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VHDL based Implementation of Stabilization Algorithms

[1] Parmeet Kaur Jaggi,[2] Dr Umashankar Kurmi
[1] Research Scholar, LNCT University, Bhopal ,[2]Prof, LNCT University, Bhopal

Abstract : This study has focused on the creation of a digital video stabilisation system based on globally retrieved characteristics. Due to the descriptor choice, the final system has been discovered to be computationally much faster, making it much quicker than the present systems and exhibiting enhanced PSNR and MSE values. The suggested HDL language, VHDL, has been used in its implementation. For purposes of verification, the MATLAB Computer Vision Toolbox Dataset has been utilised**.**

IndexTerms **- Motion detection, Motion Compensation, DVS, FPGA, HDL.**

I. INTRODUCTION

DVS is a post-processing video stabilisation method that is very quick and effective. But because of its limits, it often leads to distortions being added to the frames of the video. When interpolation is employed to fix the frames, prominent edges and high frequency details may be damaged or destroyed. Frames lose information as a result of motion. However, DVS makes real-time applications viable. For the algorithms to provide real-time performance, they must be upgraded.
Figure 1 blocks show what a typical digital video stabilisation system looks like. Motion estimation is the process of extracting broad motions from the frame data of a movie. However, motion correction makes a distinction between positive and unfavourable motions [1,2]. movements. The final stabilized video is produced via image correction, which also makes the required adjustments.

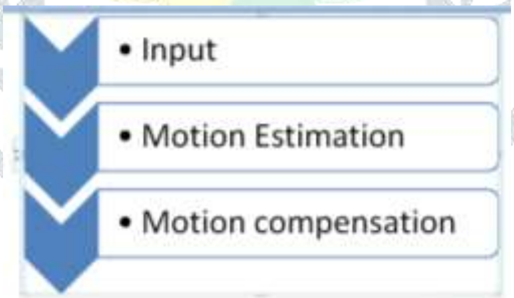

Fig 1 Video Stabilization Process

II. LITERATURE SURVEY

Gradient approaches are being developed for picture sequence analysis applications. The equation for the optical flow constraint is solved using the gradient method. Multiple extra limitations are employed to help with the solution of this problem. For instance, the Horn-Schunck method may be used to reduce the square of the optical flow gradient magnitude [3].

$$.\left(\frac{\partial v_x}{\partial_x}\right)^2 + \left(\frac{\partial v_x}{\partial_y}\right)^2 \text{ and } \left(\frac{\partial v_y}{\partial_x}\right)^2 + \left(\frac{\partial v_y}{\partial_y}\right)^2 \quad (1)$$

The benefit of unit gradient vectors is that they are insensitive to continually changing image intensity. Compared to the mentioned traditional processes, the created system purportedly offered motion estimation algorithms that were robust to changing illumination circumstances. As information is gleaned from following frames in [4], trans-rotational motions are taken into account. Following the Horn Schunck technique, which estimates motion using an affine model and optical flow, video sequences are stabilised using a model fitting filter. Although pixel recursive is a variation of closely related gradient-based algorithms, it should be acknowledged as a separate, distinct class due to its major contributions to the area of computer vision. A part of the iteratively gradient Displaced Frame Difference approach is predicted error minimization (DFD). The Netravali Robbins approach, a version of the pixel recursive method, uses the formula to update the DFD vector iteratively [5].

Block Matching Techniques are the reduction of a differentiative measure [6]. Therefore, block matching works by comparing a block from the current frame to a block from the previous frame to see whether they match. Full search is used to discover which projected representation of the current block is the best by calculating the matching criteria between the current block and all of the other blocks in the search area. As a result, the approach becomes costly and time-consuming to calculate, particularly for real-time applications. TSS (three-step search) begins with a rectangular search window and progresses to a position in the middle of the search space. The authors of [7] introduced the adaptive rood path search (N-ARPS) method with a simple motion prejudgment adjustment. (SMP). Depending on the motion characteristics, SMP will choose a search method for each block. Modern studies on the three search algorithms have only recently been disseminated in the literature. [8] examines a video stabilisation approach for translational motion analysis based on Gray coded bit plane (GCBP) matching employing a GCBP of image sequences in order to provide quick motion estimation and reduce processing burden. The three-step search (TSS) and GCBP matching, which conduct an effective search during correlation measure calculation, further increase computing efficiency. The authors employ motion search in (9) to find the block's position in the reference frame that is the closest match, and then use that location to extract the block's local motion vector in the present frame. Fewer blocks were used to reduce the algorithm's complexity. The diamond search uses a big hexagon as opposed to a huge diamond in order to follow the same search pattern as the hexagon-based search algorithm (HEXBS)[10]. In a variant of the HEXBS[11], a rood-shaped pattern is utilised to forecast motion direction, and a hexagonal-based search is employed to improve the search process (HexBS). A New Adaptive Rapid BMA [12] has also been developed, and it is useful for eliminating temporal redundancy in sequences having slow, medium, and rapid motion content. Block matching algorithms may be used to match sequences in rapid, medium, or slow motion, and it is clear from the context of the discussion that no one method will be equally effective for all types of motions. However, it has been shown that in terms of the number of computations, BBGDS (block based gradient descent search) and diamond search (DS) perform better than other methods. A short diamond search pattern (SDSP) and a long diamond search pattern (LDSP) make up the DS algorithm (LDSP). Finding a match that will occur in the centre of the LDSP is the goal of the LDSP pattern. According to a field investigation, simulation findings utilising DS are more accurate than TSS with a matching NTSS in terms of compensatory error. Some authors, including [13], did overcome this issue with an end application of stabilisation that combined the Diamond search-based quick block matching approach with the Hooke Jeeves algorithm. Their research showed that this combination significantly improved the accuracy of motion estimation.

Frequency-based methods depend on precise transformations from one frequency domain of the picture to another (e.g. Fourier or Gabor transform). To produce the measurements, a correlation factor with various phase shifts is commonly utilised (which corresponds to a translation in the image domain). A motion estimate approach based on logarithmic search was provided by [14] in an attempt to reduce spatial redundancy, however it was unable to accomplish so without becoming more sophisticated. The restored photos' visual quality suffered as a result as well. The methods in [15], [16] are among the most widely used FFT-based motion estimate methods. Frequency-based motion estimating techniques have drawbacks that make them unsuitable for a range of applications, particularly those that use real-time data. The method of calculating the Global Motion Vectors (GMV) using changes between piggybacked video frames is known as global motion estimation. Frame-to-frame motion in movies must be quantified using GME stabilisation. The digital video stabilisation system relies on estimate of the global motion parameters between adjacent frames as well as the geometric transformation parameters included in the picture plane coordinate systems of back-to-back frames. The system's jitter reduction technique influences how well the global motion parameter is calculated.

For the purpose of computing motion vectors, GME employs many methods. Using feature-based motion estimation, the 2D motion is estimated as a motion model and used to determine global motion. Two methods to classify it are in terms of local and global elements. Local characteristics are things like points, edges, corners, faces, textures, and colours that can frequently tolerate occlusion. They, on the other hand, have a lower noise tolerance. Properties between interframes may be found via feature-based motion estimation. [17] describes a new work that uses a block-based motion estimation technique to accomplish global motion estimation. When using feature matching algorithms like those described in [18], it is possible to extract the relevant features SIFT and SURF from both the current and reference frames. The necessary features are found, and utilising matching characteristics, the global motion parameters are computed. Block matching methods that just consider translational movements are less precise and flexible than algorithms that include account for other motions like rotation and zooming. Shen [19] presented a new approach to digital video stabilisation by extracting features using the PCA-SIFT (Principal Component Analysis Scale Invariant Feature Transform) technology. To choose similarly spread out locations for Harris point detection, grid sampling was used in [20]. To produce the global motion matrix, the points were matched using feature window matching and then confirmed using the distance condition. Recently, few studies that used the homography approach [21] have also been completed. Other works mentioned are [22,23,24,25,26].

III. IMPLEMENTATION

Implementing SURF-based high performance embedded system designs is not without its challenges. Interest point identification and description were incorporated in the design. For real-time calculation of interest point detection and interest point description modules on different rows of a video frame, two simultaneously operating layers will offer parallel operation. One layer is used for interest point detection, while another is used for interest point description. The matching of interest locations across frames is a component of motion estimation. The pipelined architecture that has been used consists of three steps.

1) Static block identification and description
2) Global motion calculations
3) Motion correction

When identifying interest points, a filter-like array of processing elements is employed to facilitate pipelining. Each processing unit carries out five MAC operations to determine the response of box filters and Haar wavelets from the image. The coefficients from the filters are subsequently stored by the processing components. The 4x4 Haar wavelet is subsequently stored in the central processing component of the array. For pipelined operation, a delay of one pixel arrival is required since the pixels are streamed into the rows of processing components at a certain data rate.

The last level of SURF descriptions includes processing elements as the architecture for interest point. The Haar wavelet response values, Hx and Hy, are part of the process of identifying interest points and figuring out the Hessian filter response, and they are calculated for each individual point separately.

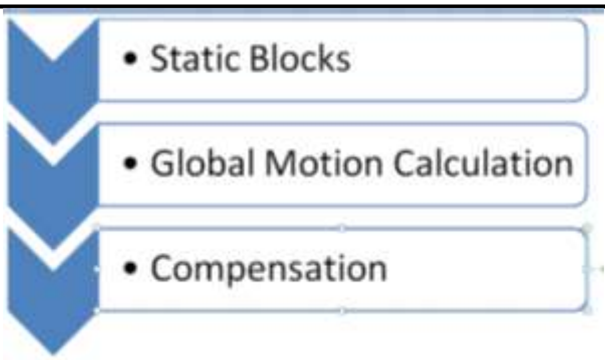

Fig 2 Scheduling in stages

IV. RESULTS AND ANALYSIS

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The dataset used to gather the videos for the system testing is the MATLAB CV Dataset. The highest PSNR values, however, are far higher than the 35 dB threshold in all of the movies, for both the Deshaker stabiliser from which the comparisons were made by [27] and the method they also recommended. The PSNR number we obtained, 41, was the lowest of all the movies we looked at in the datasets, and the average value, 37 dB, was the lowest for the MATLAB dataset. The recommended approach has continuously shown to be correct in terms of enhanced stability by generating higher PSNR. A comparison of average values from datasets is shown in Table 1. The suggested approach greatly improves the MSE values, which have a maximum average value of 3.664 and a lowest average value of 1.94 for the same shaky Rhino footage. As a consequence, the stability and video quality are greatly improved. The values are listed in Table 2. the system was sluggish and the board's resources were being used up quickly, the system is being built on a basys3 FPGA Board. When all stages of video stabilisation, including Motion estimation, correction, and smoothening, are taken into consideration, the recommended solution, which makes use of the Nexys A7 Artix-7 FPGA board, demonstrates a much better implementation and resource utilisation. An explanation of resource use is given in Table 3.

Table 1 Comparison of PSNR

	Online stabilizer like Deshaker	Proposed
PSNR	25 Db	37 Db

Table 2 Calculations for MATLAB dataset

Dataset	No of Videos	Highest Average PSNR	Lowest average P SNR	Highest average MSE	Lowest average MSE
Computer Vision Toolbox	10	37	4.66	3.664	1.94

Table 3 Artix 7 Board Utilization

Device Utilization comparison	Proposed
Board Used	Nexys A7 Artix-7
Registers	10%
Look up Table	10%
DSP	19%

V. CONCLUSIONS

Building a stabilizing system with specific uses in mind was the goal of this endeavor. We wanted to create a stabilizing mechanism that we could use on off-road vehicles and unmanned aerial vehicles. Videos taken with such recording devices have a particular sort of distortion that is more translational than rotational. As a result, the design was created with the end applications in mind, and the algorithm was changed to precisely respond to these circumstances. The system is much quicker in processing. As a consequence of these circumstances, the complexity of the suggested method was also lowered, and we were able to suggest a small-footprint, real-time Video Stabilization program that was ideal and has been implemented on to the Nexys A7 Artix-7 FPGA Board

REFERENCES

[1] T. Kondo, P. Boonsieng,"Improved gradient-based methods for motion estimation in image sequences," 2008, pp. 1120-1123.

[2] Toshiaki Kondo,Waree Kongprawechnon “Robust motion estimation methods using gradient orientation information. Science Asia , Vol 35, 2009

[3] Gong, Bansmer, “Horn Schunk optical flow applied to deformation measurement of a birdlike airfoil, Chinese Journal of Aeronautics”, Volume 28, Issue 5, 2015, Pages 1305-13154

[4] W. Xu, X. Lai, D. Xu, N. A. Tsoligkas, "An Integrated New Scheme for Digital Video Stabilization", *Advances in Multimedia, vol. 2013*, Article ID 651650, 8 pages, 2013

[5] D. Walker and K. Rao, "Improved Pel-Recursive Motion Compensation," in *IEEE Transactions on Communications*, vol. 32, no. 10, pp. 1128-1134, October 1984

[6] W. Hassen, H. Amiri, "Block Matching Algorithms for motion estimation," *7th IEEE International Conference on e-Learning in Industrial Electronics (ICELIE), Vienna*, pp. 136-139, 2013

[7] W. Lei, M. Shi and G. Wang, "Research and Verilog HDL implementation of technology for motion estimation based on new three — step method," 2017 *IEEE 2nd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), Chengdu, 2017*, pp. 1715-1719, doi: 10.1109/ITNEC.2017.8285089.

[8] M. Ahmed, "Digital Video Stabilization- Review with a Perspective of Real Time Implementation," in 2017 IEEE International Symposium on Nanoelectronic and Information Systems (iNIS), Bhopal, India, 2017 pp. 184-189

[9] M. Ahmed and L. Singh, "Verilog based Implementation of Real Time Digital Video Stabilization," *2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT)*, 2021, pp. 273-278, doi: 10.1109/CSNT51715.2021.9509625

[10] Thomas, D.M. “A Study on Block Matching Algorithms and Gradient Based Method for Motion Estimation in Video Compression”. DPPR. Communications in Computer and Information Science, vol 205. Springer, Berlin, Heidelberg, 2011

[11] M. Muzammil, I. Ali, M. Sharif and K. A. Khalil, "An efficient architecture for hardware realization of hexagonal based motion estimation algorithm," *IEEE International Conference on Consumer Electronics - Taiwan*pp. 422-423, , 2015

[12] Ali, G. Raja, M. Muzammil, "Adaptive Modified Hexagon Based Search Motion Estimation algorithm," IEEE Fourth International Conference on Consumer Electronics Berlin (ICCE-Berlin), pp. 147-148, 2014

[13] Rohan Mukherjee, Priyabrata Saha, Indrajit Chakrabarti, Pranab Kumar Dutta, Ajoy Kumar Ray, Fast adaptive motion estimation algorithm and its efficient VLSI system for high definition videos, Expert Systems with Applications, Volume 101, 2018, Pages 159-175

[14] Jifei Song and X. Ma, "A novel real time digital video stabilization algorithm based on the improved diamond search and modified Kalman filter," *2015 IEEE 7th International Conference on Awareness Science and Technology (iCAST)*, 2015, pp. 91-95

[15] Pranob K Charles , Dr. Habibulla Khan, “Enhanced Logarithmic Search Technique for Motion Estimation with Three Step Reduction”, Global Journal of Computer Science and Technology, Issue I Version I, Year 2017

[16] Mingzhou Song and Jing-ao Sun, “Motion Estimation in DCT Domain”, *IEEE Transactions on Communication, Vol. 25, pp. 1004 - 1009, Aug. 2003*

[17] G. Tzimiropoulos, V. Argyriou "FFT-based estimation of large motions in images: A robust gradient-based approach," IEEE International Conference on Acoustics, Speech and Signal Processing, 2009, pp. 969-972, 7. K. Srinivas Rao, A.V. Paramkusam, Naresh K, Abdellah Chehri,L Block Matching Algorithms for the Estimation of Motion in Image Sequences: Analysis, Procedia Computer Science, Volume 192, 2021, Pages 2980-2989

[18] K. Srinivas Rao, A.V. Paramkusam, Naresh K, Abdellah Chehri,L Block Matching Algorithms for the Estimation of Motion in Image Sequences: Analysis, Procedia Computer Science, Volume 192, 2021, Pages 2980-2989

[19] Oliveira, A.J.; Ferreira, B.M.; Cruz, N.A. A Performance Analysis of Feature Extraction Algorithms for Acoustic Image-based Underwater Navigation. J. Mar. Sci. Eng. 2021, 9, 361

[20] Shen, Yao & Guturu, Parthasarathy & Damarla, Thyagaraju & Buckles, Bill & Namuduri, Kamesh. “Video Stabilization Using Principal Component Analysis and Scale Invariant Feature Transform in Particle Filter Framework”. *IEEE Transactions on Consumer Electronics, 55(3)* , 2009

[21] Chenguang, Guo & Xianglong, Li & Linfeng, Zhong & Xiang, Luo. (2009). A Fast and Accurate Corner Detector Based on Harris Algorithm. *3rd International Symposium on Intelligent Information Technology Application, IITA 2009*

[22] *K. Wiriyaprasat and M. Ruchanurucks, "Realtime VDO stabilizer for small UAVs using a modified homography method,"* 2015 International Conference on Science and Technology (TICST), *2015, pp. 40-43, doi: 10.1109/TICST.2015.7369337.*

[23] *K. Verma, Andri, R. K. Singh, B. Kumar, R. Marathe and A. Kumar, "FAST Based Video Stabilization with Preserved Intentional Motion and Smear Removal," 2020 International Conference on Electrical and Electronics Engineering (ICE3), 2020, pp. 376-381, doi: 10.1109/ICE348803.2020.9122965.4*

[24] *G. Balachandran and J. V. G. Krishnan, "A Novel Block Based Triangulation method to improve Video Stabilization," 2019 Fifth International Conference on Science Technology Engineering and Mathematics (ICONSTEM), 2019, pp. 540-545, doi: 10.1109/ICONSTEM.2019.8918886.*

[25] *S. -J. Huang, Y. -H. Lin, C. -H. Weng and Y. -C. Lu, "A Real Time Video Stabilizer Based on Feature Trajectories and Global Mesh Warping,"* 2021 IEEE Asia Pacific Conference on Circuit and Systems (APCCAS)*, 2021, pp. 69-72, doi: 10.1109/APCCAS51387.2021.9687624.*

[26] *L. Wen, Z. Yingjun and Y. Xuefeng, "A Feature-based Method for Shipboard Video Stabilization,"* 2019 IEEE 2nd International Conference on Electronic Information and Communication Technology (ICEICT)*, 2019, pp. 315-322, doi: 10.1109/ICEICT.2019.8846432.*

[27] *P. Bansal, J. B. Dinesh, S. K. V. R., S. K. B and T. S. Chandar, "Video Stabilization Using ORB Detector,"* 2022 14th International Conference on Computer and Automation Engineering (ICCAE)*, 2022, pp. 50-55, doi: 10.1109/ICCAE55086.2022.9762438.*

[28] *Hossain, M.A., Huh, E.-N , A novel performance metric for the video stabilization method(Conference Paper), Advances in Intelligent Systems and Computing Volume 935, 2019, Pages 486-496, 13th International Conference on Ubiquitous Information Management and Communication, IMCOM 2019; Phuket; Thailand; 4 January 2019 through 6 January 2019; Code 226539*