A Technique for Object Movement Based Video Synopsis

Jeeshna P.V, Kuttymalu V.K.

Abstract— Video synopsis is the process of preserving key activities and eliminates the less important parts to create a short video summary from the long original videos. These techniques are used for fast browsing, extracting big data, effective storing and indexing. The main application of video synopsis is video surveillance. Video synopsis techniques are broadly classified into two types: object based approaches and frame based approaches. Important frames and objects are extracted and viewed as the basic building block of the synopsis, while other less important frames and objects are removed. But these approaches cannot handle the complexity of the dynamic videos. The object movement based video synopsis method focus on the movement of a single video object, and removes the redundancies present in the object movement. It helps to generate the video synopsis. The proposed method is the combination of frame based and object movement based video synopsis will generate more accurate and compact video synopsis. First frame based method will remove the nonmoving frames and object movement based video synopsis handles the moving objects. In object movement based video synopsis method the moving parts are considered as important and nonmoving parts are less important parts. The moving parts are preserved and nonmoving parts are to be eliminated. The basic aim is to work at the level of object part, and to remove the nonmoving parts. This method consists of three stages: Object Movement Partition, Assembling and Stitching. In object partition first segment and track the moving objects with the help of Kalman Filter algorithm and extracts the parts. Partition each object into several semantic parts, which produces several part movement sequences. Remove the object and repair the hole by structure completion method. In assembling select the same number of part movements from each part sequence and moving parts are then assembled frame by frame and nonmoving parts are removed. Finally stitch the assembled parts to eliminate the gaps between the frames, thus the synopsized video is produced. Many researches are going on this computer graphics and computer vision area related to video synopsis.

Index Terms—Video Synopsis, Frame and Object based method, Object movement based method (OMBVS), Kalman filter, MRF, Object movement based method.

I. INTRODUCTION

The amount of digital videos and multimedia technologies are increasing widely and rapidly. Large amount of videos are available on the web. Length and content of these videos are too long. Among these large amounts of data we need browsing, retrieving and indexing. It is time consuming and tedious process, so most of the videos are not watched. For this the important parts are preserved and less important contents are removed from the original video and create a short length video. This process is called video synopsis.

Video synopsis which can effectively reduce memory storage for large amount of videos, while preserving essential activities of original video and produce short summary, it has become an active research topic in computer graphics and computer visualization communities. Nowadays different video synopsis techniques are widely used, which can be divided into two categories: frame based and object based approaches. In frame based approaches [1] key frames are directly extracted and viewed as the basic building components of the synopsis, but other less important frames are eliminated. In object based approaches consider each moving objects and remove spatiotemporal redundancies [2] [3] between the objects. But both approaches cannot handle videos with redundancies in the moving objects themselves.

The complexity of dynamic videos can be resolved based on the movements of a single video objects, and remove the redundancies present in the object movements. It helps to generate the more compact and efficient video synopsis. The main idea of this method focuses on the moving object part and removes the non-moving object part. In this paper object movement video synopsis having three main steps: object movement partition, assembling and stitching. First extract the moving objects using Kalman filter [4], which track and segment the moving objects and moving parts into several semantic parts. Then in part movement assembling [5], MRF is used to select the same number of the important movements from each part movement sequence and remove non moving redundant parts. These selected important parts are assembled frame by frame to get the compact video synopsis.

The assembled parts of the synopsized object movements normally come from different frames, so gaps are found between the adjacent parts. To eliminate the gaps between the parts and objects, shift all the parts in their spatial space using a part movement stitching optimization, which stitches the spatially assembled parts. Based on the three steps, a new synopsized video with object movements are produced that do not exist in the original input video. This method used for online browsing, indexing, retrieval and big data archiving. Video synopsis method in this paper is different from the earlier video abstraction techniques, which explained in Section 2. In this section describes the frame based and object based video synopsis approaches and some other techniques.

Section 3, explains the overview of the method. The technical details of the method presented in section 4, where Section 4.1 describes object partition using Kalman filter, Section 4.2 explains the part assembling, Section 4.3 explains the part movement stitching optimization, and finally produce the synopsized video. Experimental results of the proposed method are in Section 5. The conclusion is in Section 6.

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II. RELATED WORKS

Submit Frame based and object based video synopsis methods are widely in research these days. Frame based methods consider frames as the basic building block for video abstraction. There are mainly two forms of video abstracts: key frames and video skim [1]. Keyframes are also known as representative frames, R-frames, still image abstracts or static storyboard. In this method [6] a collection of important images are extracted from the original video sources.

T.Liu et al. [6] explains key frame approach based on the movement of the dynamic videos. Shot reconstruction degree (SRD) will concentrate on the local and global details of a video shot. Two items are required for SRD, one is similarity function, which describes the similarity between the two video frames and second is frame interpolation function, which is expressed to calculate the distance between the key frames and the whole video shots. SRD oriented inflexion based key frame selection algorithm is used in this method. First find out which feature will mostly affect the SRD of a key frame set. Then select the frames with a sudden change in motion activity will consider as key frames at inflexions.

Shot reconstruction degree will focus the global and local details of the dynamic video. It is better to capture the detailed dynamic shots and performance is good in terms of fidelity and shot reconstruction degree. But this method will lose some contents due to the fast activities and computational cost is too high.

Other than choosing only one frame at a time, video skimming approach [7] is also called moving image abstract, moving storyboard or summary sequences which identify and extract most important video segments from the input video. The video segments are then combined by cut or gradual effect. J.Ouyang et al. [7] presented a new method replay boundary detection (RBD). One of the applications of RBD is the highlighting and replaying scenes of the sports videos. The highlights are the important events in the games and it will preserve spirit of the game. To this, first identify and detect replay boundary directly from MPEG compressed domain video with the help of MBs and MVs. These features are directly extracted from MPEG video, it will avoid the expensive inverse DCT. The inverse DCT is used to transfer values from the compressed domain to the image domain. The rules of macro block and motion vector to detect the replay boundary. The MPEG compressed domain features are macro blocks, motion vector and similar measure function based on static analysis.

The relevant video clips are easily identified and edited with replay boundary detection method. The performance of this method is faster than the real time decoding with the help of macro blocks and motion vectors. But this system is not suitable for large amount of data. It cannot recognize the fast moving objects and cannot distinguish the gradual changes.

In frame based method [8] select the most significant frames from the video, without losing the content by decreasing the potential distortion technique. In this method first, compute the color layout descriptor for each frame of the input video. Then estimate the shot detection. Based on the shot detection and a parameter value, the number of frames per shot is calculated. Finally video distortion is sequentially minimized to produce the video synopsis. The video is divided into shots and the number of synopsis frames per shot is computed based on the visual content variation. Next, select the significant frames, and then the visual content distortion between initial video and synopsis video is minimized.

The main advantages of frame based method are simple and efficient. It is widely used in many applications in image or video industry. But in this method consider a frame as a whole; they usually suffer from losing speed activities in the video. The empty space in the frames are more in frame based method , so many methods work on the moving object based approaches [2] [3].

In object based approach first extract the objects from the video and segmented into space time ’tubes’. The energy function will preserve the original activity of the video, while eliminating collisions between different shifted activities. In these object based methods, shift objects in time and produce new synopsis frames that never appeared in the input video sequence in order to make better use of space and time. The main application is surveillance.

Yael Pritch et al. [2] specified that the extracted object from the video are treated as 3D tubes, and shifted along the time axis to remove temporal redundancies among the objects. In video synopsis the activity in the video is preserved into a shorter period by simultaneously showing multiple activities even when they occur at different times. The video synopsis is also an index of the original video by focusing to the original time of each process. To generate a synopsis of endless video stream process are two major phases: online phase and response phase. Online phase runs parallel to the video capture and recording, so it does not delay the second phase. This phase moving objects are detected, tracked and finally entered as metadata into the object queue. When reaching a space limit the objects are removed from the object queue. Second response phase will generate the video synopsis as a response to the user’s query. Smaller or older objects are considered as less important and such objects are removed and other objects with higher importance are taken.

These methods have efficient activities in the video sequences and effective indexing. It enables the use of object constraints and reduce the temporal redundancy among the objects but doesn’t satisfy spatial domain. This method is less applicable in dense activity applications. Editing and change the chronological ordering is too difficult, so complexities of the dynamic videos are less.

Shifted objects not only in the temporal domain but also in the spatial domain. Y. Nie et al [3] method satisfies spatial as well as temporal optimization. In this approach expanded more motion space for objects and achieved more compact video synopsis. The basic idea is to globally shift the moving object in both spatial and temporal domain. The shifting objects temporally reduce the length of the video and shifting colliding objects spatially to avoid visible collision artifacts. The multilevel patch relocation method is to produce the compact background, in which it removes the visual artifacts for increasing the movement space of shifted objects based on the environmental context. Finally, fuse the shifted objects into the compact background to produce the final video

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synopsis.

These video synopsis structures consist of four stages. First, analyze the input video and extract the background and moving objects from the video. In second stage, shift active objects in the spatiotemporal video volume by using the global spatiotemporal optimization, which find the new positions in the synopsis for clustered objects. Third stage, using a multilevel patch relocation method, synthesizes a compact background with the scene-path context to fit the clustered objects. Finally, fuse objects into the synthesized compact background using a gradient-domain editing tool and produce the compact video.

This method will reduce the spatiotemporal redundancies of the input video as much as possible. It will preserve the chronological consistency of the important events; it will help to reduce the collision between the moving objects. This method is used for efficient browsing for the huge video data sets. But it will fail to produce the video synopsis in the crowded activity in both spatial and temporal domain. The spatiotemporal optimization stage has no interaction with the background. As a result, even if the spatiotemporal optimization works well, the background synthesis will fail to produce a consistent result. The object based approach can remove spatiotemporal redundancies, to preserve key moving objects rather than static scenes. But these methods doesn't handle video with redundancies existing during the movement of a single object.

J.Assa et al. [9] expressed action synopsis method, which selects important motions of objects from the motion sequence and represented in a still image. In [9] method first selects important poses based on the animation sequences of the skeleton, to express complex motions in a single image or a small number of concise views. This method is to embed the high-dimensional motion curve in a low-dimensional Euclidean space, where the main characteristics of the skeletal action are kept. The lower complexity of the embedded motion curve allows a simple iterative method which analyzes the curve and locates significant points, associated with the key poses of the original motion and produce the synopsis view. Pose Selection and Illustration based action synopsis satisfies the object movement but the structure recovery is not possible and fast movements cannot correctly identified.

For segmenting and tracking foreground objects from video is the difficult task. Many techniques are available for video tracking and segmenting. Video tracking is the process of locating a moving objects. Two major components of video tracking systems are target representation, localization and filtering, data association. Target representation and localization systems having blog, kernel, contour, visual feature matching and particle filter tracking algorithms. Filtering and data association systems having kalman filter and particle filter algorithms.

The hard segmentation like graph based methods [10] produce good results with non trivial user interaction. Soft segmentation such as video matting [11], in which paste the extracted object into a new background. Agarwala et al. [12] use the rot scoping method which tracks contours in video sequences with some user interaction. In this paper Kalman filter algorithm used to track and segment moving objects into different parts without any user interaction.

III. System Overview

Object movement based video synopsis has three steps: object partition, assembling and stitching. In Object partition, extract the moving objects and parts from an input video. Using Kalman filter (KF) the moving objects and parts are identified. Each identified parts and objects are partition into several parts.

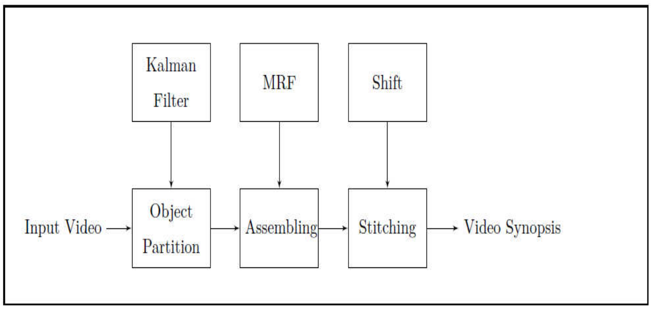

Fig 3.1: Scheme of object movement based video synopsis architecture.

In the assembling, the same number of moving parts from each sequence is selected and assembled frame by frame to produce the synopsized object movements. When selecting the most important part movements, we should satisfy two requirements i.e. spatial compatibility and chronological ordering. The part selection and assembling are solved by Markov Random Field (MRF) and Loopy Belief Propagation (LBP). After the part assembling step the most important moving parts are kept and nonmoving parts are removed successfully. After the assembling process, the assembled parts are not accurately stitch to each other, their having some gaps between each part because each part are chosen from different frames of the input video. Finally in the stitching, assembled parts and objects are stitch together to eliminate the gaps between them, which produce the spatiotemporally continuous and efficient synopsis.

IV. Object Movement Based Video Synopsis

Three stages of object movement based video synopsis are object partition, assembling, and stitching. This method effectively removes redundancies during the movement of a single video object. The basic idea is to work at the level of object part, and to remove the non moving parts.

A. Object Partition

Object partition using Kalman Filter

First step of object partition is to segment the moving objects into different parts. These different parts are used in the next steps. First automatically track and segment the moving objects from the video. It is very difficult in hard segmentation methods [12], because it needs more user interaction to get the accurate result. In contour tracking methods, user track and draw control curves around the moving object which also needs more user interaction. In this paper, Kalman filter [4] method is used o track and partition the moving object and its parts, which needs limited manual inputs.

Feature based Kalman filter is used for object tracking. This method is completely automatic and no need of user inputs in tracking process. To handle the confusing situations occlusion and merge methods are applied. Kalman filter is to

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identify object movements, based on the current object's position to the predict object's position, so it will reduce the search time and achieve fast tracking. Movement based object tracking is divided into two parts: detecting moving objects in each frame, which detect and extract moving objects using a background subtract algorithm based on Gaussian mixture models. To eliminate noise, morphological operations are applied to the resulting foreground mask. Finally blob analysis finds out the group of connected pixel, which are corresponding to moving objects. Association of detection to the same object is based simply on movements. The movement in each track is finding out by a Kalman filter. The kalman filter is used to predict the track's location in each frame, and assign each detection into each track. In track maintenance some detection are assigned to tracks and other detections and tracks may remain unassigned. The assigned tracks are updated using the corresponding detection and unassigned tracks are invisible and it begins a new track.

Background Extraction and Partition Boundaries

After an object into several parts, then in this section compute and keep partition boundaries between adjacent parts. Boolean operations are used to solve this partition problem. To get the background, first we can extract the foreground objects. Then remove the foreground object and repair the hole by image completion method [13] which is called structure propagation. User manually specifies important missing information by extending a few curves or line segments from known to the unknown regions. Structure propagation is formulated as a global optimization problem by enforcing structure and consistency constraints. If there is a single curve, then dynamic programming method is used, while multiple intersecting curves are present, then adopt Belief propagation algorithm to complete the structure. After completing structure the remaining regions fill using patch based texture synthesis. Logical AND operation is used between the each part movement to get the partition boundary of each part. Kalman filter will also ensure to preserve the faster important moving parts.

B. Markov Random Field for Assembling

After the object partition phase we get a sequence of moving parts. Choose the same number of part movements from each part sequence, and assembled them together frame by frame to produce synopsis. The non moving parts are eliminated. The selection process solved by MRF [5] should satisfy the following properties: (1) Synopsis video length is less than input video. (2)Preserve the important moving parts. (3)Spatial and chronological orders are preserved.

The graph $G = \{V, E\}$ is the connection relationship between object parts, where V is a set of nodes, E is a set of edges linking the nodes and K is the kind of object partition parts. There are two types of edges: spatial edges and temporal edges. Spatial edges connecting different type of nodes on the same frame and temporal edges connect same type of nodes on the adjacent frames. The joint probability [5] of the part movement assembling problem as:

$$P(X) \propto \prod_{i,k} \Phi(x_k^i) \prod_{i,k\binom{j}{l} \varepsilon N \binom{i}{k}} \psi(x_k^i x_l^j) \text{ ------------------ (1)}$$

Where the term $\Phi(x_k^i)$ will keeps the important moving parts. It is the convolution of χ(.) and Gaussian filter e. The χ (.) is the importance value of the moving parts, which ensures that the locally most important moving parts are selected rather than the globally important parts.

$$\Phi(x_k^i) = \chi(x_i^k).e^{-1/2(x_k^i.M/N-i/\sigma_\phi)^2}$$

Term $\psi(x_k^i x_l^j)$ preserves consistency between moving parts that are placed at spatially or temporally adjacent nodes.

$$\psi(x_k^i x_l^j) = \begin{cases} S(x_k^i x_l^j); if i = j, l \in SN(k) \\ T(x_k^i x_l^j); if k = l, j \in TN(i) \end{cases} \text{ ------- (2)}$$

The spatial domain $S(x_k^i x_l^j)$ encodes compatibility between assembled parts and temporal domain $T(x_k^i x_l^j)$ ensures the chronological order of the moving parts. The spatially adjacent nodes are *SN*(*k*) and temporally adjacent frames are *TN*(*i*). The spatial compatibility is,

$$S(x_k^i, x_l^i) = e^{-1/2(D_L(c_k^i, c_l^i)/\sigma_L)^2}.e^{-1/2(D_C(c_k^i, c_l^i)/\sigma_C)^2}$$

Thus the temporal compatibility is,

$$T(x_k^i x_l^j) = \begin{cases} e^{-1/2(x_k^{i+1} - x_k^i/\sigma_T)^2, x_k^i < x_k^{i+1}} \\ else;0 \end{cases}$$

4.2.1 Stitching Optimization

This step is used to stitch the assembled parts [5] to eliminate the gaps between the images. The moving parts on the same frame of synopsis comes from different frames of the input video, they may not correctly stitch with each other. Shift the parts by the spatial domain, and to stitch the moving parts together. The shifting vectors are computed via part movement stitching, whose objective function is the linear combination of three weighted energy terms, $E = \omega_d E_d + \omega_t E_t + \omega_s E_s$ where, ω_d, ω_t and ω_s are weights. The term E_d will prevents the moving parts from too far shifting. Term E_t will ensure temporal coherence of moving part after shifting, and E_s to reduce gap between assembled moving parts, .

The result after shifting the moving parts by part stitching optimization. The gaps among the moving parts are almost eliminated. But the boundaries do not exactly match with each other, there are small gaps between moving parts. To remove the small gaps, move the boundary of a moving part to overlap with the other boundary, and deform the rest of the parts. Then the small seam disappears and final synopsized result without gaps will obtain.

V. Experimental Results

In this section, the experiment results and comparison with other methods are presenting. Four different videos are downloaded from YouTube and cartoon movies. The length of the original video is greater than the video synopsis results. The input video having thousands of frames, while the synopsis is relatively shorter. The four different videos with different frames and different object parts are to be used. Table 1 show the experimental results based on the four videos.

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Table 1: Experimental results of object movement based video synopsis.

Video	Input Video				Object Movement Based Video synopsis		
	Duration/ Length (Sec)	No. of frames	Size (KB)	Dimension	Duration/Length (Sec)	No. of frames	Size (KB)
Surveillance	32	928	1810	262*320	4	126	66
Flower Growing	20	990	900	144*192	3	100	20
Talky Tom	12	285	710	720*1280	2	85	371
Dora	10	300	485	144*192	1	40	13

The table shows the input videos and object movement based video synopsis results. The duration of the video synopsis is shorter than the input video.

A. Comparison

Figure 5.1: Surveillance video; First row shows video synopsis of frame based method [8], second row shows a result obtained by combining frame based and object movement based video synopsis.

The proposed method is compared with the frame based and object based methods. In surveillance video, input video with 928 frames is divided into three sections: In the first section from frame 129 to 520 the man is walking along the street from left to right. In second part from frame 521 to 781, the car is arrived from the right side, crossing the man and finally park it at center. Third section from frame 781 to 877 a truck coming from left side. In figure 5.1 first row shows three frames of video synopsis with 165 frames based on frame based method [8], second row shows a result obtained by combining frame based and object movement based video synopsis. Combination of this method with others to generate good video synopsis results. The unimportant frames on the input video is removed using frame based method [8] and three stages combine together with the help of OMBVS method. Then the truck, car and person will arrive simultaneously and obtain a good result with 126 frames.

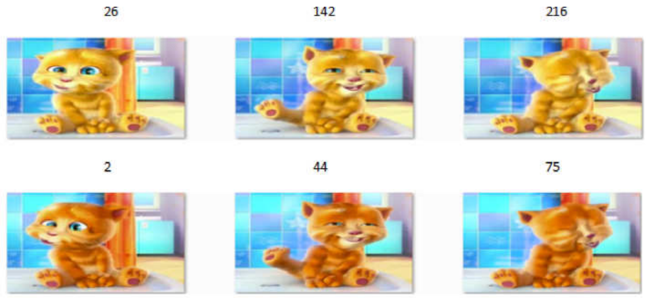

Figure 5.2: Talky Tom; First row shows video synopsis of frame based method [8]. Second row, remove the repeated movements and obtain a synopsis by the proposed method.

The input video talky tom (cartoon) with 300 frames, the cat first moves its head right, then left and then its right leg. When the head is moving towards right, the other body parts are static. The right leg is moving towards right, and then left leg and head are static. In figure 5.2 first row shows three frames of the frame based [8] video synopsis with 216 frames. The frame based method [8] will remove the whole frame when a small portion of the frame is moving. Second row shows the proposed combination of frame based and object movement based video synopsis with 75 frames. First remove the nonmoving object frames. Then OMBVS method selects the important movements existing in each part, and assembles them together to get synopsized object movements. First divide the objects parts: head, body, right leg. Directly remove the repeated part movements i.e. inner and inter part redundancies and produce a compact video synopsis.

In growing flowers video input with 990 frames, in the video one flower is already blooming and the second flower bloom from frame 17 to 548. Then the third flower blooming from frame 549 to 990. In figure 5.3 first rows shows a time lapse growing of flower by frame based method [8]. The input video will compress into a shorter video with 193 frames. By this method fast forward tool is applied to entire frame. But the synopsis result is unnatural, because only accelerate the slow object and not consider fast moving objects. In OMBVS the flowers bloom together with 89 frames. Object based fast forward can speed up the slow objects and bringing all moving objects to a uniform velocity, so its accurately eliminates the time difference of growing the flowers and result is natural and improve the temporal compression rate.

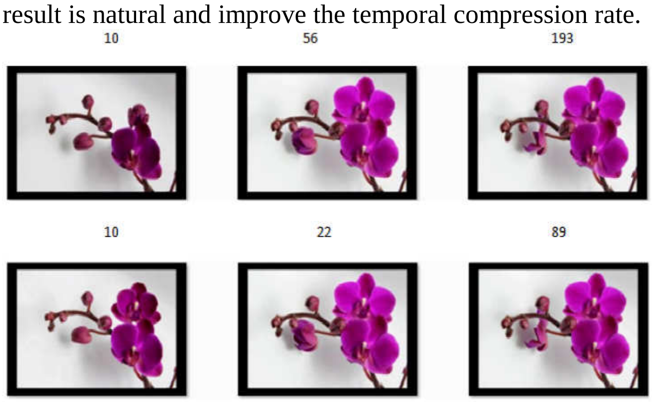

Figure 5.3: Flower Growing; First row shows a time lapse growing of flower by frame based method [8], but it is unnatural. Second row shows the obtained synopsis by frame based and OMBVS method. The flowers bloom simultaneously and it is natural.

Figure 5.4: Cartoon: Adventure of Dora and Buji; First row represents the object based method [2], Dora and Buji speak together, it is not realistic. Second row shows object movement based video synopsis each object separately to produce a synopsis [2], and preserve the chronological order of speakers.

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Proposed method compare with object based method, the input video with 300 frames shows a common cartoon conversation between dora and buji. First dora talks, then buji replays. In figure 5.4 first row shows the object based [2] method, which shifts the movements of buji forwards along the time axis, making the dora and buji speaking simultaneously which is not realistic. OMBVS method condenses each object separately by reduce redundancies present in objects themselves, and produce a synopsis with 40 frames. It keeps the chronological order of dora and buji. The proposed method will produce compact video synopsis and result is natural.

The results of four different videos consist of different duration. Based on the table 5.2 the graph 5.5 is plotted. From the experiments input videos varies from 8 sec to 38 sec. When the number of frames increased, duration or length of the video also increases. The synopsis of frame based method varies from 3 to 10 sec. The duration of object movement based video synopsis varies from 1 sec to 4 seconds, which is very shorter than the frame based video synopsis and input videos.

Table 2: Comparison Results

Number of Frames	Duration (sec)		
	Input Video	Frame based video synopsis	Object movement based video synopsis
100	8	3	1
200	11	5.7	2
300	12	8.3	3
400	32	10	4

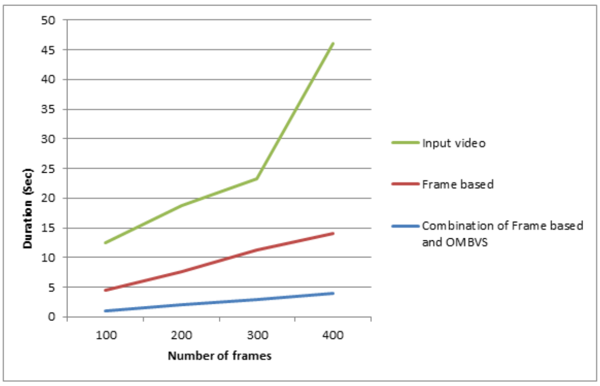

Figure 5.5: Graph of proposed video synopsis and frame based video synopsis.

OMBVS is better than frame based method, because it effectively reduce redundancies present in the part movements of object. The object based video synopsis can't deal with videos with only one object. The frame based methods remove the frames between two key frames, thus many motion details are lost, leading to rushing artifacts. OMBVS method assembling the important moving objects and different object parts simultaneously, then the synopsis become compact and also preserve most relevant movements of each part. There is no single method to effectively condense all kinds of videos, so the cooperation of the frame based and object movement based methods can obtain a better video synopsis result. Advantages: The proposed method eliminates redundancies present in the part movements of object, which cannot be eliminated by the frame based and object based approaches. The frame based approach delete a frame as a whole when a small movement occur on the frame while the object approach simply cannot deal with videos with one object. With the help of OMBVS method inner part and inter part redundancies present in the moving parts are removed and preserve the important motions. To eliminates the time difference between the actions, and make them simultaneously. It also retains the chronological order and spatiality.

Limitations: The limitations of the proposed method are damaging the structure of the object because the basic building block is object parts. The large scale movements, 3D movements, dynamic backgrounds and overlaps between the parts are challenging to produce the good synopsis results.

VI. Conclusion

Users prefer briefer and compressed important contents without eliminating the essence. This is achieved through the video synopsis. The synopsized videos will be retain only important objects, so it can effectively reduce the memory storage for large video sets. Two type of video synopsis are frame based and object based. In frame based approaches the less important frames are removed. In object based approaches eliminate the spatiotemporal redundancies between the objects. These approaches can't handle the redundancies in the moving objects. This complexity will be reduced using the object movement based video synopsis. The part based redundancies are widely existed during the movement process of video object. Assembling important moving object parts on the different frames combine together and produce video synopsis. The cooperation of frame based methods with OMBVS method will produce compact video synopsis. Frame based methods will remove the nonmoving frames and OMBVS will focuses on the movements of a single object and eliminates the less important parts present in the object movements and retain the spatial and chronological order. Object movement based video synopsis will also eliminate the part based redundancies and successfully generate more compact video synopsis. The proposed method generate compact video synopsis but it doesn't handles the large scale, 3D movements, dynamic background and overlaps between the parts. The future work focus on the dynamic background instead of static background and handles the large scale, overlaps and three dimensional movements.

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