International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)

Volume 3, Issue 11, November 2014

Video Shot Boundary Detection Techniques

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Abstract - Shot boundary detection (SBD) is the basis of revealing even higher levels of the hierarchical video structure. If we advance further from the scene level, we can try to extract even higher-level semantical information from the video by using the shot boundary information. The next structural level above the shot and scene levels in news are videos, story level which contains stories that are made of several scenes. The story boundaries thus usually overlap with some of the scene boundaries, so gathering information on the shot boundaries and scene boundaries help to solve the problem. This bottom-up approach might help us eventually to narrow the semantic gap a little bit more.

Knowing the shot boundaries is also crucial for some lower-level feature extraction methods. For example to figure the system which solve the camera movement based on the video data and differences between consecutive frames. This camera movement detection is naturally sensible only inside shot boundaries since transformations between shots confuse the camera movement detection algorithms.

Finding shot boundaries is also useful in some other applications. For example advertisement flagging and removal methods utilised by some digital video recorder systems may benefit from shot boundary information. Shot boundary detection also makes video players so the user can rewind and fast forward one shot at a time, or browsing the video contents by its key frame representation.

Keywords— Shot boundary detection, gradual boundary detection, histograms, color histogram, Running histograms thresholding, Pixel differences, Color spaces, Image edges, Motion compensated pixel differences.

I. INTRODUCTION

A video shot is classified as a continuously imaged timely segment of a video. As content of a video is largely based on its generation (imaging) process, the overall segmentation of a video into shots is a logically first step for most kinds of semantic video processing tasks. Here we present a classification of shot boundary detection algorithms, including gradual shot transitions. Shot boundary detection is the most basic temporal video segmentation task. It is basic information which is linked intrinsically and inextricably how the video is produced. It is a primary choice for video segmentation into more acceptable parts as per need, and thus it is normally the first step in algorithms which helps in other video analysis tasks, one of them is used for condensed video representation. In the case of video information access or retrieval, a video index is very small and due to which it is easy to construct and can be used as reference for whole video shots instead of every video frame. As scene change always happen on every shot change, shot boundary detection is essential as an initial step for scene boundary detection. As a result, shot transitions provide suitable detectable points for video browsing. Condensed video representation is the final output of a characteristic set of either individual frames or short sequences from a video. This information can be used as a substitution for the complete video for the purposes of categorization, comparison and indexing. It is also helpful for video browsing.

For automatic video browsing and indexing, Shot boundary detection is normally the first step. It checks and recognizes different visual discontinuities due to transitions, to segment a video stream into primary uninterrupted small content units for next high-level semantic analysis. Though long research done & numerous proposed techniques are invented, shot boundary detection is not completely solved [2][3]. One of the most challenging domains for robust shot boundary detection is sports video [4]. The underperformance of general techniques [5] will lead negatively for the subsequent tasks. Color histograms is the widely feature for cut detection [6]. J. Bescos, et al proposed a unified model for shot boundary detection, and shown excellent output on a large data set [10]. For shot boundary detection in sports video, A. Ekin, et al proposed the feature .dominant color proportion and obtained very good results than general detectors [4]. Recently, Support Vector Machine (SVM) has been successfully adopted as a statistical machine learning approach for constructing automatically a decision hyper-plane during the training procedure [9] [10]. While the algorithms in [9] and [10] only adopt normal features and their performances, though relatively high, are not satisfactory for sports video study applications. As mentioned in B. Han et al [2] proposed method, which integrated the above mentioned model and features, and found that frequently encountered problems are as below

A. When the last frame before the transformation and the first frame after the transition both have the field as their features, background, region, color histograms and dominant color proportions, are very similar this often results in a miss.

B. Histograms change as fast as camera pan during a gradual transition of frames which often results in a false.

The traditional method is takes more time and also slow because it uses human beings to manually explain the videos with text keywords. In today's fast and developed world, the rapid development of multimedia and web technologies, different video data formats are available. To enable efficient browsing, searching of information and retrieval with these huge video data resources, the video database systems are needed. Therefore, more advanced methods are required to support automatic indexing of information and access them directly based on videos content, which provide information related to video within no time and with faster speed. Shot boundary detection is one of the important techniques for digital video study. Video shot boundary detection is usually the initial important step for content-based video retrieval, which helps to segment a video with the help of boundaries detection between camera shots. A group of scene makes a digital video sequence. One or more shots collection focusing on one or more objects of interest makes a scene. One can say it is a set of frames taken from a single camera. A shot boundary differentiates two consecutive shots when one shot changes to another shot. It means that if *n* number of shots taken from various cameras with different Video shot boundary detection will have various applications in different domains like video compression, video indexing, video access and others. Most of the techniques have been developed and compared to detect frame transitions in video sequences. Simplest way of detecting shot Transition is to compare corresponding pixels between two immediate frames. Second method is by using color or grayscale histograms of two frames. There are many other methods like some predefined models, objects, regions, edge changes to detect shot changes.

II. SHOT BOUNDARY DETECTION

Shot boundaries can be broadly classified into two types: abrupt transition and gradual transitions. Abrupt transition is quick transition from one shot to the subsequent shot. Gradual transition occurs over multiple frames, which is produced through requisition of more detailed editing results involving numerous frames,

Gradual transition can be further classified into fade out/in (FOI) transition; dissolve transition, wipe transformation, and others transformation, as per the characteristics of the different editing effects. They are required for further video analysis such as.

a. Person tracking, identification
b. High level feature detection

A. *Fade transition:* This is a shot transformation with the first shot slowly pass away (fade out) before the second shot gradually appears (fade in).

B. *Dissolve transition:* This is a shot transformation or transition with the first shot step by step disappearing while the second shot slowly appears. In this case, the last few frames of the pass away shot momentarily overlap with the first few frames of the appearing shot.

C. Wipe transition: This is a set of shot change methods, where the appearing and pass away shots exist at the same time in different dimensional regions of the in-between video frames. One scene slowly enters across the view while another gradually leaves.

D. Other transition types: There is a number of innovative special outcome methods used in motion pictures. They are very rare and difficult to detect.

They provide the cue about high level semantics:
a. In video making each transition type is selected carefully to support the content & context.
b. For example dissolve occur much more often in feature films & documentaries, while wipe usually occur in news, sports & shows.

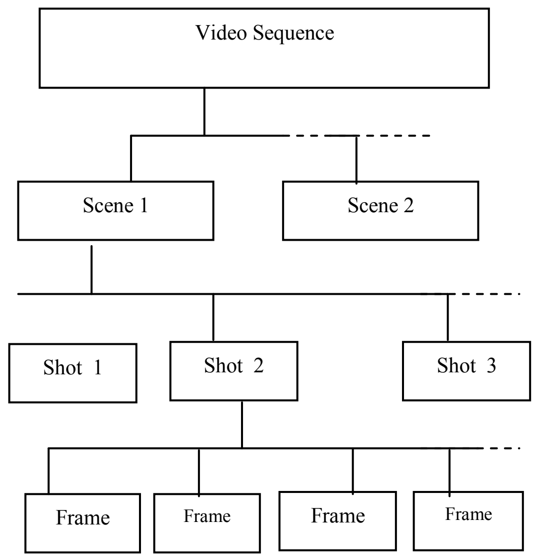

Fig 1: Common Video Structure

International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)

Volume 3, Issue 11, November 2014

(a) Dissolve image

(b) Fade – out image

(c) Fade – in image

(d) Wipe image

III. HIERARCHY OF VIDEO DATA

A video stream consists of a stream of images accompanied with an optional audio stream. The video stream can have arbitrary length. The illusion of moving picture is produced by showing rapidly a subsequent series of motionless images. The human eye is too slow to see discrete motionless images, and interprets the number of images as continuous movement. Typically the frame rates of videos are about 24 or 30 images per second, which is sufficient to produce the illusion of continuous movement.

Edited video typically consists of multiple shots. A shot is a series of sequential frames that have been filmed in a single camera run. Shots are bound together using number of cuts or transformation effects. In movie terminology one or more shots form a scene. Scene is defined as a set of successive shots that form an entity that seems to be constant in time, or is filmed in a one location. Shot also define as, they are bounded by visual boundaries, while scenes are bounded by somewhat more abstract semantic boundaries [20]. In some shot boundary -related literature [21, 11] the terms shot and scene have been used as synonyms, but later using the terminology as described here has become the established practice.

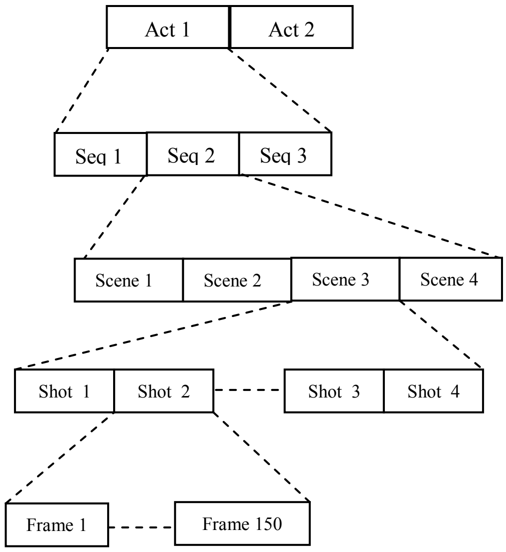

Fig 2: The hierarchical semantic structure of typical movies and fictional television programmes. Documentaries might also have a similar structure.

If we move up in the structural hierarchy of typical movies, the next more abstract level in movie terminology is the sequence level. A sequence is a set of consecutive scenes, which are semantically interrelated and are connected by a continuous relation in either time or location. The grouping of scenes into sequences requires human intervention since at present the sequence boundaries seem to be semantically too abstract to be found using only low-level features [20]. Multiple sequences on the other hand form an act, which are the building blocks of an entire movie. This kind of a movie structure is illustrated in Figure 2.

In news broadcasts the terminology can be defined in a slightly different manner. The scenes form stories, and stories form the entire news programme [9]. A story contains all the scenes related to a single news topic. Typical news story starts with a scene made into a movie in the news studio in which the news anchor presents the topic and some background information. Then some video footage related to the story is displayed, with possibly other reporter reporting live from the event location. Sometimes the anchor and the news studio is shown again one or multiple times also in the middle of the story, especially if there are live reports or live interviews in the story.

If the shots are automatically classified to several categories like "anchor shots", this typical structure of stories can be used in story boundary detection as has been done in [22] and [23].

Each shot, scene and story, and perhaps even sequence and act, can be depicted coarsely with a key frame, or a small number of key frames, for visualization and summarization purposes. Content-based video retrieval systems can also use key frames and traditional image retrieval methods to perform the searches [24]. A key frame is the frame that helps to capture the most important visual content of the corresponding video segment. Depending on the complexity of the video segment, there can be one or multiple key frames depicting it. The key frames are usually extracted from the shot level, and relevant shot key frames can then be selected to represent the higher-level components in the video hierarchy. The simplest key frame extractors just capture the first, middlemost and/or last frame of the video segment, but more sophisticated methods can use for example motion information to determine the key frames.

IV. CLASSIFICATION OF SHOT BOUNDARY DETECTION ALGORITHMS

A. Features Used

Nearly all shot change detection algorithms reduce the huge dimensionality of the video domain by selecting few features from each video frame. These are extracted either from the entire frame or from a subset of it, which we can call a region of interest (ROI). Such features include:

a. Luminance / color: The easiest feature is used to characterize a ROI is its average gray scale luminance [12]. This, however, is susceptible to illumination changes. A good choice is to use statistics of the values in a color space [14, 15].

b. Luminance / color histogram: A main feature for a ROI is the grayscale or color histogram. It is quite discriminate, easy to compute and mostly insensitive to rotational translational or zooming camera motion, for the above reasons it is widely used [13].

c. Image edges: A natural choice of feature is edge information in a ROI. Edges can be combined into objects or used to extract ROI statistics. They are not changing to illumination changes and most motion, and they correspond somewhat to the human visual perception. Their main disadvantage is noise sensitivity, computational cost, and high dimensionality.

d. Transform coefficients (DFT, DCT, and wavelet): These are a standard way to elaborate the texture of a ROI. The DCT coefficients are also present in MPEG encoded video streams or files. Their main problem is that they are generally not invariant to camera zoom.

e. Other features: Most of features are used in the literature, such as the color anglogram.

f. Multiple features: Many algorithms extract different types of characteristics either to use them in combination or for subsequent processing and analysis.

B. Spatial Feature Domain

The size of the region from which independent features are extracted plays a great role in the performance of shot boundary detection. A small region tends to decrease detection invariance with respect to motion, while a large region tends to miss transformations between similar shots.

a. One frame pixel per feature: Some algorithms use a one frame pixel per characteristic. This characteristic can be luminance, edge strength [16] or other. However, such an approach results in a very large characteristic vector and is very sensitive to motion.

b. Rectangular block: Another method is to segment each frame into same-sized blocks, and select a set of features per block [14, 15]. This approach is invariant to small camera and object motion. By calculating block motion, we can easily enhance motion invariance, or to use the motion vector itself as a characteristic.

c. Arbitrarily shaped region: Feature extraction can also be applied to arbitrarily shaped and sized regions. This results the most homogeneous regions, enabling quality detection of discontinuities. Object-based feature extraction is also included in this category. The main disadvantage is high computational complexity and instability due to the complexity of the algorithms involved.

d. Whole frame: The algorithms that select characteristics from the whole frame at once [13] have the advantage of being very resistant to motion, but might have poor performance at detecting the change between two similar shots.

C. Temporal Domain of Continuity Metric

Another major view of shot boundary detection algorithms is the temporal window of frames which is used to perform shot change detection, which can be described as follows:

a. Two frames: The simplest way to detect discontinuity is to lookout for a high value of the discontinuity metric between two subsequent frames [14]. However, such an approach fails when there is significant variation inactivity among different parts of the video, or when certain shots contain events that cause short-lived discontinuities (e.g. photographic flashes).
b. N-frame window: The most common method for alleviating the above problems is to detect the discontinuity by using the characteristics of all frames within a temporal window [13]. This is either by computing a dynamic threshold against which a frame-by-frame discontinuity metric is compared or by computing the discontinuity metric directly on the window.
c. Entire current shot: Second method is to calculate one or more statistics for the whole shot and to check if the successive frame is same as previous with them, as in [13, 16]. But if there is variability within shots, statistics computed for an whole shot may not be representative of its end.
*d. Entire Video: F*eatures of the entire video into consideration when checking a shot change, as in [17]. Again, the problem is that the video might have high variability within and between shots.

D. *Shot Change Detection Method*

a. Thresholding: This means comparing the calculated discontinuity value with a fixed threshold [13, 16]. This method only performs well if video content exhibits stationery with time, and only if the threshold is adjusted manually.
b. Adaptive Thresholding: The obvious solution to the problems of the simple thresholding is to vary the threshold depending on the average discontinuity within a temporal domain, as in [12].
c. Probabilistic Detection: A strict way to detect shot changes is to model the pattern of specific types of shot changes and calculate optimal a posteriori shot change, presupposing specific probability distributions for shots. This is demonstrated in [14, 15].
d. Trained Classifier: A radically different method for detecting shot changes is to formulate the problem as a classification task, with the classes being “shot change” and “no shot change” [17].
e. Heuristics: A number of authors use various domain-specific heuristics for the detection of different transition types
f. User interaction: If automatic procedures fail, cut detection in ambiguous cases can be resolved by user input.

V. SHOT BOUNDARY DETECTION ALGORITHMS & TECHNIQUES

Various methods of automatic shot boundary detection have been identified and claimed to perform reliably. Although the detection of edits is fundamental to any kind of video analysis since it segregates a video into its basic components, the shots, only few comparative investigations on early shot boundary detection algorithms have been published. We selected the following five algorithms:

A. Histograms:

One threshold is used. We compute a 64-bin gray-scale histogram over the complete frame. The difference measurement is the summation of the absolute bin-wise histogram differences. A shot boundary is declared if the histogram difference between consecutive frames exceeds a threshold.

B. Region histograms:

Two thresholds are used. Each frame is divided into 16 blocks in a 434 pattern. A64-bin gray-scale histogram is computed for each region. Histogram differences are computed for each region between consecutive frames. If the number of region differences that exceed the difference threshold is greater than the count threshold, a shot boundary is declared.

C. *Running histograms:*

This algorithm closely resembles the algorithm described by Zhang, Kankanhalli, and Smoliar.1 Two thresholds are used. This computes a 64-bin gray-scale histograms over each image. If the histogram difference between consecutive frames exceeds the high threshold, a cut is declared. If the histogram difference exceeds the low threshold we assume that we are starting a gradual shot transition, so we start computing differences from the start of the gradual transition. If this running difference exceeds the high threshold, we will declare a gradual transition once the run ends. If the difference drops below the low threshold for more than two frames, we stop computing running differences and decide that the gradual transition, if there was one, must be over. To reduce false positives due to camera motion or the motion of large objects, we compute a set of motion vectors based on block matching in a 4×3 grid. If the motion vectors for a frame indicate this type of excessive motion, we assume that a pending gradual transition is false, and we stop computing running differences until the motion ends.

D. *Motion compensated pixel differences:*

This algorithm resembles the algorithm described by Shahraray,4 although many details are not specified there. There are three threshold values: cut, high, and low. Each frame is divided into 12 blocks in a 4×3 pattern. Block matching with a 24×18 search window is used to generate a set of motion vectors and a set of block match values. The two highest and two lowest match values are discarded and the remaining values are averaged to produce the match value. If the match value exceeds the cut threshold, then a cuts declared. We keep a cumulative total of the amount that the match value goes above or below the low threshold, with the idea the match values above the low threshold indicate that we might be in a gradual transition. If the cumulative total exceeds the high threshold, we declare a gradual transition once the match value drops below the low threshold. To guard against false positives due to motion, the motion vectors are examined, just as in the running histogram algorithm, to determine if there is a lot of uniform motion. If there is sufficient motion, the cumulative total is reset to a low value.

E. *DCT coefficient differences:*

This algorithm nearly similar to the algorithm described by Arman, Hsu, and Chiu.10 One threshold is used. We take the same 15 DCT coefficients from each block of frame and concatenate them to produce a vector. The difference measure is computed by subtracting the inner product of the vectors of consecutive frames from one. If this difference exceeds the threshold, declare a possible shot boundary. Arman, Hsu, and Chiu used two thresholds and used color histograms to decide the in-between cases. We chose to use only one threshold to evaluate the effectiveness of using this algorithm as a filter for other algorithms.

VI. COMPARISON OF VIDEO SHOT BOUNDARY TECHNIQUES USED:

A. Histogram differences:

Histograms are the most common method used for comparing images. And this technique can be extended to find the image whose histogram varies significantly from the previous image histogram. Thus we can detect shot boundaries. The histogram method computes 64 bin gray level histograms of the two images and Euclidean distance measure is used to find the histogram difference. If this distance between the two histograms is more than a threshold, a shot change or boundary is assumed [1].

B. Region based Histogram differences:

In this method [1], each image is divided into 16 blocks in a 4x4 pattern. For every image, a 64-bin gray-scale histogram is computed for each region. A Euclidean distance measure is used to find the difference between the region histograms of two consecutive images. If the distance is above a threshold, the region count for that image is incremented. If the region count is above than some predefined threshold, a shot change or boundary is assumed. Thus, we use two thresholds.

C. Statistical differences:

As in the previous method [1], each image is divided into 16 blocks. Then, for each block the mean and the standard deviation is found. I have used a Euclidean distance measure to find the mean and standard deviation differences between the corresponding blocks of two consecutive images. Similar to the previous method, two thresholds are defined. If the region count is more than the second threshold, a shot boundary is assumed.

D. Pixel differences:

This is the simplest method [1] for determining shot boundaries. The difference between respective pixels of two successive images is computed. If the difference is greater than some threshold, than a shot boundary is assumed.

E. Color spaces:

Besides grayscale, I have considered other color spaces like RGB, HSV and YIQ in the 64 bin histogram difference method [18].

F. Distance measure:

Besides Euclidean distance, I have used Chi-square distance measure in the 64 bin histogram difference method [18].

G. Threshold values:

The threshold values were predefined and tuned to get accurate results. This technique worked well with "Bombay" video. In the "Walk" video, technically the entire video is just a single shot.

VII. CHALLENGES IN SHOT BOUNDARY DETECTION

Shot boundary detectors essentially try to monitor discontinuities in the visual stream to spot shot boundaries. However, there can be differences of varying magnitude between consecutive frames within a shot, and the detector should be able to distinguish these from real shot boundaries. These differences are mainly caused by camera or object motion and lighting changes [15]. Especially camera flash lights are known to cause problems when handling news videos. A flashlight changes the illumination of the entire room for a short while, which is usually seen as two sharp discontinuity peaks in the visual flow. Ideally the detector should not react to this kind of differences. This could be achieved for example by using feature extraction methods that are as invariant as possible to lighting and translation. Object and camera motion causes difficulties especially when something enters or leaves the screen. This is emphasized when the entering or leaving object or piece of background has some unique visual characteristics not found elsewhere on the screen, as it changes the average visual properties of the image significantly. News scroller bars, subtitle texts and other similar on-screen graphical effects suddenly appearing on the screen might also confuse the detector for the same reason. Slow gradual transition detection can also be challenging since the detector should be sensitive enough to spot the slow transitions, but not too sensitive to react to fast visual changes within a shot. If the video sequence is fast-paced, but contains very slow gradual transitions, it might be difficult to find suitable detector parameters that detect the transitions, but avoid false positive decisions. There are many diverse shot boundary detection algorithms, but most of them are not able to detect all types of boundaries with high detection performance. Consequently, constant detection performance for arbitrary video cannot usually be guaranteed without manual fine-tuning of parameters [15]. For example the average characteristic properties of transitions in movies and news videos are different.

VII. CONCLUSION

The different techniques are discussed to detect a shot boundary depending upon the contents and the change in contents of video. As the key or important frames need to be processed for annotation purpose, the important information must not be missed. We found Histograms Differences as most suitable method used for comparing image and using this technique can find the image whose histogram varies significantly from the previous image histogram. Thus we can detect shot boundaries.

ACKNOWLEDGMENT

I cannot complete my work without support of my internal guide.

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