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Frame Selection for Video Watermark Embedding using Scene Change Detection Algorithm

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***Abstract* – Video watermarking has a number of new issues than image watermarking. Due to abundant amount of data and redundancies between frames, video signals are more susceptible to piracy attacks, like frame averaging, frame dropping, frame swapping, statistical analysis, etc [4]. Applying a fixed image watermark to each frame in the video leads to problems of maintaining statistical and perceptual invisibility. Furthermore, such an approach is necessarily video independent; as the watermark is fixed while the frame changes. Applying independent watermarks to each frame also presents a problem. Regions in each video frame with little or no motion remain the same frame after frame. Motionless regions may be statistically compared or averaged to remove independent watermarks. In addition, video watermarking schemes must not use the original video during watermark detection as the video usually is in very large size [4][8][34] and it is inconvenient to store it twice. The currently proposed algorithms do not solve these problems effectively. We deal this problem by applying scene change detection. In this paper we discussed various scene change detection techniques and their challenges.**

***Keywords* – Digital Video Watermarking, Security, Scene Change Detection, Image Subtraction.**

I. Introduction

Video watermarking is one of the most popular techniques among the various watermarking techniques currently in use. This is because maximum occurrences of copyright violation and misuse happen for video media content [2]. Watermark generation, Watermark embedding and watermark extraction are three main modules of any watermarking process. Selecting a frame to embed watermark is main step of video watermark embedding algorithm. Same watermark can be embedded in all frames, but statistical averaging can detect it. Different watermark for each frame can be detected by frame averaging. Randomly selecting frames can suffer from frame dropping attack.

We proposed to use scene change detection algorithm to choose a frame for embedding watermark. In this paper we provide a survey of the various techniques that are employed to scene change detection. The paper is organized in the following sections. In Section 2 we describe survey carried out. In Section 3 Algorithms for different SCD approaches. In Section 4 we compare these algorithms. We conclude this paper in section 5. Scean change detection – A survey Pik Wah Chan et.al. [1], proposed the novel algorithm, hybrid digital video watermarking, based on scene change technology and error correction code. They verified system resistant against attacks based on video characteristics and image processing techniques. They suggested enhancing the system by combining with audio watermarks for error correction capabilities and the hybrid scheme for attack resisting.

M.IIsever et.al.[2], proposed two novel pixel based change detection methods. Haitao Jiang et. Al [3] discussed scene change detection for video database system. They presented various algorithms and discussed criteria of benchmarking SCD algorithms. Jianhao Meng et.al.[4] presented SCD in MPEG compressed video sequence. They used DCT DC coefficients and motion vectors with minimum decoding bitstream. Shiu-Ching Chen[5] proposed effective SCD method using an unsupervised segmentation algorithm by comparing segmentation masks between two successive frames. Anastasios Dimou et.al.[6] studied the correlation between local statistical characteristics, scene duration and scene change. Based on this analysis, they proposed and implemented a novel scene change detection method for H.264 codec, defining an automated, dynamic threshold model which can efficiently trace scene changes. Anurag Mittal et.al.[7] proposed a prediction-based online method for the modeling of dynamic scenes. Their The core contribution is the integration of a powerful set of filter operators with a linear prediction model towards the detection of events in a dynamic scene. They also proposed the use of on-line adaptation techniques to maintain the selection of the best filter operators and the prediction model. Last but not least, appropriate detection measures have been developed that are adaptive to the complexity of the scene.

II. Scene Change Detection Techniques

Video data can be divided into different shots. A shot is a video sequence that consists of continuous video frames for one action. Scene Change Detection is an operation that divides video data into physical shots. Scene change in a video can be abrupt or gradual. SCD is usually based on some measurement of the image frame like color, spatial correlation, object shape, motion, or DC coefficients. In general, gradual scene change detections are more difficult to detect than abrupt scene changes [2]. SCD algorithms can be classified in three main categories

- Approaches for uncompressed full image sequence
- Algorithms for compressed video
- Algorithms based on explicit model

Full Image Scene Change Detection

Most of the video SCD are based on full image video analysis. The algorithms differ with the measurement function used, features chosen, and the subdivision of video frames. Many algorithms use either the intensity feature or motion information to compute inter-frame difference.

Following methods are used to calculate inter-frame difference.

1. Image Differencing /Template matching

In this method, images of the same area, obtained from times t1 and t2 are subtracted pixel-wise. Mathematically, the difference image is

$$I_d(x,y) = I_1(x,y) - I_2(x,y) \quad (1)$$

where, I_1 and I_2 are the images obtained from t1 and t2, (x, y) are the coordinates of the pixel. The Resulting image I_d represents intensity difference of I_1 and I_2.

The change is detected by applying simple thresholding to $I_d(x,y)$ as

$$T(x,y)\begin{cases}1 & I_d(x,y) \geq \tau \\ 0 & otherwise\end{cases} \quad (2)$$

where, the threshold τ is determined empirically.

This method is very sensitive to noise and object movements. It is strictly tied to pixel locations. This can cause false SCD.

2. Image Rationing

Similar to image differencing, images are compared pixel-wise in this method. The ratio of the two images is calculate by

$$I_r(x,y) = \frac{I_1(x,y)}{I_2(x,y)} \quad (3)$$

I_r image takes values in the range [0, ∞). If intensity values are equal, it takes the value 1. Same thresholding technique is used as in eq. 2 to detect change.

3. Image Regression

In image regression, the I2 image (obtained from t2) is assumed to be a linear function of I1 image (obtained from t1). Using least-square regression estimate of I2 can be calculated as

$$\hat{I}_2(x,y) = aI_1(x,y) + b \quad (4)$$

The estimate parameters a, b are calculated using squared error between measured data and predicted data for each pixel as

$$e^2 = (I_2(x,y) - \hat{I}_2(x,y))^2 = (I_2(x,y) - aI_1(x,y) - b)^2 \quad (5)$$

This error value gives us significant change between estimated and actual values. This technique gives slightly better performance compared to image differencing

4. Color Histogram

The color histogram of an image can be computed by dividing a color space, e.g. RGB into discrete image colors called bins and counting number of pixels falling into each bin. The difference between two images based on their color histograms H1 and H2 can be calculated as

$$d(I_1, I_2) = \sum_{k=1}^{n} |H_{1k}(x,y) - H_{2k}(x,y)| \quad (6)$$

Sometimes simple color histograms may not detect the scene changes very well, since two images can vary different in structure and yet have similar pixel values.

SCD for Compressed Video [4,5,6]

To efficiently store and transmit video data, various video compression schemes (MPEG, DVI, and H.26x) have been proposed and standardized. To detect scene change in those video streams, two approaches can be taken - Fully decompress the video into a sequence of frames and then perform full image scene change detection. This is computationally expensive. - SCD without fully full decompression. It is capable of producing similar results as full image based approach more efficiently.

Most of the algorithms in this category are based on DCT based standard compressed video data. Some algorithms operate on DC image sequence and some use DC Coefficients and motion vectors.

1. DC image-sequence-based approach [4,5]

DC image is spatially reduced version of given image. It can be obtained by first dividing the original image into blocks of n X n pixels each, then computing average values of pixels in each block, which corresponds to one pixel in DC image. For compressed video data a sequence of DC images can be constructed directly from compressed video sequence, which is called DC sequence. These DC sequences are smoothed versions of the corresponding full images, so less sensitive to camera and object movements. Template matching is sufficient in most cases to detect scene change. This approach in very promising and about 70 times faster than full image sequence approach.

2. DC coefficients-based approach [6,9]

A frame in the compressed video sequence is represented by a subset of blocks. A subset of the AC coefficients of the 8 X 8 block is chosen to form a vector. It is assumed that the inner product of vectors from the same scene is small. A global threshold is used for scene changes and in case of uncertainty few neighboring frames are selected for further decompression. This approach is computationally efficient but does not address gradual transitions.

SCD for model based video[8,10]

All previous approaches were based on image-processing techniques. It is possible to build an explicit model of the video data to help SCD process. The advantage of the model based SCD is that a systematic procedure based on mathematical models can be developed. The performance of such algorithms depends on the models they are based on. These algorithms mainly used in video editing, maintaining large video database. Following are the steps in SCD algorithm

1. To reduce the resolution of frame image by under sampling to overcome the effect of camera and object motion.
2. Compute histogram of pixel difference values.
3. Count number of pixels whose change of value is within a certain range determined by particular model
4. Different scene changes are then detected by checking the resulting integer sequence.

III. Comparison of SCD Algorithms

Performance of SCD algorithms can be measured against following criteria's

1. CPU time spent for given video file, e.g. the number of frames processed by SCD algorithm per time unit.
2. Average success rate or failure rate for SCD over various video files.
3. SCD granularity, ability of an algorithm to decide between which frame scene change occurred
4. Stability, i.e. sensitivity to the noise in the video stream.
5. Type of scene changes and special effects that it can handle.
6. Generality- it be applied to various applications
7. Formats of video it can accept.

Table 1: SCD Approaches

Sr. No.	Algorithm	Methods
1	Uncompressed full image sequence	Image Differencing / Template Matching
		Image Rationing
		Image Regression
		Color Histogram
2	Compressed Video	DC image-sequence-based approach
		DC coefficients-based approach
3	Model based Video	Video editing model
		Maintaining Video Database

IV. Conclusion

In this paper we presented various scene change detection techniques. Criteria for benchmarking SCD algorithms are also discussed. SCD algorithms are reached to the maturity but still there is a scope for future development, like,

1. Other features like motion of object, object shapes, captions, audio information can be used instead of color and intensity information.
2. Develop adaptive SCD algorithm which can combine several SCD techniques and can self adjust to various parameters.
3. Use combination of various scene change models.

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