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Procedia Engineering 15 (2011) 5483 – 5487

Procedia Engineering

www.elsevier.com/locate/procedia

Advanced in Control Engineeringand Information Science

Algorithm Research on Moving Vehicles Detection

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Abstract

Moving vehicles detection is an important part of Intelligence Transport System (ITS). Traditional method of moving vehicles detection from video is image subtraction which is apt to be affected by brightness changing, in this paper a kind of moving vehicles detection algorithm based on optical flow is purposed: estimate optical flow through two consecutive frames' image pyramids and compute every optical flow image's threshold with which images are be segment into binaryzation images, after that, through morphological transformation operator and rectangular splitting algorithm on images, moving vehicles' images will be extracted from background. Experiment shows that the algorithm framework is practicable.

Keywords: Moving Vehicles Detection; Optical Flow; Image Pyramids;

1. Introduction

Moving vehicle [1] detection is an important part of Intelligence Transport System (ITS). The goal of moving vehicle detection is to separate moving vehicles from background, and its detection result has a great impact on post image processing. At present, moving vehicles detection method from video are mainly temporal difference between two consecutive frames [2], image subtraction with background [3] and optical flow estimation [4].

Due to detection accuracy of optical flow is higher than that of temporal difference and image subtraction with background, so optical flow algorithm is more suitable for multiobjective moving analysis, through optical flow estimation, motion parameters of moving objects can be get, at the same time, phenomenon of image block and overlap can be avoided as far as possible[5]. For these advantages

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doi:10.1016/j.proeng.2011.08.1017

of optical flow estimation on moving objects detection, in this paper, so called image pyramids optical flow, one kind of optical flow algorithm, is used for moving vehicle detection [6][7][8].

2. Algorithm of Image Pyramids Optical Flow

2.1. Optical Flow Constraint Equation

Assume that a 3D scene is mapped onto an image plane by a pin-hole camera model. Assume further that the time sampling interval $\triangle t$ is sufficiently short (another argument for a real-time implementation), so the instantaneous two-dimensional motion field, which may contain rotations, may locally be approximated by small translations $(\triangle x, \triangle y)^T$. Let $I(x, y, t)$ represent the image intensity at a point (x, y) and time t. We may then describe the time varying imagery by

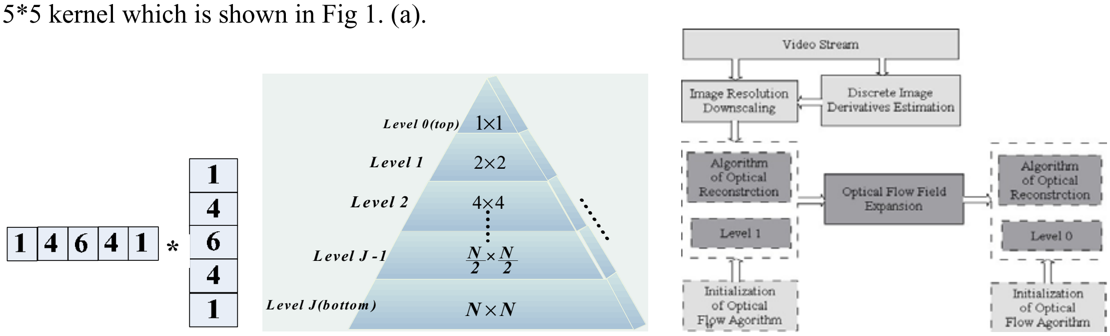
$$I(\triangle X, \triangle y, t+\triangle t) = I(x, y, t) \qquad (1)$$

If we denote the optical flow $(u, v)^T = (\triangle x/\triangle t, \triangle y/\triangle t)^T$, a first order Taylor expansion of Eq. (1) with respect to yields the basic optical flow constraint equation [9]:

$$I_x u + I_y v + I_t = 0 \qquad (2)$$

2.2. Pyramidal Optical Flow

In this paper, a kind of pyramidal optical flow algorithm based on image pyramids [10]-[14] is adopted for tracking feature points in the image sequence, if image is stratified with image pyramids algorithm, velocity and accuracy on tracking feature can be risen notably. The basic idea of the pyramidal optical flow is to construct image pyramids which resolution reduce gradually from bottom to top of the pyramid, that is to say, image's resolution is highest on the bottom and on the top is lowest, each level on the pyramid is constructed from previous level by fist low-pass filtering the image with a Gaussian filter and thereafter sub-sampling with a factor two. The Gaussian low-pass filter [9] is implemented as a separable 5*5 kernel which is shown in Fig 1. (a).



(a) (b) (c)

Fig. 1. Pyramidal Optical Flow Algorithm. (a) The Gaussian low-pass (sub-sampling) Filter; (b) Image Pyramids; (c) Algorithm of Pyramidal Optical Flow.

This above sampling process repeated continuously until optical flow constraint equation is meet, and then, one frame is decompose into a sequence of images called "image pyramids" which resolution reduce gradually from bottom to top. As shown as Fig 1. (b)

In principle, Gaussian pyramid is a set of downscaled with a Gaussian kernel convolved pictures. On the lowest level of pyramid is original picture $I(x, y)$, after the filtering with predefined Gaussian kernel, the result is reduced (sub sampled) by factor of two in each coordinate. More algorithmic details can be found in [15][16]. In this paper, a five-level Gaussian pyramid which principle can be introduced from Fig 1. (c), a two-levels Gaussian pyramid–only one reduction in scale. The main information is illustrated in [17].

3. Algorithm of Moving Vehicles Detection Based on Image Pyramids Optical Flow

To solve moving vehicles detection, the algorithm works as follows:

Step 1 Computing Optical Flow: Compute optical flow vector $[u^k_{x,y}, v^k_{x,y}]$ of one frame with pyramid optical flow algorithm and getting optical flow image;

Step 2 Computing Threshold of Optical Flow Image: Compute average T of all pixels' with optical flow value;

Step 3 Threshold Segmentation: With T, segment image and getting binaryzation image P^T;

Step4 Morphological Transformation Filter on Image: Using dilation operation on P^T, getting filled image of binaryzation image P^T, where B is morphological transformation filter operator;

Step 5 Extracting Vehicle Images with Rectangle: Based on image P^T, Segment image into vehicle images, then read next frame and go Step2.

3.1. Computing Optical Flow

First, an optical flow image is get using algorithm mentioned in 2.2, result is as shown as Fig 2.

(a) (b) (c)

Fig. 2. Computing Optical Flow On Sequence Frames (a) The Last Frame; (b) The Current Frame; (c) Pyramidal Optical Flow Image on (a) and (b)

3.2. Computing Threshold of Optical Flow Image

Suppose resolution of image is $m \times n$, definition of one pixel's optical flow algebraic formula is $\left|U_{x,y}\right|^2 = u^2_{x,y} + v^2_{x,y}$, so threshold[18] of optical flow image can be computed as following formula:

$$T^k = \frac{1}{2} \times \left(\frac{1}{m \times n} \sum_{i=0}^{m} \sum_{j=0}^{m} \left|U^k_{x,y}\right|^2 + \frac{1}{m \times n} \sum_{i=0}^{m} \sum_{j=0}^{m} \left|U^{k-1}_{x,y}\right|^2 \right)$$

3.3. Threshold Segmentation on Optical Flow Image

Because someone pixel's optical flow algebraic formula is $\left|U_{x,y}\right|^2 = u_{x,y}^2 + v_{x,y}^2$, so one image's optical flow value must be a matrix defined as $A^k_{\left|U_{x,y}\right|^2}$, one binaryzation matrix P^k including moving vehicle information can be get through threshold segmentation on value T^k, P^k shows as follows:

$$P^k = \begin{cases} 1, & \left|U_{x,y}\right|^2 \geq T^k \\ 0, & \left|U_{x,y}\right|^2 \leq T^k \end{cases}$$

, Fig 3. Shows the image after binaryzation.

(a) (b) (c)

Fig. 3. (a) Binaryzation Image after Segmentation with Optical Flow Threshold; (b) The Current Frame; (c) Image extracted from with Rectangle Division Algorithm.

3.4. Morphological Transformation Filter on Image

Because binaryzation images may be including many useless small holes and separated pixels which are smaller than structural element *B*, so for the binaryzation image use a kind of morphological transformation filter[19] called morphological closing operation which works two steps: first dilating P^k with *B* and then eroding result with *B*, after morphological closing operation, on condition that vehicle's appearance does not be destroyed, one Objects including many small holes and separated pixels may be connect into one big actual vehicle objects. The following is definition of morphological closing operation and structural element *B*.

$$CLOSE(P^k, B) = P^k gB = (P^k \oplus B)\Theta B \text{ , where } B = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

3.5. Extracting Vehicle Images with Rectangle Division Algorithm

After morphological closing operation, vehicle images can be separated from background using rectangle division algorithm [1] [6]-[8] which works as follows and result shows Fig 3.

Step1: Scanning white pixels line by line and column by column on binaryzation image;

Step2: Given a threshold of rectangle division, doing rectangle division when quantity of black pixels is less than above threshold;

Step3: Deleting those rectangles whose length and width is less than the threshold given in step2;

Step4: The left rectangles after Step3 are moving vehicle image which are extracted by the algorithm.

4. Conclusion

At present, many algorithm of moving objects detection achieves by image subtraction (including sequence images subtraction and background subtraction), but the key point of image subtraction algorithm is how to construct background model which is easy to be affected by light change of surround. So in order to avoid light change affect detection result, in this paper, an algorithm of moving vehicle detection based on pyramid optical flow is purposed. Experiment on actual AVI (Audio Video Interleaved) files shows that the algorithm is effective with high accuracy.

References

[1] Wei Zhan, Zhiqing Luo.Research of Vehicle Type Recognition System Based on Audio Video Interleaved Flow for Toll Station[J]. *Journal of Computer*.(Publishing)

[2] Ballard D H. Generalizing the Hough transform to detect arbitrary shapes[J]. Patter n Recognition, 1981, 13(2) :111-122.

[3] Illingworth J, Kittler J. Survey of the Hough transform[C]. *CVGIP*, 1988, 44: 87-116.

[4] Xuejie Shi. Research on Moving ObjectDetection Based on Optical Flow Mechanism[D]. *University of Science and Technology of China*, 2010: 6-14.

[5] Qiaona Pei. Moving Objects Detection and Tracking Technology basen Optical Flow[D]. *North China University of Technology,* 2009:11.

[6] Wei Zhan, Research of Vehicle Recognition System for the Road Toll Station Based on AVI Video Flow[D]. *China University of Geosciences,* 2006.

[7] Wei Zhan, ZhiQing Luo. System Design of Real Time Vehicle Type Recognition Based on Video for Windows (AVI) Files[C]. *2011 International Conference on Intelligent Computing and Information Science, ICICIS 2011,* Chongqing, China, 2011.

[8] Wei Zhan, ZhiQing Luo. Real Time and Automatic Vehicle Type Recognition System Design and Its Application[C]. *2011 3rd International Conference on Computer and Network Technology, ICCNT 2011,* Taiyuan, China, 2011.

[9] Johannesson, M., Gokstorp, M. Video-rate Pyramid Optical Flow computation on the Linear SIMD Array IVIP[C]. *Computer Architectures for Machine Perception, 1995. Proceedings. CAMP '95,*1995.

[10] Burt, P.J. Fast filter transforms for image processing[J]. *Computer Vision, Graphics and Image Processing, vol 16,* pages 20-51, 1981.

[11] Burt, Peter and Adelson, Ted. The Laplacian Pyramid as a Compact Image Code[J]. *IEEE Trans. Communications,* 9:4, 532–540, 1983.

[12] Crowley, J. and Parker, A.C. A Representation for Shape Based on Peaks and Ridges in the Difference of Low Pass Transform[J]. *IEEE Transactions on PAMI,* 6(2), pp 156-170, March 1984.

[13] Crowley, J. L. and Sanderson, A. C. Multiple resolution representation and probabilistic matching of 2-D gray-scale shape[J]. *IEEE Transactions on Pattern Analysis and Machine Intelligence,* 9(1), pp 113-121, 1987.

[14] P. Meer, E. S. Baugher and A. Rosenfeld. Frequency domain analysis and synthesis of image generating kernels[J]. *IEEE Transactions on Pattern Analysis and Machine Intelligence,* vol 9, pages 512-522, 1987.

[15] DERPANIS K. The Gaussian Pyramid, WWW: http://www.cse.yorku.ca/~kosta/CompVis_Notes/gaussian_pyramid.pdf.

[16] KOPPARAPU S., DESAI U. Bayesian Approach to Image Interpretation[M]. *The Springer International Series in Engineering an d Computer Science,* ISBN: 978-0-7923-7372-8, 2001

[17] Suplata, M. ; Ravas, R. Gaussian pyramid based acceleration of optical flow reconstruction[c]. *Radioelektronika, 2009. RADIOELEKTRONIKA '09. 19th International Conference,* 2009.

[18] The MathWorks. Matlab Documentation[Z].2007.

[19] Rafael C. Gonzalez. Digital Image Processing (Second Edition)[M].Publishing House of Electronics Industry, BeiJing, March 2005.