Adaptive Shot Change Detection using Mean of Feature Value on Variable Reference Blocks and Implementation on PMP

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ABSTRACT

Shot change detection is an important technique for effective management of video data, so detection scheme requires adaptive detection techniques to be used actually in various video. In this paper, we propose an adaptive shot change detection algorithm using the mean of feature value on variable reference blocks. Our algorithm determines shot change detection by defining adaptive threshold values with the feature value extracted from video frames and comparing the feature value and the threshold value. We obtained better detection ratio than the conventional methods maximally by 15% in the experiment with the same test sequence. We also had good detection ratio for other several methods of feature extraction and could see real-time operation of shot change detection in the hardware platform with low performance was possible by implementing it in TVUS model of HOMECAST Company. Thus, our algorithm in the paper can be useful in PMP or other portable players.

Keywords: shot change detection, adaptive threshold, variable reference block, portable multimedia player

1. Introduction

Shot change detection is a basic technique and one of important things for management of efficient video data [1]. It is enable to reconstruction, and it has a function to divide and searching for data. Shot change detection is a technique to detect between shots of the video data and boundary [2].

Shot change detection algorithms is approached by a various researched, but now it is not commonly use in real-time processing application. Because of previous algorithms have a defeat which is not robust use in a various genre. Because previous approached is focus on accuracy of detection ratio. In this field, it has a few studies for the reduction of computation. Furthermore the study is not accomplished with device on exception of PC. Like as PMP and most of portable device include Media player function, so it is necessary for the study in real time. Shot change detection algorithms require not only PC but also others devices.

A PMP is needed to real time shot change because of these things. First, PMP has restrictive hardware resource. Second, PMP is supply to restrictive electric power. Third, the users get an answer immediately. When you use not real-time algorism, you have a complaint because of you have to check all things if users want to next shot change frame. Shot change detection have to real time system that is needed to small cash memory, using the low power consumption and a quick answers.

In this paper, we aim to develop shot change detection algorithm considering real-time application. When real time detection is using the study, light scheme is essential. In order to light scheme adapt the sub-sampling and it has little loss. To meet this condition, we extract a feature of shot change frame using variance of difference frame. Proposed method takes small computation amount and is invariant from sub-sampling. There is no user's command in setting threshold, to process in real-time. To satisfy this term, we set mean of weighting variance in variable block as adaptive threshold.

2. Related Works

Shot change detection algorithms are approached by a various researched in spatial domain and frequency domain. In 1993, Zhang et al introduced pixel-wise comparison [3]. Pixel-wise comparison is a scheme to use difference intensity for each other pixel at continuous two frames. However, this method has the drawback of failing to distinguish between significant variations in a small section of video data.

The block-based scheme focuses on local features that, otherwise, would be sensitive to camera and object activities [4]. In 1993, Zhang et al introduced likelihood ratio comparison. This scheme decide for shot change's point through a frame by frame, each frame has pair of blocks. But these methods would be sensitive to camera and object activities.

The histogram based methods is widely used in detecting shot changes [5]. Tonomura proposed the simplest scheme for detecting threshold-based scene changes through comparing among gray-level histograms. Nagasaka et al proposed x^2-test scheme for focusing on the difference value between two frames as well as on the motion of a camera or object.

A number of shot change detection methods have been proposed in frequency domain [6]. In order to reduce the high complexity caused by IDCT, the approaches for shot change detection in MPEG compressed domain have been developed. Meng et al use the variance of DC coefficients and motion vectors to analyze shot changes. Yeo et al use DC image sequences to analyze shot changes. These

approaches are faster than the frame-based approaches, but they are not still suitable for a low-powered PMP.
Fernando et al use the macro-block prediction statistics of B-pictures. However, they cannot be applied to the high quality video-stream which consists of only I-pictures and P-pictures without B-pictures. Sethi et al use the luminance histogram difference of the DC coefficients of successive I-pictures. It is much faster than the above methods but less accurate. Kim et al implemented the shot change detection algorithm using reduced images of only intra pictures in MPEG-2 compressed domain and demonstrated the efficiency of algorithms in a commercial PVR [7].

3. Proposed Method

3.1 Mean of histogram

In this paper, we use mean of difference histogram to detect change frame between shots. Mean of difference histogram is calculated from a difference histogram of continuous two frames. Eq. 1 is represented mean of difference histogram.

$$MDH_i = \frac{\sum_{j=1}^{256} | H_i(j) - H_{i+1}(j) |}{256} \quad (1)$$

MDH_i is a mean of difference histogram, H_i is histogram of current frame, H_{i+1} is histogram of next frame. Generally, we determine shot change frame when MDH_i is large a threshold.

3.2 Adaptive Threshold Setting Scheme

Threshold is one of the important factors that determine detection result. Proposed method utilizes mean feature value on variable reference blocks. In this paper, mean of histogram become feature value. But proposed method have good detection ratio for other several methods of feature extraction. Eq. 2 is shown setting scheme of threshold.

$$TH_i = \frac{\sum_{j=sf_p+1}^{sf_c-1} MDH_j}{sf_c - sf_p + 1} \times w_i \quad (2)$$

TH_i is adaptive threshold, sf_c is current frame, sf_p is previous shot change frame, W is threshold weighting. Adaptive threshold TH_i is defined the value that W_i is multiplies mean(MDH_j) of weighting variance of difference frame from next frame of previous shot change frame to previous frame of current frame. Proposed method alters reference block size whenever comparative frame number is moved. If shot change happen, previous reference blocks is removed and new reference block begin. Therefore, proposed method can conduct correct shot change detection, because it should be refer to feature value of similar shots with current shot.

3.3 Weighting Setting Scheme

In proposed method, weighting is very important factor. If we do not use weighting, namely, case of $W_i=1$, the result is $TH_i \fallingdotseq MDH_i$. Because TH_i consist of mean of MDH values. It makes similarly threshold and MDH, so many false alarm occurred. It decreases reliability of induced threshold TH_i. Therefore, we should be applied weighting to increase reliability of threshold.
In this paper, we propose two ways to decide weight W_i. First method is using fixed value. If video size is fixed with same size, we can find certain value to take best result for each other difference video thought experiment. We obtain best result from 2.5 to 3.0 in 176×144 size video. It is reliable search if it has threshold more than three times of mean of *MDH*. Also if we use fixed threshold, it has a safety search because it has less than three times of mean of f in non shot change frame. However, a week point of this method is non-automatic or semi-automatic. So we propose follow method.
Second method is using variation between successive frames. It use ratio between variation and non-variation. Eq. 3 presents weight determines equation, when we use histogram.

$$NZM_i = \frac{\sum_{j=sf_p+1}^{sf_c-1} NZ_j}{sf_c - sf_p + 1}, \quad W_i = \frac{512}{NZM_i} \quad (3)$$

NZM_i is mean of *NZ* on variance reference block in *ith* frame, NZ_j is a number of non-zero bins in different histogram of *jth* frame. *512* means sum of a number of bins in two successive frames. This method can be possible complete automatic threshold setting without user's command. Also, we obtain improved detection ratio better than fixed weighting.

4. Experimental Environment

The proposed method was tested following conditions. Environment of PC is CPU Pentium-4 2.8GHz and RAM 1G. A detection program is implemented using VC++ .net 7.1 and Matlab 7.3. We used ten video data which have 176×144 size, YUV(4:2:0) format, 9000 frame. A total number of shot change frame is 736. Proposed method is evaluated by precision and recall, F1 [10].
The proposed method was tested four experiments. In first experiment, we compared proposed method with traditional SCD algorithms (T0-T9). They is implemented the best detection result through iterative experiments of fixed threshold. Table 1 shows results of first experiment. The proposed method is improved with 2.5~23.9% in precision, 0.6~21.3% in recall, 1.2~22.6% in F1, which may vary according to comparison methods.
In experiment 2, we compared proposed method with algorithms based on adaptive threshold (A1-A2). Table 2 shows results of experiment 2. The comparative methods have high detection ratio in recall, but they have normal detection ratio in precision. In synthesis result F1,

proposed method is improved more than 6.6%, so it operate effectively to detect shot change frame. Also comparative methods are impossible real-time processing, require run-time more than proposed method.

Table 1. Performance comparison with conventional methods (experiment 1)

	Methods	Precision	Recall	F1
T0	Pixel-wise comparison[3]	84.5	84.5	84.5
T1	Likelihood-ratio[3]	95.9	95.8	95.9
T2	MSE comparison[7]	90.0	90.2	90.1
T3	Intensity Histogram[4]	93.5	93.2	93.3
T4	Color Histogram[4]	96.5	96.6	96.5
T5	Chi-square test[5]	95.5	95.7	95.6
T6	Variance comparison[1]	88.4	88.0	88.2
T7	Variance of different histogram[2]	83.4	83.4	83.4
T8	Variance of different frame[6]	87.0	87.0	87.0
T9	DC-coefficient[7]	75.1	75.0	75.1
P1	Proposed Methods	99.0	96.3	97.7

Table 2. Performance comparison with adaptive threshold based methods (experiment 2)

	Methods	Precision	Recall	F1
A0	Cheng's Method[8]	76.0	75.4	75.7
A1	Ko's Methods[9]	79.1	79.2	79.2
P1	Proposed Methods	99.0	96.3	97.7

Table 3. Results applied variable reference block in other methods (experiment 3)

	Methods	Precision	Recall	F1
P1	Proposed Methods	99.0	96.3	97.7
P2	Weighting Variance[3]	95.5	93.2	94.4
P3	Chi-square test[5]	96.8	98.0	97.4
P4	Color Histogram[4]	98.6	96.0	97.3

Table 4. Performance comparison with fixed reference block based methods (experiment 4)

	Methods	Precision	Recall	F1
F0	Intensity Histogram[4]	95.7	93.9	94.8
F1	Color Histogram[4]	96.7	91.3	93.9
P1	Proposed Methods	99.0	96.3	97.7

In experiment 3, we showed detection results in other features value applied variable reference block (P2~P4). Table 3 shows results of experiment 3. In other three feature values, proposed method has higher detection ratio. Therefore proposed threshold setting method has reliability when we use other three feature extraction method.

In experiment 4, we compare proposed method with fixed reference block based algorithms. The reference block size is 122 frames. Because 122 is mean of shot change detection length of whole video used experiments. Table 4 shows results of experiment 4. The proposed method is improved with 2.3~3.3% in precision, 2.1~5.0% in recall, 2.9~3.8% in F1, which may vary according to comparison methods. We knew to detect effective variable reference than reference of fixed length.

We verified performance of proposed method through experiments of four kinds. We have higher detection ratio than fixed threshold based methods through experiment 1. We verified fast and improved accuracy than conventional adaptive threshold based methods with experiment 2. Also, proposed method can operate independent from feature value. We could see more dependably block of proposed method better than reference of fixed length through experiment 4. Accordingly, proposed method can be applied effectively to detection shot change of video data. Proposed method is perfect automatic algorithm which does not need user's command at same restrictive condition of our experimental environment.

5. Implementation on PMP

In this paper, proposed method is applied in PMP for verify of real-time processing. Devices which have a small size and easy mobility like PMP have lower hardware performance than a general personal computer. So it has a restricted hardware resource. Implementation to Used PMP to implement is TVUS in Homecast which have DM320 to main processor to play multimedia contents. It has DSP to have 100MHz speed. To play Uncompressed SD(Standard Definition) video needs clock signal of 27.5MHz and owing to need to have more clock to decode compressed video it is restricted resource to another process . Therefore, to implement in PMP low computation complexity scheme like as proposed method.

Video data is processed through the event process among internal five threads(Gui, Bsi, Bso, Maf, Dsp). Gui handle about it in case of manipulating button on PMP and inform start of run to Bsi, Bso and Maf use by a start event when open the media file. Bsi transfer frame information of video according to Gui event order to Maf and Maf store decoded video data using Dsp in shared buffer. Saved video frame format is YCbCr(4:2:2). Bso convert YCbCr to RGB format to play stored video frame. In PMP, a detection program is implemented using WinCE5.0 and Embedded Visual C++ 4.0.

When we apply to our method in PMP, it doesn't have false alarm, and we confirmed it doesn't have any factors for the effective in repeating. Furthermore there is no delay and buffering. It just has one frame delay when beginning shot change detection. Therefore we verified our proposed method is implemented in PMP. Detection result is similar to in experiment of PC. Figure 1 presented result image of shot change detection using the PMP.

Figure 1. Result of shot change detection on actual PMP

6. Conclusions

In this paper, we propose an adaptive shot change detection algorithm using the mean of feature value on variable reference blocks. Our algorithm determines shot change detection by defining adaptive threshold values with the feature value extracted from video frames and comparing

the feature value and the threshold value. The result of proposed method is improved compare with conventional methods in the experiment with the same test sequence. We had good detection ratio for other several methods of feature extraction and obtained better detection ratio than the conventional methods maximally by 15%. We also could see real-time operation of shot change detection in the hardware platform with low performance was possible by implementing it in TVUS model of HOMECAST company. Thus, our algorithm in the paper can be useful in PMP or other portable players.

7. References

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