candidates cannot hit any tracking or tracking acquisition targets, new tracking acquisition targets will be created.

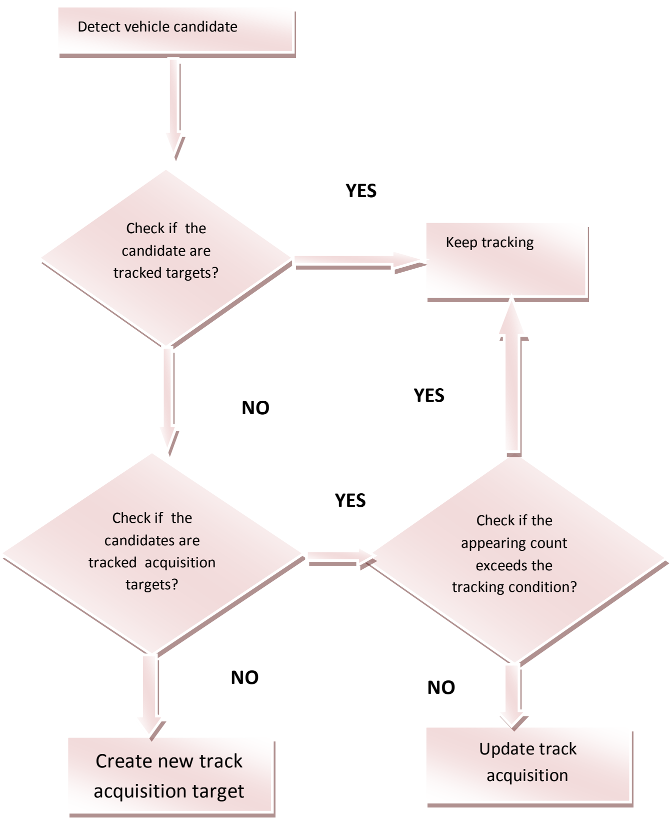


Fig.(11) Proposed Tracking Procedure

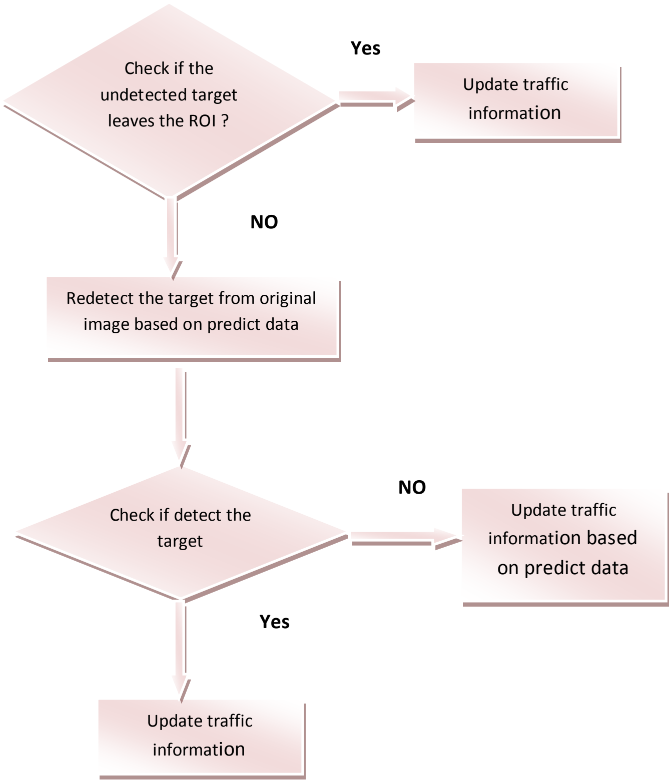


Fig.(12) Proposed Error Compensation

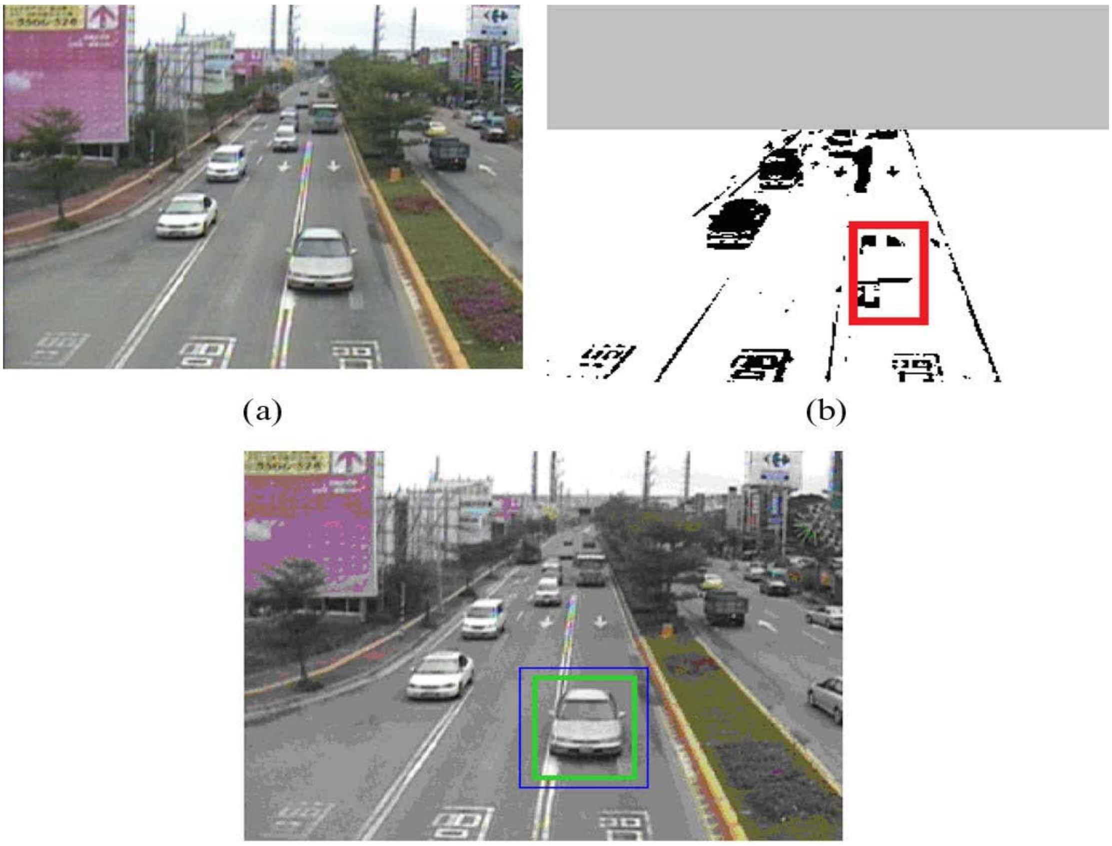
All undetected tracking targets should be checked if they leave the ROI. The flowchart of proposed error compensation is shown in fig. (12). When a tracking target leaves the ROI, it should be removed from the tracking list and the traffic parameters should be updated. When a vehicle is on track, its motion should not rapidly change in a short time.

If the target does not leave the ROI, the target should be redetected in the original image within a searching range based on its color transformation, denoted as TA. The searching rule is based on given equation (27) & (28)

$$S(i,j) = \sum_{x=x_0}^{x_1} \sum_{y=y_0}^{y_1} |f(x+i, y+j) - TA(x,y)| \qquad (27)$$

$$\left(x_c, y_c = \underset{i,j}{arg}\left(\min\left(S(i,j)\right)\right)\right) \qquad (28)$$

where, (x_c, y_c) = best predicting position in the searching range, i is the searching index for the horizontal with searching range [-M, M], j is the searching index for the vertical with searching range [-N, N], f(x,y) is the pixel value of the original image, (x_0,y_0) is the left bottom point and (x_1,y_1) is the right top point of the undetected tracking targets. An example of error compensation is shown in fig. (13).



(a) (b)

(c)

Fig. (13) Example of the error compensation procedure
(a) Original image
(b) vehicle is misdetected
(c) Re-searching the vehicle in the original image

In the evaluation of traffic parameters, vehicle classification plays an important role. Basically two types of vehicle classification is there, involving large vehicles including buses and tracks and small vehicles including cars and sedans. The determination for small cars is based on equation (29)

$$\begin{Bmatrix} W < 0.8 * W_L \\ H < 3 * W_L \end{Bmatrix} \quad (29)$$

where, W and H is the width and height of the vehicle resp. and W_L is the width of the lane . If above condition is satisfied then small vehicle otherwise large vehicle.

VI. EXPERIMENTAL RESULT

A comparison with other approaches is listed in Table II. As shown, the accuracy ratios for detecting vehicles in [1] are similar to the proposed system. However, it does not detect the vehicle velocity and vehicle classifications. The detection ratios in [14] are lower than the proposed system. In addition, it evaluates fewer traffic parameters. The detection ratios in [18] are also lower than the proposed approach. It also calculates fewer traffic parameters.

Scenarios	Type	Cucchiara et al. [14]	Gupte et al. [18]	Yang [1]	Proposed System
(a) Sunny Day	DC/TTC	97.8%	96.8%	98.5%	99.38%
	CR/DC	N/A	92.5%	N/A	92.4%
	DCV/DC	N/A	N/A	N/A	96.5%
(b) Cloudy Day	DC/TTC	97.6%	98.87%	99.2%	99.17%
	CR/DC	N/A	91.5%	N/A	92.1%
	DCV/DC	N/A	N/A	N/A	95%
(c) Shadow Effects	DC/TTC	95.8%	94.8%	96.5%	99.4%
	CR/DC	N/A	90.2%	N/A	91.6%
	DCV/DC	N/A	N/A	N/A	97.4%
(d) Rainy Day	DC/TTC	91.5%	92.5%	94.2%	93%
	CR/DC	N/A	88.6%	N/A	87.2%
	DCV/DC	N/A	N/A	N/A	90.1%
(e) Night Time	DC/TTC	78.6%	70.5%	89.2%	93.7%
	CR/DC	N/A	70.5%	N/A	74.6%
	DCV/DC	N/A	N/A	N/A	83.7%
(f) Heavy Traffic	DC/TTC	96.2%	90.2%	96.8%	97.5%
	CR/DC	N/A	85.5%	N/A	90.8%
	DCV/DC	N/A	N/A	N/A	94.4%
(g) Traffic Jams	DC/TTC	96.8%	92.5%	97.2%	98.3%
	CR/DC	N/A	90.6%	N/A	96.6%
	DCV/DC	N/A	N/A	N/A	85.2%

Table II
Comparison with other approaches

(*) DC-Detection Count, TTC- Total Target Count, CR-Accuracy Ratio for vehicle classification, DCV-correct detection count for velocity

VII. CONCLUSION

An adaptive vehicle detection approach for complex environments has proposed methods for solving vehicle tracking in traffic jams and complex weather conditions, such as sunny, rain, sunrise, sunset, cloudy, or snowy days. HE is used to remove the effects of weather and light impact. The method is applied to improve the tracking accuracy ratio and simplify the system parameter settings. GDVM is used to dynamically segment moving objects. Finally, tracking and predict compensation are applied to refine the target tracking quality. The tracking accuracy ratio of the proposed system is quite good in traffic jams and complex weather conditions, particularly when applying the error compensation procedure. In the comparisons with other approaches, the proposed method not only has higher detection ratios but gathers more useful traffic parameters as well. In addition, the proposed system can easily be set up without being given any environment information in advance. Many useful traffic parameters are built, and they can be used to control the traffic. Furthermore, this information can be combined with a personal digital assistant (PDA) or mobile phone system to provide traffic conditions for vehicle drivers.

In future, some additional work can also be done to improve the accuracy ratio when it is raining and at night. Also, to make the system practical for commercial usage the detection of motorcycles is also required.

References

1. Bing-Fei Wu and Jhy-Hong Juang" Adaptive Vehicle Detector Approach for Complex Environment ,"*IEEE Trans. Intell. Transp. Syst.*, vol. 13, no. 2, June 2012
2. Y. Wang, "Joint random field model for all-weather moving vehicle detection," *IEEE Trans. Image Process.*, vol. 19, no. 9, pp. 2491–2501, Sep. 2010.
3. L.-W. Tsai, J.-W. Hsieh, and K.-C. Fan, "Vehicle detection using normalized color And edge map," *IEEE Trans. Image Process.*, vol. 16, no. 3, pp. 850–864, Mar. 2007.
4. W. Zhang, Q. M. J.Wu, and X. Yang, "Multilevel framework to detect and handle vehicle occlusion," *IEEE Trans. Intell. Transp. Syst.*, vol. 9, no. 1, pp. 161–174, Mar. 2008.
5. N. K. Kanhere and S. T. Birchfield, "Real-time incremental segmentation and tracking of vehicles at low camera angles using stable features," *IEEE Trans. Intell. Transp. Syst.*, vol. 9, no. 1, pp. 148–160, Mar. 2008.
6. J. Melo, A. Naftel, A. Bernardino, and J. Santos-Victor, "Detection and classification of highway lanes using vehicle motion trajectories," *IEEE Trans. Intell. Transp. Syst.*, vol. 7, no. 2, pp. 188–200, Jun. 2006.
7. H.-Y. Cheng, B.-S. Jeng, P.-T. Tseng, and K.-C. Fan, "Lane detection with moving vehicles in the traffic scenes," *IEEE Trans. Intell. Transp. Syst.*, vol. 7, no. 4, pp. 571–582, Dec. 2006.
8. M. Vargas, J. M. Milla, S. L. Toral, and F. Barrero, "An enhanced background estimation algorithm for vehicle detection in urban traffic scenes," *IEEE Trans. Veh. Technol.*, vol. 59, no. 8, pp. 3694–3709, Oct. 2010.
9. J. Zhou, D. Gao, and D. Zhang, "Moving vehicle detection for automatic traffic monitoring," *IEEE Trans. Veh. Technol.*, vol. 56, no. 1, pp. 51–59, Jan. 2007.
10. D. Koller, K. Daniilidis, and H. Nagel, "Model-based object tracking in monocular image sequences of road traffic scenes," *Int. J. Comput. Vis.*, vol. 10, no. 3, pp. 257–281, Jun. 1993.
11. J. C. Tai, S. T. Tseng, C. P. Lin, and K. T. Song, "Real-time image trackingfor automatic traffic monitoring and enforcement applications," *ImageVis. Comput.*, vol. 22, no. 6, pp. 485–501, Jun. 2004.
12. D. Koller, J. Weber, T. Huang, J. Malik, J. Ogasawara, G. Rao, and S. Russell, "Towards robust automatic traffic scene analysis in real-time," in *Proc. 12th Int. Conf. Comput. Vis. Image Process.*, 1994, vol. 1, pp. 126–131.
13. B. Coifman, D. Beyber, P. McLauchlan, and J. Malik, "A real-time computer vision system for vehicle tracking and traffic surveillance," *Transp. Res. Part C*, vol. 6, no. 4, pp. 271–288, 1998.
14. Y. K.Wang and S.H.Chen, "Arobust vehicle detection approach," in *Proc. IEEE Conf. Adv. Video Signal Based Surveillance*, 2005, pp. 117–122.
15. R. Cucchiara, M. Piccardi, and P. Mello, "Image analysis and rule-based reasoning for a traffic monitoring system," *IEEE Trans. Intell. Transp. Syst.*, vol. 1, no. 2, pp. 119–130, Jun. 2000.
16. D. Beymer, P. McLauchlan, B. Coifman, and J. Malik, "A real-time computer vision system for measure traffic parameters," in *Proc. IEEE Conf. Comput. Vis. Pattern Recog.*, San Juan, PR, Jun. 1997, pp. 496–501.
17. W. L. Hsu, H. Y. Liao, B. S. Jeng, and K. C. Fan, "Real-time traffic parameter extraction using entropy," *Proc. Inst. Elect. Eng.—Vis. Image Signal Process.*, vol. 151, no. 3, pp. 194–202, Jun. 2004.
18. G. D. Sullivan, K. D. Baker, A. D. Worrall, C. I. Attwood, and P. M. Remagnino, "Model-based vehicle detection and classification using orthographic approximation," *Image Vis. Comput.*, vol. 15, no. 8, pp. 649–654, Aug. 1997.

19. S. Gupte, O. Masoud, R. F. K. Martin, and N. P. Papanikolopoulos, "Detection and classification of vehicles," *IEEE Trans. Intell. Transp. Syst.*, vol. 3, no. 1, pp. 37–47, Mar. 2002.
20. B. F. Wu, S. P. Lin, and Y. H. Chen, "A real-time multiple-vehicle detection and tracking system with prior occlusion detection and resolution and prior queue detection and resolution," in *Proc. 18th ICPR*, Aug. 2006, vol. 1, pp. 828–831.