Chapter 2
Improved Illumination Independent Moving Object Detection Algorithm

ABSTRACT

A real time change detection technique is proposed in order to detect the moving objects in a real image sequence. The described method is independent of the illumination of the analyzed scene. It is based on a comparison of corresponding pixels that belong to different frames and combines time and space analysis, which augments the algorithm's precision and accuracy. The efficiency of the described technique is illustrated on a real world interior video sequence recorded under significant illumination changes.

1. INTRODUCTION

Detecting important changes, i.e. moving objects in dynamic real scenes, has become very popular research area in recent years. First of all, this problem is present in several domains of image processing as well as in digital signal processing area. There is a great interest in this kind of systems because of its wide application and huge spectra of use. The systems have practical application in traffic regulation (Inigo, 1989), (Mecocci, 1989), (Rourke, 1990), (Fathy, 1995), video surveillance, securing different objects in interior or exterior, national security, etc (Corall, 1991), (Foresti, 1998), (Foresti, 1994).

Real time image processing algorithms should be fast, simple and computationally feasible in order to support practical applications. The most of the existing algorithms for change detection in real time use various techniques for segmentation of the fixed background, based on changing decision threshold. That is why the accuracy of these methods depends significantly on the appropriate choice of the adequate threshold as well as on the precision of the background updating technique.

Improved technique for moving object detection in real sequences independent of illumination variation, based on the method explained in the previous chapter, is presented. The new technique exploits information extracted from a sequence of images relying on time and space analysis performed in parallel. This augments the accuracy of the algorithm.

2. METHODOLOGY

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

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Skifstad and Jain, (Skifstad, 1989), use the ratio of pixel intensities in mask A_i between two a reference and a current frame to estimate the pixel variance σ_i^2 as follows:

$$\sigma_i^2 = \frac{1}{card\{A_i\}} \sum_{m \in A_i} \left(\frac{B_m}{C_m} - \mu_{A_i} \right)^2, \; i = 1..n \,. \quad (1)$$

Here, pixel intensities within mask A_i are denoted with B_m for a reference, background frame that does not contain changing regions and with C_m for a current frame where moving objects are being identified. The mean of the pixel intensity ratio within A_i is denoted with μ_{A_i}. If $\sigma_i^2 \geq \varepsilon$ (where ε is a suitable threshold), the center of the mask A_i is marked as changing region.

Experiments in (Inigo, 1989), (Mecocci, 1989), (Rourke, 1990), (Fathy, 1995), (Corall, 1991), (Foresti, 1998), (Foresti, 1994) have shown that for significant illumination changes this method fails, i.e. some pixels are falsely assigned to changing regions. A modified technique based on adaptive coefficient for illumination compensation is proposed in this chapter. Pixel variance is estimated as:

$$\sigma_i^2 = \frac{1}{card\{A_i\}} \sum_{m \in A_i} \left(\frac{B_m}{C_m} K_i - median\{A_i\} \right)^2, \quad (2)$$

The median instead of mean value is used in order to reduce sensitivity on outliers. The illumination compensation coefficient is defined as

$$K_i = \frac{\sum_{m \in A_i} C_m}{\sum_{m \in A_i} C_{1m}} = \frac{\mu_i}{\mu_1}, \quad (3)$$

where C_{1m} is pixel intensity for the first frame in the sequence.

2.1 Improved Method

The modified shading model method illustrated in previous chapter is fairly robust to significant and sudden illumination changes (up to roughly 50% of change in comparison to the starting illumination level), due to the coefficient K_i that enables sensitivity suppression.

The improved version of the algorithm is proposed here to further improve the behavior of the existing method. It performs the analysis in time and space at the same time and improves resistance to the illumination changes and reduces the false detection, i.e. noise. It successfully detects the inner parts of the moving objects and the thicker edges as well.

In the technique proposed here, pixel variances for three successive pairs of frames are average estimated and its average value is thresholded in order to determine the presence of moving objects. This represents temporal analysis. The ratio of pixel intensities in A_i between two frames is used to estimate the pixel variance ${}^I\sigma_i^2$ for three pairs of successive frames. The estimation of pixel variance was done on following pairs of frames *i*-3 and *i*-2, *i*-2 and *i*-1 and *i*-1 and *i*, where *i* is the current frame. Thus, three pixel variances for three successive and corresponding variance pairs ${}^I\sigma_{i-2}^2$, ${}^I\sigma_{i-1}^2$ and ${}^I\sigma_i^2$ are obtained. Subsequently, the average value of these three variances is computed as follows:

$${}^I\sigma_{mean}^2 = ({}^I\sigma_{i-2}^2 + {}^I\sigma_{i-1}^2 + {}^I\sigma_i^2) \,/\, 3, \quad (4)$$

After that, the mean value is subtracted from the pixel variance of the current and previous frame:

$${}^I\sigma_{i'}^2 = {}^I\sigma_i^2 - {}^I\sigma_{mean}^2, \quad (5)$$

If ${}'\sigma_{i'}^2 \geq \varepsilon$ (a suitable threshold), the center of A_i is marked as changing region, i.e. as moving object.