A Multi-resolution video Segmentation Scheme for Wipe Transition Identification

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ABSTRACT

This paper presents a new methodology for wipe transition identification.Shot transition detection is an important technique for making videos easier to handle. Due to the wide variety, wipe transition appears to be the most difficult one to be detected among all types of shot transitions. We propose an approach that takes advantage of the production aspect of video. 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. In our system, wavelet transformation is used for multi-resolution decomposition.

Keywords*: video segmentation, shot transition detection, video sequence analyses, digital video database*

1. Introduction

A shot is a single sequence of a motion picture or a television program shot by one camera without interruption, i.e., it consists of a sequence of frames which represents a continuous action in time and space. It is a basic unit for video understanding. A list of keyframes extracted from the shots of a video clip can give user a rough idea about the story of the video clip and are usually used for video content analyses. Shot transition detection is a process for detecting the boundaries between uninterrupted camera shots. Technically, it can be done by the analyses of a time-varying characteristic function of the frames.

Shot transition detection has wide range potential applications including intelligent video indexing, browsing and editing; perceptual video coding; video steganography; etc. Due to the large amount of data, video sequences are often hard to manipulate. One of the purposes of shot transition detection is to simplify the video data for easy handling. It is an important first step for the aforementioned applications. Once each individual shot is identified, we can use other mechanisms, like content-based analyses, etc., to manipulate and process the data for certain applications' needs.

Generally speaking, there are two kinds of shot transitions: abrupt (discontinuous) shot transition including cut transition; and gradual (continuous) shot transition including fade, dissolve and wipe transitions. Among these four types of typical shot transitions, cut and fade are easier to be detected but dissolve and wipe, especially wipe is much more difficult to be detected due to the wide range of variations of the transitions.

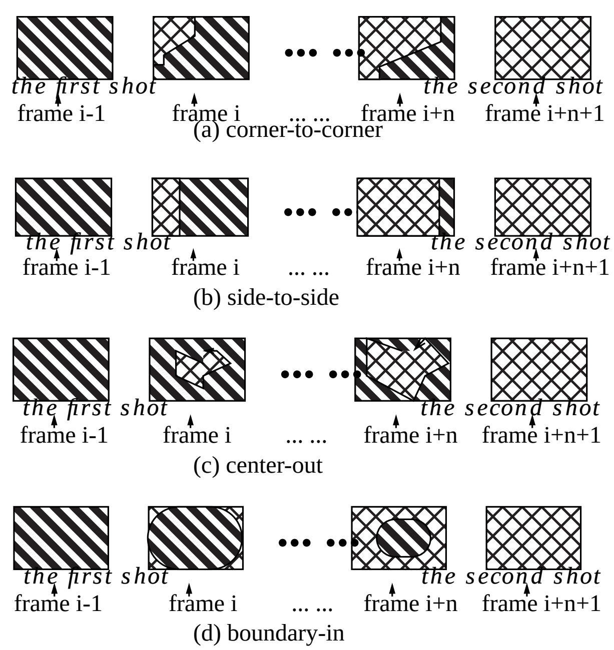


FIGURE 1. Wipe transition illustration

Starting from the 90's, lots of shot transition detection techniques have been developed by researchers [1][2][3]

[4][5][6][7][9][10][11][12][13][14][16]. Among those, histogram differencing, frame differencing, motion vector analysis and compression difference are the most widely used ones for cut detection. Various successful results have been shown by researchers or implemented in all kinds of systems. In recent years, some successful algorithms for fade and dissolve detection have also been developed[8] [9][18][19]. However, algorithms for successful wipe detection have been left out due to the broad range variations of wipe transitions that come from the large scale use of video editor. The most popular ones include side-to-side (including left-to-right, right-to-left, bottom-up, top-down), corner-to-corner, center-out and boundary-in transitions. Although, according to the statistics, wipe transitions occurs only less than ten percent on average (of all the transitions occurrences) in the overall television programs, the need for high accurate video segmentation algorithms for various applications as mentioned earlier makes wipe transition detection an important problem.

2. Wipe transition characterization

A wipe transition is a transition from one scene or picture to another made by a line (a curve or a polygon) moving across the screen. Visually we see one scene is gradually moving out of the picture while another scene is gradually uncovered. From the production point of view, one part of the original image is replaced by another fragment from another image. In other words, during a wipe, one portion of the image has a much more significant difference than the rest portions of the image when it is compared to the original image (the previous frame) on a pixel by pixel level differencing. It is a result of the continuity of one shot. In the mean time, there usually has a fine line between the exiting image and the entering image due to the production effect (see Figure 2).

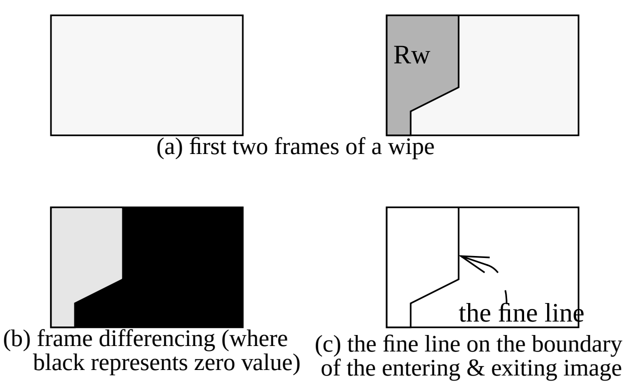


FIGURE 2. An illustration of wipe characterization

We can model the changing characteristics of a wipe transition as:

$$E(x, y, t) = \begin{pmatrix} S_1(x, y, t), \forall(x, y) \in R_w \\ S_2(x, y, t), \forall(x, y) \notin R_w \end{pmatrix} \quad \text{(EQ 1)}$$

Where S_1, S_2 are unedited moving image sequence characteristic functions; R_w defines the uncovered wipe region as shown in Figure 2 (a).

Based on the above observation, we propose a multi-resolution wipe transition detection scheme that utilizes frame differencing as well as the edge image to model the changing statistics of a wipe transition.

3. Wipe transition detection

In a previous paper [18][19], we described our multi-resolution algorithm for fade and dissolve transition detection using wavelet transformation. Here we have a reasonable assumption that cuts, fades and dissolves have been detected. Furthermore, since we used wavelet transformation for image decomposition in our fade and dissolve detection scheme, another reasonable assumption is the low-resolution and the high-resolution components are ready to use when we identify wipe transition. There is no computational overhead for multi-resolution decomposition in the process of identifying wipe.

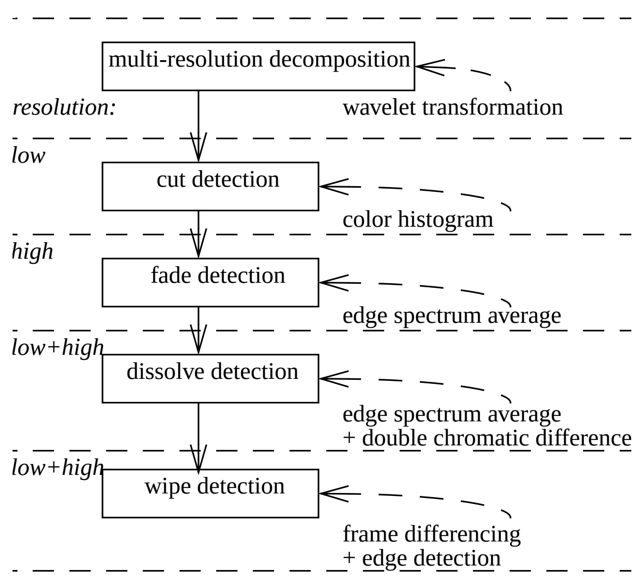
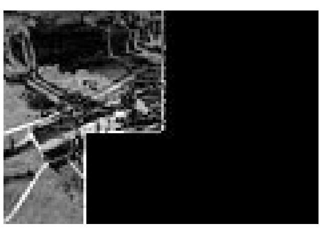


FIGURE 3. The system hierarchy for multi-resolution shot transition detection

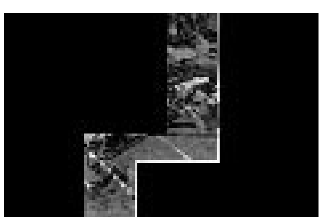
(a) the first shot

(b) the starting frame of a wipe

(c) the next frame of the wipe



(e) frame differencing of (a) & (b)



(f) frame differencing of (b) & (c)

* *This is an ideal wipe with neither local nor camera motion*

FIGURE 4. A sample differencing low-resolution image of two consecutive frames during a wipe

FIGURE 5. The edge images of frame (a), (b) and (c) in Figure 4

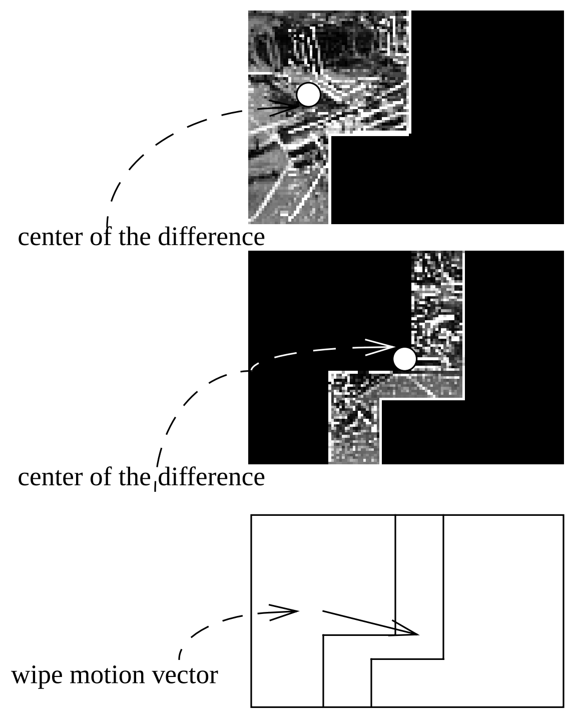


FIGURE 6. The reproduced wipe characterization image of frame (b) in Figure 4

A frame differencing is first done on the low-resolution image (see Figure 4). An edge image of each frame is generated (see Figure 5) using the high-resolution component and is recombined with the differencing low-resolution image (see Figure 6). The changing statistics are then analyzed to identify a wipe transition. In the mean time, the center and the variance of the differencing region can be easily calculated with:

$$\boldsymbol{mm1} = \boldsymbol{r_0} = \int \boldsymbol{r}\rho(\boldsymbol{r}, \theta) \bullet \boldsymbol{r} d\theta d\boldsymbol{r} \qquad \text{(EQ 2)}$$

$$mm2 = \int (\boldsymbol{r} - \boldsymbol{r_0})^2 \rho(\boldsymbol{r}, \theta) \bullet \boldsymbol{r} d\theta d\boldsymbol{r} \qquad \text{(EQ 3)}$$

A side product of this wipe identification algorithm is that it also tells us the boundary moving direction during a wipe. The wipe motion vector can be calculated by analyzing the movement of the center of the differencing region (during a side-to-side or a corner-to-corner wipe) or the variance of the differencing region (during a center-out or a boundary-in wipe). This motion vector (see Figure 6) can be used for further analyses in video content understanding, shot recovery, motion analyses, and etc.

Also notice that this methodology can also be used to detect wipe transitions that happen in a sub-region of image. For example, a rectangle region or an oval region in the middle of the image that happen the most in sub-region wipe transitions. The difference between a sub-region and a full-region wipe transition is the scan region will scan over a sub-region of the image vs. the entire image and leaving the rest part of the image unchanged

4. Conclusion

We proposed a complete frame work for wipe transition detection. Wipe transitions are characterized with a reproduced differencing image. Unlike previous approaches which only can detect left-to-right wipe transition, our method can detect various wipe transitions including side-to-side (left-to-right, right-to-left, top-down and bottom-up), corner-to-corner, center out and boundary-in wipes. Future works include the study of techniques for those wipes with the entering shot also moving into the frame instead of being uncovered only; wipes with high local motion and camera motions.

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