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A Video Watermarking Algorithm based on Motion Vector

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Abstract

This paper proposes a new fragile video watermarking algorithm based on motion vector, we first use the frame difference method to detect moving targets, determine the motion macro blocks. Then in the macroblock by the diamond search, the fragile watermark is embedded in the P-frame motion vectors for inter prediction, so that by changing the mapping of pixel precision motion vector is to be embedded watermark information embedding watermark information. Experimental results show little effect on the video quality of the algorithm.

Keywords: *Video watermark; motion vectors; inter-frame difference*

1. Introduction

In recent years, computer and communication technology which are unprecedented flourish in China, Internet is deep into the household, computer and network-based information exchange provide a convenient way for the use of multimedia digital works, but the digital works are vulnerable to be illegally copying and tampering, which makes protecting the information security of digital works has become a very urgent problem that needs to be solved timely [1].

Currently video watermarking algorithm is divided into methods based on the original video and based on compressed video [2]. At present, the motion vector based on the video watermarking scheme is an efficient implementation of the video information protection method, it has the advantage that does not affect the subjective visual quality, and the embedded watermark can have the respective blocks to reduce the computational complexity of the search block matching, meanwhile, also has low impact on the increasing rate of the embedded watermark and the PSNR value, however, the anti-attack capability of based motion vector video watermarking scheme is relatively weak, it belongs to fragile watermarking, for example the secondary compression rarely has resistance basically. Because of this feature, the motion vector based on the video watermarking scheme can be integrally certification effectively [3].

2. Based on the Motion Vector Video Watermarking

2.1 The Motion Vector Field of Watermark Embedding

The motion vector reflects the motion of coding macro-block in a frame or a shape and texture of video object plane (VOP) of the absolute amount of displacement of the motion information in the time domain, is important information for video encoding compression or encoding compression domain, which can be used as a hidden position for video embedding, for carrying the information, encoded and transmitted along with the video data, and at the receiving-end to detect and extract the watermark information from the motion vector. In the video watermarking algorithm based on motion vector, people often use the characteristics of the human visual system to select the appropriate motion vectors, the hidden information is

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embedded in the magnitude of the motion vector, phase angle, direction of movement, the horizontal and vertical components, among the predicted value and the motion residuals[4].

2.2 Generating Motion Vectors

This article makes the embedding process of fragile watermark to combine with the moving target detection procedure, the following i will describe the basic principles of interframe difference method under the moving target detection technology. Assuming we get a series of successive images is stationary from a instrument, then the interframe difference method is a very simple moving object detection algorithm, the basic principle is to distinguish two consecutive frame pictures to do moving targets detection.

As a general rule, the light will not change too much in the continuous video by testing, we set $f_i(x,y)$ and $f_{i+1}(x,y)$ to express the i frame and the $i+1$ frame in the luminance component of the pixel point (x,y), separately,i denotes frame number ($i=1,2,\ldots,N$), N is the number of frames in total in this sequence.So now $f_i(x,y)$ and $f_{i+1}(x,y)$ can be expressed as:

$$f_i(x,y) = A_i(x,y) + B_i(x,y) + n_i(x,y) \qquad (1)$$

$$f_{i+1}(x,y) = A_{i+1}(x+\Delta x,\Delta y) + B_{i+1}(x,y) + n_{i+1}(x,y) \qquad (2)$$

Wherein, $A_i(x,y)$ is the foreground region of moving changes which is contained in the i frame, $B_i(x,y)$ is the background area, $n_i(x,y)$ is the noise region.

The concrete steps to detect continuous moving objects in video images by using inter-frame difference method are as follows:

The first step, the inter-frame difference method is used to extract moving targets by differences in successive video frames on the image pixels, therefore, using the formula (3) to calculate the differences between $i+1$ frame image $f_{i+1}(x,y)$ and the i frame image $f_i(x,y)$, and to get the two consecutive frames difference image $G_i(x,y)$.

$$\begin{aligned} G_i(x,y) &= \left| f_{i+1}(x,y) - f_i(x,y) \right| \\ &= \left\| \left[A_{i+1}(x+\Delta x,\Delta y) - A_i(x,y) \right] + \left[B_{i+1}(x,y) - B_i(x,y) \right] + \left[n_{i+1}(x,y) - n_i(x,y) \right] \right\| \end{aligned} \qquad (3)$$

The second step, we can set a threshold value T to distinguish the two regions of $G_i(x,y)$, and using formula (4) to do binary progress, making $F_i(x,y)$ is the collection of pixels by the motion from T in the $G_i(x,y)$, there into the value of 1 pixel point is considered to be the result of the movement, its expression formula is as follows:

$$F_i(x,y) = \begin{cases} 1, if\ G_i(x,y) \ge T \\ 0, if\ G_i(x,y) \ge T \end{cases} \qquad (4)$$

The key of frame difference method is that the choice of threshold value, the low threshold value can not be effectively suppress noise in the image, while the high threshold value may suppress image useful changes, because the threshold value of the image can be divided into global threshold value and local threshold value, and in view of the noise in the image caused by different light regions are not the same, thus this article using local threshold value to suppress noise, and then to determine the range of a threshold value based on the scene lighting and cameras and other external specific environmental conditions.

The third step, for binary image morphological filtering process (such as erosion, dilation, opening and closing operations, etc.), to eliminate noise in the small area, which can accurately estimate the position of the moving target.

The fourth step, since the actual movement of the target corresponding to the communication area of a certain dimension in the image, so the image after the morphology processing will be analyzed and determined connectivity. When the number of pixels in a

connected region is greater than a given threshold value, then means that target is detected, and the region is a regional campaign objectives.

Frame difference method has many advantages: less affected by changes in light of the difference image, and can effectively detect the relative motion of objects in the adjacent images; fast speed on the algorithm detection, low computational complexity; more sensitive for moving objects, and also applies to dynamic environment; hardware implementation easily.

2.3 Watermark Embedding Algorithm

We use the principles and procedures of the inter-frame difference method, and differential video image sequences adjacent to complete the implementation process of moving target detection technology. First, the partial decoding of the original video sequence, the video sequence divided into successive image frame by frame, and then the corresponding pixel values of two consecutive frames of video image and get the absolute value of the subtraction to obtain the difference image, by determining whether the luminance difference greater than a given threshold value to obtain a binarized image, and the binarized image morphology filter processing to eliminate the noise region , the last mark in the original image macroblock motion. Algorithm embedding watermark information in one bit in each P-frame motion vectors, to be noted that, P_skip block without the motion vector residual value, the no-pixel residual value, so the algorithm does not embed a watermark to the P_skip blocks.

Combining AVS sub-pixel sample interpolation process, we find that the sample position of the four quarter-integer pixel can not be embedded as a watermark around the point, because of the amplitude in the vicinity of the threshold value and the location in which four quarter-sample motion vector position on the quarter-precision adjustments may cause the motion vector magnitude falls below the threshold.

Specific embedding step is:

The first step, for the various motion division patterns in each of the motion vectors, first, the integer pixel accuracy and 1/2 pixel motion accuracy estimation was found to best integer pixel precision and 1/2 pixel search points.

The second step, due to movement of a video sequence having a cross-shaped center-offset properties, located on a horizontal or vertical direction is much larger than the probability of the best matching point falls on the probability of other locations [5]. So we have the best half-pixel taken as the center point of the cross, as the search range of 1/4 pixel.

The watermarking algorithm proposed in the motion vector between pixel accuracy and binarized watermark information to be embedded establish the mapping relations, so that by changing the pixel precision motion vector maps for the information to be embedded watermark, the watermark information is embedded.

Specific mapping rules are:

Half-pixel precision the watermark information bits are mapped to "1", 1/4-pixel accuracy is mapped to "0".

The third step, using the prediction residual MVD watermarked MV and MVP seeking motion vectors, and encoded MVD.

The fragile watermarking algorithm greatly improves the watermark embedded real-time, and since it is not directly modify the MVD, the algorithm does not exist error accumulation, less impact on the video bit rate and visual quality.

2.4 Watermark Extraction

Extraction steps in this article fragile watermarking algorithm is as follows:

The third step, make non-fully decoded for H.264 compressed stream to obtain P-frame motion vector prediction residuals MVD.

The second step, The horizontal component of the motion vector MV is MV_X , who provided a P-frame prediction residuals MVD, then according to the equation (5) carried out the extracting of fragile watermark sequence.

$$W_i^* = MVD\_X \bmod 2 \qquad (5)$$

Also, because the algorithm during the watermark extracting, it does not need to participate in the original video, it is possible to achieve a blind extraction.

3. Experimental Results and Analysis

The experimental using the H.264 coding standard reference software JM8.6 [6], the operating environment is a windows xp system, test frame as the standard reference frame foreman, News, Carphone and Clair. Structure is IPPP test video frame format, I-frame and P-frame have the initial quantization step size QP is 28, a total of 30, the video size is 144 × 176, one bit in a fragile watermark information is embedded for every P-frame motion vector.

The experimental results are as follows:

(1) The video image before and after watermark embedding subjective evaluation

Quality comparison chart before and after the embedding are subjective video quality evaluation, then, the video quality objective evaluation of the watermark, the standard test used herein is the peak signal to noise ratio (PSNR), in general, the higher the PSNR are, the quality of the video high; and vice versa.

(a) before embedding (b) after embedding.

Figure 1. Subjective Evaluation of Video Images

(2) Video quality objective assessment

Table 1. The PSNR of The Test Sequence

Test Sequence	*The Value of PSNR*		
	Before Embedding	*After Embedding*	*Decrease*
Foreman	37.16	36.32	2.37%
News	37.31	36.17	3.06%

Silent	36.15	35.68	1.31%
Clair	40.64	39.34	3.2%

Generally believed that, if PSNR values above 36dB, the video is basically the human eye to distinguish the difference between the two images could not come out[7] . From the table, we can see a video of PSNR although a slight decline, but does not affect the quality of the video.

4. Conclusions

This article based on the characteristics of the video sequence, an improved video watermarking scheme.On the one hand, using the moving target detection technology, according to the motion characteristics of the video image adjacent to, the two adjacent images to identify the movement region of the macroblock as an embedded watermark. Then the prediction residual method watermark embedding process is completed by the motion vectors. The simulation results show that, The algorithm has a better visual effect, and the algorithm is simple, less calculation, real-time extraction and detection for the watermark. With a detailed study, to ensure the integrity of the video , at the same time finding a safe and strong, robustness high, with the perfect combination of compression standard algorithm is the direction of our further research.

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