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Comparative Study of Classical Graph Theory Approach and Nodal Analysis Based Graph Theory Approach of Shot Boundary Detection

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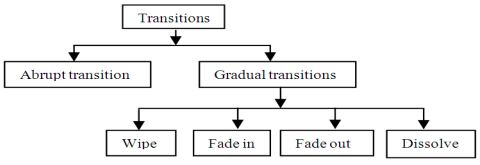
Abstract

Media represents an integrated combination of video and audio processing. This media offers a communication channel between individuals and outside world. Video processing is a vast research area with the general objective of video analysis like video database storage, video indexing, and video retrieval. One of its fundamental applications is video shot boundary detection. This detection of boundaries between shots is carried out using various existing methods like edge detection, gesture interpretation, colour histogram etc. In this paper we present a comparative study between classical graph theory and nodal analysis based graph theory approach.

Keywords: *shot boundaries, shots, graph, spanning tree, histogram, and HSV model.*

1. Introduction

Video processing methods stems from two basic principal application areas: improvement of pictorial information for human interpretation; and processing of video data for storage, transmission and representation for autonomous mechanism. The fundamental unit of video is shot which is define as a collection of frames recorded from a source i.e., camera continuously. Thus shot boundary detection implies the dissimilarity existing between different scenes and shots. By investigating the behaviour of occurring transitions in consecutive frames one can be able to detect these shot boundaries. The transition in general are categorised into two types: abrupt transition and gradual transition. [1, 2]



The hard cut signifies an impulsive changes occurring between two consecutive shots. While the gradual cut is a slow change taking place between multiple frames. [4] Wipe, dissolve, fade fall under gradual transition. Wipe represent deliberate variation in its frame content in different pattern like circular, diagonal, vertical, horizontal. Fade shows variation in brightness of the video frame. In case of fade in the shots begin with black frame and continue till the current frame whereas in fade out current frame moves out into black frame. Dissolve is the integrated form of fade in and fade out in which one frame fade in into the next frame thus depicting the overlap between the two shots.

2. Comparative Study Analysis

Comparative study gives us a platform to study the relative differences that exist between various methods in terms of different parameters like hit rate, miss rate. [9] Many algorithm have been proposed in this respect[1,2,3,4,5] of these methods colour histogram, pixel difference, Transform based method are the classical approaches producing efficient result with some drawback in region of camera motion, luminance. Graph theory approach is an innovative approach towards shot boundary detection. This paper is focussed on the analysis of classical and modern graph theoretic approach.

In classical graph theory approach extraction of colour feature is done using HSV model to compute video frame dissimilarity. HSV model possesses good linear scalability and visual perception for human eye. According to the visual perception the model is being divided into three sections namely Hue space(H), Saturation space(S) and brightness space(V).[6].For constructing 1D feature vector the HSV is needed to partition in such a manner like 1=9H+3S+V, where hue is

divided into 9 parts, saturation in 3 and brightness in 1 respectively. The dissimilarity between frames i and j can be given by

$$D(H_i, H_j) = \sqrt{\sum_{k=0}^{n} |H_i(k) - H_j(k)|^2} \quad (1)$$

In graph theory video frames are considered as vertices whereas the frame difference as weight of edges. Thus the graph G can be defined by G= (V, E). A graph is a set of vertices and edges that connect them. The term TREE stands for the graph without a cycle. The classical graph theory approach is based on minimum spanning tree (MST) formation using vertices, (n-1) edges and its weight. [7]

In this approach first compute frame difference and regard it as edges and video frame as vertices. Then form minimum spanning tree using edge and vertices. Decide a proper threshold value and compare it against weight of edges. Discard all the edges whose weight exceeds T_L. Compute minimum distance between two vertices number, if this distance is less than T_L connect that two vertices number and form a tree. Find all the tree and isolated point (consist of 1 video frame) and group them separately.

For detection of abrupt changes define a threshold T_H such that if successive frame difference of different group exceed T_H and the frame number in the two different group both exceed 3, then there exist a shot boundary. In case of gradual transition, successive frame in several different group are present and if every group consist of 3 successive frames then the gradual change is given by the condition.

(Number of successive group-1) > (Sum of frame in the middle group-1)

3. Nodal Analysis Based Graph Theory Approach

Classical method of graph theory approach is robust in shot boundaries detection but beside its advantageous factor it has disadvantage too. Due to its complexity level, processing of large video is tedious job and time consuming too. Thus, grouping of successive video frames of different group needs proper thresholding for boundary detection. Some kind of innovation is being done in graph theory approach to overcome the drawbacks of classical approach. The nodal analysis based graph theory approach relies on dominant set. Dominant sets are defined as a set of the nodes in a graph, mostly similar to each other and dissimilar to the others. In order to achieve this goal, shot boundaries are determined by using simply histogram difference for abrupt changes and standard deviation of pixel intensity using contrast change parameters for gradual transition between consecutive frames [10]. Proposed method works on nodal difference analysis that construct graph using frames in the testing sequence. Each frame component in the sequence corresponds to a node in the graph; pair-wise dissimilarities between the nodes are calculated by using above mentioned algorithm. By utilizing the complete information of the graph, its discontinuities are measured and compared against a threshold level. The threshold value is different for both abrupt and gradual transition including fade in, fade out, dissolve.

The abrupt transition values vary from cut to cut, and sometimes all the transitions cannot be identified using a fixed threshold value. An adaptive threshold value can be used in that case. Adaptive threshold measure the average discontinuity within a temporal domain. One of the methods to mark the gradual transitions is the twin-comparison approach, where two thresholds are defined: higher T_H for abrupt cuts and lower T_L for gradual transitions. In this approach the cuts are first detected using the higher threshold, and then for the remaining video T_L are used to spot the gradual transitions. The algorithm tries to mark the difference values that all exceed the lower threshold. If the sum of these difference values exceeds the higher threshold value, then it is referred as a gradual transition.
The nodal analysis based graph theory takes the advantage of previously existing methods to overcome the drawback of classical method. It produces efficient result and robust to camera motion and luminance factor.

4. Experimental result

This section present an evaluation technique that can be used to measure the performance of shot boundary detection The experimental result can be computed in terms of TRECVID[8], Recall, Precision. Here we are using recall and precision method as the appropriate evaluation criteria.

Recall defines the percentage of desired items that are retrieved whereas precision in turn defines the percentage of retrieved items that are desired [1] and is given by

$R = N_C / (N_C + N_M)$

$P = N_C / (N_C + N_F)$

Where N_C is correctly detected shot, N_M is missed detected shot and N_E is error or falsely detected shot.

Table No. 1: Result of classical graph theory approach: [7]

video	N_C	N_M	N_F	RECALL	PRECISION
SPORTS	74	3	21	95.9%	77.2%
NEWS	22	1	3	95.7%	88%
MOVIES	138	13	34	90.6%	78.6%
MTV	50	4	17	92%	73%

Table No. 2: Result of Nodal analysis based graph theory approach:[10]

VIDEO	NO. OF FRAMES	DURATION	N_C	N_M	N_F	RECALL	PRECISION
Abrupt cut video	902	30 Sec.	6	1	0	86%	100%
Dissolve Video	1637	2 min. 16 Sec.	13	1	2	92.8 %	87%
Wipe video	963	32 Sec.	7	1	2	87.5 %	77.7%
Fade in Fade out Video	1067	35 Sec.	7	1	3	87.5 %	70%

5. Conclusion

In this paper we present a brief comparison between classical graph theory and nodal analysis based graph theory. Although the former approach is robust in shot boundary detection but due to some of its drawback its precision rate is quite less efficient compare to latter approach. Both this approach belongs to graph theory for shot boundary detection. The above mentioned approach utilizes the video feature of data available. In future it can merge with textual and audio feature to improve its performance.

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