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Extraction of Key Frames from News Video Using EDF, MDF AND HI Method for News Video Summarization

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***Abstract*— The key frame extraction algorithms aim at reducing the amount of data in video processing. In order to extract valid information from news video, process video data efficiently and reduce the transfer stress of network, more and more attention is being paid to the news video processing technology. The amount of data analysis in news video processing can be greatly reduced by video segmentation and key frame extraction. In this paper a new technique to select and extract key frames from a news video shot has been proposed. Here the key frames or representative frames are selected based on dissimilarity between each pair of consecutive frames. To compare each pair of consecutive frames in the news video shot or to analyze how visual contents are changing frame difference values are computed taking into consideration three visual descriptors. The three different frame difference values are computed using three different formulas. Again, the three frame difference values obtained are combined to form the combined or total frame difference values known as cumulative frame difference. Then a curve is constructed using the cumulative frame differences of each pair of frames to select key frames or the representative frames in the news video shot. From the curve the key frames are selected as those points are the points at the sharpest angles of the curve. Then from the obtained key frames a summarized output video is reconstructed.**

***Index Terms*— Video segmentation, Key frame, Visual descriptor, Cumulative frame difference, Video summary.**

I. INTRODUCTION

Many research efforts have been done in the field of key frame extraction from video since a long time. It started during the era of early 90's with the emergence of video indexing, summarization and retrieval for reducing the transfer stress of network, fast browsing and efficient handling of video. From the last few decades, the multimedia information specially, news video has been increasing very rapidly and again news video is the most informative and challenging since it is a combination of all other media. With the day by day increasing amount of news video, it becomes increasingly difficult to browse and retrieve them for the purpose of selection of appropriate video element. Due to the uncertain length and formats of videos, accessing them still remains a challenge. For video, a common first step is to segment the videos into temporal shots, each representing an event or continuous sequence of actions. A shot represents a sequence of frames captured from a unique and continuous record from a camera. Key frame is the frame which can represent the salient content and information of the shot. The key frames extracted must summarize the characteristics of the video, and the image characteristics of a video can be tracked by all the key frames in time sequence. Key-frame extraction technique is also used for abstraction and summarization. Shots are the building blocks of video. It is defined as a sequence of frames recorded from a single camera. Entire shots can be mapped into a small numbers of representative frames called key-frames. In order to reduce the transfer stress in network and invalid information transmission, the transmission, storage and management techniques of video information become more and more important. Video segmentation and key frame extraction are the bases of video analysis and content-based video retrieval. The use of key frames reduces the amount of data required in video indexing and provides the framework for dealing with the video content. Key frame extraction, is an essential part in video analysis and management, providing suitable video summarization for video indexing, browsing and retrieval. In the project, we are analyzing the performance of other key frame extraction algorithms based on different approaches. Eventually we will compare the results of these algorithms and try to come up with a better algorithm for extraction of key frames from the videos.

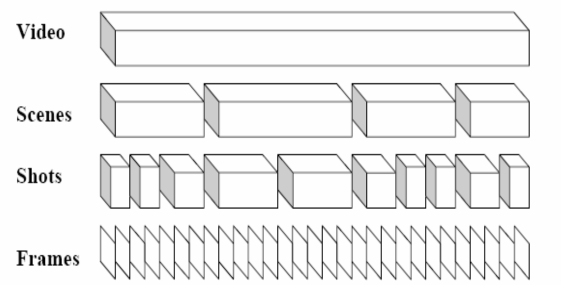

FIG 1: BREAKDOWN OF VIDEO SHOT INTO SUBSEQUENT FRAMES

II. RELATED WORK

A wide number of research efforts have been made in the area of key frame extraction which can be grouped into the following categories:

a) Shot boundary based approach: O'connor et al. used either of the first, middle or the last frame of the shot as the shot's key frame.

b) Motion analysis approach: Wolf first computes the optical flow for each frame and then computed a simple motion metric based on the optical flow.

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c) Visual content based approach. Zhang et al. proposed color and motion features independently to extract key frames. Thresholding technique is used to find the similarity between the current frame and the last extracted key frame.

O'connor's approach have been seen as the most easy way to extract the key frames but it lacks in capturing the visual content of the video shot. Wolf's method was quite appreciable, but computationally expensive due to motion analysis. Zhang's method is relatively fast, but their performance depends on the choice of the threshold by the user. Threshold adjustment proves a serious issue for this method.

A. Clustering technique

There is a Probabilistic Framework of Selecting Effective Key frames for Video Browsing and Indexing [6] where a new strategy to extract the most characteristic frame is proposed. The main idea is to cluster similar or redundant views within the shot together. Clusters are approximated by a mixture of Gaussians using standard Expectation Maximization algorithm. Bayes Information Criterion is used to choose the appropriate number of clusters. From each obtained clusters, the closest frames to the median of its frame is taken to be a reference key frame. The cluster content is then verified against the reference key frame on the variation of time and appearance. Application of temporal filter is done on the set of all selected frames to remove the overlapping between the constructed set of frames. The most distinguishing work of this work is that the selection of key frames is a fully automated process where no user intervention is required in terms of the input parameters. The temporal variation of color histogram in RGB color space is modeled by the Gaussian mixture density. The Histogram approach has been followed in this work due to its simplicity, speed and robustness. The estimated Gaussian models of tracked objects can be used to recognize similar objects for the whole video.

B. A robust algorithm with real time capabilities

There is also a paper on Efficient Key-frame extraction and video analysis [7] where analysis is done on the compressed video features. The paper proposed a real time algorithm for scene change detection and key-frame extraction that generates the frame difference metrics by analyzing statistics of the macro-block features extracted from the MPEG compressed stream. Discrete contour evolution algorithm is applied on difference metrics curve simplification to extract the key frames from the input video. A new approach was suggested in this paper where the algorithm for the temporal segmentation. and the extraction was combined into a robust algorithm with real time capabilities. The initial research was done on evaluating the performance of the main video processing algorithms in the compressed domain using the already existing international video standards: MPEG 1-2, H.263 and MPEG4.Here a general difference metrics is generated and a specific discrete curve evolution algorithm is applied for curve simplification. High accuracy and robust performance under real time environment along with good customization possibility was showed by the proposed algorithm. The future work is to be directed towards performance improvement in terms of speed and preciseness.

C. An approach to extract key frames using K-means algorithm

Another one is Key-frame Extraction for Video tagging and Summarization [8] where unsupervised learning for video retrieval and summarization technique was proposed. The approach uses shot boundary detection to segment the video into shots and the K-means algorithm to determine cluster representative for each shot that are used as key-frames. The new approach is the combination of shot boundary detection and an intra-shot clustering of frames to find an adequate number of representative key frames for the given shot with respect to its visual complexity. The researchers used the MPEG-7 Color Layout Descriptor (CLD) as a feature for each frame and computed the differences between consecutive frames. Adaptive Threshold Technique is used to detect shot boundaries. The nearest frame to the mean of every cluster is used as the representative for the shot after clustering. Bayesian Information Criteria (BIC) is used to estimate the number of clusters. The shortcoming of Shot boundary detection and Intra-shot clustering was found to be the redundancy of the same content by multiple key frames due to the missing inter-shot reasoning. This redundancy occurs when the same artist is shown indifferent shots throughout the video. The researchers directly used the already extracted key frames by previously existing methods and clustered them using the k-means algorithm.

D. Extraction of key frames utilizing the features of I-frame, P-frame and B-frame

In the paper, Key-frame Extraction from MPEG Video Stream [9], where they used an improved histogram matching method for video segmentation. Secondly, they extracted the key frames utilizing the features of I-frame, P-frame and B-frame. Fidelity and compression ratio are used to measure the validity of the method. The researchers proposed a new algorithm for key frame extraction from compressed video data. The proposed algorithm compensates the shortcomings of other algorithms and tries to improve the techniques of key frame extraction based on MPEG video stream. Experiments showed the achievement of good fidelity and compression ratio along with low error and high robustness. The suggested algorithm is based on shot. The first frame is extracted as key frame and the other frames are calculated according to macro block motion when abrupt transitions occur. The average compression ratio of the new algorithm is found to be 99.48% while the average fidelity is .76. Experiments using the algorithm revealed that the representative key frames can be extracted accurately and semantically from long video sequences or video with more transitions, reflecting the whole video in concise manner.

E. Adaptive Temporal Sampling(ATS)

There is an Adaptive Temporal Sampling (ATS) algorithm of [4] in which selection of the key frames is done on the basis of the cumulative frame differences. It computes the color histogram differences on the RGB color space, and plots them on a curve of cumulative differences. The key frames are selected by sampling the y-axis of the curve of the cumulative differences at constant intervals. The corresponding values in the x-axis represent the key frames. More key frames are likely to be found in intervals where the frame differences are pronounced than in intervals with lower values for frame differences. The user needs to set the number of key frames to be extracted which is the only input parameter.

F. Flexible Rectangles algorithm

Another one is the Flexible Rectangles (FR) algorithm of Hanjalic [2] in which color histogram differences are used to build its curve, but the histograms are computed on the YUV color space. The curve of cumulative differences is approximated by a set of rectangles, each of which used to select a key frame. As the widths of the rectangles calculated to minimize the approximation error, an optimization algorithm is required (an iterative search algorithm is used). The input parameter of the algorithm is the number of key frames (and thus of the approximation rectangles) to be extracted. These authors also propose a strategy for deciding how many key frames to select from the shots of the video sequence. In the paper, it is suggested that the frame differences are taken to build a "content development" curve that is approximated using an error minimization algorithm, by a curve composed of a predefined number of rectangle.

G. Shot Reconstruction Degree Interpolation (SRDI) algorithm

There is a Shot Reconstruction Degree Interpolation (SRDI) algorithm of Tieyan Liu[15] where motion vector are used to compute the frame's motion energy. All the motion used to build a motion curve that is passed to a polygon simplification algorithm. This algorithm retains only the most salient points that can approximate the whole curve. The frames corresponding to these points form the key frame set. If the number of frames in the final set differs from the number of key frames requested, the set is reduced or increased by interpolating frames according to the Shot Reconstruction Degree criteria. When the number of frames is lower than the number desired, the shot is reconstructed by interpolating the frames in the frame set, and the interpolated frames that have largest reconstruction errors are retained up to the number of key frames needed. When the number of frames in the frame set is greater than the number of key frames needed, the frames in the frame set are interpolated, and those with the minimal reconstruction error are removed from the set.

H. An optimized Key frame Extraction Scheme based on SVD and Correlation Minimization

In this method by Ntalianis, KlimisS [16] an optimized and efficient technique for key frames extraction of video sequences is proposed, which leads to selection of a meaningful set of video frames for each given shot. Initially for each frame, the singular value decomposition method is applied and a diagonal matrix is produced, containing the singular values of the frame. Afterwards, a feature vector is created for each frame, by gathering the respective singular values. Next, all feature vectors of the shot are collected to form the feature vectors basin of this shot. Finally, a genetic algorithm approach is proposed and applied to the vectors basin, for locating frames of minimally correlated feature vectors, which are selected as key frames. Experimental results indicate the promising performance of the proposed scheme on real life video shots.

I. Extraction of key frames based on a triangle model of perceived motion energy (PME)

Researchers Tianming Liu, Hong-Jiang Zhang and Feihu Qi proposed a triangle model of perceived motion energy (PME) [14] to model motion patterns in video and a scheme to extract key frames based on this model. The suggested key frame extraction process is threshold free and fast since the motion information in MPEG can be directly utilized in motion analysis, while the key frames are representative. The approach combines motion based temporal segmentation and color based shot detection. The turning pointof motion acceleration and deceleration of each motion pattern is selected as key frame.

J. A novel inflexion based key frame selection algorithm using the new SRD criterion

Researchers Tieyan Liu, Xudong Zhang, JianFeng, Kwok-Tung Lo recommended Shot reconstruction degree (SRD) as a novel criterion for key frame selection based on the degree of retaining motion dynamics of a video shot. According to them, the key frame set produced by SRD can capture the detailed dynamics of the shot in a better way as compared to the widely used Fidelity criterion. Using the new SRD criterion, a novel inflexion based key frame selection algorithm is developed. More emphasis is laid on the local detail and the evolution trend of a video shot as the new measure for key frame selection. The basic idea is said to be that if the shot reconstructed by interpolating the key frames can approximate the original shot well, then it can be said that the key frame can capture the detailed dynamics of the shot. Regarding this view, it can be said that the rectangular points are better than circular ones, and such criteria is suggested as SRD. According to the researchers, if all local features of the shot are approximated well, then the global features can also be approximated well. Hence, the key frames which can reconstruct the shot well will also lead to a high fidelity. Based on the SRD criteria, a novel inflexion-based key frame selection algorithm has been developed which led to high performance in terms of both fidelity and Shot Reconstruction degree. Future work in this field demands more human perceptions for the video summarization techniques.

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III. EXTRACTION OF KEY FRAMES

In most of the previous project that have been studied, single visual descriptor is used to compute the frame difference value [1] i.e. to compare dissimilarity between each pair of frames. But single visual descriptor is not sufficient to capture all pictorial details needed to estimate changes in visual content in the frames. For example, the usage of color histogram as a frame descriptor computes the difference between the frames on the basis of color properties, but at the same time, structural differences like position and orientation differences of each object of individual frames are not taken into consideration. Inclusion of the structural properties along with the color properties during the frame comparing process may result into more detailed frame analysis and may provide better frame difference values.

There are many information carriers in a video stream, as is the visual content, the narrative or speech part, possible text captions etc. Visual content remains the most important and the most difficult one to tackle as well. Simply put, video usually contains an enormous amount of visual information, since it could be stream off large number of frames every second with a high resolution and a high color depth. Now, this poses a very important indexing consideration since we only wish to keep a representative frame or key frame from a long scene with little or no change, instead of a few hundred or thousands of frames. The goal of extraction of key frames is to remove the visual content redundancy among the news video shot. The summarized output video is reconstructed using the key frames. Algorithm effectiveness is evaluated using the measures of Fidelity Measure, Shot reconstruction degree and Compression ratio measure.

The proposed key-frame extraction strategy involves computation of frame difference between each pair of frames in the video shots to compare dissimilarity between each pair of frames in the news video shot. In this approach, instead of taking the whole video at once, a video shot is taken at a time and break down into sequential frames. After that, the frame difference value between each pair of frames in the video shots is computed. Now in order to compute the frame difference, three frame descriptors are employed which are:

1. Color Histogram.
2. Edge Direction Histogram.
3. Wavelet Statistics.

Three descriptors are used because single visual descriptor cannot capture all pictorial details needed to estimate dissimilarity in visual content in the frames or simply dissimilarity between frames. The whole discussed method can be broadly divided into two categories:

1. Computation of frame difference.
2. Selection of key frames.

A. Computation of frame difference

Color histograms are frequently used to compare images based on color properties and they are simple to compute. Image Histograms may be defined as the probability mass function of image intensities. Computationally, by counting number of pixels belonging to each color histograms are formed. In the method that has been proposed the difference between two color histogram of two frames is computed using the histogram intersection formula given by:

$$d_H(H_t,H_{t+1})=1-\sum_{j=0}^{63} \min(H_t(j),H_{t+1}(j+1))\ldots(1)$$

Where H_t and H_{t+1} are the color histograms for frame F(t) and frame F(t+1) respectively. To compute edge direction histograms, two Sobel filters are applied to obtain the gradient of the horizontal and vertical axes of the frame. These values are used to compute the gradient of each pixel; those pixels that exhibit a gradient above a pre defined threshold are taken to compute gradient angle than a histogram. The distance between two edge direction histograms is computed using Euclidean distance formula:

$$d_D(D_t,D_{t+1})=\sqrt{\sum_0^{71}(D_t(j)-D_{t+1}(j+1))^2}\ldots2$$

Where D_t and D_{t+1} are the edge direction histograms for frame F(t) and frame F(t+1) respectively .

Multiresolution wavelets are used to provide representations of both spatial and frequency information that are present in image data. The difference between two wavelet statistics is computed using Mahalanobis distance formula.

$$d_W(W_t,W_{t+1})= ((W_t(j) - W_t(j+1))\ S^{-1}(W_t(j) - W_t(j+1))^T\ )^{1/2} \ldots\ldots(3)$$

where j=0 to total number of frames, S is the covariance matrix and W_t and W_{t+1} are the wavelet statistics for the frames F(t) and F(t+1) respectively.

Then the three resulting values obtained from the three methods are combined to form final frame difference measures using formula:

$$d_{HWD}= d_H.d_W + d_W.d_D + d_D.d_H \ldots\ldots(4)$$

B. Selection of key frames

The cumulative frame difference values initially obtained are used to construct the curve which describes how the visual content of the frames change over the entire shot. Significant changes in visual content are indicated by the Sharp slopes in the curve. These cases must be taken into account in selecting the key frames. They are identified in the curve of cumulative frame differences as those points at the sharpest angles of the curve (corner point). The key frames are those corresponding to the mid points between each pair of curvature point. To detect the high curvature points we use the algorithm proposed by Chetverikov. The algorithm was originally developed for shape analysis in order to identify salient points in a 2D shape outline. The high curvature points are detected in a two-pass processing. The algorithm defines as a "corner" a location where a triangle of specified size and opening angle can be inscribed in a curve. Using each curve point *P* as a fixed vertex point, the algorithm tries to inscribe a triangle in the curve, and then determines the opening angle a*(P)* in correspondence of *P*. Different triangles are considered using points that fall within a window of a given size *w* centered in *P*; the sharpest angle is retained as a possible high curvature point. Once the high curvature points have been determined, key frames can be extracted by taking the midpoint between

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two consecutive high curvature points. The algorithm detects a high curvature point within the curve of cumulative frame differences. The first and last frames of the shot are implicitly assumed to correspond to high curvature points. The frames corresponding to the midpoints between each pair of consecutive high curvature points are selected as key frames. If a shot does not present a dynamic behavior, i.e. the frames within the shot are highly correlated; the curve does not show evident curvature points, signifying that the shot can be summarized by a single representative frame.

IV. RESULTS

The extraction of the key-frames is done in a totally automatic way without requiring that the user specifying the number of key frames to be extracted as a parameter. Also it is flexible enough to extract the variable number of key frames. Key frames or Representative frames that are obtained are sufficient enough to represent the original shot with little or no change. Relatively lower numbers of key frames are extracted as compared to the consecutive frames obtained after disintegrating the video shot. The obtained video is able to represent the input video shot in a short and concise manner. In the project, the visually redundant frames were removed which have been termed as the non-significant frames. Variable numbers of key frames are generated depending on the size of the input video shot. By the inclusion of three frame frames descriptors and distance formula, the obtained results generated lesser number of key frames yet they are able to reflect the significant properties of the input video frames. The important part is that the results are entirely based on the visual details of the input video.

Fig 2: Part of the extracted sequential frames from the news video shot

Extracted key frames are shown below and they are sufficient enough to represent the whole original video in a concise manner. The size of any video shot can be reduced to a significant level by the key frame extraction

The main features of the video shot are grabbed efficiently by the extracted key frames which when summarized can represent the whole video in a concise manner

Fig 3 : Parts of the extracted key frames using Cumulative frame difference

Fig 4 : Parts of the extracted key frames using only Euclidean distance formula

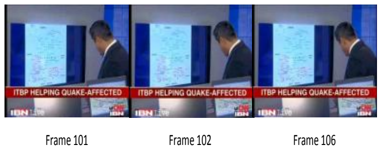

Fig 5 : Parts of the extracted key frames using Thresholding technique

From some parts of the extracted key frames suppose from 93.jpg to 103.jpg the other two algorithms extracts key frames from 102.jpg to107.jpg but the technique that we have proposed extracts key frames from the entire range (93.jpg, 97.jpg, 107.jpg) and it is because of the consideration of three visual descriptors which are **sufficient enough to detect small changes in visual content.**

A. Reconstruction of a summarized output video using the key frames

Summarized output videos are reconstructed using key frames from the three methods. Key frames or the representative frames obtained are enough to represent the whole video shot. The size of any video shot can be reduced to a significant level by the key frame extraction. The main features of the video shot are grabbed efficiently by the extracted key frames which when summarized can represent the whole video in a concise manner. The reconstructed summarized output videos are then compared based on compression ratio, shot reconstruction degree [15] and no of key frames obtained**.**

V. COMPARISON

Table1: Computational time of three algorithms on the five videos:

Video	Thresholding technique	Using only EDF	Using EDF,MDF, HI together
News1	2.86	3.08	2.71
News2	3.97	4.55	3.65

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News3	6.97	7.02	6.34
News4	1.35	1.53	1.42
News5	1.65	1.75	1.55

Table2: Theoritical complexity of the three algorithm:

Technique	Complexity
Thresholding technique	$O(958B)_{+}$
Using only EDF	$O(3P + 9N)$
Using EDF,MDF, HI together	$O(72P + 13N)$

EDF: Euclidean Distance Formula
MDF: Mahalanobis Distance Formula
HI: Histogram Intersection

Table3. Comparison of the three algorithm key frame extraction algorithms used in the experiment:

	Thresholding technique	Use of EDF	Use of EDF,MDF, HI together
Variable number of key frames	Y	N	Y
On-the-fly processing	Y	Y	N
Automatic key frames selection	Y	Y	Y

Table4: Comparison of reconstructed output video based on compresion ratio:

	Compression ratio	No of key frames
Thresholding technique	0.982	889
Use of EDF	0.980	776
Use of EDF,MDF, HI together	0.971	668

	Fid. HST	Fid. HST (mi)	Fid. HST (sd)	Fid. HWD	Fid. HWD (mi)	Fid. HWD (sd)
Threshoding	0.762	0.072	0.236	0.899	0.133	0.203
EDT	0.770	0.072	0.236	0.885	0.184	0.185
EDF+HI+MDT	0.761	0.077	0.236	0.899	0.298	0.184

Table5: Comparison of algorithms based on Fidelity measure computed using the histogram (HST) and the HWD descriptors.

The minimum (mi) and standard deviation (sd) of the Fidelity measures are computed.

Table6: Comparison of algorithms based on Shot reconstruction degree (SRD) measure computed using the histogram (HST) and the HWD descriptors.

	SRD HST	SRD HST (mi)	SRD HST (sd)	SRD HWD	SRD HWD (mi)	SRD HWD (sd)
Thresholding	3.520	2.122	1.350	5.663	3.279	2.357
EDT	3.147	1.714	1.504	6.188	4.296	2.064
EDF+HI+MDT	3.534	2.006	1.504	5.527	3.218	2.273

The minimum (mi) and standard deviation (sd) of the SRD measures are computed.

VI. Conclusion

Variable numbers of key frames are extracted for different input video shot, which indicates the dynamic nature of the code. The code may be used in future for different purposes. Key frames or the representative frames obtained are enough to represent the whole video. The main features of the video shot are grabbed efficiently in the extracted key frames which when summarized can represent the whole video in a concise manner. Relatively lower number of key frames are extracted which reduces the size of the summarized video. The main purpose of the proposed work is fulfilled since the numbers of the extracted key frames are far lesser than the number of sequential frames obtained after the video is broken down initially. Key frames or the representative frames obtained are enough to represent the whole video shot. The main features of the video shot are grabbed efficiently by the extracted key frames which when summarized can represent the whole video in a concise manner. Relatively lower numbers of frames are extracted as compared to the original one which reduces the size of the video. The size of any video shot can be reduced to a significant level by the key frame extraction. . The summarized video is able to highlight the key contents of the original video shot.

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