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Moving object area detection using normalized self adaptive optical flow

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ABSTRACT

Optical flow estimation is one of the oldest and still most active research domains in computer vision. This paper proposes a novel and efficient method of moving object area detection in the video sequence employing the normalized self-adaptive optical flow. This new approach first performs smoothing on the individual frame of the video data using Gaussian filter, then determines the optical flow field with an existing optical flow algorithm, next filters out the noise using adaptive threshold approach, after that normalize, morphology operation, and the self adaptive window approach is applied to identify the moving object areas. The proposed work is accurate for detecting the moving object areas with varying object size. The proposed scheme has been formulated, implemented and tested on real video data sets that provides an effective and efficient way in a complex background environment.

1. Introduction

Motion detection from video stream or image sequence is one of the main tasks in many computer vision applications such as people tracking, traffic monitoring, scene analysis, driver assistance and video surveillance. Extracting moving object efficiently and accurately is the foundation of tracking [1] and sorting of the moving target in computer vision. To calculate moving object area the system divides the scene into two regions, foreground and background, where only the foreground holds the regions of interest, and the background is relatively stationary with time. The moving object area is mostly detected by temporal difference, background subtraction and optical flow analysis approaches.

Some filtering methods like Gaussian filter [2], PDE filter [3], and global filter [4] are used for pre-processing of input frames to reduce negative influence of false alarm on the result. These methods are also used to enhance important structure of frames [5]. To reduce noise and improve accuracy of detection [6,7], Kalman filter [8], median filter (MF) [9], and bilateral filter (BF) [10] are the widely used post-processing techniques employed on the optical flow field.

Extensive studies have been conducted for optical flow field calculation. With the help of background subtraction, optical flow, and separable morphological edge detector, Wei et al. [11] proposed a foreground detection method for surveillance applications. However it fails to detect all the components of foreground and this result in bad target recognition. MF can be used to remove flow noise, but in some cases, it over-smoothes the edge features [12]. Rashidha et al. [13] proposed a modified weighted median filter method to stop over smoothing, which also reduces the computational time by completely smoothing the detected motion boundaries. To improve the accuracy of optical flow estimation, Tu et al. [14] proposed an additional

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post-filtering schemes. This method is used to reduce the effect of outliers and to preserve discontinuities, however the filtering window size is not adaptively set. In [15] the authors incorporate a sift flow-based method for modeling the background and extracting moving objects from a video sequence. Every pixel is modeled as a group of adaptive sift flow descriptor those are computed over a rectangular neighborhood around the pixel and the background model is dynamically updated. In order to realize the detection of the moving objects with camouflage color, an approach based on optical flow model was put forward [16]. Dou and Li [17] presented a moving object detection method based on *improved visual background extractor* [18] and *graph cut method* [19] from monocular video sequences. Lan et al. [20] proposed an approach for vehicle speed measurement method, which holds the improved *3-frame difference* [21] algorithm and the *gray constraint optical flow* [22] algorithm.

Lots of other methods have been presented for object detection in a video sequence, however there still remain some problems in the moving object area detection under various complex situations like the variation of the object size and camera shake problem, etc. A perfect foreground cannot be attained by using optical flow alone due to background noises which arise from some brightness change. The background noise emerges randomly because optical flow techniques analyze the image as a whole and compute the flow for every pixel. So due to this the flow is also detected in the background. We have proposed a novel approach for moving object detection to overcome the problems stated above. In this approach first we smooth the individual frame using Gaussian filter, subsequently we apply optical flow method, self-adaptive threshold algorithm, and normalization to detect moving objects directly in a complex environment without extracting and updating a reference background. With the help of Otsu [23] method and morphological operation, we have also computed the adaptive window to detect moving object area in gray as well as in binary format. We have applied our approach on different publicly available video datasets. Results show that our algorithm outperform other widely used optical flow techniques for a person tracking application; where we make attempt to locate a slow moving and running person within the flow frames.

This paper is organized as follows. In Section 2, we present the proposed approach including optical flow, normalization and moving object area detection. Section 3 presents implementation details. In Section 4, the experimental results and comparisons with performance evaluation are conducted to show the effectiveness of the proposed method, and our conclusions are given in Section 5.

2. Proposed method

Entire process of the proposed moving object area detection is summarized as follows:

- Extraction of frames from video data.
- Conversion of frame to grayscale, if it is in color format.
- Frame smoothing using Gaussian filter.
- Estimation of optical flow.
- Noise suppression by self adaptive Otsu threshold approach.
- Normalization followed by binarization of the noise reduced optical flow field.
- Determination of the moving object area using morphological operation and self adaptive window.

Below we elaborate the methodology.

2.1. Optical flow

The movement in space can be described as motion field, however with the image plane, the object motion is embodied through the gradient of different grayscale distribution. So, if the motion field in space is transformed into an image, it will be known as optical flow field which shows the technique used to characterize the image motion. With the help of brightness and smoothness constraint, Horn and Schunck (HS) [24] proposed the variational optical flow method for motion estimation between two successive frames. According to brightness constancy assumption:

$$f(x, y, t) = f(x + dx, y + dy, t + dt) \tag{1}$$

Here $f(x, y, t)$ is the gray value of a pixel located at coordinate $X = (x, y)$ of a given frame f_t at time instant t, but at time $t + dt$ pixels have moved at the new coordinate position $X' = (x + dx, y + dy)$, and gray value becomes $f(x + dx, y + dy, t + dt)$. By Taylor series expansion:

$$f(x, y, t) = f(x, y, t) + \frac{\partial f}{\partial x}dx + \frac{\partial f}{\partial y}dy + \frac{\partial f}{\partial t}dt \tag{2}$$

$$f_x dx + f_y dy + f_t dt = 0 \tag{3}$$

$$f_x u + f_y v + f_t = 0 \tag{4}$$

Here f_x, f_y and f_t are the gradient in spatial (x, y) and temporal t direction respectively. $u = (dx/dt)$, $v = (dy/dt)$ are the estimated optical flow between frames f_t and f_{t+dt} in the horizontal and vertical direction respectively.