

Chapter 5

Improved Spatial–Temporal Moving Object Detection Method Resistant to Noise

ABSTRACT

The resistance of the improved moving objects detection algorithm to various types of additive and multiplicative noise is discussed. The algorithm's first phase contains the noise suppression filter based on spatiotemporal blocks including dimensionality reduction technique for a compact scalar representation of each block, and the second phase consists of the moving object detection algorithm resistant to illumination changes that detects and tracks moving objects.

1. INTRODUCTION

The performance of the improved moving object detection algorithm resistant to the additive Gaussian, Salt and Pepper and Speckle noise of various variances is presented and evaluated in this chapter. The main goal is to demonstrate that this novel technique is resistant to influence of various types of noise and to augment the reasons for such desirable behavior.

A common feature of the most common approaches for moving object detection is the fact that they are pixel based (Jain, 1977), (Haritaoglu, 2000), (Oliver, 2000), (Remagnino, 2002), (Wren, 1997). Recent approaches are however based on the spatiotemporal blocks. While the pixel based techniques are shown resistant to the illumination change they are prone to the influence of noise. On the other hand, block-based methods are shown resistant to noise. To combine these desirable prop-

erties, both approaches are combined in the new improved method (Pokrajac, 2003). The novelty that is introduced is image preprocessing similar to that used in the block-based method. The pixel and region levels are combined to a single level texture representation with 3D blocks and the image processing is continued on such spatially-temporally filtered pixels. More precisely, a given video is decomposed into overlapping spatiotemporal blocks, e.g., 7x7x3 blocks centered at each pixel, and then a dimensionality reduction technique is applied to obtain a compact representation of color or gray level values of each block as a single scalar value. The principal component analysis is applied and the dominant eigenvector (corresponding to the largest eigenvalue) is used to obtain the coefficients of three dimensional filter, employed on every current frame. Such filtered images are subsequently treated with the moving detection algorithm based on pixel value.

It should be noted that the standard input of pixel values that are known to be noisy and in this way the main cause of instability of video analysis algorithms are avoided. In contrast, the application of principal component projection instead of original pixels is expected to retain useful information while suppressing successfully the destructive effects of noise. Hence, it is anticipated that the proposed technique will provide motion detection robust to various types of noise that may be present in video sequence, including additive Gaussian, Salt and Pepper and Speckle noise. This chapter shows the practical approval of this theoretically asserted claim on a test video from PETS repository.

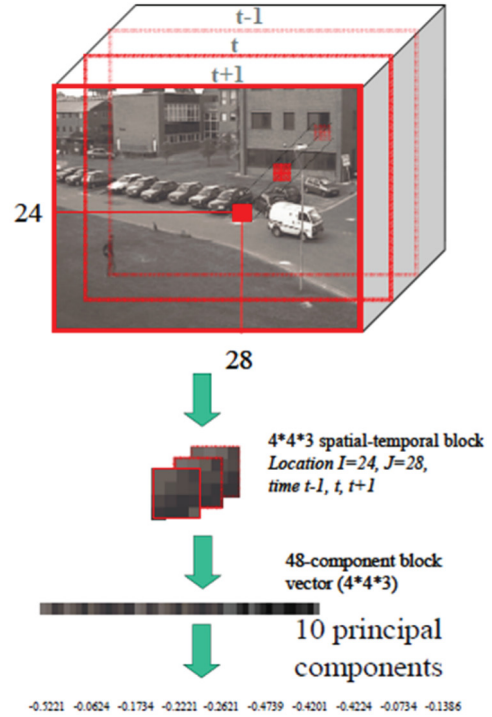
2. METHODOLOGY

The used technique for moving object detection consists of four major phases:

1. Extraction of the 3D filter coefficients with the PCA analysis.
2. Dimensionality reduction by spatiotemporal blocks.
3. Image filtering of a current frame with the noise removal filter.
4. Detection of moving objects applying the pixel based method for moving object detection resistant to illumination changes.

A given video is treated as three-dimensional (3D) array of gray pixels $p_{i,j,z}$, $i=1,\dots,X$; $j=1,\dots,Y$; $z=1,\dots,Z$ with two spatial dimensions X , Y and one temporal dimension Z , which can be found in the literature mentioned in the references. Spatiotemporal (3D) blocks are used, represented by N -dimensional vectors $\mathbf{b}_{I,J,t}$, where a block spans $(2T+1)$ frames and contains N_{BLOCK} pixels in each spatial direction per frame ($N=(2T+1) \times N_{\text{BLOCK}} \times N_{\text{BLOCK}}$). To represent the block vector $\mathbf{b}_{I,J,t}$ by a scalar while preserving information to the maximal

Figure 1. Dimensionality reduction using spatial-temporal blocks



possible extent, principal component analysis is used. It is illustrated in Figure 1.

For principal component analysis, sample mean and covariance matrix are estimated of representative sample of block vectors corresponding to the considered types of movies and use the first eigenvector of the covariance matrix $\mathbf{S}$ (corresponding to the largest eigenvalue) that represents the coefficients of the 3D filter that suppresses the noise. In practice, the 3D filter can be emulated by three 2D filters applied on frames $z-1$, z and $z+1$.

The fourth phase of the proposed method implies the application of a pixel based algorithm for moving object detection and tracking, mentioned in Chapter 2.

Consider image sequence I consisting of N video frames. The sliding mask A_i is applied on every frame.

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