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An Efficient Method for Detection of Wipes in Presence of Object and Camera Motion

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Abstract--Shot boundary detection is essentially the first step in analyzing content of the video. Wipe transition is an important type of gradual transition eminently used in the video production industry to smoothen the transition between two shots. Wipes involve almost 30 different types of transitions and hence it becomes very difficult to detect them as compared to detection of other shot boundaries such as cut, fade and dissolve. Most of the researchers who have worked in shot boundary detection domain have concentrated on fade, dissolve and cuts, because of the complexities involved in detection of wipes due to noise, object and camera motion. This study proposes an efficient wipe transition detection method which combats the hindrances caused by noise as well as object and camera motion in detection of wipes. The proposed algorithm uses mean of statistical image differences as the pivotal basis in discriminating wipes from object and camera motion.

Keywords: Gradual transition detection, video indexing, video summarization, shot boundary detection, Wipes, Wipe detection Algorithms, Wipe transition effects

I. INTRODUCTION

An important first step in analyzing the video is its breakdown in different units called shots. A shot is defined as the sequence of frames captured by the camera without any break involved. Typically there are two major types of shot transitions possible, i.e. abrupt transition and gradual transition. Abrupt transition involves a shot change over single frame only whereas gradual transition occurs over multiple consecutive frames. An example of abrupt transition includes cuts and gradual transition can be further divided into fades, dissolves and wipes. A Wipe involves movement of a line on the screen which goes from one end to another end. Depending upon how the line moves, wipes can be further divided into various subtypes such as horizontal wipe, vertical wipe, diagonal wipe, square wipe and many such others. Figure shown below depicts the various types of wipes.

Horizontal wipe

b) Vertical wipe

c) Diagonal wipe

Figure 1: Wipe transition effects

Thus from the above diagrams it is obvious that horizontal wipe involves movement of the line from one end of the screen to the other end horizontally whereas diagonal wipe involves line movement from one corner of the screen to the other corner. Now it can be predicted that unanimous method development for detection of all types of wipes is a cumbersome effort seeing the various patterns involved in wipes.

II. RELATED RESEARCHES

We studied various different approaches for wipe transition detection. The details of the survey are given below.

An efficient wipe detection algorithm is put forward by Shan Li et al [1]. In the proposed scheme the properties of independence and completeness are used for faithful wipe boundary detection. Dynamic threshold calculation is used for extending the detection for different genres of video. A methodology for wipe detection is proposed by Adnan M. Alattar et al by developing a model for wipe region which derives the statistical characteristics of the frames in wipe region [2]. In the proposed literature M Alattar has stated that the means and the variances of the frames in the wipe region have either a linear or quadratic behavior. Min Wu et al have proposed a schematic method for detection of wipes [3]. In the proposed algorithm both structural and statistical information is exploited to detect potential wipe effects. The author has worked with MPEG streams and DC images. According to the proposed literature a DC image is a scaled variant of the original image where each pixel of DC image is the DC coefficient scaled with some factors of the corresponding 8x8 block in the original image. Li Yufeng et al have proposed a wipe detection methodology [4], in which each frame of color sub-image and edge sub-image are decomposed using Db-4 wavelet transform. To minimize the noise influence effectively, the color sub-image is divided into 8*8 pixel blocks and a Gaussian mode is used to amend the threshold dynamically in detecting the potential wipe transition. An interesting method for wipe detection is the Spatio-temporal slice analysis, proposed by C.W.Ngo et al [5]. For various types of wipes, the author states that there are corresponding patterns on the spatio-temporal slices. Based on this observation, Ngo et al. metamorphosed the detection of wipes to the recognition of the typical patterns on spatio-temporal slices. The proposed schema also uses color texture properties of the potential wipe frames to detect wipe transitions. Umut Naci and Alan Hanjalic have proposed a schematic algorithm for potential wipe transition detection based on analysis of spatio-temporal video data blocks [6]. This algorithm is different from the previous approaches in the way that it takes volumetric data cubes in the video as the basic processing unit for the algorithm. This algorithm is based on the analysis that two different adjacent shots before and after wipes are spatially well separated at any time. R Zabih et al have proposed a method for detection and classification of scene breaks in video sequences [7]. The proposed method can detect and classify different types of scene breaks including wipe. The proposed algorithm handles the object and camera motion by global motion computation. A potential algorithm based on histogram characteristics is proposed by Robert A Joyce et al [8]. The proposed algorithm operates in compressed domain requiring only partial decoding of the compressed video stream. The experimental results have shown that this algorithm performs well better than full frame algorithms. The proposed schema carefully models the histograms during wipe region.

A wipe detection model which is based on statistical characteristics of the frames in wipe region has been developed by Alattar A.M et al [9]. The proposed wipe detector exploits the linear change in the means and the variances of the frames in the wipe region. However the proposed algorithm has a high false alarm rate due to the influence of object and camera motion. Pei Soo-chang et al has developed a model which uses the macroblock information to detect potential wipe transition frames [10]. Prediction directions of B frames are analyzed, which are revealed in the MB types, the scene change region of each frame can be extracted. Once the accumulation of the scene change regions covers almost all of the area of the frame, the sequence will be considered a motionless wipe transition frame sequence. A method for wipe detection discriminating object and camera motion is proposed by K.Warhade et al [11]. In the proposed algorithm first the moving strip due to wipe is detected, which eliminate most of the edges due to object boundaries and retain true wipe transition boundaries, and then Hough transform is used on these moving lines to detect and categorize various wipe types. An algorithm for wipe detection is proposed by Hang Bin et al [12]. In this literature, a method for wipe detection is put forward based on three-dimensional wavelet transforms and motion vector. Global motion compensation is used with Gaussian weighted Hausdorff distance to restrain the effects of camera and object motions. An approach that takes advantage of the production aspect of video is proposed by Fernando W.A.C. et al [13]. In the proposed methodology each video frame is first decomposed into low-resolution and high-resolution components which are analyzed respectively and further recombined together to form a wipe transition detector. This approach is proposed by Mark S. Drew et al. In the proposed work a 2D histogram based on chromaticity is formed and then this computed histogram is intersected with that of the previous frame [14]. The result is an image in which the wipes appear as very prominent edges. K. D. Seo et al have proposed a method based on visual rhyme spectrum [15]. The authors have stated that the Visual Rhythm Spectrum contains distinctive patterns or visual features for many different types of video effects. The proposed algorithm searches for lines in VRS for detection of potential wipe frames. A method based on Motion Activity and Dominant Colors is put forward by Sławomir Maćkowiak et al [16]. In the proposed idea motion activity which is defined as a degree of activity, in video sequence, has been included as a descriptor in MPEG-7 standard. The technique is based on automatic generation of motion activity descriptors. A new approach for wipe detection based on pattern independent model is put forward by Kota Iwamoto et al [17]. The proposed model is based on the characteristics of image boundary lines dividing the two image regions in the transitional frames. Wipes are modeled as frame sequences where either a single boundary line moves seamlessly in a time sequence, or multiple boundary lines form a quadrilateral within a frame. A novel method is proposed by Francisco Nivando Bezerra [18]. In the proposed schema the authors have used longest common subsequence (LCS) between two strings to transform the video slice into one-dimensional signals to obtain a highly simplified representation of the video content, after this, authors have proposed a chain of operations leading to detection of wipe transitions.

III. METHODOLOGY

a) Statistical image difference method

Detection of a wipe transition is done by comparing various features of the video frames. The mean of statistical image difference method provides a compact summarization of the data in a video frame and are also resistant to object and camera motion. In the proposed methodology desired number of frames from the video is taken out first and converted into 256 x 256 sizes. In order to minimize the computations these frames are converted into 64 x 64 by taking the mean of each 4 x 4 block. Thus the 64 x 64 frames are chosen to carry out the remaining computations for wipe transition detection. This 64 x 64 image is termed as statistical images. The stepwise details of the algorithm can be written as shown in the next subsection.

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IV. ALGORITHM STEPS

1. Desired numbers of frames are read from the video and every frame is converted into a gray scale image of size 256 X 256
2. Each frame is then divided into 4 × 4 pixel block and mean of each block is taken, which will convert every 256 x 256 image into 64 x 64 images. This image is termed as statistical image(SI)
3. Mean of statistical image difference between consecutive frames is calculated using

$$\mathbf{MOSID(k)} = \sum_{i=1}^{64}\sum_{j=0}^{64} \mathbf{SI(i,j,k) - SI(i,j,k+1)}$$

4. Where k changes from 1 to Z-1 and Z is the number of frames used for the analysis from the video. Statistical image difference is less sensitive to motion as compared to pixel wise difference. This gives an edge over pixel wise difference method
5. local threshold ST is calculated as a linear combination of μ and σ by

$$\mathbf{ST = (\alpha \times \mu) + (\beta \times \sigma)}$$

6. Where μ and σ are the mean and standard deviation of MOSID for all frames used for the analysis at a time. 'α' and 'β' are two adjustable coefficients and are tuned to set threshold at relatively low values such that true sequence of wipes will not be eliminated. Based on extensive simulation results with different movie videos, the values of Alpha and Beta are determined as α = 0.125 and β = 0.125, for a reasonable trade-off between recall and precision.
7. Frames having MOSID (k) > ST are then stored in a separate Matlab array and remaining frames are simply neglected since frames having MOSID (k) > ST are considered as potential wipe frames.
8. Matlab operations are performed on the array from step 7 and a consecutive sequence of frames which lasts for more than 20 consecutive frames are chosen as actual wipe frames. The algorithm works on the assumption that wipe transition normally lasts for 20 frames. This number 20 is finalized based on a detailed observation of wipes in different movies.

V. PERFORMANCE EVALUATION

Almost all of the researchers who have worked in shot boundary detection have used Recall and Precision as the performance evaluation basis. Recall gives the performance of the algorithm in terms of 'How many wipes were observed manually in the video and how many were accurately detected by the automated algorithm. Whereas precision gives the accuracy of the algorithm when faced with the challenge of minimizing the false positives detected by the algorithm. False positives are those detections which actually do not exist in the video but detected as wipes using the algorithm. False positives are the performance hampering detections caused due to noise, object and camera motion.

Recall and Precision are mathematically defined as

$$\mathbf{Recall} = \frac{\textbf{Number of frames correctly detected}}{\textbf{Number of frames correctly detected} + \textbf{Number of frames for miss detections}}$$

---------- Equation 1

$$\mathbf{Precision} = \frac{\textbf{Number of frames correctly detected}}{\textbf{Number of frames correctly detected} + \textbf{Number of frames for false detections}}$$

---------- Equation 2

In addition to recall and precision many of the studies have used two more performance evaluation parameters which are namely, F1 measure and Retrieval Success Index (RSI). F1 measure is harmonic mean value that treats recall and precision equally. RSI combines correct detections, false detection and miss detections to yield a single platform for performance evaluation.

F1 measure and RSI are defined mathematically as

$$\textit{F1 measure} = 2 * \frac{\textbf{Recall} * \textbf{Precision}}{\textbf{Recall} + \textbf{Precision}}$$

---------- Equation 3

$$\mathbf{RSI} = \frac{\textbf{Correct detections}}{\textbf{Correct detections} + \textbf{Miss detections} + \textbf{False detections}}$$

---------- Equation 4

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VI. RESULT AND ANALYSIS

To test wipe transition detection using the proposed algorithm, the developed algorithm was tested and implemented on several selected videos obtained from different movies of different genres. To measure the accuracy of detecting the wipe between shots a comparison has been done between the wipe transition that has been detected manually and those that detected using the developed algorithm. The Correct, False & Missed detected transition given by the algorithm is presented in Table 1.

Movie Name	Correct Detections	Miss Detections	False Detections
Star War 1	890	218	137
Jodha Akbar	327	74	69
The Hidden Fortress	229	49	38

Table 1: Algorithm results

Based on the results shown above, recall, precision and the F1 measure of the algorithm can be tabulated as

Movie Name	Recall	Precision	F1 Measure	RSI
Star War 1	81	87	83.89	70
Jodha Akbar	82	83	82.50	71.5
The Hidden Fortress	83	86	84.47	72.46

Table 2: Recall, Precision and F1 measure

The measurement of Recall and Precision is used in the table 2 to evaluate the algorithm implementation results. From this data it can be seen that recall and precision resulted high performance and accuracy of wipe transition detections. In some videos, the wipe transitions registered lower rate in their precision and recall. The reason for this is owing to the number of the camera and object motion as well as the luminous which were there for more than 20 consecutive frames. The observed increase in the missed detections within wipe transitions could be attributed to the similarity between entering and exiting scene involving a wipe transition. There is a certain scope of improvement for the developed algorithm when wipe transitions involve two similar kinds of shots with similar backgrounds.

On a conclusive note, the implementation of the proposed algorithm on the video data set was a very efficient in detecting wipe transitions. However, most of missed detections were caused due to similarity between two adjacent shots involving wipe transition and false detections were caused due to extensive object or camera motion which lasted for more than 20 consecutive frames. However, it is being observed that generally object and camera motion lasts for less than 10 frames only so our proposed methodology efficiently avoids false detections caused due to object and camera motions.

We compared the results obtained using our approach with the results of previously developed algorithms. The same can be tabulated as shown below in table 3

Algorithm	Video →	Star War I	Jodha Akbar	The Hidden Fortress
Proposed Algorithm	Recall	81	82	83
	Precision	87	83	86
	F1 measure	83.89	82.49	84.47
An algorithm that used Linear change in means and variances of the frames	Recall	73.57	79.23	----
	Precision	73.03	86.06	----
	F1 measure	76.20	48.21	----
An algorithm that used structural properties of the frames	Recall	50	66	----
	Precision	81	88	----
	F1 measure	62	75	----

Table 3: Comparison of the algorithms

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The trade-off between recall and precision is plotted as shown in the figure below

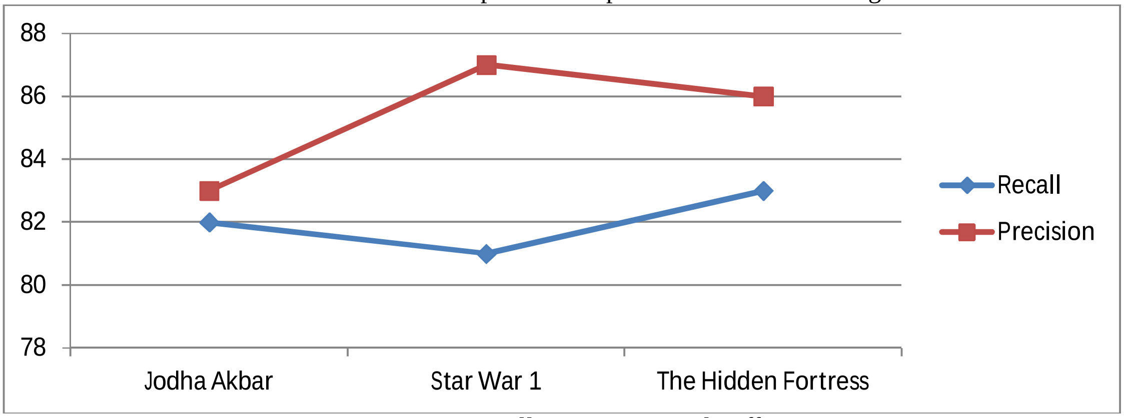

Figure 2 : Recall & Precision trade-off

VII. LIMITATION

Despite of the fact that, proposed method is simple to apply in a video sequence along with the accuracy it provided in detecting wipe transition. It still encounters one major drawback which is the sensitivity from object motion and camera motion which lasts for more than 20 consecutive frames. Fast movement of the object and camera increase the number of false positives. The false positives are generated from fast movement of object or camera causing changes in the content-features of images within shot as well as across adjacent shots. On the other hand, many researchers have addressed this shortcoming by developing new methods to reduce the negative impact of object and camera motion.

VIII. CONCLUSION

This study has investigated in the video processing topic. The purpose of the current study was to determine the occurrence of the wipe transition in a video sequence. Wipe transitions seem to be more complicated to identify whereas cut transition and other gradual transitions are more simple and easy to detect. Hence, we addressed the issue of wipe transition detection. In order to detect wipe transitions, this study has implemented the mean of statistical image differences method which allows dynamic threshold calculations to determine the wipe transition efficiently. Different number of video clips has been chosen for the experimentation purpose. The result obtained from human observation has been compared with the result obtained from automated algorithm. In order to measure the performance of this implementation, recall and precision have been calculated. We got maximum recall of 83%, and a maximum precision of 87%. The results of this algorithm show high accuracy in detecting wipe detection. Also, statistical difference method is less sensitive to noise when compared with the direct pixel wise difference method. The most important limitation lies in the fact that the detection process can be affected from camera and object motion which lasts for more than 20 consecutive frames which is very rare case.

Overall, this algorithm can be used to expand targeted study aimed at shot boundary detection. The comparison table shows our technique is efficient in comparison with other techniques for wipe transition detection. Also it has been observed that our algorithm has given splendid results when faced with extensive fire flickering in the video.

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