Engineering, Coimbatore Amrita Vishwa Vidyapeetham, Amrita University, India

** Assistant Professor, Dept. of Electrical and Electronics Engineering, Amrita School of Engineering, Coimbatore Amrita Vishwa Vidyapeetham, Amrita University, India

*** Professor, Centre for Computational Engineering and Networking(CEN), Amrita School of Engineering, Coimbatore Amrita Vishwa Vidyapeetham, Amrita University, India

Machine SVM [7][6]. Even though Adaboost helps to improve the speed of system with HAAR features, it lack robustness and is found to be inferior to HOG with SVM. Jorge Martinez-Carballido *et.al* proposed a technique [10] which uses the shape of the shoes to identify pedestrian. The Region of Interest (ROI) considered in this approach was small hence it gave quick result for detecting pedestrian close to the vehicle. However this approach fails to detect pedestrians wearing no shoes or shoes with a different shape.

Human body has symmetrical characteristics and this could be used to identify pedestrians as proposed by A. Broggi *et.al* [5]. A scheme of fusing the data from vision based system with that of Laser Scanner was proposed by A. Broggi *et.al* [4][3]. The Background Modeling approach in [2] by Kang *et.al.* requires knowledge of internal parameters of camera which makes it difficult. Amitha Viswanatha *et.al* [1] proposed a vision based technique of modeling dynamically varying background. The modeling approach discussed in [1] could be enhanced and adapted for pedestrian detection. This article focuses on identifying foreground pixels from the modeled background and uses blob analysis for pedestrian detection.

The rest of the article is structured as follows. Section 2.1 discusses about the modeling of moving Background. Detection of moving objects is narrated in section 2.2. The presence of a pedestrian among moving object is determined in section 2.3. Experiment and results have been delineated in section 3 and conclusion in section 4 respectively.

2. PPS DESCRIPTION

The pedestrian protection systems can be divided into four stages. Figure 1. explains the flow diagram of the pedestrian detection system. In the first stage initial frames are taken to model the initial background to

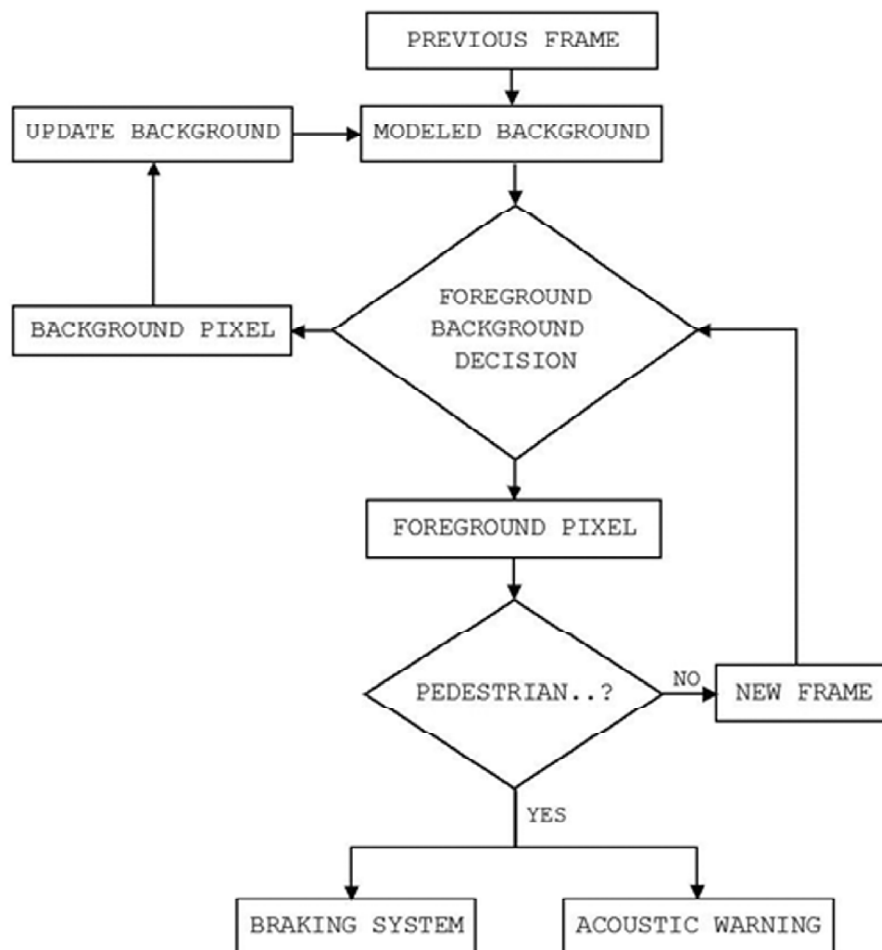


Figure 1: Flow diagram of pedestrian detection system

be black or binary '0'. In the second phase the foreground moving objects are detected, that is white in colour or binary '1'. Each time a new frame is taken, it is compared with modeled background in order to find out foreground pixels if present. If there is no much deviation from the modeled background, the background is updated by accommodating the new pixels.

In the third stage the detected foreground pixels are analyzed to detect the presence of pedestrian using Blob analysis considering Pedestrian Size Constraints (PSC). The camera is interfaced to a laptop and the image processing is done in OpenCV. A microcontroller interfaced with the laptop provides an alert and actuate the brakes if needed.

2.1. Background modeling

Background is modeled and foreground is segmented similar to the method followed by Amitha[1]. The initial frames are taken to model the initial background (modeled background). Then new incoming frame is taken and corner features are extracted using Haris corner detectors [11] and used to calculate the relation with corner features of the modeled frame. This relation, homography matrix, between the extracted features of current frame and that of modeled frame is calculated by taking Direct Linear Transformation

(DLT) [1] between these features. This homography matrix, is used to warp the background frame with the current frame. Warping overlaps most of the regions in the background frame.

The warped and current frame pixels are compared with a predefined threshold $Dx_c x_i$ [1].

$$Dx_c x_i = \frac{1}{(\sum(x_i))^T (\sum(x_i))} (I(X_c) - \mu(X_i))^T (I(X_c) - \mu(X_i)) \quad (1)$$

Here x_c is a pixel in the current frame and x_i is the i^{th} neighbor of the corresponding pixel in the background. $\sum(\cdot)$ and $\mu(\cdot)$ represents covariance and mean respectively of the background. $I(\cdot)$ represents intensity value of a pixel in the current frame.

If the warping error is less than threshold, the pixel belongs to background. Here the threshold chosen was 2.8. The background pixel is represented by binary '0' or black in the processed image as delineated in Figure. 2.

2.2. Foreground detection from background

The foreground pixels can be identified using spatial information around each pixel of warped frame. If this value transcends the threshold, this pixel is considered as foreground pixel and it is represented by



Figure 2: Modeled background of an original background



Figure 3: The foreground pixels represented as binary '1'

binary '1' or white. The white pixel over the black pixel gives a clear distinction between foreground objects over the modeled background. The original and the modeled background with foreground pixel is elucidated in Figure 3.

2.3. Blob analysis

An upright walking pedestrian shares some common visual appearance with respect to geometry. So an upright rectangle can be modeled to represent a human considering Pedestrian Size Constraints (PSC). So the PSC is first evaluated in the experimental method [17]. The average height of a human is estimated to be 1.70m. At a distance of 30m, it is estimated that a pedestrian with average height takes minimum 120 foreground pixels in the processed image. This information is used to create a window for the pedestrians. Blob analysis is one of the best available machine vision based technique to analyze consistent image region. Due to its advantage of possessing high performance and flexibility, it can be used in applications in which objects which are clearly discernible from the background are inspected as that of detecting pedestrians from the background.

The pedestrian in the foreground image tends to be a distinct object. Blob analysis is used to distinguish multiple distinct objects in a binary image. The foreground- background appears to be a binary image as discussed earlier. So a pedestrian, which appears as a contiguous group of pixels of same colour, is considered as a single blob. By comparing the window created using PSC with that of pedestrian present in the foreground pixels, the presence of pedestrian can be found out as shown in the Figure 4. If a pedestrian is present a signal is sent out to the braking system.



Figure 4: Blob analysis performed over the foreground pixels. The rectangle represents detected pedestrians.

3. EXPERIMENTS AND RESULTS

The pedestrian protection system was implemented as a two stage system. In the first stage the presence of pedestrian was detected using the above discussed algorithm. The detection stage was carried out under various scenarios as discussed in simulation results. The second stage is the protection stage in which a hardware was set up for providing acoustic warning and automatic braking.

3.1. Simulation results

The camera was mounted on a car and interfaced to the laptop running the algorithm implemented in OpenCV. The system was tested under various scenarios and was found to detect pedestrians a) possessing



(a)



(b)



(c)



(d)

Figure 5: Pedestrian detection under different scenarios (a) without pedestrians (b) with single pedestrian (c) with multiple pedestrian crossing the road (d) with multiple pedestrian facing the vehicle

different postures, b) carrying different objects and c) wearing different coloured cloths. Figure.6 depicts is the modeled background and detection of single pedestrian, pedestrian carrying an object and explains the detection of multiple pedestrians under two contexts; pedestrian crossing the road and facing the vehicle.

3.2. Hardware implementation of Driver alert system

Once the pedestrian is detected the driver as well as the pedestrian are given an initial warning acoustically. This control action is performed by using an ARM based controller (LPC1728)[16] serially connected to the processing system. In addition to the acoustic alert, an automatic braking action is performed by actuating a motor that is connected to the brake pedal of the automotive. The control for the braking is also given by the same controller. Figure 5 depicts hardware of the braking unit. In case of automotives with brake by wire technology the controller could be directly interfaced with the ABS.



Figure 6: Hardware of the braking unit

4. CONCLUSION

Automotive industry has been very keenly focusing on driver assistance systems. An ADAS to detect pedestrian crossing based on image processing was proposed and prototyped. The proposed system was able to detect pedestrians and satisfy the real time requirements with an accuracy of 90% within a distance of 30 meters. The distance can be further increased if the camera resolution is increased but it will affect the processing time as well as the cost of the system. Extensive experiments with various environmental as well as traffic conditions are to be evaluated.

ACKNOWLEDGMENT

The authors record their sincere gratitude towards Ms. Soumya V, Assistant professor (Centre for Computational Engineering and Networking) for her contributions in background modeling.

REFERENCES

- [1] Viswanath, A., Behera, R. K., Senthamilarasu, V., & Kutty, K. (2015). Background Modelling from a Moving Camera. *Procedia Computer Science*, 58, 289-296.
- [2] Kang, S., Paik, J. K., Koschan, A., Abidi, B. R., & Abidi, M. A. (2003, April). Real-time video tracking using PTZ cameras. In *Quality Control by Artificial Vision* (pp. 103-111). International Society for Optics and Photonics.
- [3] Broggi, A., Cerri, P., Gatti, L., Grisleri, P., Jung, H. G., & Lee, J. (2009, June). Scenario-driven search for pedestrians aimed at triggering non-reversible systems. In *Intelligent Vehicles Symposium, 2009 IEEE* (pp. 285-291). IEEE.
- [4] Broggi, A., Cerri, P., Ghidoni, S., Grisleri, P., & Jung, H. G. (2009). A new approach to urban pedestrian detection for automatic braking. *Intelligent Transportation Systems, IEEE Transactions on*, 10(4), 594-605.
- [5] Broggi, A., Bertozzi, M., Fascioli, A., & Sechi, M. (2000, October). Shape-based pedestrian detection. In *Proceedings of the IEEE Intelligent Vehicles Symposium* (pp. 215-220).
- [6] Dalal, N., & Triggs, B. (2005, June). Histograms of oriented gradients for human detection. In *Computer Vision and Pattern Recognition, 2005. CVPR 2005. IEEE Computer Society Conference on* (Vol. 1, pp. 886-893). IEEE
- [7] Zhang, L., Wu, B., & Nevatia, R. (2007, June). Pedestrian detection in infrared images based on local shape features. In *Computer Vision and Pattern Recognition, 2007. CVPR'07. IEEE Conference on* (pp. 1-8). IEEE.
- [8] Viola, P., Jones, M. J., & Snow, D. (2005). Detecting pedestrians using patterns of motion and appearance. *International Journal of Computer Vision*, 63(2), 153-161.
- [9] Geronimo, D., Lopez, A. M., Sappa, A. D., & Graf, T. (2009). Survey of pedestrian detection for advanced driver assistance systems. *IEEE Transactions on Pattern Analysis & Machine Intelligence*, (7), 1239-1258.
- [10] Martinez-Carballido, J., & Morales-Velázquez, M. (2012, February). Using adaptive threshold to detect pedestrians crossing on a street for Advanced Driver Assistance Systems. In *Electrical Communications and Computers (CONIELECOMP), 2012 22nd International Conference on* (pp. 179-182). IEEE.
- [11] Harris, C., & Stephens, M. (1988, August). A combined corner and edge detector. In *Alvey vision conference* (Vol. 15, p. 50).
- [12] Tamura, T., Yoshimura, T., & Sekine, M. (2007, August). A preliminary study to demonstrate the use of an air bag device to prevent fall-related injuries. In *Engineering in Medicine and Biology Society, 2007. EMBS 2007. 29th Annual International Conference of the IEEE* (pp. 3833-3835). IEEE.
- [13] Luo, X., Du, W., & Zhang, J. (2014, October). Safety benefits of motorized seat belt as a component in ADAS in front-end collisions. In *Intelligent Transportation Systems (ITSC), 2014 IEEE 17th International Conference on* (pp. 661-666). IEEE.
- [14] Lee, K. C., Jeon, J. W., Hwang, D. H., Lee, S. H., & Kim, Y. J. (2004, November). Development of antilock braking controller using hardware in-the-loop simulation and field test. In *Industrial Electronics Society, 2004. IECON 2004. 30th Annual Conference of IEEE* (Vol. 3, pp. 2137-2141). IEEE.
- [15] Okuda, R., Kajiwara, Y., & Terashima, K. (2014, April). A survey of technical trend of ADAS and autonomous driving. In *VLSI Technology, Systems and Application (VLSI-TSA), Proceedings of Technical Program-2014 International Symposium on* (pp. 1-4). IEEE.
- [16] NXPLPC1768, Retrieved from <https://developer.mbed.org/platforms/mbed-LPC1768>.
- [17] García, F., Olmeda, D. D., Armingol, J. M., & de la Escalera, A. (2010, June). Hybrid fusion scheme for pedestrian detection based on laser scanner and far infrared camera. In *Intelligent Vehicles Symposium (IV), 2010 IEEE* (pp. 1134-1139). IEEE.