A Study on Video Stabilization

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Abstract- *Stabilization is the process of estimating and compensating for background image motion occurring due to the ego-motion o camera. Video stabilization is a vital technique to remove visually distributing shaky or unstable motions from videos. With the introduction of the video camera as associate degree integrated a part of mobile instrumentality creates the necessity for video stabilization. Video stabilization is used for astrophotography, tracking targets in military, earth motion etc. Researchers have proposed many approaches of video stabilization. This paper provides an analysis of different techniques used for video stabilization.*

Keywords- Stabilization, Video Stabilization, Motion Estimation, Image warping.

I. INTRODUCTION

Most amateur videos are captured using hand-held cameras. They are often very shaky and difficult to watch. The videos taken from hand held mobile cameras suffer from different undesired and slow motions like track, boom or pan, these affect the quality of output video significantly. Video capturing by nonprofessional user unremarkably can result in unexpected effects. Putting of the system plays a crucial role, particularly to the output video. If the camera is placed in someone's hand or on moving object (car, tank etc.) then the ensuing video stream is of terribly poor quality. Associate best answer is to put the camera on the stable holder, however if the peak of the holder is simply too massive, the camera are going to be exposed to the influences of the encircling i.e. wind, waves of the ocean etc. The unwanted motions can disturb the perception of captured scene. Therefore, video stabilization become important and should be enforced to enhance the frame look quality of the hand-held mobile devices. The goal of video stabilization is to get rid of annoying shaky motion from a video sequence [1]. Stabilization is achieved by synthesizing the new stabilized video sequence; by estimating and removing the undesired inter frame motion between the successive frames. Generally the inter frame motion in mobile videos are slow and smooth. [2].

1. Biological Motivation: Insect Navigation

- Insects have relatively small nervous system with very few neurons when compared to the human brain, they are still capable of complex tasks, such as safe landing, obstacle avoidance.
- Behavioral research with insects suggests that insects primarily use visual information.
- Insects have immobile eyes with fixed focal length. Moreover, they do not possess stereoscopic vision. Insect eyes possess inferior spatial acuity but their eyes sample the world at a significantly higher rate than human eyes do.
- The study can serve as a pure motivational tool indicating that such complex tasks, such as stabilization, can be performed real-time, with the accuracy desired. Second, this study can lead us into the paradigm of "active vision" or "purposive vision".
- In fact, several researchers have used such biologically inspired mechanisms for flight control and obstacle avoidance.
- Bees that fly through holes tend to fly through the center of these holes. Bees, like most other insects, cannot measure distances from surfaces by using stereoscopic vision.
- Recent experiments have indicated that bees balance the image motion on the lateral portion of their two eyes as they fly through openings.
- Bees were trained to fly in narrow tunnels with certain patterns on the side walls of the tunnels. It was shown in that bees tended to fly at the center of this tunnel when the patterns on the side walls were stationary.
- If one of these patterned side walls was moved in the direction of the bee's flight, thereby reducing the image motion experienced by the bee on that side, then the bees moved closer to that side wall. Similarly, when one of the patterned side walls was moved in the direction opposite to the direction of the bee's flight, the bee moved away from the moving wall.
- Collision avoidance is another task that is visually driven in most insects. When an insect approaches an obstacle, its image expands on it's eyes. Insects are sensitive to this image expansion and turn away from the direction in which the image expansion occurs, thereby avoiding collision with obstacles.

Figure 1. Stabilization

II. RELATED WORK

In [3] the author presented a novel video stabilization and moving object detection system based on camera motion estimation. Local feature extraction and matching is used to estimate global motion and demonstrate that SIFT keypoints are suitable for the stabilization task. Future work is to increase the accuracy of matching point, color information can be involved for a robust point matching strategy helping the affine transform estimation and also more local and global features, such as object contour and geometrical relationship, can be applied to trade of noise and significant image distortion. A different descriptor for feature point has to be constructed for this purpose. In [4] this paper presents a video stabilization algorithm based on the extraction and tracking of SIFT features through video frames. Implementation of SIFT operator is analyzed and adapted to be used in a feature-based motion estimation algorithm. SIFT features are extracted from video frames and then their trajectory is evaluated to estimate interframe motion. A modified version of iterative least squares method is adopted to avoid estimation errors and features are tracked as they appear in nearby frames to improve video stability and intentional camera motion is filtered with Adaptive Motion Vector Integration. Experiments have confirmed the effectiveness of the method. Further works include improvements in the SIFT extraction and in the motion filtering stage to handle different resolution videos. In [5] the goal of video stabilization mainly is to solve the blurred video caused by the unwanted camera movements. This paper proposes an algorithm, which can treat the different video objects respectively based on their value of information and reduce the time wasted on the background region effectively. Compared with existing algorithms, the performance of the algorithm proposed by the paper has been greatly enhanced and improved in some areas. In [6] a novel method is proposed which synthesize shaking videos from stable frames. The shaking video synthesis method can not only give a benchmark for full-reference video stabilization performance assessment, but also provide a basis for exploring the theoretical bound of video stabilization which may help to improve existing stabilization algorithms. With the existence of ground-truth videos and its shaking ones, it is possible to make more robust assessment on video stabilization algorithms, especially for those with close performance judged by human eyes. Moreover, we could try to analyze the theoretical bound of video stabilization for improvement on existing algorithms. In [7] removal of visually unpleasant motion from videos is an important video enhancement technology. Feature-based approach is presented for video stabilization that produces stabilized videos, while preserving the original resolution. Future work is to conduct more in-depth experiments including: the comparison of the state-of-the art video stabilization methods and the investigation/comparison of the more sophisticated feature extraction methods so as to evaluate the proposed method quantitatively and qualitatively. In [8] an adaptive parameterization technique is proposed to define the characteristics of the filter used to eliminate high frequency components in the motion path. Motion of the camera is estimated using SIFT feature tracking. To improve the algorithm so that the feature tracking procedure is not affected by lack of insufficient lighting. Future work in this area also includes improvement of the algorithm to achieve real-time performance.

Most previous video stabilization methods follows the same framework and on improving components.

III. PHASES OF STABILIZATION

In video stabilization, we need to analyze the image motion and obtain models for the global motion in image sequences. Generally the process of stabilization has to go through two phases:

- motion estimation
- motion smoothing

1. Motion Estimation:

Video stabilization is achieved by first estimating the inter frame motion of adjacent frames. The inter frame motion describes the image motion which is also called global motion. By using different motion estimation techniques it is possible to estimate object motion or camera motion observed in video sequence. Object motion defined as local motion of the scene, and camera motion is defined as the global motion. The motion estimation technique can be classified as feature based approaches or direct pixel based approaches. Feature based approach is faster than direct pixel based approach [9].

2. Motion Smoothing:

The goal of motion compensation is to remove high-frequency jitters from the estimated camera motion. It is the component that most video stabilization algorithm attempt to improve and many methods have been proposed, such as particle filter, kalman filter, gaussian filter [10].

3. Image warping:

Image warping wraps current frame according to the smoothed motion parameters and generates the stabilized sequence [10].

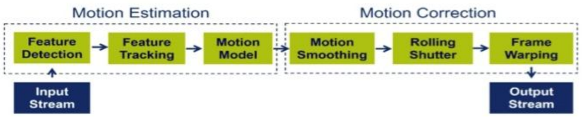

Figure 2. Phases of Video Stabilization

IV. VIDEO STABILIZATION

The digital image stabilization tries to smooth and compensate the undesired motion by means of digital video processing. In the image post processing algorithm, there are typically three major stages constituting a video stabilization process viz. camera motion estimation, motion smoothing or motion compensation, and image warping, fig 4. Various techniques have been proposed to reduce the computational complexity and to improve the accuracy of the motion estimation [11]. The global motion estimation can either be achieved by feature based approach or pixel based approach. Feature based methods are generally faster than pixel based methods but they are more prone to local effects and there efficiency depends upon the feature point's selection. Hence they have limited performance for the unintentional motion. Essentially features are relevant points in the image which may be easily tracked between different images. Feature tracking estimates the motion of the frame by selecting features from the previous frame and finding them in the current one, evaluating how these points moved between frames. It is clear that features should be accurately and efficiently tracked and then coupled among different frames without errors: techniques use corners, edges, regions, textures and intersections. [12]

Video stabilization techniques can be broadly classified as:

- Mechanical stabilization
- Optical stabilization
- Digital video stabilization.

1. Mechanical Video stabilization

Mechanical stabilization systems based on vibration feedback through sensors like gyros accelerometers etc. have been developed in the early stage of camcorders [13].

Mechanical stabilization could be a quite video stabilization methodology wherever stabilization is realized automatically. That is, mechanical equipment's area unit to estimate and proper unintentional motions to get stabilized video. In mechanical stabilization, motion is calculable by motion sensors. Counting on the applying, kind and range of used motion sensors might amendment. As an example, if camera is exposed to motions solely within the x direction, it's enough to use only one motion sensing. In mechanical stabilization, camera movement area unit is obtained by measurement of the acceleration or speed of the camera and manipulating a series of mathematical operations over this information. Acceleration and speed area unit measured by accelerometers and gyros severally that area unit the foremost usually used mechanical phenomenon motion sensors for not solely stabilization systems however additionally guidance systems, automotive, etc. Accelerometer could be a quite motion sensing element that live the linear acceleration in x , y and z directions. To get linear movements of the camera, acceleration information should be regenerate into displacement information. Accelerometers, fig 4.1, live the acceleration solely in one preset direction that is mostly indicated on the measuring instrument.

If it's placed on x axis, acceleration on the x axis is obtained. Therefore, the amount of measuring instrument during a system depends on the amount of needed acceleration information in several directions. Gyro, fig 4.2, is a kind of sensor which measures the angular velocity in roll, pitch and yaw directions. It could be a quite sensing element that measures the angular speed in roll, pitch and yaw directions. Since speed is that the computation of displacement, displacement is obtained by taking 1integration over the speed. The formula for this is:

$$x(\theta 2) - x(\theta 1) = \int_{\theta 1}^{\theta 2} \omega(\theta) d\theta$$

Figure 3. accelerometer

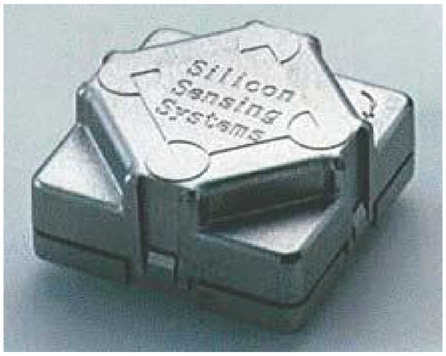

Figure 3. Gyro

In mechanical video stabilization, it's aimed to stay the position of the camera stable with reference to its reference position. Therefore, all the calculable movements to that camera are exposed area unit taken as unintentional motions. Since stabilization is to get rid of solely unintentional motions, there's no have to be compelled to have motion correction half in mechanical stabilization

2. Optical Video Stabilization

Optical stabilization can be thought as a kind of mechanical stabilization. The main difference between optical and mechanical stabilization is the image correction part which is realized by a kind of optical mechanism instead of a mechanical platform. In optical stabilization, it is aimed to remove the effects of relatively high frequency motions of the camera. Optical image stabilization employs a prism or moveable lens assembly that variably adjusts the path length of the light as it travels through the camera's lens system. It is not suited for small camera modules embedded in mobile phones due to lack of compactness and also due to the associated cost. The digital image stabilization tries to smooth and compensate the undesired motion by means of digital video processing.

The Optical Image Stabilization (OIS) system, in contrast to the DIS system, manipulates the image before it gets to the CCD. Once the lens moves, the light rays from the subject are bent relative to the optical axis, leading to associate unsteady image as a result of the light rays are deflected. By shifting the IS lens cluster on a plane perpendicular to the optical axis to counter the degree of image vibration, the light rays reaching the image plane is steady. Since image vibration happens in each horizontal and vertical directions, 2 vibration-detecting sensors for yaw and pitch are wont to find the angle and speed of movement then the mechanism moves the IS lens cluster horizontally and vertically therefore counteracting the image vibration and maintaining the stable image [14].

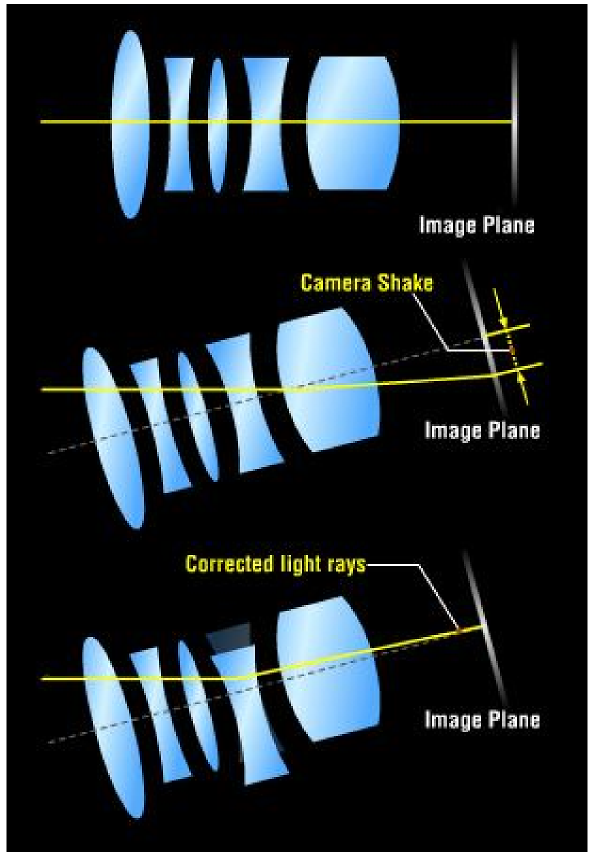

Figure 4. Floating lens group

The Shift-IS component is located within the lens groups and is most effective for lower frequency movements caused by platform vibration or wind effect without increasing the overall size and weight of the master lens.

3. Digital Video Stabilization

Digital stabilization systems use completely electronic processing to control the image stability. That is, only software algorithms are used rather than hardware components such as motion sensors, actuators or floating lenses to compensate the disturbances. This makes digital stabilization more portable and cost effective among other methods. In digital stabilization, interframe global motions are obtained by taking consecutive two frames of the video and performing a series of operations over the frames. Because of exhaustive image processing operations, motion estimation is the most time consuming and difficult part in digital stabilization. The output of motion estimation is Inter frame global motions which contain not only unintentional motions but also intentional motions. After motion estimation, motion correction part differentiates intentional motions from unintentional motions. The last step is the alignment of the frames with respect to the estimated jitter. In this part, same amount of movements are given to the frames in the inverse direction with the jitter in order to obtain stabilized video sequence [15]. Various motion estimation approaches are employed in the video stabilization algorithms. It includes

- Direct technique
- Feature extraction technique.

V. COMPARISON

Three different categories of video stabilization are discussed in this paper. Image correction is the third and final step in video stabilization. Realization of image correction may change with respect to the video stabilization methods. That is, if mechanical or optical video stabilization is considered, image correction is realized by motors and a kind of mechanical structure. But, in digital video stabilization, image correction is realized only by software. Therefore, digital video stabilization is the most cost effective among all methods.

VI. CONCLUSION

In this paper, the main concern is to propose a solution related to video stabilization for a kind of mobile robot application in which a series of different image/video processing operations such as depth estimation, object detection, object recognition, etc. are performed in addition to video stabilization. If we put these operations in order, video stabilization comes first within the whole process and then all other operations take their actions using the output of video stabilization. Therefore, the results of video stabilization directly affect the results of other.

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