Effective Video Shot Boundary Detection and Keyframe Selection using Soft Computing Techniques

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ABSTRACT
The amount of video data generated and made publicly available has been tremendously increased in today’s digital era. Analyzing these huge video repositories require effective and efficient content-based video analysis systems. Shot boundary detection and Keyframe extraction are the two major tasks in video analysis. In this direction, a method for detecting abrupt shot boundaries and extracting representative keyframe from each video shot is proposed. These objectives are achieved by incorporating the concepts of fuzzy sets and intuitionistic fuzzy sets. Shot boundaries are detected using coefficient of correlation on fuzzified frames. Further, probabilistic entropy measures are computed to extract the keyframe within fuzzified frames of a shot. The keyframe representative of a shot is the frame with highest entropy value. To show the efficacy of the proposed methods two benchmark datasets are used (TRECVID and Open Video Project). The proposed methods outperform when compared with some of state-of-the-art shot boundary detection and keyframe extraction methods.

KEYWORDS
Correlation Coefficient, Entropy, Fuzzy set, Intuitionistic fuzzy set, Keyframe extraction, Shot boundary detection

1. INTRODUCTION
The tremendous advancement in the internet technology has led to exponential growth of multimedia technology. Also, the availability of digital cameras at lower cost has resulted in creation of innumerable video repositories. This demands the creation of new technologies to facilitate better video archiving, indexing, browsing and retrieval of videos. Hence, to enable efficient video retrieval and browsing, some interesting techniques have been proposed and attracted researchers in recent years. Shot Boundary Detection (SBD) is an essential preliminary step in content-based video retrieval process. A shot is a continuous sequence of interrelated frames captured between start and stop operation of a camera. SBD is the process of segmenting the video sequence into shots. A video is comprised of several shots combined with abrupt and gradual transitions.

Summarized video is a short summary which reflects significant frames that represents the content of the video. A video summary is represented as a sequence of still images (keyframes/static story board) or unstill images (video skims/moving story boards) (Li et al., 2001). Girgensohn and Boreczky (2000) proposed a novel technique to provide good representation of the whole video by determining keyframes which are different from each other. Compared to keyframes, video skim has got the ability to include audio and motion elements to enhance the amount of information conveyed by the summary (De et al., 2011). However, keyframes are not restricted by any timing or
synchronization issues. Therefore, they offer much more flexibility in terms of organization for the purpose of browsing and navigation. Hence, in recent years, many approaches (Mundur et al., 2006; Gianluigi, 2006) have focused to organize extracted key frames into static video abstracts.

The focus of this work is to generate summarized videos, which is nothing but the collection of keyframes extracted from various shots of the videos. The recent literature in the field of image and video analytics has revealed that the methods based on soft computing techniques have shown better performance when compared to conventional methods. This is because of the fact that the methods based on soft computing techniques can effectively capture the uncertainty and vagueness present in the image and videos. Theory of fuzzy sets (Zadeh, 1965) and Intuitionistic Fuzzy sets (IFS) (Atanassov, 1986) has gained importance in this context. Correlation concept has been investigated to establish linear relationship between fuzzy sets by Chiang and Lin (1999) and IFS by Szmidt and Kacprzyk (2010). This idea has been explored in the current study. Further, it has been revealed by Singpurwalla and Booker (2004) that the concept of probability theory used in modeling uncertainty is inadequate in handling certain kind of uncertainty. Zadeh (1995) has also claimed that “probability must be used in concert with fuzzy logic to enhance its effectiveness”. Possibility theory is one such alternative which empowers probability measure on fuzzy sets (Singpurwalla and Booker, 2004; Dhar, 2013). This statement has motivated the authors to propose this work.

In this work, fuzzy sets and IFS techniques has been incorporated for SBD and keyframe extraction. Triangular and trapezoidal membership functions are explored for the purpose of fuzzification. In SBD phase, correlation coefficient between fuzzified frames is computed. Using global thresholding approach, the abrupt shots are detected. In the subsequent keyframe extraction phase, probabilistic entropy measure is applied on each fuzzified frame of the corresponding shot to obtain entropy features. Finally, the frame that corresponds to the maximum entropy value within a shot is chosen as the keyframe from each shot. The video summary is thus generated by concatenating the selected keyframes from every shot. Extensive experiments are conducted and the results obtained from shot boundary and keyframe extraction phase exhibits good performance when compared with the state-of-the-art algorithms.

Rest of the paper is organized as follows: Section 2 gives a detailed description of the related work. Section 3 presents the proposed methodology covering the details about feature extraction, shot boundary detection and keyframe extraction process. Experimental analysis and results are discussed in section 4 followed by conclusion in section 5.

2. LITERATURE REVIEW

Many researchers have emphasized their focus on video segmentation and summarization process. In this section, some of the interesting works in the literature related to video segmentation and keyframe extraction are presented.

2.1. Shot Boundary Detection

Several attempts have been made by many researchers to propose efficient and effective SBD methods. Approaches based on pixel, histogram, edge, block based, texture etc., are proposed for shot boundary detection. Several major challenges of shot boundary detection are identified and a comprehensive review of existing techniques is presented by Yuan et al., (2007). A simple way to declare abrupt cut is pair-wise pixel comparison proposed by Zhang and Smoliar (1993). Guru and Suhil (2013) present a non-parametric approach for shot detection using color histogram representation of a frame followed by split and merge framework using Fisher Linear Discriminant criterion. Based on edge information, the histogram features are constructed by assigning the binary weights to each sliding window of 2x2 mask of a video frame in overlapping and non-overlapping mode by Rashmi and Nagendraswamy (2016a). The distance between the adjacent histogram values are utilized for shot detection. Many researchers have studied the applicability of texture descriptors for SBD. An extension to basic
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