Research Paper

Volume : 5 | Issue : 2 | February 2016 • ISSN No 2277 - 8179

A Threshold Using Fuzzy Logic for Background Subtraction of Video Sequences

Computer Science

KEYWORDS : background subtraction, frame difference, threshold, linear index of fuzziness

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ABSTRACT

One of the fundamental steps of object recognition in computer vision applications is background subtraction. The most widely used method for background subtraction is the frame difference method which identifies the pixels that significantly differ from the background using a threshold. The threshold plays a crucial role in differentiating the foreground and background pixels. In this paper, a fuzzy logic based technique is used to obtain the threshold. The proposed method is evaluated using a benchmark dataset and is compared with the fundamental frame difference method. The results indicate that the proposed method is promising.

INTRODUCTION

Background subtraction is one of the important tasks in computer vision. It is useful for the extraction of the foreground objects which is used for object/ activity recognition and tracking. A lot of work has been carried out in background subtraction, and most of these techniques are based on statistical methods [2], subspace learning methods [3] and fuzzy based methods [1]. One of the most common approaches of statistical based methods for background modeling is based on mixture of Gaussians. Subspace learning methods including principal component analysis and incremental maximum margin criterion have been used for background modeling. Fuzzy concepts have also been used in various steps of background subtraction. The challenges in background subtraction such as dynamic backgrounds, illumination changes have motivated the development of background subtraction techniques which will robustly detect moving objects in such challenging environments.

The three steps involved in a typical background subtraction method are 1) background initialization 2) foreground detection and 3) background maintenance. In background initialization a background image is initialized based on the first N frames. This background image does not have any moving objects. Foreground/ moving objects are detected by classifying the pixels as foreground or background. In order to consider the changes in the background, the background image is updated over time. Finding an appropriate threshold which correctly differentiates foreground objects from the background is an important aspect involved in the second step. In most of the background subtraction techniques, the second step checks whether the current pixel is significantly different from the corresponding pixel in the background image using a threshold. Hence, determination of the threshold is crucial for classifying the pixels as foreground and background.

In this paper, the threshold is determined based on a measure called linear index of fuzziness [6]. The rest of the paper is organized as follows. Section 2 describes the proposed methodology for background subtraction using a threshold obtained using linear index of fuzziness. Section 3 presents the experimental results and section 4 gives the conclusion.

PROPOSED METHODOLOGY

In this paper, a frame difference based method is proposed which works based on the threshold obtained from a fuzzy logic based technique. In the proposed method the initial background image B_0 is the mean of the initial n frames. The next step is to determine the foreground and background pixels from the current frame, $I_t(x, y)$. The choice of threshold is essential to differentiate the foreground object from the background. It the value of the threshold is small, then some of the background pixels may be detected as foreground. If the value of the threshold is large, then it may not detect some of the foreground pixels. In this paper the threshold T is computed based on linear index of fuzziness [6].

Let the difference between the current image and background image be represented as D_t with the size MxN. Let the minimum and maximum values of D_t be l_{min} and l_{max}. Also let the histogram of the difference be represented as $h(g)$ and the fuzzy membership function $\mu_x(g)$. The linear index of fuzziness for this difference can be defined using [4] as

$$\mu_l(x) = \frac{2}{MN}\sum_{g=l_{min}}^{l_{max}} h(g)[\mu_x(g), 1-\mu_x(g)] \text{ --Eqn 1}$$

The steps involved in determining the threshold, T, is based on the thresholding procedure described in [7]. These steps are as given below:

Step 1: 'S' membership function is selected for the fuzzy membership function, $\mu_x(g)$.

Step 2: The histogram of D_t is calculated and is represented as $h(g)$.

Step 3: For each position of $h(g)$, $\mu_x(g)$is shifted and at each position the linear index of fuzziness, $\mu_l(x)$ is calculated using equation 1.

Step 4: The position, g_{min}, where the linear index of fuzziness is minimum, is considered as the threshold T.

The classification is performed by taking the absolute difference between current frame, $I_t(x,y)$ and background image $B_t(x,y)$ and comparing with the threshold T. If the absolute difference is greater than the threshold, then the corresponding pixel in the current image belongs to the foreground, otherwise it belongs to the background. This step is represented as

$$\begin{matrix} if\ |\ I_t(x,y) - B_t(x,y)| > T & then\ (x,y)\ is\ foreground \\ otherwise & (x,y) is\ background \end{matrix} \quad \text{--Eqn 2}$$

This step is repeated for all the frames in the video sequence.

The background image at time $t+1$ is same as the background image at time t. The background image is not updated in the present work.

EXPERIMENTAL RESULTS

The proposed method is evaluated using I2R dataset [4, 5]. It includes nine video sequences which are Bootstrap, Campus, Curtain, Escalator, Fountain, Hall, Lobby, ShoppingMall and WaterSurface. The ground truth of some frames are also available in the dataset. For each sequence the first 30 frames are used to initialize the background. The background subtraction technique is applied to the remaining frames. $F-measure$ is used to evaluate the proposed technique which is defined as:

$$F-measure = \frac{2*precision*recall}{precision+recall} \quad \text{--} \quad \text{Eqn 3}$$

where

$$precision = \frac{TP}{TP+FN} \quad \text{--} \quad \text{Eqn 4}$$

and

$$recall = \frac{TP}{TP+FP} \quad \text{--} \quad \text{Eqn 5}$$

TP, FN and FP are number of true positive, false negative and false positive pixels respectively. $F-measure$, $precision$ and $recall$ are calculated for three frames for which ground truth images are available for each video sequence. The proposed method is compared with the fundamental frame difference method. The $F-measure$, $precision$ and $recall$ for the nine sequences for the proposed method are given in table 1. The $F-measure$ values are also plotted as a graph in figure 1 for the proposed method and for the frame difference method. The results indicate that the proposed background subtraction method based on a threshold obtained using linear index of fuzziness is promising.

TABLE – 1
EVALUATION OF THE PROPOSED METHOD

Sequence	Method	Precision	Recall	F-measure
Bootstrap	Frame Difference	0.1477	0.5451	0.2208
	Proposed	0.1576	0.4880	0.2264
Campus	Frame Difference	0.0458	0.7983	0.0840
	Proposed	0.0636	0.7261	0.1055
Curtain	Frame Difference	0.7040	0.7436	0.6923
	Proposed	0.8458	0.6506	0.7353
Escalator	Frame Difference	0.1850	0.2410	0.2042
	Proposed	0.2010	0.7515	0.3096
Fountain	Frame Difference	0.3015	0.6542	0.4087
	Proposed	0.3273	0.6428	0.4337
Hall	Frame Difference	0.2157	0.7347	0.3280
	Proposed	0.2530	0.6743	0.3575
Lobby	Frame Difference	0.6907	0.6252	0.6168
	Proposed	0.9435	0.3831	0.5034
Shopping Mall	Frame Difference	0.4302	0.5974	0.4947
	Proposed	0.4954	0.5125	0.5033
Water Surface	Frame Difference	0.9490	0.7014	0.8098
	Proposed	0.9395	0.7131	0.8346

CONCLUSION

In this paper, a fuzzy logic based threshold is proposed for the frame difference based background subtraction. This threshold is determined based on linear index of fuzziness. The determined threshold is used to differentiate the foreground and background pixels in video sequences. The proposed threshold is used with the fundamental frame difference method. The results obtained from the proposed method are compared with the results obtained from the fundamental frame difference method and the results are promising.

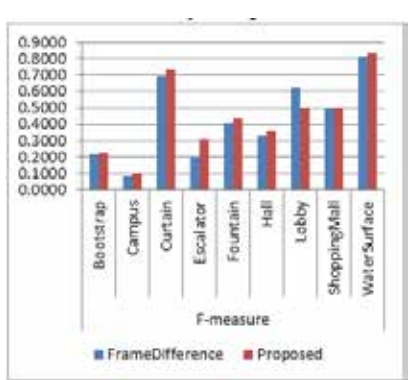

Figure 1: F-measure values for the video sequences

In the present work, background update is not implemented. This can be done in the future work in order to incorporate the changes in the background.

Volume : 5 | Issue : 2 | February 2016 • ISSN No 2277 - 8179

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