Dynamic Image Segmentation for Sport Graphics Based on Wavelet Transform

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Abstract: In this paper, an image segmentation algorithm based on wavelet transform is presented. The proposed image segmentation algorithm performs the segmentation in the combined intensity-texture-position feature space in order to produce connected regions that correspond to the real-life objects shown in the image. This segmentation algorithm is applied to reduced versions of the original images in order to speed-up the completion of the segmentation. As shown by experimental evaluation, this novel scheme provides fast segmentation with high perceptual segmentation quality.

Keywords: image segmentation; wavelet transform; image analysis; sport graphics

1 Introduction

Wavelet transform is a new transformation technology, it is a time-frequency analysis method which different from the traditional frequency-domain analysis of a pure Fourier methods, and wavelet transform has a good localization properties both in the time-frequency and frequency-domain. Wavelet transform has an adjustable step length in the time domain sampling for different frequency components. Therefore, wavelet transform is a way to get better image quality and able to adapt to the future development of transformation technology. Wavelet transform has become the major directions of research in image segmentation region.

With the ever increasing growth of the Internet and information technology, the image segmentation is essential to many areas, such as network communication, information engineering, image processing, medical imaging, image archiving and so forth. Image segmentation techniques play an important role in the image processing. The image is divided into a number of mutual and non-overlapping regions according to certain criteria. The elements in each divided regions should meet the homogeneity and Uniqueness, whereas the elements in adjacent regions should exist significant difference. Therefore, the wavelet transform has the features to remove the correlation which can be applied to image segmentation technique, and this paper uses this method to achieve the image segmentation.

2 Wavelet Transform

Wavelet transform overcomes the defects of the time-frequency domain, based on Fourier transform you can pinpoint the location of mutations in the signal because of high and narrow window at high frequency, and wavelet transform is suitable for analysis of gradient signals because of short and wide window at low frequency.

Continuous wavelet transform in mathematics is defined as:

$$W(a,b) = \frac{1}{\sqrt{a}} \int R f(t) \Psi^* \left[\frac{t-b}{a}\right] dt \qquad (1)$$

$\psi^*(.)$ and $\psi(.)$ for complex conjugate

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \Psi\left(\frac{t-b}{a}\right) \qquad (2)$$

a is a scale parameter and b is a translation parameter.

In order to analyze the details of the signal, we need to decompose and reconstruct using the wavelet coefficients of the signal. Wavelet decomposition and reconstruction in mathematics is defined as:

For the original signal $f_0(t)$, $f_0(t) = f_1(t) + g_1(t)$ refers to first-level wavelet composition,

$$f_1(t) = f_2(t) + g_2(t)$$

$$f_{J-1}(t) = f_J(t) + g_J(t) \qquad (3)$$

$$f_j(t) = \sum_k s_k^{(j)} \varphi_{jk}(t), \qquad (4)$$

$$g_j(t) = \sum_k w_k^{(j)} \psi_{jk}(t) \quad (5)$$

Here, s is scaling function and w is a wavelet coefficient. Therefore, the original signal can be expressed as:

$$f_0(t) = \sum_{j=1}^{J} g_j(t) + f_j(t) \quad (6)$$

From above,it can be achieved multi-resolution analysis of wavelet.

3 Segmentation Analysis

The overall segmentation algorithm consists of the following stages[1][2]:

Stage a. Extraction of the intensity and texture feature vectors corresponding to each pixel. These will be used along with the spatial features in the following stages.

Stage b. Estimation of the initial number of regions and their spatial, intensity and texture centers, using a novel initial clustering procedure.

Stage c. Conditional filtering using a moving average filter.

Stage d. Final classification of the pixels, using segmentation algorithm.

In computer vision literature, several techniques were proposed to perform a segmentation of mobile object in the scene. The motion detection is a binary labeling problem. It consists in attributing to each pixel p of an image I at time t one of the two following label values:

$$e_p = \begin{cases} 1 \\ 0 \end{cases}$$

if $p \in$ moving object then e_p is 0, if $p \in$ static background then e_p is 1.

In order to carry out the binary labeling task, we use two observations. For each pixel p at time t , we calculate[3]:

(1) the difference between the reference image and the current image:

$$o_{dr}(p,t) = \left| I(p,t) - I_{ref}(p,t) \right| \quad (7)$$

(2) the difference between the two successive frames:

$$o_{dt} = \left| I(p,t) - I(p,t-1) \right| \quad (8)$$

To find the most probable label field with these two observations, we can use the conditional probability (Bayes theorem) proposed a MAP criterion to obtain the most probable configuration. In our application, we used a logical AND in order to cope with the embedded target. We introduce a threshold on both images o_{dr} and o_{dt} and then we compute the logical AND. So the pixel label is given by the following equation.

$$e_p = ((o_{dr} > T_f) AND (o_{dt} > T_f)) \quad (9)$$

The moving object threshold T_f is determined according to an automatic entropy based threshold selection. The gradient mathematic morphology filter is used to improve the binary mask obtained. To determine a threshold T_f , we used an entropy power for threshold selection. T_f is given by:

$$T_f \approx 2^{H_{bit}} \quad (10)$$

where H_{bit} is the entropy of an information source (observations) that is classically defined as follows:

$$H = -\sum_{i=0}^{N=255} p_i \log p_i \quad (11)$$

where p_i is the probability that the observation at any site takes the value i , and log denotes binary logarithm.

4 Experiment result and analysis

We used the same scheme as developed in to estimate a reference image in embedded device. For each grabbed frame, the background image is updated. The method consists in the modeling of each pixel with K Gaussian distributions. $p(x_t)$ represents the probability for a pixel to have the intensity x_t at time t . This probability is estimated by[4]:

$$p(x_t) = \sum_{j=1}^{k} \frac{w_j}{(2\pi)^{\frac{d}{2}} \left|\Sigma_j\right|^{\frac{1}{2}}} e^{-\frac{1}{2}(x_t-\mu_j)^T \Sigma_j^{-1}(x_t-\mu_j)} \quad (12)$$

where w_j is the weight of distribution j , μ_j is the mean of distribution j and $\sum_j$ is the covariance for the distribution j and d = 3. For computational reasons, the covariance matrix is assumed to be of the form $\sum_j = \sigma_j^2 I$. The first B distributions are used as a model of the background of the scene where:

$$B = \arg\min_b \left(\sum_{j=1}^{b} w_j > T \right) \quad (13)$$

T is the fraction of the total weight given to the background model and $3 \le k \le 5$. The parameters (w_j , μ_j , σ_j^2)of the matched and unmatched components are updated according a specific method.

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Figure 1 (a) original image

Figure 1 (b) Intermediate processing results

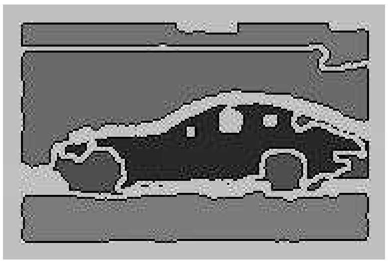

Figure 1 (c) the final processing results

Figure 2 (a) original image

Figure 2 (b) Intermediate processing results

The experiment is carried out to confirm the validity of the algorithm. Based on two sport graphics, segmentation results for two images are shown below.

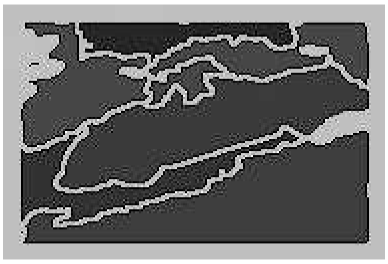

Figure 2 (c) the final processing results

5 Conclusions

The segmentation algorithm based on wavelet transform is implemented and it reaches the expected performances[5]. The classical background subtraction technique is used to perform the segmentation of the objects. This algorithm improves the time efficiency of the segmentation process. The proposed algorithms are appropriate for use as part of an object-based application, such as object-based image querying or for defining regions of interest for content-based coding of images.

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