A Hybrid Intelligent Algorithm Based on the Method to Realize the Vehicle Tracking System

Donghua Feng\textsuperscript{1,2, *} and Meng Li\textsuperscript{2}

\textsuperscript{1}School of computer science and technology, Wuhan University of Technology, Wuhan 430070, China
\textsuperscript{2}School of computer and Information Engineering, Nanyang Institute of technology, Nanyang 473004, China

*Corresponding author e-mail: ny6688@qq.com

Abstract. Aiming at the problem in accident vehicle tracking system and the flaws of low detection precision and slow speed in the traditional algorithm designed a vehicle that based on hybrid intelligent algorithm. First getting moving objects by using frame differential method and picking up accurate target image by using differential background image, then abstracting the light stream of the target and marking object the area of interested to overcome the problem of empty, duplicate detection and illumination influence, reduce the time complexity to improve the reliability of target tracking and reduce the test time. According to the result of the experiment, compared with the traditional algorithms, the system can quickly and accurately track the vehicle, with strong validity and practicality.

1. Foreword

Now to deal with traffic Accident, tracking that often need to compare the artificial one image frame by frame is very difficult, to track the direction of the escaped vehicle. It bring many difficulties to police. How to use the existing moving target detection technology to create the efficient practical accident vehicle tracking system has a certain practical significance and value. Currently the detection methods of moving target mainly are frame difference algorithm, background subtraction algorithm and the optical flow algorithms. \cite{1} Using the frame difference to get the maximum possible movement of the target area, have a cracking environmental adaptability, but if the target move much too fast, there will be empty or repetitive testing; \cite{2} Using background subtraction to obtain complete information to track targets but it is easily influenced by illumination; \cite{3} Separating the moving object and the background by optical flow method, it can capture the objectives of the campaign, but the calculation is difficult. So it is unable to achieve high-speed real-time detection.

This paper aim to the problem in accident vehicle tracking system and the flaws of low detection precision and slow speed in the traditional algorithm designed a vehicle that based on hybrid intelligent algorithm. Full use of the good environmental adaptability of frame difference method target detection and the accuracy of the background subtraction to reduce the target detection area, combined with the optical flow algorithm to capture moving target. It is not only overcome the void, duplicate detection and illumination on the defects, but also reduce the complexity of time and
improve the speed of detection. Experimental results show that compared with the traditional method, the system can quickly and accurately track the vehicle, with strong validity and practicality.

2. Extract Moving Object

The moving object can be detected by the algorithm from a large number of the changes in the video image and extracting the target area, but the data of video capture is huge, and the calculate of time is difficult, it is difficult to achieve real-time detection, and there is scene changes due to the weather, wind, light, etc. extract the moving target is more difficult. Moving target is detected into the camera still and moving camera, because of this article that the vehicle tracking system using a fixed camera each traffic intersection, so only researches the former detection algorithm. In order to improve the detection speed real-time, they can accurately acquire moving targets; can take advantage of the good environmental adaptability frame difference method, the target detection accuracy and advantages of optical flow algorithm background subtraction, using a frame difference, background subtraction optical flow algorithm three intelligent hybrid algorithm.

2.1. Frame differential method

Frame difference method is the most commonly used method for moving object detection [4], by extracting successive two or three images using pixel subtraction formula to calculate the difference image, then binary it process to extract motion area. Three frames of the image frame images I i-1, I i, I i 1, set the threshold T, and calculates a difference between the images difference in the formula:

$$d_{(i,i-1)}(x,y) = |I_i(x,y) - I_{i-1}(x,y)|$$

$$d_{(i,i+1)}(x,y) = |I_{i+1}(x,y) - I_i(x,y)|$$

Then get b by binarization:

$$b_{(i,i-1)}(x,y) = \begin{cases} 1 & d_{(i,i-1)}(x,y) \geq T \\ 0 & d_{(i,i-1)}(x,y) < T \end{cases}$$

$$b_{(i,i+1)}(x,y) = \begin{cases} 1 & d_{(i,i+1)}(x,y) \geq T \\ 0 & d_{(i,i+1)}(x,y) < T \end{cases}$$

Thus get the target image. But the algorithm is not perfect, affected by environmental change on complex moving target, will produce empty, repeat testing and other issues, can not accurately extract the moving target [5].

2.2. Background differential method

Background subtraction is get the motion area by current frame and background images, target detection will get good accuracy. Update the above motion area, the formula is:

$$B_i(x,y) = \begin{cases} B_{i-1}(x,y) & b_{(i-1)}(x,y) = 1 \\ aI_i + (1-a)B_{i-1}(x,y) & b_{(i-1)}(x,y) = 0 \end{cases}$$

After according to the above equation by m (maximum number of iterations is set) iterations, to obtain the exact background image Bi (x, y), where a is the iteration acceleration factor. Then the current Frame and background subtraction to obtain the target image d’.
\[ d'\equiv |I_i(x, y) - B(x, y)| \]  
\[ DB_i(x, y) = \begin{cases} 
  1 & d' \geq T \\
  0 & d' < T 
\end{cases} \]  

\( DB_i(x, y) \) show target image pixel gray value that is binarized. Since only update the area of interested, thus greatly reducing the computational complexity, it is possible to achieve real-time monitoring purposes.

2.3. Optical flow calculation and extraction

Optical flow is two-dimensional velocity vector projected on the plane of the three-dimensional velocity, which is two-dimensional instantaneous velocity field. If you give each pixel an image speed, constitute an image velocity field. With the moving, the presence of the target point of the three-dimensional motion of each point on the image on the one mapping, the mappings can be obtained by the projection. The optical flow vector of the instantaneous is the rate of change of the two-dimensional image coordinates of the gradation points. Optical flow field (optical flow field) is a two-dimensional vector field, is the apparent motion of the image gray mode, it contains information is the instantaneous speed of movement vector information of each image point. Optical flow field can be approximately figure up cannot directly get from image sequences. Optical flow field can be simply understood as the velocity vector field of the object, including the two components u, v. Assuming there is a point \((x, y)\) located on the plane in the scene that it is represented by a point \((x, y, z)\) projected in the image plane, the point of the gray value at this moment \(I(x, y, t)\). Assumed that the point \((t \Delta t)\) move to \((x \Delta x, y \Delta y)\), in a very short time interval \(\Delta t\) in the gray value remains unchanged, i.e.:

\[ I(x + u\Delta t, y + v\Delta t, t + \Delta t) = I(x, y, t) \]  

There into, u, v are the optical flow of the point x, y in the direction of the component. Assuming brightness \(I(x, y)\) smooth changes over time; the above equation can be expanded by Taylor formula, get:

\[ I(x, y, t) + \Delta x \frac{\partial I}{\partial x} + \Delta y \frac{\partial I}{\partial y} + \Delta t \frac{\partial I}{\partial t} + e = I(x, y, t) \]  

There into e contain \(\Delta x, \Delta y, \Delta t\) quadratic or more terms, the elimination of the formula \(I(x, y, t)\), in addition to the equation on both sides by \(\Delta t\) and \(\Delta t \to 0\) take the limit, can be evaluated obtain optical flow constraint equation:

\[ \frac{\partial I}{\partial x} \frac{dx}{dt} + \frac{\partial I}{\partial y} \frac{dy}{dt} + \frac{\partial I}{\partial t} = 0 \]  

This formula can be abbreviated as:

\[ I_x u + I_y v + I_t = 0 \]  

\[ I_x = \frac{\partial I}{\partial x}, I_y = \frac{\partial I}{\partial y}, I_t = \frac{\partial I}{\partial t}, u = \frac{dx}{dt}, v = \frac{dy}{dt} \]
I_s = \frac{1}{4\Delta x}[(I_{i+1,j,k} + I_{i+1,j,k+1} + I_{i+1,j+1,k} + I_{i+1,j+1,k+1})
- (I_{i,j,k} + I_{i,j,k+1} + I_{i,j+1,k} + I_{i,j+1,k+1})]
(12)

I_y = \frac{1}{4\Delta y}[(I_{i,j+1,k} + I_{i,j+1,k+1} + I_{i+1,j+1,k} + I_{i+1,j+1,k+1})
- (I_{i,j,k} + I_{i,j,k+1} + I_{i+1,j,k} + I_{i+1,j,k+1})]
(13)

I_r = \frac{1}{4\Delta t}[(I_{i,j+1,k} + I_{i,j+1,k+1} + I_{i+1,j,k+1} + I_{i+1,j+1,k+1})
- (I_{i,j,k} + I_{i,j,k+1} + I_{i+1,j,k} + I_{i+1,j,k+1})]
(14)

The optical flow has two components u, v, but an equation with two unknowns, needs an additional constraints [6].

3. The accident vehicle tracking system

In this paper, the camera is static to target motion for the study, firstly using the frame difference method most possible area of difference image, re-use background subtraction method to extract the precise target area of interest, and then use the optical flow method to calculate the difference between the characteristics of the target area image Point of optical flow.

Overall algorithm steps: (1) Deal with the captured video image by denoising, smoothing, to enhance pretreatment [7], as shown in Figure 1 (a). (2) Using the frame difference algorithm and enhancements to get the largest possible area of difference between the target images. Extracting three consecutive frame images I_{i-1}, I_i, I_{i+1}, calculate the difference image d, set the threshold T, obtain image after the binarization as shown in the binary image b_1 (b), the binary image obtained by filtering, denoising, and the projection plane, the extraction target region of the maximum possible area, in order to ensure increased length and width of the original on the basis of (W, H) on the integrity of the rectangular region plus the pixel N, N can be obtained by experiment Suitable values.

\[ w = W + N \]
\[ h = H + N \]
(15)

Rectangular region of interest of FIG. 1 (c). (3) Using background subtraction algorithm to obtain precise target area, and marked. Update the background image, taking the maximum number of iterations m = 100, \alpha = 0.003. Then subtract the current frame and background subtraction to obtain the target image d'. In this region of interest is updated only greatly reduces the computer complexity, it is possible to achieve real-time monitoring purposes. (4) Conducting flow calculation and morphological filtering [8] using optical flow clustering extraction targets. In the image plane sufficiently small region ROI, and within a sufficiently short time interval, the motion between two frames can be approximated as linear least squares using the optical flow obtain Optical Flow Field:

\[ V = [A^TW^2A]^{-1}A^TW^2b \]
(16)

\[ V = \left[ \begin{array}{c} u \\ v \end{array} \right], A = [\cdot I(x_1,y_1), \cdot I(x_2,y_2), \cdots, I(x_n,y_n)] \]
(17)
Due to the presence of optical flow field discontinuities and unreliability, and the emergence of noise, so set the threshold function $\varepsilon$, when it exceeds this numerical value, no longer extract the optical flow, otherwise extract the optical flow marked with a red arrow, as shown in Figure 1 (d).

\[
V = \text{diag}[w(x_1, y_1), \cdots w(x_n, y_n)]
\]
\[
b = -[I_t(x_1, y_1), \cdots I_t(x_n, y_n)]^T
\]

(18)

\[
\varepsilon = \sum w_i \left( \frac{I_{\mu}u + I_{\nu}v + I_{\sigma}}{\sqrt{I_{\mu}^2 + I_{\nu}^2}} \right)
\]

(19)

(5) Target tracking and speed of calculation

(A) Original image                    (B) difference image

(C) The region of interest             (D) optical flow calculation

Figure 1. The vehicle tracking process image

4. Results
Experiments used a traffic intersection cameras shoot video in city. Video resolution is 640*480, the camera itself has a noise, and there is light changes in the environment, the air flow, the background color of the complex, all the camera image are stationary target motion, the movement and the computing enforced by the VC++. Respectively, make the compared experiments by difference method, background subtraction, optical flow method and the proposed method. Results are shown in Table 1:
### Table 1. The results in Table 1 Track

| Methods               | Rebuild time (s) | Accuracy |
|-----------------------|------------------|----------|
| Frame difference      | 1.95             | 57%      |
| Background subtraction| 1.78             | 62%      |
| Hybrid difference     | 0.67             | 81%      |
| Optical Flow          | 1.09             | 86%      |
| This method           | 0.16             | 98%      |

According to this result, this method greatly improves computing speed and accuracy are higher than the other three methods. This paper uses a frame difference method to get moving region, extracting precise target use of background subtraction method, which reduces the computational complexity, increase the speed of reconstruction, and then extract the optical flow of interested area of the target feature point and marked, so tracking the target the accuracy is improved. Experimental results show that the method is feasible and effective.

### 5. Conclusion

This paper aims to the problem in accident vehicle tracking system and the flaws of low detection precision and slow speed in the traditional algorithm designed a vehicle that based on hybrid intelligent algorithm. Take full advantage of the frame difference method target detection accuracy environmental adaptability and background subtraction, using a frame difference method to obtain the goal of the movement area of interest, and then update to get accurate target image by background subtraction, and then calculate the target image feature points optical flow and the region of interest at the label, so that the calculated optical flow is more accurate and reliable. It not only overcome the void, duplicate detection and illumination on the defects, but also reduces the complexity of time and improve the detection speed. The results of experiment show that, compared with the traditional method, the system can quickly and accurately track the vehicle, reduce the difficulty of police to trace vehicle, with strong validity and practicality.

### References

[1] Ha J E. Foreground objects detection using multiple difference images [J]. Optical Engineering, 2010, 49 (4): 047201-1-047201-5.

[2] Jodoin P M, Mignotte M, Konrad J. Statistical background subtraction using spatial cues [C]. IEEE Transactions on Circuits and Systems for Video Technology, 2007, 17 (12): 1758-1763.

[3] Dessauer M P, Dua S. Optical flow object detection, motion estimation, and tracking on moving vehicles using wavelet decompositions [J]. Proc SPIE, 2010: 76-94.

[4] T U Li-fen, ZHONG Si-dong, PENG Qi. Moving target detection based on hybrid difference method [J]. Science, technology and engineering, 2012, 12 (2): 325-329.

[5] LIU Zhi-yu, WANG Guan-jun. Dynamic target detection method research in intelligent traffic detection system [J]. Journal of computer applications and software, 2010, 27 (1): 29-31.

[6] CHENG Yi-wei, Ride on a moving target tracking system based on ARM [J]. The design and implementation of manufacturing automation, 2012 (7): 94-96.

[7] ZHU Qing, LIU Hong-li, CHEN Bing-quan, LJ Jin-ju, WAN Qin, SUN Meng, YUAN Xiao-fang. An improved method for multiple targets tracking [J]. Journal of Central South University, 2012, (10): 2852-2859.

[8] LI Jian-feng, HUANG Zeng-xi, LIU Yi-guang. The adaptive scheme based on optical flow field estimation - Shift target tracking algorithm [J]. Journal of photoelectron. Laser, 2012, (10): 1996-2002.