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A UNIFIED APPROACH TO SCENE CHANGE DETECTION IN UNCOMPRESSED AND COMPRESSED VIDEO

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ABSTRACT

There is an urgent need to extract key information automatically from video for the purposes of indexing, fast retrieval and scene analysis. To support this vision, reliable scene change detection algorithms must be developed. This paper describes a novel unified algorithm for scene change detection in uncompressed and MPEG-2 compressed video sequences using statistical features of images. Results on video of various content types are reported and validated with the proposed scheme in uncompressed and MPEG-2 compressed video. Furthermore, results show that the accuracy of the detected transitions is above 95% and 90% for uncompressed and MPEG-2 compressed video respectively.

1. INTRODUCTION

Due to rapid advances in video products such as digital cameras, camcorders, storage devices (DVDs) and the explosion of the internet, the digital video "for every one" is now becoming a reality. The demand for digital video is also increasing in areas such as video conferencing, multimedia authoring systems, education and video-on-demand systems. Today, the major bottleneck preventing the widespread use of digital video is the finding a desired information from a huge database. This paper presents a hierarchical unified approach for scene change detection in both uncompressed and compressed video sequences, which facilitates a solution to this problem.

A common and natural idea is to index the video sequences first into video shots by identifying scene changes and then to extract features. Therefore, a powerful scene change detection algorithm, which can operate both in uncompressed and compressed domain, is required to allow for a complete characterisation of the video sequences. Considerable work has been reported on detecting scene changes both in uncompressed video and compressed video [1,2,3,4,5,6]. However, most algorithms are for specific scene change detection either in uncompressed or compressed domain. This paper proposes a simple unified approach to scene change detection in uncompressed and compressed video using statistical features of images. We also propose a novel technique to extract statistical features (mean and variance) from compressed video without full frame decompression.

2. PROPOSED SCHEME

Proposed scheme has three steps. In the first step, we identify sudden scene changes by calculating mean square error (MSE) using global mean and variance of each image. If there are no sudden scene changes we check for dissolve and fade scene changes. This is achieved by considering the ratio between the second derivative of the variance and the first derivative of the mean. If a dissolve or fade region is not detected, we use statistical features together with structural properties to identify wiping. This scheme employs Hough transform for wipe detection.

2.1 Sudden Scene Change Detection

A MSE is suggested to detect sudden scene changes based on the assumption of uniform second-order statistics over a region. If the MSE exceeds a certain value sudden scene change is declared.

2.2 Fade/Dissolve Detection

It can be proved that mean ($m(n)$) and variance ($s(n)$) have linear and quadratic behaviour respectively during fade/dissolve transitions [3]. However, these statistical behaviours may be slightly distorted for a practical video sequence due to motion. Therefore, a smoothing filter is used to compensate this error. Then, the ratio between the second derivative of the variance curve and the first derivative of the mean curve should be a constant during a fade/dissolve transition. Thus, the differentiation of this ratio ($R(n)$) is checked to identify fading and dissolving with a threshold. It can also be proved that variance is zero at the start of a fade-in sequence and at the end of a fade-out sequence [3]. These properties are used to distinguish fade-in, fade-out and dissolving.

2.3 Wipe Detection

A statistical image (S-image) has been defined by spatially reducing the original image into blocks of $M'xN'$ pixels. The (m,n) pixel of the S-image has two elements, defined as in Equations (1) and (2).

$$S'_{\mu,m,n} = \frac{1}{M'N'}\left(\sum_{i=1}^{M'}\sum_{j=1}^{N'}\Omega_{(m-1)M'+i,(n-1)N'+j}\right) \quad (1)$$

$$S'_{\sigma,m,n}(2) = \frac{1}{M'N'}\left(\sum_{i=1}^{M'}\sum_{j=1}^{N'}\left(\Omega_{(m-1)M'+i,(n-1)N'+j} - S'_{\mu,m,n}\right)^2\right) \quad (2)$$

where Ω - original image and S' - S-image.

Therefore in this proposed scheme, each original frame in the video sequence is mapped into S-sequence. Then, mean square error (MSE) is calculated for corresponding pixels of consecutive frames in the S-sequence to ascertain whether there is a significant change in each pixel of the S-image.

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All MSEs are subjected to a threshold (T_{MSE}) and a binary image, $diff\_W(n,i,j)$ as explained in Equation (3) is formed to identify exact transition region. Finally, Hough transform is used with $diff\_W(n,i,j)$ to identify the transition region.

$$diff\_W(n,i,j) = \begin{cases} 1 & if\, MSE_{i,j} > T_{MSE} \\ 0 & if\, MSE_{i,j} \le T_{MSE} \end{cases} \quad (3)$$

where, $i = 1: {}^{M}/_{16}$ and $j = 1: {}^{N}/_{16}$

We developed a novel technique for extracting mean and variance in MPEG-2 compressed domain without full frame decompression. When statistical features are extracted, the same algorithm is applied as explained before to identify scene changes in compressed video. Figure 1 explains the complete algorithm for scene change detection in uncompressed and compressed video sequences.

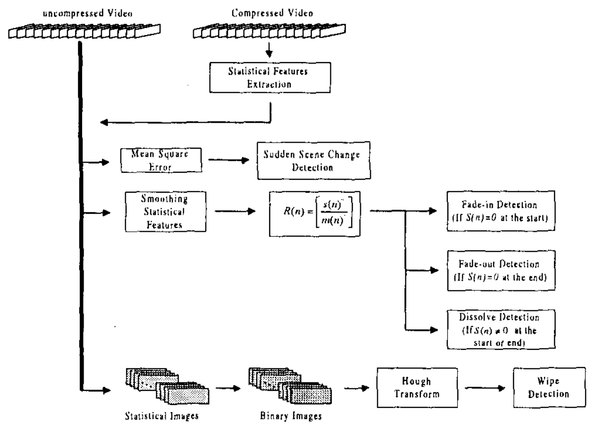

Figure 1: Complete algorithm

3. RESULTS

Proposed algorithm is validated with a variety of 176x144 QCIF format video contents. Considered video sequences contain most scene changes such as abrupt scene changes, fade/dissolve, wipe and camera movements. Table 1 summarises some results with the proposed algorithm. Results show that the algorithm is capable of detecting all scene changes accurately. Therefore, the proposed algorithm can be used in both uncompressed and compressed video to detect scene changes with a high reliability. Main advantage of the proposed scheme is that they can identify both sudden and gradual scene changes in compressed and uncompressed domain within a single framework with less computational cost.

4. CONCLUSIONS

In this paper, we have presented a novel algorithm for scene change detection in video sequences. We exploited the statistical features of the images to identify scene transitions. In compressed domain, statistical features are extracted without full frame decompression and used these statistical features for detecting scene transitions. Results show that the algorithm is capable of detecting all scene changes accurately. Therefore, the proposed algorithm can be used in uncompressed and compressed video to detect scene changes with a high reliability. Future work is required to extend the algorithm for camera movements detection within the same framework.

Actual transition region	Detected transition region (Uncompressed)	Detected transition region (Compressed)	Classification
95	95	95	sudden scene change
203-237	203-237	204-237	horizontal-backward wiping
340-378	341-378	344-378	corn-backward wiping
397-442	397-442	397-441	horizontal-barn-doors (in-word) wiping
446-496	446-497	446-497	dissolve
510	510	510	sudden scene change
539-574	539-574	540-574	horizontal-barn-doors (out-word) wiping
602	602	602	sudden scene change
688-725	688-725	688-724	horizontal-forward wiping
754-778	754-778	754-778	fade-out
804-868	804-868	804-868	dissolve
924	924	924	sudden scene change
989	989	989	sudden scene change
1010-1089	1010-1089	1012-1089	dissolve
1168-1232	1169-1232	1169-1233	dissolve
1301	1301	1301	sudden scene change
1356-1424	1356-1424	1356-1424	dissolve
1500-1550	1500-1550	1500-1552	fade-in
1620-1680	1620-1681	1620-1681	fade-in
1710	1710	1710	sudden scene change
1760-1840	1761-1840	1762-1840	fade-out
1920-1985	1920-1985	1920-1985	fade-out
2206	2206	2206	sudden scene change
2360	2360	2360	sudden scene change
2431	2431	2431	sudden scene change

Table 1: Summarised results

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