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Video Stabilization Using Block Based Motion Vectors

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ABSTRACT:In recent years, from teenagers to adults use advanced multimedia devices (camcorders, Personal digital assistants, mobile phone cameras, Tablets, etc)for taking pictures and videos. Due to handshaking of user, cameras placed on moving platform cause some undesirable motion effects, and vibrations in videos. Thus, to acquire good quality video it needs video stabilization. The digital video stabilization aims at getting rid of undesirable movements, unwanted jiggle, poor quality and video. There are various video stabilization techniques are developed with many algorithms & methods. The paper presents a block based algorithm the motion estimation and video stabilization. This paper focuses on Full search or Exhaustive Block Matching Algorithm (EBMA). Block Based approach divides each frame from video into macroblocks and matches current frame with the previous frame from the video sequence. Applying the block matching criteria such as Sum of Absolute Difference (SAD) we acquire difference between two frames. Using proposedblock matching algorithm, motion vectors are calculated. The stabilized video is achieved by applying steps such as Motion Estimation (ME), motion vector validation, motion Correction (MC) by padding and histogram equalization and at final stage motion compensation is done. With the use of video stabilization quality standards such as PSNR & ITF, we can plot graph and analyze the proposed algorithm.

KEYWORDS: Exhaustive Block Matching Algorithm (EBMA), Block Matching, Sum of Absolute Difference (SAD), Macroblocks, Motion Estimation, Motion vector, Video stabilization.

I.INTRODUCTION

Due to increasing popularity of many applications such as hand held devices like unmanned aerial vehicle (UAV) systems, webcams, smart phone cameras, digital cameras, , aerial surveillance systems, the video processing has gained high importance. But, due to handshaking of user, cameras placed on moving objects or vibrations due to moving objects in the scene causes some undesirable motion effects, jitter, blur and vibrations in videos which makes it unstable. Therefore to acquire good quality video to get rid of undesirable motion it is desirable to apply digital video stabilization algorithm. Digital Video stabilization techniques have been developed and studied for decades for better visual quality of video sequences. Video stabilization deals with object motion and camera motion. Video stabilization approaches can be classified as Hardware approach and post processing approach. In Hardware approach, motion sensors or mechanical devices such as gyros, accelerometers, mechanical dampers are used for providing stability to the camera. Optical image stabilization (OIS) method uses Hall sensors, CMOS sensors. This method of stabilization is expensive but its computational complexity is low. Post processing approach of video stabilization includes object tracking stabilization which deals with tracking of person, vehicle, any object. While Digital Video stabilization (DVS) is the latest trend among them. This approach estimates motion and by generating motion vectors, we achieve stability in video sequence and can get better video quality. In this paper, the proposed method is based on DVS with block based algorithm. Removal of unwanted, parasitic vibrations in video induced by camera motion in video sequence is an essential part of video acquisition in broadcasting as well as for industrial and consumer applications. Use of Digital Video Stabilization (DVS) leads to improve video quality.

In this paper, we focus on the block based algorithm for video stabilization. Digital video stabilization algorithm pipeline, are made up of two principal units: Motion Estimation (ME) and motion correction (MC) units. The ME unit estimates Local motion vectors (LMVs) and validates them, while Global motion vectors (GMVs) are generated between every two consecutive frames of input video sequence in this unit. MC unit corrects motion with the help of padding and histogram equalization method. Calculated motion vectors are kept in certain range this process is called

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as padding. Histogram equalization of motion vectors tries to uniform these motion vectors. In motion compensation macroblocks are adjusted according to motion vectors to obtain stabilized frame. In block based algorithm, particular size of macroblocks is defined and for certain search range,motion vectors are calculated. Using Sum of Absolute Difference (SAD) cost function, we acquire difference between previous frame and current frame of the video sequence. Experimental results show good performance for the proposed DVS algorithm.

II.RELATED WORK

In past few years, researchers have developed and experimented various algorithms for video stabilization. Matsushita et al. [6], explored direct pixel based full frame video stabilization method with motion inpainting. In this method affine motion model was used for estimation and for smoothen camera motion Gaussian kernel filtering was used. Motion estimation (ME) is the foundation of any video stabilization algorithm

A robust block-based image/ video registration approach for mobile imaging device was explored by Battiato et al. [7]. With the use of some simple rejection rules he estimated Interframe camera transformation parameters from local motion vectors (LMVs). To stabilize video frames, in this registration approach they used motion estimator, filters and error matrix. The whole work was tested on ARM device and achieved stabilized video sequence for the real time performance. Cai et al. [2] developed and tested camera motion estimation algorithm using histograms of local motions for mobile platforms. By considering highest peak in each histogram of local motions, they sorted arrays to implement and to avoid selecting the number of bins for histogram.

A fast and robust method for video stabilization was proposed by Okade et al. [8] for a novel compressed domain framework As an enhancement in the development, they utilized wavelet analysis for estimating the camera motion parameters from block motion vectors. This method was efficient and better in case to avoid computational complexity. For removing high frequency jitters, Rawat and Singhai [5] proposed adaptive motion smoothening method. This algorithm achieved stability for worst and large motion videos in which multiple moving objects were present in the scene or a frame. Manish Okade et.al [10] developed robust learning based camera motion characterization scheme for stabilizing video sequence. The experimental validations were carried out using exhaustive block matching algorithm (EBMA) of motion estimation as well as H.264/AVC and reduced processing time for stabilizing video sequence.

III.PROPOSED WORK

The flowchart of the proposed digital video stabilization System is depicted in fig. 1. The details of proposed system are described in the sequel.

A. Motion Estimation (ME) Unit:

Motion Estimation is heart of DVS system. The motion of any pixel between two consecutive frames can be estimated either by global motion or by local motion. Global motion occurs due to camera motion but in local motion object in the scene is in motion. In case of non-stationary camera or for small motion of the object, motion is estimated by a global motion model. In this paper, the global motion is estimated by the DVS system based on block motion vectors.The LMVs are estimated based on block matching using a standard criterion of Sum of Absolute Difference (SAD). A global motion vector is computed for each video frame based on validated LMVs. GMVs represent camera motion during the time interval of two frames.

In the proposed method, we are using Full search or Exhaustive Block Matching algorithm with full pixel resolution which takes over the whole search range to achieve high PSNR and reliable motion vectors. Block based Method is very efficient method for video stabilization.In this block based approach each video frame gets divided into macroblock (size: 16*16). Macroblocks of current frame and previous frames in a particular video sequence are matched on the basis of block matching criteria; here we consider it as Sum of Absolute Difference (SAD).

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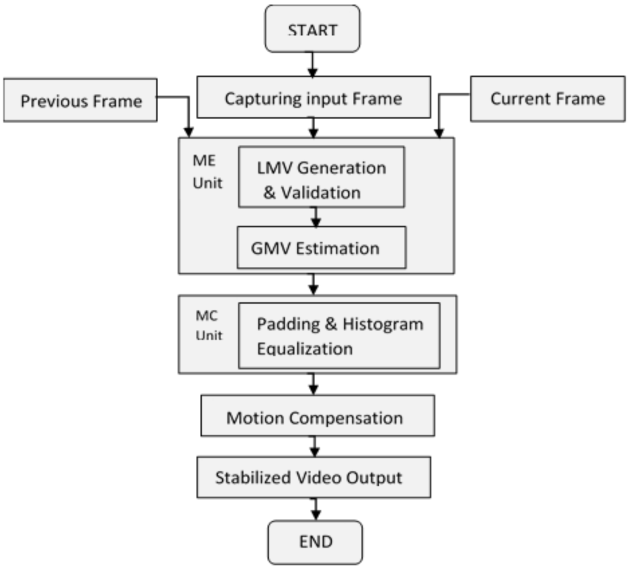

Fig.1: Flowchart of Digital video stabilization using block based algorithm.

Minimum is the value of SAD, we get the best match of macroblocks. We use Full search Algorithm as it gives best PSNR (Peak Signal to Noise Ratio) and ITF (Interframe Transformation Fidelity) but no. of search points are high compared to other block matching algorithms. Block matching criteria SAD is applied over the frame from left to right and top to bottomwithin the search range.MSE, MAD, PSNR and ITF are the video stabilization quality standards [1] which are used for our proposed method.

B. Motion Correction (MC) Unit:

In motion estimation unit motion vectors were calculated. There were some distortions or shaky movements present in the frame, thus motion correction unit is another important stage in DVS system. There is certain desired motion vector range to get minimum displacement of motion vectors within the frame. In this unit, Motion is corrected applying padding & Histogram method to the consecutive frames. Padding is the process of keeping motion vectors within certain search range applied over the frame. Histogram equalization method equalizes these motion vectors and makes them uniform. Padding & Histogram equalization of motion vectors arrange motion vectors within certain range and uniformly distribute them.

In padding method, the peripheral part of block gets copied to form a new column and row to its adjacent area. While, in the histogram equalization uniforms motion vectors to simplify motion compensation procedure. The idea comes from a well-known procedure of histogram equalization to improve contrast of an image. In this procedure, brightness or darkness which has been accumulated at particular region is made uniform to improve the contrast of an image. In the similar manner, maximum of the motion vectors will be made uniform.

C. Motion Compensation Unit:

Motion compensation is a combination of reconstruction of frames and compensation for prediction error. First of all reconstruction of the frame according to motion vectors obtained through ME and MC units. In reconstruction of frame, first of all, macroblock in previous frame is simply copied to same position in current frame. And then according to the motion vectors obtained from previous procedures it is shifted to a new position in current frame. This procedure is done over all the macroblocks to reconstruct current frame.Suppose, if any new object comes into the scene in the current frame which was not present in the previous frame, then SAD values over the macroblocks in the region of new object suddenly goes very high which should be as minimum as possible. Hence, the current frame is unable to find its matching macroblock in the previous frame. This is called as prediction error. The motion estimation and motion compensation jointly compensates this prediction error.

The motion estimation calculates the difference between the previous frame's pixel value and that of current frame consisting of new object. (i.e. the frame which would have been considered as the current frame if new object would not have come into the scene)And in motion compensation process, it adds the obtained difference in motion estimation

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process to the pixel value of current frame with that new object to form new current frame compensating the prediction error.

IV.RESULTS AND DISCUSSION

MATLAB2014b is used on Intel core2 Duo CPU running with 2GB RAM for testing different video sequences. The Block motion vector field is generated by Exhaustive Block Matching Algorithm (EBMA) considering the resolution of input and output frame in GUI = 320x 240,block size = 16 x16, search range -7 to +7, video format = .aviformat and cost function set to SAD for any number of frames. Plot function in MATLAB is used to obtain graph. Every video is tested with different frame numbers. The video sequence of "Fly On Leaf" and "Shaky Car" are used for testing purpose and the results are shown.

(a) (b)

Fig2:(a) Unstable input frame (b)Stable output frame for "Fly On leaf" videoframe.

Fig. 2(a) shows unstable input video frame which is a fly on leaf. This unstable input when applied to the proposed method, we get stable output frame shown in Fig. 2(b). As a result, we can compare both frames and plot a graph for ITF values Vs frame number. We also have provision to calculate ITF average of nonstable video and stable video.
ITF of output video is compared with that of unstable i.e. shaky input video at particular frame and the graph plotted shows results for all frames. In Fig.3 it can be seen that ITF of output video is much more than that of input unstable video frame in almost all frames in video sequence.

Video Sequence	***No. of frames***	***Average of ITF of Input Video***	***Average of ITF of output Video***
Fly on leaf	10	22.29	25.76

Table I .ITF Of Input and Output video: Fly on Leaf

With reference to the input and output video frames and the graph plotted,Table I shows total no. of frames and average ITF values for input and output video sequence.We can conclude from the table above that more the value of avg. ITF of output video, more stable is the output. We have successfully stabilized the unstable input video.
The fig. 3 shows Bar graph plotted for ITF vs frame number. Dark blue bar shows non stable ITF values and the cyan color shows stable ITF value of video. Here, we have considered 10 frames from video sequence.Thus, for each frame it shows that,we have gained stable video ITF value is more than that of the unstable ITF value per frame.

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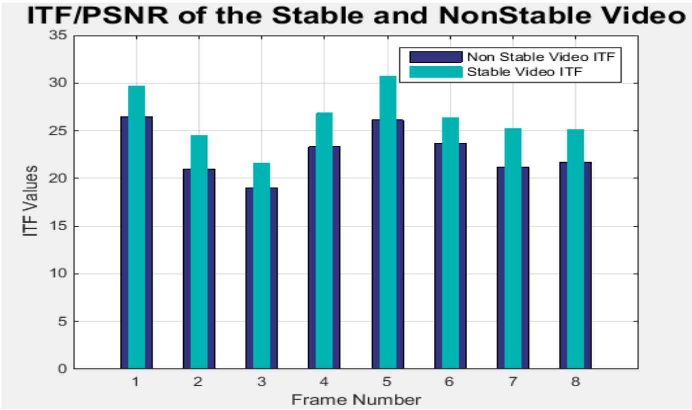

Fig. 3:Comparison of ITF of stabilized and Non-stabilized Video over each frame.

Fig. 4(a) shows unstable input video frame which is a shaky car. This unstable input when applied to the proposed method, we get stable output frame shown in Fig.4(b).

(a) (b)

Fig 4:(a) Unstable input frame (b)Stable output frame for "Shaky Car" video frame.

Total numbers of frames in this "Shaky Car" video are 132. Our algorithm stabilizes shaky frames among all these frames and gives stable output and the respective ITF graph. Fig 4(b) shows black edges outside the stable frame which indicates motion compensated area of the shaky frame.As a result,we can compare both frames and plot a graph for ITF values Vs frame number. We also have provision to calculate ITF average of nonstable video and stable video.

ITF of output video is compared with that of unstable i.e. shaky input video at particular frame and the graph plotted shows results for all frames. In Fig. 5, it can be seen that ITF value of output video is much more than that of input unstable video frame in almost all frames in video sequence.

Video Sequence	***No. of frames***	***Average of ITF of Input Video***	***Average of ITF of output Video***
Shaky Car	132	23.66	27.66

Table II .ITF Of Input and Output video: Shaky Car

With reference to the input and output video frames and the graph plotted,Table II shows totalno. of frames =132 and average ITF values for input and output video sequence.We can conclude from the table above that more the avg. Value of ITF, more stable is the output. We have successfully stabilized the unstable "Shaky Car" input video.

The fig. 5 shows Bar graph plotted for ITF vs frame number. Dark blue bar shows non stable ITF values and the cyan color shows stable ITF value of video. Here, we have considered 132 frames from video sequence.Thus, for each frame it shows that, we have gained stable video ITF value is more than that of the unstable ITF value per frame.

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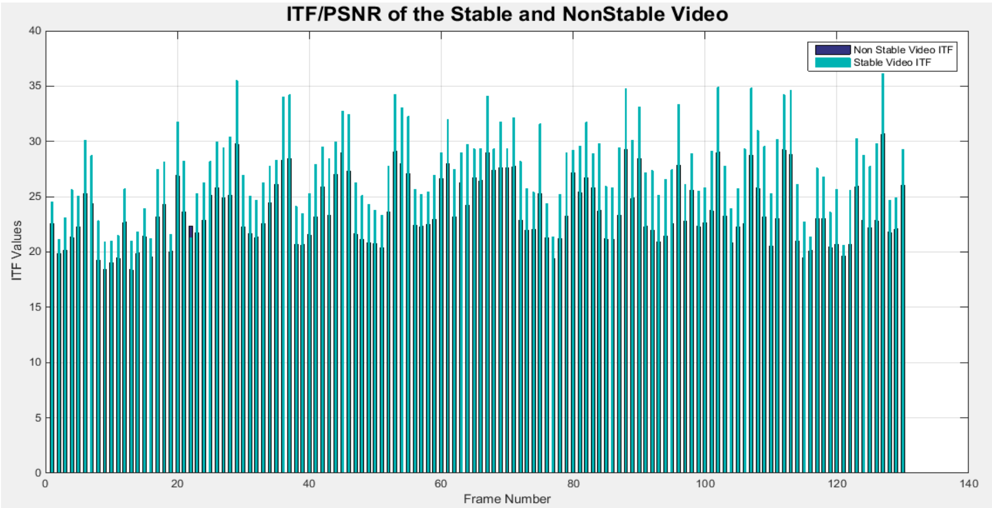

Fig. 5:Comparison of ITF of stabilized and Non-stabilized Video over each frame.

V.CONCLUSION

The development and implementation of software for video stabilization technique using block based motion vectors is done successfully for video frames. It is tested for the different video sequences. Following conclusions are obtained from the results:

1. The unstable input frames and stabilized output frames are shown in "Fig 2: (a) Unstable input frame (b) Stable output frame for "Fly On leaf" video frame"and "Fig 4: (a) Unstable input frame (b) Stable output frame for "Shaky Car" video frame." This gives satisfactory outcome.
2. ITF of output video is better than that of the input video. (From Fig. 3: Comparison of ITF of stabilized and Non-stabilized Video over each frame, Fig.5: Comparison of ITF of stabilized and Non-stabilized Video over each frame and Table I .ITF Of Input and Output video: Fly on Leaf , Table II .ITF Of Input and Output video: Shaky Car)
3. The unstable input and stabilized output frames are clearly distinct and the output is improved in present work.
4. From tables (Table I .ITF Of Input and Output video: Fly on Leaf, Table II .ITF Of Input and Output video: Shaky Car), where the number of frames are 10 and 132 respectively, the average ITF is more for the more number of frames. Thus, this video stabilization technique provides better quality of video for the increase in the number of frames in the video sequence.

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