401 A Study on Robust Event Detection with High Accuracy

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Abstract This paper proposes a robust background model for event detection with illumination changing environment. The main concept of the proposed method is searching the smaller intensity-difference pixel pairs above certain threshold that consistently yields high detection accuracy. Meanwhile, a faster version using caculation diminution and spatial sampling is presented which reduces computation time without decreasing accuracy.

1 Introduction

Background subtraction is one of the typical approaches in automated surveillance technology. In which, the most difficult problem is how to deal with illumination variance. In literature, scholars have done researches focused on this area for several years [1][2]. However, these methods cannot accurately detect objects in illumination changing circumstances. To address these limitations, in this paper, a novel model for background based on spatial intensity difference named as Gray Arrange Pair is proposed.

2 Gray Arrange Pair

In this section, we describe a background model based on the intensity relationship of two optional pixels. Given the sequence sample images for background modeling as $I_t(t=1,\dots,T)$.

2.1 Definition

Before introducing the proposed algorithm,the definition will be made first.

- Target point: The pixel that to be classified as background or foreground. In each image for background modeling, we define $P=(u,v)$ as target point.
- Reference point: The pixel has special intensity relationship with target point that can be defined by $Q_n=(u',v')$.

The intensity relationship between target point P and Q_n in different situation can be defined as follows. When in the case of $I_t(P)\geq I_t(Q_n)$,we mark Q_n as Q_n^+ , and the set expression of point pair can be presented as,

$$X^+(P,Q_n^+)=\{Q_n^+|S^+(P,Q_n^+)\geq W_P\} \tag{1}$$

$$\begin{aligned}&S^+(P,Q_n^+)=\\&\#\{t|I_t(P)-I_t(Q_n)\geq W_G,1\leq t\leq T\}/T\end{aligned} \tag{2}$$

While in the case of $I_t(P)<I_t(Q_n)$,we mark Q_n as Q_n^- which is defined as the same as Q_n^+.

2.2 Event detection

Selecting the right reference points plays a critical role in background modeling step which is closely related to object representation. The central issue in Gray Arrange Pair proposed in this paper is to directly pick the pixels with smallest intensity difference which can control the real difference value between two points.

1. First, the mean intensity $\overline{I(P)}$, for every target point is defined as follows.

$$\overline{I(P)}=\frac{1}{T}\sum_{t=1}^{T}I_t(P) \tag{3}$$

2. Then, consider the mean intensity $\overline{I(Q_n)}$ for every candidate reference points Q_n which meet the intensity requirement $Q_n^+\in X^+(P,Q_n^+)$ and $Q_n^-\in X^-(P,Q_n^-)$. They can be defined as,

$$\begin{aligned}\overline{I(Q_n^+)}&=\frac{1}{T}\sum_{t=1}^{T}I_t(Q_n^+)\\ \textit{and}\quad \overline{I(Q_n^-)}&=\frac{1}{T}\sum_{t=1}^{T}I_t(Q_n^-)\end{aligned} \tag{4}$$

3. Therefore, the difference intensity between them called as Df can be calculated using,

$$\begin{aligned}Df_n^+&=\overline{I(P)}-\overline{I(Q_n^+)}\\ \textit{and}\quad Df_n^-&=\overline{I(Q_n^-)}-\overline{I(P)}\end{aligned} \tag{5}$$

4. Picking sample pixels $Q_1^+,Q_2^+\in X^+(P,Q_n^+)$ for example, we can define the order $<_p$ like this,

$$Q_1^+<_p Q_2^+\overset{\text{def}}{\Leftrightarrow}Df_1^+<Df_2^+ \tag{6}$$

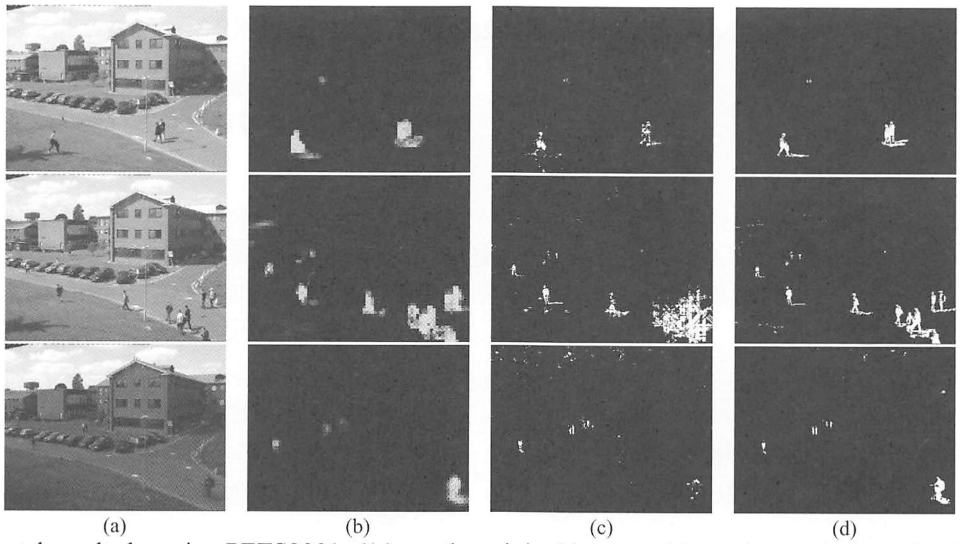

Fig. 1: Experimental results by using PETS2001. ((a) are the original images; (b) are the results by using Cooccurrence;(c) are the results by using SRF; (d) are the results by using Gray Arrange)

Sort the set $X^+(P, Q_n^+)$ and $X^-(P, Q_n^-)$ separately by this order and take the first 8 elements each of whom for reference points around the point P. In other word, $min^8_{<_p} X^+(P, Q_n^+)$ has the nearest mean intensity of P in the set $X^+(P, Q_n^+)$,while $min^8_{<_p} X^-(P, Q_n^-)$ has the nearest mean intensity of P in the set $X^-(P, Q_n^-)$.

Then with an input image J, since we have obtain the reference points $Q_n^+ \in min^8_{<_p} X^+(P, Q_n^+)$ and $Q_n^- \in min^8_{<_p} X^-(P, Q_n^-)$ according to each target point P, the probability in different intensity cases of achieving a desired foreground pixel can be estimated as,

$$\xi^+(P) = \frac{\#\{Q_n^+ | I(P) > I(Q_n^+) \cap J(P) > J(Q_n^+)\}}{\#\{Q_n^+\}} \quad (7)$$

$$\xi^-(P) = \frac{\#\{Q_n^- | I(Q_n^-) > I(P) \cap J(Q_n^-) > J(P)\}}{\#\{Q_n^-\}} \quad (8)$$

Using this probability estimate, the pixel P in input image can be considered to be a background pixel if only $\xi^+(P) > W_H \cap \xi^-(P) > W_H$.

3 Time reduction

A faster version based on Gray Arrange method can be proposed by using calculation diminution and adopting spatial sample. The basic procedure of calculation diminution is based on reducing the operation of calculating the statically intensity difference between each two pixels which is considered the most time costing step. While in the spatial sample step, picking some appropriate sample target points in spatial domain for calculation would speed up the background modeling time.

4 Performance evaluation

In order to test the performance of proposed method, two experiments have been done. For the first experiment, we demonstrate the performance on different condition with sharp illumination change. We performed quantitative analysis in pixel level by using 300 frames picked from PETS2001(3) for background modeling which are shown in Fig.1. Clearly, the detection results is better than SRF and Co-occurrence approach.

The next experiment is aimed at compare results with Gray Arrange and its time reduction version. The accurate comparison results by only using the calculation diminution step and combining spatial sample with calculation diminution are almost same but their computation time has been reduced by 73.1% and 82.1% separately.

5 Conclusion

In this paper, we proposed a novel background modeling method called Gray Arrange for event detection in strong illumination change scene, and the experimental results are good.

Reference

[1] M. Seki, T. Wada, H. Fujiwara, and K. Sumi: "Background Subtraction based on Cooccurrence of Image Variations", Proc. of 2003 IEEE Computer Society Conference on CVPR, pp.65-72, 2003.

[2] R. Ozaki, and Y. Satoh, et.al: "Statistical Reach Feature Method And Its Application To Template Matching", Proc. of the IAPR Conference on MVA2009, pp.174-177, 2009.