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Review OF Block Based Video Stabilization

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Abstract: The stabilization of video is achieved by removing unintentional motion in scene and jitter (distortion) due to camera shake. Block based approach divides each frame of video into 16*16 blocks and matches blocks between current frame and previous frame using different block matching criteria. Lesser the value of criteria better is the matching. But, for this, search points are required to be chosen where block matching criteria is to be applied. For finding this search points different block matching algorithms have been proposed. After that, motion vectors are calculated over each matching block. The motion vectors due to unintentional motion are then filtered out to achieve stabilization of video.

Keywords: Block Matching Criteria, Digital Video Stabilization, Fast Block Matching Algorithm, Motion Estimation, Motion Smoothing.

I. INTRODUCTION

Due to advancement in the technology, it is now possible to take videos from cheaper multimedia devices like mobile phones. But, due to handshaking of user, the cameras on moving things (global motion) or vibration produced due to moving objects in the scene (local motion), the captured video becomes unstable.

To stabilize the video the approaches proposed can be classified as mechanical, optical and digital video stabilization techniques. [1] So, instead of holding camera in hand, mechanical stabilization proposes putting camera on some mechanical devices. This is probably simplest, cheapest and obvious method. The mechanical devices on which camera are to be put has included tripod, steadicam. But, the mechanical device mostly used is gyroscopic sensor.

Due to handshaking of user, the light rays which are supposed to fall on image sensor, actually falls somewhere else. So, optical image stabilization technique ensures that the light rays fall properly on image sensor even if handshaking of user or camera movements takes place [2].

The mechanical and optical stabilization techniques try to reduce camera shake by using mechanical devices to stabilize video. But, digital video stabilization technique processes video, frame by frame, post whole video is taken. Also, as mechanical and optical stabilization technique require some hardware it obviously needs some space to accommodate that hardware and is unsuitable in small devices like mobile phones.

Also, optical stabilization is much expensive method compared to digital technique. The digital stabilization technique considers motion estimation and motion smoothing. Motion estimation compares the current frame with previous frame to find best matching block and calculates motion vectors for that block and motion smoothing removes motion vectors due to unintentional motion to give stabilized video.

II. MECHANICAL STABILIZATION

The gyroscopic sensor (gyros) can be made smaller and cheaper due to MEMS. [3] Very popular form of MEMS gyroscope is micro machined vibratory gyroscope [MVG] or simply Vibratory Gyroscope. Vibratory Gyroscope is best suited to consumer electronic applications due to its lower power consumption, low weight and small size [4].Vibratory gyroscope works on principle based on Coriolis effect. Hence it is also called as Coriolis effect gyroscopes.

As shown in fig.1, two dampers and two springs are suspended along X and Y-axis to proof mass m. The component attached to X-axis is driving mode and to Y-axis is sensing mode. The displacement along X-axis due to force applied to proof mass is given by:

$$x(t) = A_x .\cos (W_x . t)$$

Where, A_x= amplitude

W_x= driving angular frequency

The Coriolis Effect takes place along Y-axis. The coriolis acceleration effect of Ω_z (angular rate along Z- axis) is given by:

$$a_y = -2\,\Omega_z\, A_x\, W_x \sin(W_x t)$$

The amplitude along Y-axis and bandwidth will be maximum and minimum when driving mode and sensing mode are fully matched.

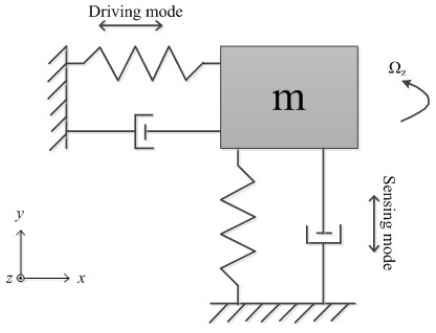

Fig.1 Vibratory Gyroscope

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III. OPTICAL IMAGE STABILIZATION

A. OIS Architecture

The optical image stabilization architecture consists of use of gyroscope,microcontroller,Hall sensor and control algorithm which is described one by one as follows:

Gyroscopes(Gyros)

Gyroscopes are used to measure angular displacements. Yaw gyros measures angular displacement along Y-axis and pitch gyros measure that along X-axis. The Yaw and pitch gyroscope chosen should have low power consumption, minimum phase delay and low noise density.

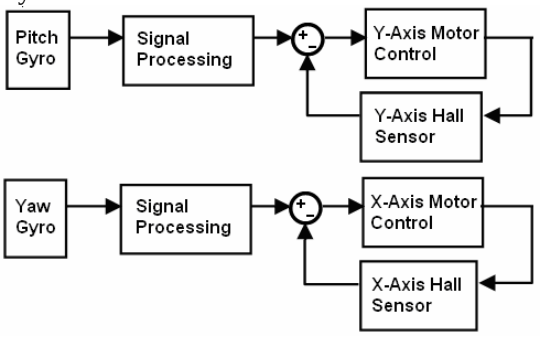

Fig.2 OIS Control Loop Block Diagram

Microcontroller

Microcontroller communicates with gyros and driver to retrieve information from them. The control of system is done through an algorithm which is executed by microcontroller. Camera module is to be actuated according to new conditions by driver. Microcontroller directs driver with that conditions.

Hall Sensors

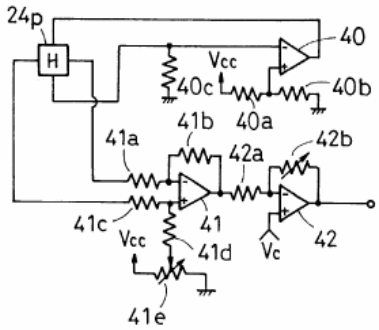

Fig.3 Cannon Hall Sensor Conditioning [5]

Hall Sensors must be placed in respective axes so that it does not measure from other axes. Also, the circuitry should be designed keeping in mind that Hall sensors are temperature dependent. For this current source is used in circuit. As shown in figure, out of four contacts to Hall sensors, two measures current and remaining two measures deflection in current.

OIS Control Algorithm

As stated earlier, gyros measure angular displacement. Filtering stage filters angular rate data to remove offset drift. In post filtering and data integration section angular displacement by jitter is obtained and data is integrated. In controller deployment function, OIS controller processes angular rate data and camera module data, setting new set points. Jitter effect is nullified by assigning these new set points to driver.

IV. DIGITAL VIDEO STABILIZATION

Digital video stabilization technique takes account of motion estimation and motion smoothing. But, this technique relies on motion estimation which is heart of any digital video stabilization.Better the motion estimation performed better will be the results.

A. MOTION ESTIMATION

The estimation of movements of objects between current and previous frame is called as motion estimation.[6] Motion Estimation is classified as:

1)Feature Based Motion Estimation

2)Direct Methods

1) Feature Based Motion Estimation

In Feature based motion estimation, searching of points is not done over all pixel points. But, specific points called feature points are extracted using SIFT(Scale Invariant Fourier Transform).[7] But, the usual method have lack of robustness that it gives no feature points in moving things. Also feature points may have different Depth of Field.The first disadvantage can be tackled by using RANSAC and other one by using SFM (Structure From Motion). But, RANSAC too has disadvantage that it fails when object is moving slow.This problem can also be tackled by weighting the feature points and using weighted least square algorithm.[8].

The disadvantage of feature based methods is that they are overdependent in terms of accuracy on feature point extraction step.[9]

2. Direct Methods

Due to its more accurate and robust performance direct methods are prefered over feature based methods for motion estimation. Direct methods are classified as:

1. Phase Correlation Method And Its Extension To Subpixel Registration
2. Block Based Method

Phase Correlation Method And Its Extension To Subpixel Registration Subpixel registration is based on interpolation approach.Though there are subpixel registration which are based on non-interpolation approach.The extension to phase correlation lies in interpolation approach.[10] The principle of operation of this method is fourier shift transform.The fourier two images between two frames are computed. The shift in spatial domain is nothing but phase difference of frequency domain of fourier transform of that two images.[11] Phase correlation is then obtained by taking inverse fourier transform.

Block Based Method

Block based approach divides each frame of video sequence into 16*16 blocks called macroblock and then macroblock of current frame is compared with that macroblock of previous frame to calculate motion

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vectors.The matching between macroblock of current and previous frame is done on the basis of block matching criteria.Lesser the value of matching criterion better is the match between macroblock.

V. BLOCK MATCHING CRITERION

Few of the block matching criterion are explained below

A. SAD (Sum Of Absolute Difference)

SAD is most used criterion and is given by:

$$SAD = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} |fcurrent(j,i) - fref(j + \mathrm{Vx}, i + \mathrm{Vy})|$$

, N= height of block

M= width of block

i= index of horizontal direction

j= index of vertical direction

V_x,V_y= motion vectors of reference block

$f_{current}(x,y)$= pixel intensity at current block

$f_{ref}(x,y)$= pixel intensity of reference block

B. Partial Distortion Elimination (PDE)

SAD requires very high number of computation.To reduce number of computations Partial Distortion Elimination is used which is given by[12]:

$$Partial\ SAD(k) = \sum_{i=0}^{k} \sum_{j=0}^{M-1} |fcurrent(j,i) - fref(j + \mathrm{Vx}, i + \mathrm{Vy})|$$

Where, M=width of block

k= number of rows evaluated

VI. FAST BLOCK MATCHING ALGORITHMS

The very common block matching algorithm is Full Search Algorithm (FSA) or Exhaustive Search which searches from top to bottom, left to right in the block. This method gives the best PSNR(Peak Signal to Noise Ratio)of any block matching algorithm but has very high number of searching points compared to other methods.

Hence, many fast block matching algorithms have been proposed which are as follows.

A. Three Step Search (TSS)

In the first step of this algorithm, total nine points are considered one at centre and other eight in all direction equidistant at a distance of step size of 4 from central point.

The block matching criteria at each of these nine points is applied and point at which this criteria gives minimum value is considered a new centered point for next searching. In the second step, new step size that is half of step size used in first step is applied.

The searching procedure continues till the step size equals to one. At the point where block matching criteria gives minimum value when step size is one is the best matching macro block in current frame.[13]

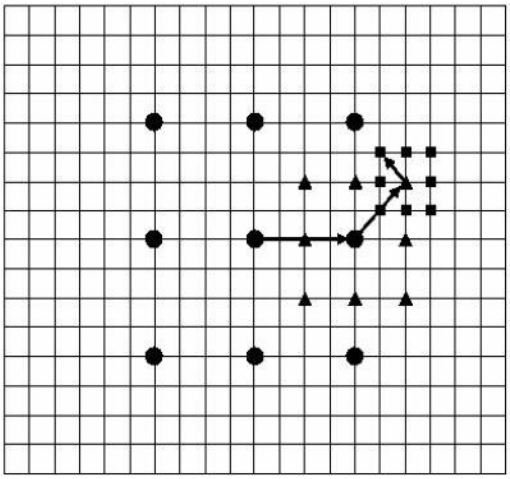

Fig.4 Three Step Search

B. Diamond Search

Diamond Search algorithm considers two patterns for searching. One is Small Diamond Search Pattern (SDSP) and other is Large Diamond Search Pattern (LDSP). SDSP consists of five checking points while LDSP consists of nine checking points with one point at centre and others being around that centre point.

At nine points of LDSP, Minimum Block Distortion (MBD) is calculated. If that point is other than centre point then new LDSP is formed. i.e. other new eight points with previous MBD point as centre is considered. This procedure repeats until the MBD point is at achieved at centre point. Once that MBD is found at centre, LDSP is switched to SDSP at which MBD is found. The block at which MBD is achieved is the best matching block.[14]

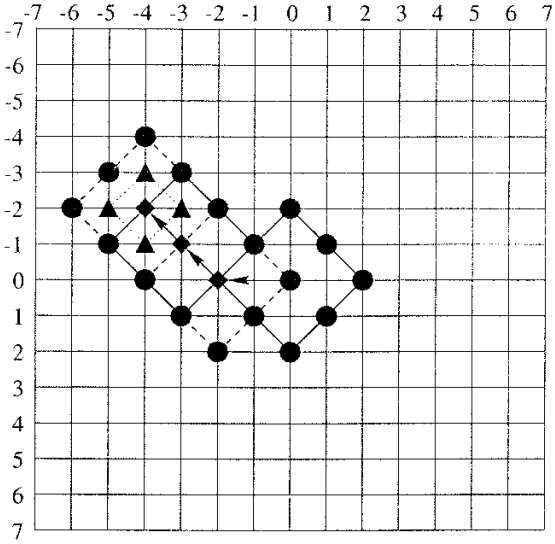

Fig.5 Searching Procedure In Diamond Search

C. Adaptive Rood Pattern Search

Adaptive Rood Pattern (ARP) search is done in two steps. The first one is initial search and other is refined local search. The initial search finds good point to start and in refined local search rood pattern of unit size is applied to find final motion vectors. In this search macroblock is moved to particular direction to find similar motion vector. The overall scheme is shown in fig.

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Generally, the motion vectors of video sequence are in horizontal or vertical direction. As ARP considers both directions it detects good matching very fastly.With considering that point as centre diamond search is applied.But, instead of applying LDSP and then converting to SDSP, directly SDSP is applied until least weighted point is the central point.[15]

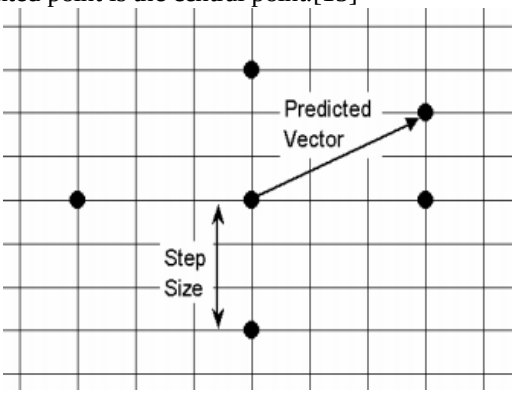

Fig.6 Adaptive Rood Pattern

Apart from the fast block matching algorithms, Battiato et al. proposed totally different block matching algorithm which considers two thresholds th_{hist} th_{rand}.The necessary thing in the algorithm is to know number of selected vectors which are given by th_{hist}* V_{max} and th_{rand}*V_{max} in both block history and random insertion situation.Vmax is the number of blocks in which local motion vectors are to be computed. First of all dilation and erosion operators are applied over Boolean matrix B which contains history of information of reliable vector positions at t-1 frame (previous frame). The pruning step is then performed to remove redundant vector so as to not cross the threshold limit th_{hist}, in history of block situation. Other than history vectors, other vectors are randomly chosen from image I which is divided into M*M rectangular regions. N regions are then selected from them to select point p. [16]

VII. MOTION SMOOTHING

Until now motion estimation is considered. The goal of motion estimation is to calculate motion vectors. These motion vectors are achieved from intentional motion and unintentional motion also. The video stabilization is achieved by filtering the motion vectors from unintentional motion. This process is called motion smoothing.Many approaches to achieve motion smoothing have been proposed. Low pass filter, IIR, FIR and Kalman filter have been used for motion smoothing. But these methods were complex and not useful for videos having fast moving objects. So, first order adaptive IIR filter is used which removes above drawback. [17] This method splits motion vectors in X and Y direction and uses IIR filter to smooth vectors in respective directions.

VIII. CONCLUSION

In this paper, various techniques of video stabilization are discussed.The latest technique of MEMS have been used in the form of Vibratory Gyroscope.Also, the basic architecture of Optical Image Stabilization is considered.The basics of digital video stabilization i.e. motion estimation and motion smoothing have been discussed . The block matching criterion and various fast block matching algorithm have been discussed in detail.The latest method of block matching algorithm is discussed

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