Performance Analysis Of SIFT and SURF Approaches For Video Stabilization

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Abstract- Aerial video surveillance means gathering data form air so as to monitor the change in information usually of people to influence, manage, direct, or protect them. Aerial video surveillance provides large amount of data but usually suffers from unintentional motion of cameras due to which there is shakiness in the video. The main task of video surveillance is to track the moving object in moving platform. Video stabilization aims to remove the shakiness in the video caused by the undesired movement in the camera thus stabilizing the video captured during aerial surveillance. In the video stabilization algorithm for detecting and matching the interest points mainly Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) are used. Kalman filter and RANSAC are used to filter the noise and remove the outliers detected while extracting interest points. Finally affine transformation is applied to estimate the global motion parameters thus stabilizing the video. Present paper proposes the video stabilization technique that uses Speeded Up Robust Features (SURF) and extended kalman filters. SURF is used to detect the interest points and extended kalman filter is used for global motion detection, then using affine transformation for motion compensation thus stabilizing the video. Proposed system proved to be more accurate and efficient than the existing system.

Index Terms – Aerial Surveillance, Extended Kalman filters, SIFT, SURF, Video stabilization.

1. INTRODUCTION

Video is a visual interactive media source formed by combining the sequence of images and the combination of frames captured in air rather than on ground are called aerial videos.

Aerial video surveillance means capturing data from air so as to monitor the change in information usually of people to influence, manage, direct, or protect them. [1] The main task of video surveillance is to track the moving object in moving platform because aerial video surveillance suffers from undesired motion of cameras due to which there is shakiness in the video. Therefore there is need for video stabilization algorithm to remove the shakiness.

1.1 Applications of aerial video survelliance

Aerial surveillance is now a day's very popular for

1. Broadcasting news,
2. Shooting or gathering data from air and
3. Providing large quantity of video data for many purposes, including
   a. Search and rescue,
   b. Military operations,
   c. Commercial applications,
   d. Counter terrorism and
   e. Border patrol. [1]

1.2 Challenges in Aerial Video Surveillance

Some of the challenges in aerial video surveillance are mentioned below:

1. Objects of interest move in and out of the field of view [2]
2. Video contains much more data than film frames; Storage is expensive [2]
3. Aerial surveillance usually suffers from undesired motion of cameras, which presents new challenges. [1]
4. The main challenge is to trace the moving object in mobile platform including moving camera.

In order to overcome the challenges there is a need to stabilize the aerial videos.

2. VIDEO STABLIZATION

Video stabilization is a technique used to improve the video quality by removing unwanted camera movements due to hand shaking and unintentional camera shake. Video stabilization aims to smooth blurred video caused by the undesired movement in the camera. Fig 1 shows the un-stabilized and stabilized video sequence consisting of four frames each of stabilized and unstabilized video sequence. The uneven line in frames 1, 2, 3, 4 of unstabilized video sequence shows the shakiness in the video. To remove the shakiness stabilization algorithm is applied. The straight line in frames 1, 2, 3, 4 of stabilized video sequence shows the smoothness in the video.

2.1 Types of video stabilization

There are two types of stabilization: Hardware and software based stabilization. In hardware-based stabilization sensors and lens are used to reduce the movement of cameras. However, these hardware-based systems fail to provide desired stabilization to compensate for complex camera motions and jerks. Therefore, to obtain stable videos, post- processing video stabilization is required. Video stabilization removes the undesired motion from input video by accordingly warping the images. It is not a real-time solution but can be applied to the aerial videos [2].

In software-based video stabilization video is stabilized in three steps as shown in fig. 2. Firstly motion estimation is done between two sequential frames i.e. the previous and current frames. [2] Motion compensation provides the computation of global transformation to stabilize the frame content. [2] Steps followed for motion compensation are:

i. Split video into two parts i.e. static parts and moving parts.
ii. Get the data of the previous frame on the basis of motion vectors.
iii. Use filters to obtain the forecast difference block between previous and current frame.
iv. Static parts and the forecast difference block are combined and new image is regenerated. [1]
v. And finally warp the current image with the previous image on the basis of transformation. [2]

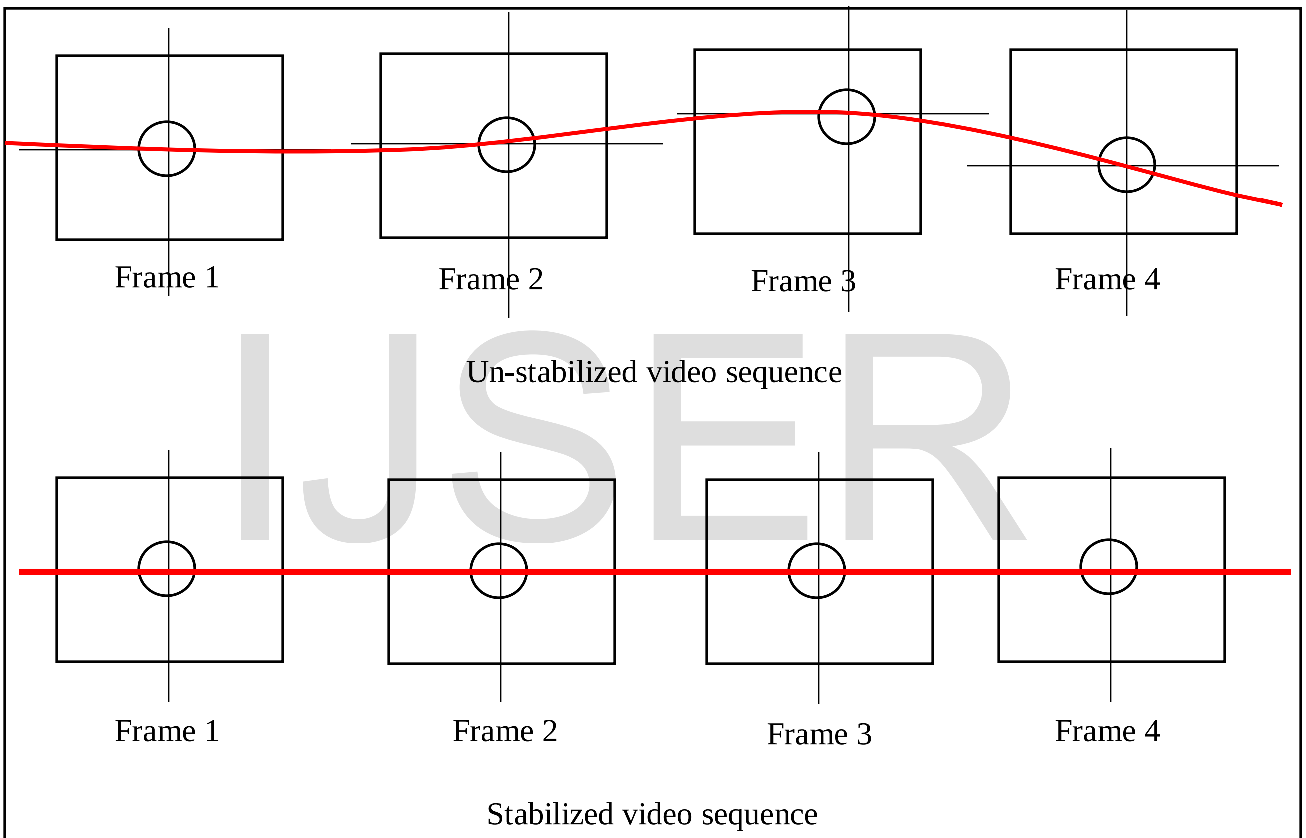

Fig. 1 Example of un-stabilized and stabilized video sequence

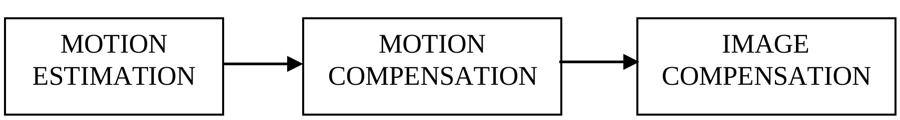

Fig. 2 General Video Stabilization Method [2]

3. LITERATRE SURVEY

This section reviews various papers on video stabilization. Based on the study video stabilization helps to improve the video quality by removing unwanted camera shakes. Video stabilization aims to smooth the blurred video caused by the undesired movement in the camera. Table 1 gives the review of various papers.

TABLE 1
LITERATURE REVIEW

S. NO	AUTHOR NAME	FEATURE DETECTION	MOTION COMPENSATION	REMARKS
1.	Walha A. et. al. [1]	SIFT	Kalman Filters	SIFT features are robust but accuracy of the matching points needs to be improved
2.	Kim J.Y. et. al. [3]	SIFT, SURF, FAST, ORB	Histograms of oriented gradients (HOG)	Effective but there is need for improvement in SIFT feature extraction
3.	Battiato S. et. al. [4]	SIFT	Modified iterative least square method	SIFT extraction needs to be improved
4.	Zhang G. et. al. [5]	SIFT	Prediction filter	Problem of object extraction in complex environment needs to be improved
5.	Chen Y.H. et. al. [6]	SIFT	Time domain filters	Feature extraction needs to be improved so as to evaluate the method both quantitatively and qualitatively
6.	Santhaseelan V. et. al. [7]	SIFT	Zero-mean guassian filter	Algorithm needs to be improved so that feature extraction is not affected by light and to achieve real time performance
7.	Yang J. et. al. [8]	SIFT	Particle filter	Proposed algorithm is accurate and efficient. Particle filter can be used to increase the accuracy when particles are large in number.
8.	Suaib N.M. et. al. [9]	SIFT and SURF	-	SURF detects more features in less time than SIFT
9.	K. Madhavi, et. al. [10]	PCA-SIFT, SIFT, SURF	RANSAC and Particle filter	Proposed algorithm has high precision and good robustness but feature extraction needs to be improved
10.	Zheng X. et. al. [11]	SURF	Least square method and RANSAC	Hybrid method is efficient for mobile vehicle detection in aerial videos. Accuracy and speed of SURF is better than SIFT
11.	Chunxian G. et. al. [12]	SURF	RANSAC	Accuracy of matching point needs to be improved and correspondence between speed, complexity and robustness needs to be done.
12.	H. Kandil et. al. [13]	SIFT and SURF	Particle filter	Accuracy and point detection of SURF-Particle is more efficient than SIFT-Particle
13.	Shen Y. et. al. [14]	PCA-SIFT	Particle filter and RANSAC	Accuracy of SIFT features needs to be improved.
14.	Oyallon E. et. al. [15]	SURF	-	Filters are required to detect the non-linear change in frames.
15.	Pinto B. et. al. [16]	SURF	Discrete Kalman filters	Accuracy and efficiency of matching points needs to be improved

4. APPROACH FOR AERIAL VIDEO STABILIZATION

4.1 Aerial video stabilization using SIFT and Kalman filters

Aerial video stabilization using SIFT and Kalman filters approach uses SIFT feature detector to detect the features for estimating the global motion followed by outlier removal using RANdom SAmple Consensus (RANSAC) and then kalman filters are applied to filter the noise. After estimating the global motion, affine transformation is used for motion compensation thus stabilizing the video.

4.2 Aerial video stabilization using SURF and Extended Kalman filters

Aerial video stabilization using SURF and Extended kalman filters approach uses SURF feature detector to detect the features for estimating the global motion followed by outlier removal using RANdom SAmple Consensus (RANSAC) and then extended kalman filters are applied to filter the noise. After estimating the global motion, affine transformation is used for motion compensation thus stabilizing the video. Table 2. describes the difference between the two feature detectors i.e. SIFT and SURF and table 3 gives the difference kalman and extended kalman filters.

Table 2
COMPARISON OF SIFT AND SURF

S.NO.	SIFT (Scale Invariant Feature Transform)	SURF (Speeded Up Robust Features)
1.	SIFT is a feature detecor [1, 9, 13]	SURF also known as approximate SIFT is also a feature detector [9, 13, 20]
2.	SIFT detect local extremity of the image is filtered with difference of guassians (DOG). [20, 9]	SURF uses fast hessian detector originated hessian matrix. [1, 9]
3.	Scale space is produced by convolution of input image with variable scale Gaussian. [20, 9]	Simple box filters are used to smoothen the image derivatives. [1, 9]
4.	SIFT is stable to scale, rotation, affine transformation. [2, 3, 13]	SURF is stable to rotation, scale, transformation, illumination and small change in viewpoint [2, 3, 13]
5.	Not as efficient as SURF	Efficiency of SURF for video stabilization is better [12]
6.	Detects less no of features as compared to SURF [9, 11, 13]	SURF is more efficient, reliable and accurate as it detect more number of features [9, 11, 13]
7.	SIFT takes more time to detect the features as compared to SURF [9,11,13]	SURF takes less time to detect the features [9, 11, 13]

Table 3
COMPARISON OF PREDICTION, KALMAN AND EXTENDED KALMAN FILTERS

S.NO.	PARTICLE FILTER (PF)	KALMAN FILTER (KF)	EXTENDED KALMAN FILTER (EKF)
1.	Particle filter is used for estimating the global motion between successive frames [8]	Kalman filter is used to filter dynamic noise system and is also used to detect the global motion [1]	Extended kalman filter is the filter used to detect the global motion between the frames and is also used to filter the noise [1]
2.	It is used to solve not aligned and non-Gaussian problems [13]	This filter cannot be applied on the whole frame because it solves aligned and Gaussian problems. [1, 21, 22]	It is used to solve the not-aligned and non-Gaussian problems [21, 22]
3.	It requires extra load to compute motion and detection of particles and is also not able to remove the outliers.	Kalman filter recognizes the intentional movement in frames. [8, 10]	EKF is used to separate desired motion from the undesired motion [1, 21, 22]

After doing the extensive study on video stabilization algorithms following gaps are identified:

1. SIFT is not as efficient and accurate as SURF and detects less no of interest points.
2. Kalman filters are linear filters used to filter noise. These filters can be applied to linear and Gaussian problems only.
3. There is need to improve the accuracy of feature point detection.

Considering the above gaps it is concluded that there is need for a video stabilization algorithm which detects more no of features and can be applied to non-linear and non-Gaussian problems. So as to improve the accuracy of matching points.

4. RESULTS

5.1 Performance evaluation

Performance of the proposed algorithm is evaluated on the basis of various performance evaluation parameters like number of interest points, mean square error, peak signal to noise ratio and interframe transformation fidelity and the results are evaluated on various unstabilized videos. Table 4 and 5 shows the average of interest points, MSE, PSNR and ITF for both approaches.

a. Interest points

Interest points are the stable features in the image that are stable with the change in the viewpoint of the image. To extract the interest points various features detectors are available. Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) are the most commonly used feature detectors.

b. Mean Square Error (MSE) [1, 4, 10, 14]:

It is the mean square error between the frames. It is a risk function that calculates the difference between the two images.

$$\text{MSE}(n) = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I_n(x,y)\ I_{n+1}(x,y)]^2$$

[1, 4, 10, 14]

Where M and N are frame dimensions.

c. Peak Signal to Noise Ratio (PSNR) [1, 4, 10, 14]:

It is used to measure the error and compare the quality. Quality is compared by checking the value of each frame of the original video with that of our stabilized version. Higher PSNR between two stabilized frames indicates good quality of stabilized video.

$$\text{PSNR} = 10*\log_{10}(I_{max} / \text{MSE}(n))$$

Where I_{max} is the maximum intensity value of the pixel.

d. Interframe Transformation Fidelity (ITF) [1, 4, 10, 14]:

It gives the average of the PSNR between two consecutive frames. This average is used to obtain the rough estimate of the quality of stabilized video in a single value. Like PSNR, higher value of ITF represents good quality of stabilized video.

$$\text{ITF} = \frac{1}{N_{frame-1}}\sum_{k=1}^{N_{frame-1}}\text{PSNR}(k)$$

TABLE 4
AVERAGE OF INTEREST POINTS, MSE, PSNR AND ITF USING SIFT

VIDEOS	SIFT AVERAGE				
	INTEREST POINTS		MSE	PSNR	ITF
	BEFORE FILTERING	AFTER FILTERING			
VIDEO 1	81.75	70.90	6.8011	13.9104	55.5710
VIDEO 2	79.00	49.70	7.5308	13.3980	56.6654
VIDEO 3	89.75	68.15	1.2334	11.1448	44.9195
VIDEO 4	38.30	22.65	4.4376	14.3433	50.8801
VIDEO 5	1.200	0.05	7.6999	13.1813	52.3455

TABLE 5
AVERAGE OF INTEREST POINTS, MSE, PSNR AND ITF USING SURF

VIDEOS	SURF AVERAGE				
	INTEREST POINTS		MSE	PSNR	ITF
	BEFORE FILTERING	AFTER FILTERING			
VIDEO 1	127.90	107.65	6.7782	14.6177	58.6588
VIDEO 2	123.25	75.30	6.9596	14.8313	63.1121
VIDEO 3	140.15	104	1.2160	12.2517	47.7933
VIDEO 4	57.45	32.95	4.3614	15.0816	53.3155
VIDEO 5	1.25	0	7.4022	14.0714	55.9798

5. CONCLUSION AND FUTURE SCOPE

Video stabilization is a technique used to improve the video quality by removing unwanted camera movements due to hand shaking and unintentional camera shake. Video stabilization aims to smooth blurred video caused by the undesired movement in the camera and is used to stabilize the video captured during aerial surveillance for broadcasting news, shooting or gathering data from air and providing large quantity of video data for many purposes, including search and rescue, military operations, commercial applications, counter terrorism and border patrol.

There are many algorithms used for video stabilization. These algorithms used various approaches to stabilize the videos. In the video stabilization algorithm for detecting and matching the interest points mainly Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) are used. Kalman filter and RANSAC are used to filter the noise and remove the outliers detected while extracting interest points. Finally affine transformation is applied to estimate the global motion parameters thus stabilizing the video.

After doing the study on video stabilization algorithms following gaps are identified:

1. Scale Invariant Feature Transform (SIFT) is not as efficient and accurate as Speeded Up Robust Features (SURF) and detects less no of interest points.
2. Kalman filters are linear filters used to filter noise. These filters can be applied to linear and Gaussian problems only.
3. There is need to improve the accuracy of feature point detection.

Present paper compared the performance of various video stabilization algorithm on the basis of performance evaluation parameters like interest points, mean square error, peak signal to noise ratio and interframe transformation fidelity.

The accuracy of the matching points is improved using Speeded Up Robust Features (SURF) feature detector as it detects more interest points than Scale Invariant Feature Transform (SIFT) and the results of MSE, PSNR and ITF shows the better results with SURF and extended kalman filters.

In future, a new technique can be proposed to further improve the accuracy of the results. Possibility of soft computing techniques can also be explored.

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