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Research Article

Android Application for Video Stabilization and Rolling Shutter Correction using Inbuilt Mobile Sensors

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Abstract

Most of today's mobile video recording devices, such as cell phones, use a rolling shutter camera. The video is captured by handheld camera, resulting in object or target image distortion shifting as well as frame-to-frame jitter. The traditional way of stabilizing the video is by using external accessories such as a tripod stand. The proposed application uses accelerometer and gyroscope to estimate camera orientation by the image distortion induced by video recording system movement using image processing with rolling shutter camera correction. To produce a smoothened camera motion, adaptive filter algorithms can be used and frame to frame jitter can be reduced using smoothing camera motion. The proposed application can be implemented on any android Smartphone which having inbuilt accelerometer and gyroscope sensors.

Keywords: *Android Application; Rolling Shutter Camera; Video Stabilization; Accelerometer; Gyroscope*

Introduction

In many smart applications, such as transportation systems, security systems, monitoring systems, the vision system plays important roles. Generally, people carry mounted system with camera to capture photos or videos. Videos taken from mobile cameras kept by hand suffer from various unwanted and slow motions such as track, boom or pan, which significantly affect the quality of performance footage. Stabilization is accomplished by synthesizing the current stabilized video sequence; by measuring and eliminating between the successive frames the undesired interframe motion.

Fig. 1 RS distorted image captured [5].

The interframe This information can also be used to correct RS distortion generated by motion of the device via image processing of a recorded video. Fig. 1 displays an RS distorted image captured while there coordinating device was in motion. Capturing video by hand also results in visible jitter frame-to-frame. Much of this jitter can be minimized by measuring a smooth motion similar to the device's real motion and uses image processing. [1] The procedure of correcting video distortions caused by motion of an RS camera device that includes gyroscope and accelerometer can be divided into the following main steps. Video Stabilization is an image processing technique to elimin ate blurry or distorted movements from images that are visuall y transmitted. Such image distortion can be caused by the came ra holder's handshake or screen movements [2]. A Rolling Shutter (RS) camera is used by most of today's mobile video recording devices, such as cell phones and music players. By capturing each frame line-by-line from top to bottom of the image, an RS camera captures video. It compares with a Global Shutter camera in which each video frame is recorded at once in its entirety [3]. The RS technique gives rise to image distortions in situations where either the device or the target is moving. Since the device almost always is in motion while capturing video there is a need of correcting this type of distortion. Recently it has become common to equip handheld devices with sensors such as accelerometers and gyroscopes to detect orientation and motion in order to enhance the user experience

1. Simultaneously capture video and collect accelerometer and gyroscope data.

2. Estimate the orientation of the device using accelerometer and gyroscope data.
3. Manipulate the video frames according to the estimated motion of the device.

Data is obtained from three different sources in the first stage. Due to the low processing power of today's handheld devices, at the highest available frequency, it is not always possible to simultaneously record data from all sources without causing sudden drops in frame rate. Therefore, the goal is to log data from the sensor at the highest possible frequency while maintaining a constant frame rate. As mentioned in step 2, use the available sensor data to produce the best possible estimates of the device's orientation. Through deriving mathematical models for the sensors and the device's rotational motion, sensor fusion algorithms can be used to measure these figures. The third and final step is to use the projections to process the image on each video frame to correct the distortions. Besides correcting the distortion of RS, it is also necessary to stabilize the recorded video. A new smooth motion can be measured by applying Low-Pass (LP) filtering to the projected rotational motion. In order to achieve a stable output video, each video frame can be processed using this motion as a reference. The purpose of the project is to implement and test on a mobile device a video stabilization algorithm and a rolling shutter correction algorithm using gyroscope and accelerometer data to monitor the device's orientation. The goal is to create an android application that will decrease the distortion of the video caused by the movement of the cell phone and its camera. The sequences generated should match those produced from commercial products [4].

The organization of the paper is as follows. The Literature review is discussed in section 2 followed by proposed methodology in section3. Experimental setup is explained in section 4. Finally, the paper concludes in section 5.

Literature Survey

Currently there are many Video Stabilization Techniques available in the market which consider various different parameters. Research has been carried out in this field and the following papers have been referred for the purpose of research and study. In the paper [5] system is described, with rolling shutter cameras, rectifies and stabilizes video sequences on mobile devices. Using measurements from inbuilt mobile sensors, the device corrects the rolling-shutter distortions. Adaptive low pass filter algorithm is used by author to obtain a stable video while holding most of the material in view at the same time. Using ground truth data from a motion capture device, the precision of the orientation predictions was tested experimentally. Author performed a user analysis in which device performance, implemented in IOS, was compared with that of three other applications and incorrected video output.

Kornilova A. V., Kirilenko I. A. [6] developed the general mathematical models needed to implement the MEMS sensor readings based on the video stabilization module. The main goal is to stabilize the video transmitted to the remotely controlled not only mobile robot operator but also to increase the accuracy of video-based navigation for autonomous subminiature models. The current stabilization methods using data from sensors were analyzed and viewed in a real-time environment from the application's point of view. The main limitation that arose during the experiments that the previous research papers did not resolve like, calibration and synchronization of camera as well as sensor, increasing the accuracy of sensor data determination of camera position. The authors propose potential solutions to these issues that would help improve existing algorithms quality, The main result of a system for applying video stabilization algorithms focused on the reading of MEMS sensors.

A robust video stabilization and rolling shutter correction technique based on commodity gyroscopes is presented in this paper [7]. In this D. Jacobs, J. Baek developed new approach for stabilizing video by using gyroscope. The author shows results for videos of large moving foreground objects, parallax, and low illumination using the proposed algorithm. It contrasts paper approach with stabilization algorithms based on commercial image. The proposed solution is more stable and cheaper in terms of computation. The algorithm directly implemented on a mobile phone and demonstrates that it can eliminate camera shake and roll shutter artifacts in real time by using the phone's built-in gyroscope and GPU.

Neel Joshi, Sing Bing Kang presents a deblurring algorithm using a hardware attachment coupled with a natural image before the consumer cameras deblur images. In an energy optimization framework, paper approach uses a combination of inexpensive gyroscopes and accelerometers to estimate a blur function from the acceleration and angular velocity of the camera during an exposure. During an exposure, the author solves the camera movement at a high sampling rate and uses a joint optimization to infer the latent picture. The paper method is fully automatic, handles per-pixel, blur spatially varying, and outperforms the current leading image-based methods. Research paper experiments show that it handles large kernels with a typical size of 30 pixels, up to at least 100 pixels. The author also provides a method for conducting camera motion blur "ground-truth" measurements used and same in used to verify the deconvolution and hardware. To the best of Researchers ' knowledge, this is the first work to use DOF inertial sensors for dense, spatially varying per-pixel image deblurring and the first work to collect dense ground-truth measurements for camera-shake blurring [8].

In this paper an algorithm [9] is suggested to remove the frame to frame jitters to solve the problem which occurring during video recording by smartphone. In this paper Author founded first silent feature points of original video and then optimize and stabilize it by using video stabilization function. The proposed method presented in this paper decreases the jitters from many different types of situation and stabilize the video.

Javaria Maqsood, Asma Katiar proposed A robust technique for tracking objects is proposed in this paper [10]. A fusion of global motion estimation and Kalman filter-based tracking algorithm that detects and tracks all the moving objects in the video is implemented in this work. In the subsequent frames of the input video, the algorithm detects corners in a frame and tracks moving ones. A moving object's movement is traced by persisting on that object's motion trajectory of corner points. Video stabilization is also applied in order to process and adjust the moving or unstable video in order to apply the Kalman filter. The proposed methodology achieved a precision of 94.73 percent which is quite good in comparison to other published techniques

In this paper to develop stabilized video frame, a novel motion model, Steady Flow, was proposed. [11] A Steady Flow is a particular optical flow by imposing strict spatial coherence, so that trajectories of the smoothing function can be replaced by smoothing pixel profiles that are motion vectors obtained in the Steady Flow over time at the same pixel position. In this way, in a video stabilization device, the author can prevent fragile feature monitoring. In addition, Steady Flow is a more general model of 2D motion that can accommodate spatially-variant motion. The author initializes the Steady Flow by optical flow and then by spatial-temporal analysis discontinuous motions are discarded and the incomplete regions are filled by completion of motion. The paper studies illustrate stabilization efficiency on images that are daunting in the real world.

Proposed Methodology

The basic overview of proposed methodology is shown in Fig. 2 In this methodology first the values of accelerometer and gyroscope are initialized and take their fused values. Now by this accelerometer and gyroscope fused values to develop a game rotation vector which is in quaternion form. The next stage is to find wrong sensor data from both sensors raw values and filter out it by applying adaptive Kalman filter according to sensors. After filtered quaternion calculate space coordinates according to Equation (2) where Q stands for Coordinate and camera coordinates in terms to remove the shakes and jitter and in last stage its delta values are calculated and rearrange the frame sequence. In this by applying all the steps mentioned above can successfully stabilize the video.

$$Space\ Q = Camera\ Q \times Camera\ Calibratio \quad (1)$$

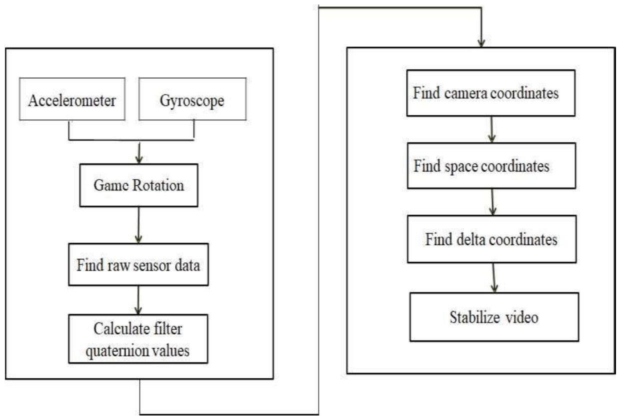


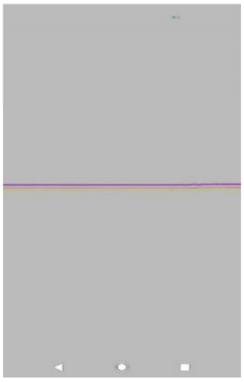
Fig. 2 Block Diagram of Proposed Application

A. Kalman Filter

The Kalman filter provides an estimate to the state of a discrete-time process defined in the form of a linear dynamical system [12]: x(t+1)=F_x(t)+w(t), with process noise w(t). The Kalman filtering has been employed in various fields of image processing such as video restoration [13]. In case the process to be estimated, or the measurement relationship to the process is nonlinear, a Kalman filter that linearizes about the current mean and covariance, referred to as the extended Kalman filter can be employed. For example, the use of an extended Kalman filter for the real-time estimation of long-term 3D motion parameters for model-based coding has been presented in [14]. The use of an extended Kalman filter for object tracking has been presented in [15]. For the Kalman filter-based image stabilization system, presented in this paper, linear global camera motion models are used, and the observations are also linearly related to the process state. Therefore, the standard Kalman filter system has been employed for the stabilization system. In this paper author capture sensor values from mobile devices they are not in synchronize mode. It may be possible that sensor values are logged at different timestamp values. So, it is very difficult to make them in synchronize mode. Kalman filter is mainly used in this paper for to get accurate orientation of device using sensor values as well as to linearization of sensor values

Experimental Setup

Synchronization of sensor readings and camera is performed by an application, described in the corresponding section. The proposed system implemented the prototype of the algorithm utilizing the Synchronization of sensor readings and camera, performed by an application, on the android studio platform with hardware requirement of i3 processor, with at least 5 GB hard disk with 1 GB ram and one android smartphone with at least 512 MB ram. The proposed algorithm has given synchronized sensor readings and frames, as well as intrinsic camera parameters, and has shown great significance as in Fig 5. Currently proposed methodology is successfully developed and run to get stabilized video. the background work of algorithm is also visualized by using graph as in Fig. 3, Fig. 4. Fig. 3 and Fig. 4 below is demo graph snippets when mobile is in different motion. Like in Fig. 3 the original data line i.e. blue line and filtered data line i.e. pink line are in one plane and fused yellow line is parallel to that position means there is no motion or jerks are present while in Fig. 4 we can see little bit jerks in original data blue line and that jerks are filtered as shown in pink line and yellow line is mixture of both which seems that mobile is position in when android device get tilted or not in stable motion.



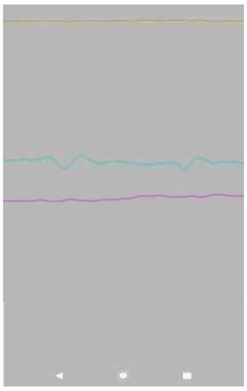


Fig. 3 Demo graph at Stable   Fig. 4 Demo graph at Unstable Position

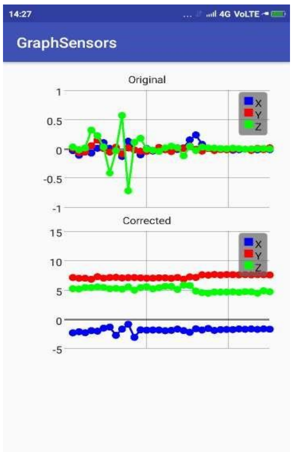


Fig. 5 Graphical representation of real time data

Fig. 5 show the both original sensor graph of real time data and stabilized sensor graph of proposed methodology in corrected data in which directly difference of shakes and jitters has been shown which seems in original data there are jerks present and in corrected graph these all jerks are smoothened and stabilized very well. Because of low consistency of reliable quantitative measure for video stabilization, getting experimental results is very hard. Presenting experimental results of video stabilization is not an easy task. The most widely used quantitative video stabilization efficiency metric is the peak signal-to-noise ratio (PSNR) in MSU Video quality management tool. In this paper author used PSNR.

$$PSNR = 10.log_{10}\frac{MaxErr^2.w.h}{\sum_{i=1,j=1}^{w,h}\left(x_{i,j}-y_{i,j}\right)^2} \quad (2)$$

Equation (2) shows PSNR formula, video width and video height are represented by w and h respectively. Mixer stands for maximum possible absolute value of color components
difference. [16]

Author record video for experimentation which named as LAB video. The LAB video has a resolution of 1280x720 and a framerate of 26.79 frames per second. The total duration of the video is about 7 seconds. The video is set indoors and is taken from a handheld smartphone camera.

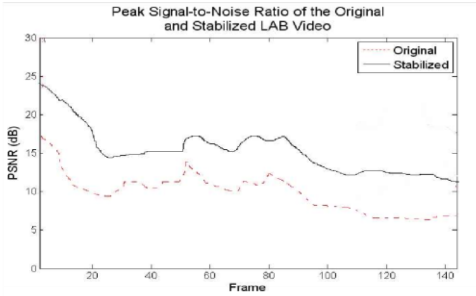


Fig. 6. The peak signal-to-noise ratio, in decibels, of the original and stable LAB videos.

Fig. 6 shows that the PSNR value of stable LAB video tends to be higher than the PSNR value of the original.

Conclusions

Current video stabilization techniques have been studied for this strengths and limitations. The paper shows the original video values and stabilized video values in the graphical representation form to better visualization background work. In this field a lot of scope is present to stabilize the video by studying the challenges and problems described in literature survey. The next goal of proposed application is developing the same in cross platforms.

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