Analysis of Harris Corner Detection For Color Images

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***Abstract*— Corner detection algorithm is an algorithm which helps in identifying the corners in an image. Corners are mainly formed by the combination of two or more edges. These corners may or may not define the boundary of an image. Here the method used is Harris corner detection algorithm. It helps in pointing out the corners in a color image, for each component. This improves the detection efficiency and the experimental results shows that this method is more reliable than traditional methods.**

Keywords— corner;edge; harris; traditional methods;

I. INTRODUCTION

The corner point determines the local feature extraction when an image is given as input. Corner detection is a method for calculating the number of corners an image is having. This approach is used in many computer vision systems, mainly for extracting the corners and certain features in an image. This corner detection is frequently used in detection of motion, registration of images, tracking of videos, mosaicing the images, stitching the panorama images, modeling the 3D objects and recognition of objects. Corner detection is somewhat similar to the interest point detection.

In images, corners are important because they are the local features. Generally, these points will have high value and these lies in between the two regions or on boundaries. In some images, these corners are not affected by illumination and also have the property of rotational invariance. The total percentage of the local features is 0.05% n the whole pixels. Extracting corners can minimize the processing data without losing image data. Hence they play an important role in all its applications.

Mainly here a window is used which is allowed to pass through the image. An edge can be easily recognized by looking at the intensity values within a small window. When it is encountered by a flat region then there will be no change in all directions. When it is encountered by an edge then there will not be any change along edge directions. But, when it is encountered by a corner then there will be significant changes along all directions.

Harris corner detection algorithm is found out by calculating each pixel's gradient. If the absolute gradient values in both the directions are great, then consider the pixel as a corner. This method is followed by mathematical formulas. By taking in to considerations of the differential of the corner score with respect to direction directly, Harris and Stephens improved the Moravec's corner detector instead of using shifted patches.

II. LITERATURE SURVEY

A window approach can be used for locating the corners.[2]. It also helps in the accuracy of the images. Here there are mainly two steps: the first step is to locate the corner points using this corner detection and the second step is to improve the accuracy of the sub-pixels. The accuracy of the extracted points will affect the accuracy of camera calibration parameters and its post processing problems of image quality.[2]

An improved version of harris detection is described in [3]. The name of the new method is Barron operator. Different steps are included in it: The first step is, to calculate the image gradient using Barron operator. Second step is to smooth the image, remove noises and extract the corner better than any other methods using B-spline function. The third step is to identify whether the detected corners are real or not. A square window is placed on the center pixel, to calculate the corner response function. It also calculates whether the response is non-maximal in the window or not.[3]

This paper [4] uses the concept of excluding the neighboring points by introducing the concept of image sub-blocking where a filter using B-spline is constructed. By comparing it with the Harris method, this improved algorithm can effectively detect the corner of the image and helps in getting a more accurate corner location. [4]

A new concept of corner detection has been introduced in this paper [5].Traditionally harris corner detection has been used for gray scale or color images in two dimensions. Here, detection has been extended to multispectral images. The experimental results show that the proposed detection algorithm can detect corners of multispectral images more

efficiently. These corners are having significant variations both in spatial domain and spectral domain.[5]

In this paper [6], corner detection is used for classifying breast mammograms as normal or abnormal. It is done with the help of the training data set used for Support Vector Machine (SVM). Here, improved Harris Corner Detection produces the output as corner pixels which are the taken as the input for the training set. The result shows that the proposed approach can improve both the accuracy and the performance of computational speed to classify the breast mammogram image as normal or abnormal. [6]

Harris corner detection for wavelets has been proposed in this paper [7]. In traditional methods some corner points are omitted based of certain criterion, but this problem is solved here. The motion of the vehicle is estimated based on the algorithm optical flow and multi-scale corner detection. Result shows that even though the camera and vehicle is moving the corner points will remain the same. The tracking algorithm helps in accurately match the feature points with the high real-time performance.[7]

Harris corner algorithm is proposed in this paper [8] which end up being robust in changing motion and illuminated lightning conditions. The main idea behind this paper is to locate the license plate. Here, harris corner detection is applied to extract the feature from the image.[8]

In this paper [9], localization of eyes in human faces is done with this corner detection method. Here, a new method based on filter combination is suggested. It is mainly for eyes localization where filters are used to find out and highlight corners of region with local maximum intensity. Then that region is categorized as sharp region. This approach gained good results.[9].

This approach is widely used in sea security issues [13]. Here features are extracted from high pixel, large size and low contrast images. The experimental results show that this method has gained good and effective results. [13].

Here [14] harris corner detection is used mainly for region based corner detection. Different densities of buildings are used as the input for the algorithm. It also compares the result with the other algorithms showing that this method gives a good result.[14]

In this paper [15], the human eyes are detected from the color images of the human faces. The first step is to recognize the face and the second step is to identify the eyes from the face with only two attributes. This method has gained 80% result with varying input images.[15]

In this paper[20], the harris corner detection is used to identify the watermarked regions of attacked images. The watermarked regions are those regions which are detected by corner algorithm as interest points. An algorithm that extracts more stable interest points, and those which gives promising performance is also proposed.[20]

This paper[21] is mainly working on medical imaging. Here it measures the measure and depth of the calcium deposit from IVUS images. This method reduces the errors caused during the process. It gives better results,[21]

III. ALGORITHM

HARRIS CORNER DETECTION FOR COLOR IMAGES

The color details of the image can also be taken into consideration. In case of gray scale images the color details of the image is lost. So to employ the color information, here the algorithm is used for color images.

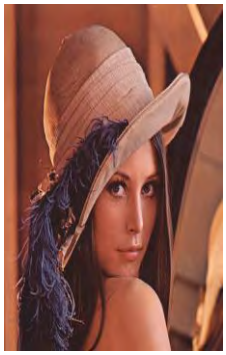

Fig 1: Color images showing the input and the corner detected

There are certain steps in Harris corner detection. The algorithm is as follows:

Step 1: Find out the x and y derivatives of the image

$$I_x \Leftrightarrow \frac{\partial I}{\partial x} \qquad I_y \Leftrightarrow \frac{\partial I}{\partial y} \qquad I_x I_y \Leftrightarrow \frac{\partial I}{\partial x}\frac{\partial I}{\partial y}$$

Step 2: Find out the products of the derivatives of each pixel

$I_x^2 = I_x * I_x$ $\qquad$ $I_y^2 = I_y * I_y$ $\qquad$ $I_{xy} = I_x * I_y$

Step 3: Calculate the covariance matrix M

$$M = \sum_{x,y} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix}$$

This is calculated by a window function: w(x, y)

That is:

$E(u, v) = \sum_{xy} w(x, y) [I(x+u, y+v)-I(x, y)]$

Where: I(x+u, y+v) is known as the shifted intensity

I(x, y) is known as the intensity

The above equation can be simplified as:

$$E(u,v) \approx [u \;\; v] \; M \begin{bmatrix} u \\ v \end{bmatrix}$$

From that calculate M which is the second moment matrix.

Step 4: Calculate the Eigen values λ: If λ is close to 0, then it is not a corner. So look for conditions where it is large.

Step 5: Calculate the corner response function R:

$$R=\det(M)-\alpha \text{ trace } (M)^2=\lambda_1 \lambda_2-\alpha (\lambda_1+\lambda_2)^2$$

Here, α value is between 0.04-0.06

Also if the value of R:

R<0: it is an edge

R>0: it is a corner

|R| is small: it is a flat region

Hence after computing all these steps the corner is detected in an image. Here we are calculating the values for each red, green and blue component.

Step 6: For calculating the common corner points, we apply AND operation. So the formula is:

crnr=(temp1)&(temp2)&(temp3)

Here, temp 1,temp 2 and temp 3 are the space where corner values of red, green and blue are stored.

Step 7: For calculating the corner points by using OR operation:

crnr=(temp1)|(temp2)|(temp3)

Step 8: Now find out the color gradient vector values

$$g_{uu} = \mathbf{u}\cdot\mathbf{u} = \mathbf{u}^T\mathbf{u} = \left|\frac{\partial R}{\partial x}\right|^2 + \left|\frac{\partial G}{\partial x}\right|^2 + \left|\frac{\partial B}{\partial x}\right|^2$$

$$g_{vv} = \mathbf{v}\cdot\mathbf{v} = \mathbf{v}^T\mathbf{v} = \left|\frac{\partial R}{\partial y}\right|^2 + \left|\frac{\partial G}{\partial y}\right|^2 + \left|\frac{\partial B}{\partial y}\right|^2$$

$$g_{uv} = \mathbf{u}\cdot\mathbf{v} = \mathbf{u}^T\mathbf{v} = \frac{\partial R}{\partial x}\frac{\partial R}{\partial y} + \frac{\partial G}{\partial x}\frac{\partial G}{\partial y} + \frac{\partial B}{\partial x}\frac{\partial B}{\partial y}.$$

Where, u, v are the x and y values and g_{uu} and g_{vv} are the I_{xx} and I_{yy} values. g_{uv} value correspond to the I_{xy} values. Here we are finding out the density value at each point and then comparing the corner responses.

IV. EXPERIMENTAL ANALYSIS AND RESULTS

The output of Harris corner algorithm is the detection of the corners in an image. By using AND operation we will be able to extract the corner points which are common to the three components: R G B. These points are selected in such a manner that, where there is a common corner value for the three components, then that value is considered as the interest point. The above algorithm has worked successfully for various images and the results are shown:

The input and output is as follows:

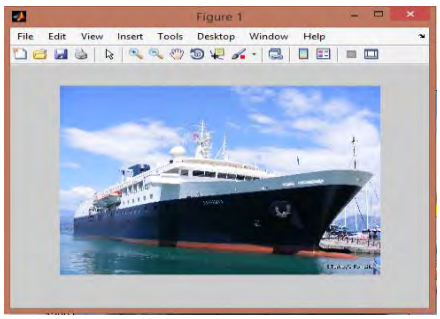

Fig 2: The input image

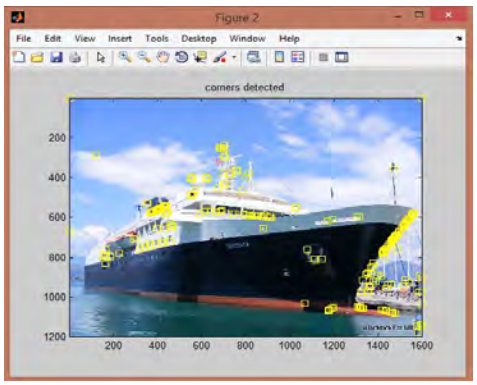

Fig 3: The output image for red component

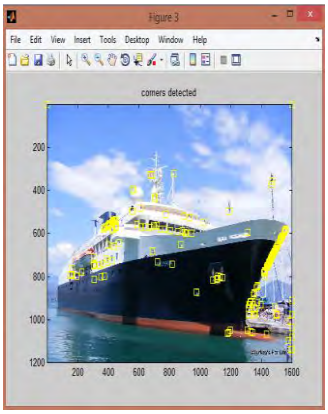

Fig 4: For green component

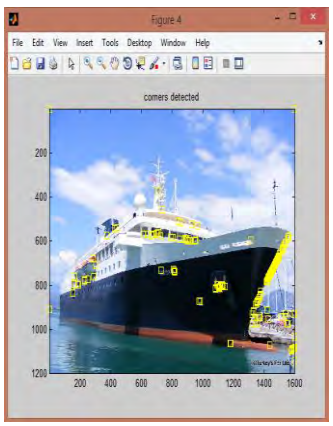

Fig 5: For blue component

After applying the AND operations the results will be a single image showing the common interest points among the three components RGB.

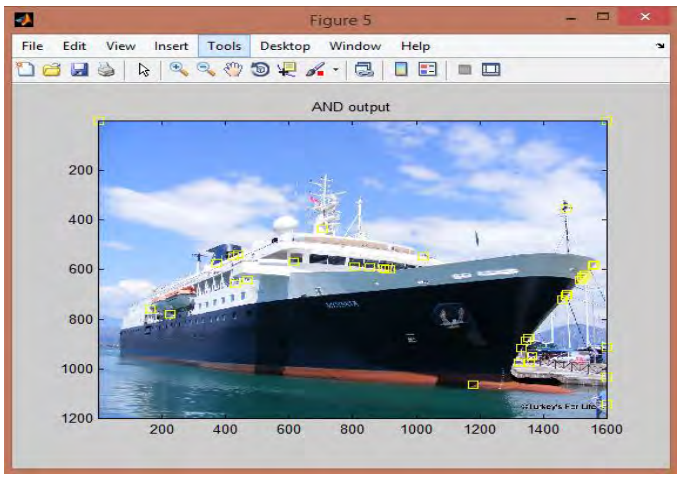

Fig 6: Output for AND operation

After applying OR operation the result will be:

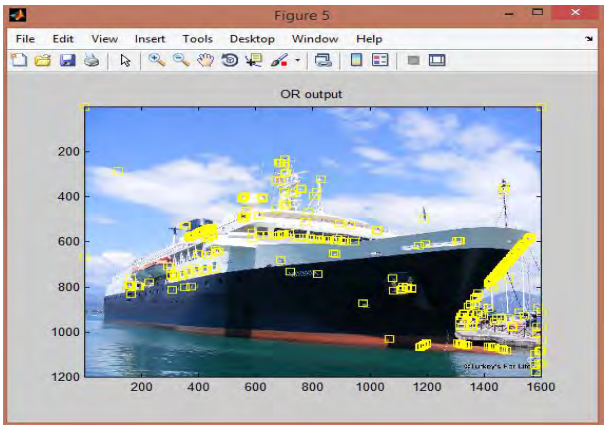

Fig 7: Output for OR operation

By changing the threshold value, more corner points will be detected. If we change the threshold value the result will be:

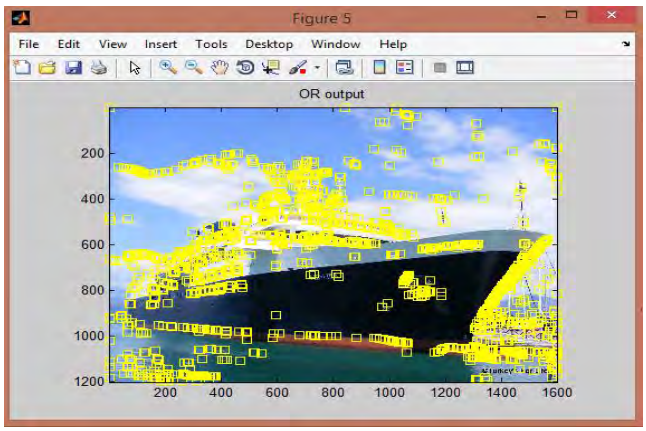

Fig 8: Output for different threshold value

Here we are also calculating the color gradient factor because this harris corner method is invariant to rotations. So this method has gained a good result in the output. In these methods we are not converting the given input image into a gray scale image. We are taking it as a color image itself. By converting it into gray image most of the color information and other important details will be lost. So, without losing the important information we are finding out the best results.

We are also showing the outputs of the images when the given image contains only red component, only green component and only blue component.

In case of red only image:

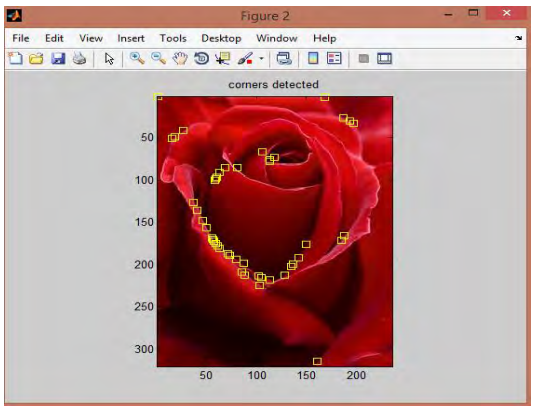

Fig 9: For red component

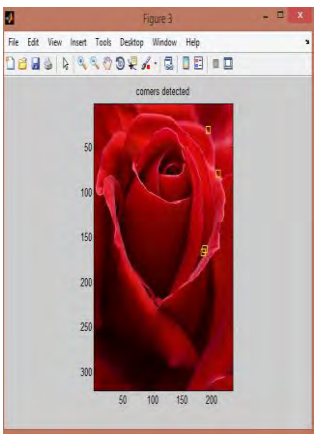

Fig 10: Green component

Fig 11: Blue component

In case of green only images:

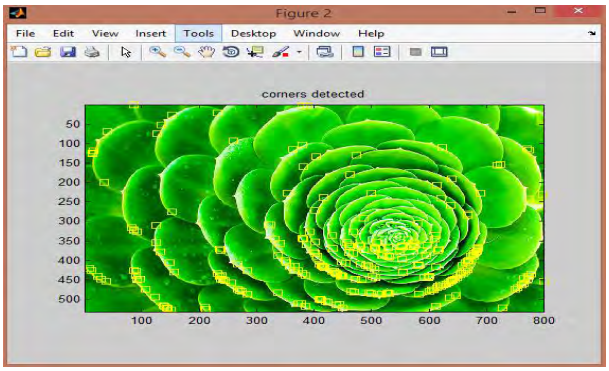

Fig 12: Green component in green image

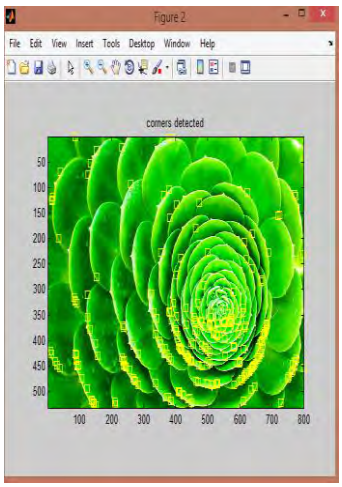

Fig 13: Red component

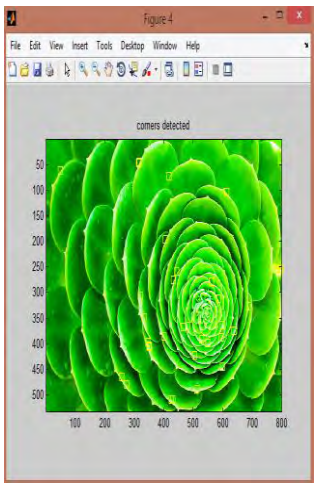

Fig 14: Blue component

In case of blue component only:

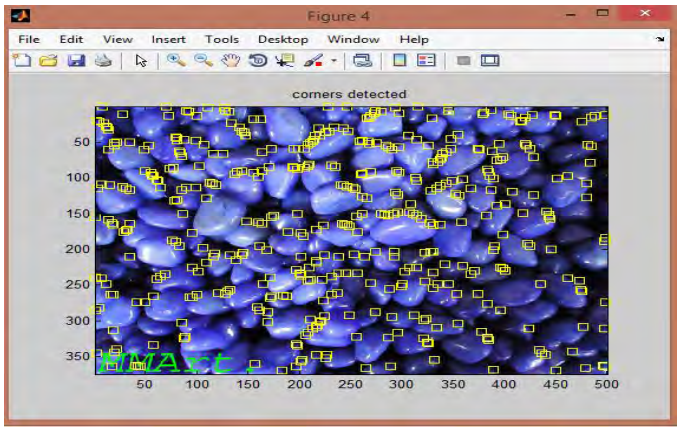

Fig 15: Blue component in a blue image

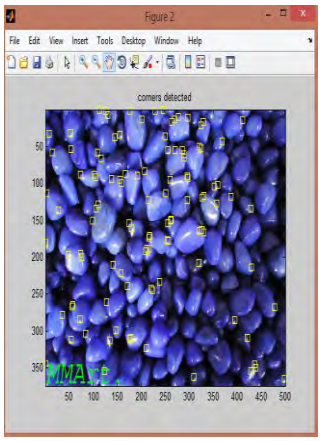

Fig 16: Red component

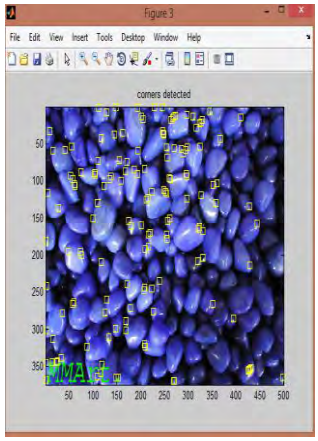

Fig 17: Blue component

V. *CONCLUSION*

This paper gives an idea of how the corners are detected when an image is given as input. It also explains how the Harris corner detection algorithm works for a color image. It also explains AND operation and OR operation work successfully for different images. Traditional methods used to convert the input image to a gray scale image for the detection. This algorithm is a technique which works faster than the other traditional techniques without converting to gray scale image. But by applying these operations it may sometimes cause unwanted corner to be detected. Even though by considering the above issue harris corner algorithm is an emerging technique, it has a wide range of applications. It is used in 3D modeling, video tracking and in many other areas.

References

[1] R.Aarthi, S.Padmavathi, J.Amudha,Amrita School of Engineering, Coimbatore, India, "Vehicle Detection in Static Images Using Color and Corner Map", 2010 International Conference on Recent Trends in Information, Telecommunication and Computing

[2] Yujing Qiao School of Mechanical and Power Engineering Harbin University of Science and Technology Harbin, China," Improved Harris Sub-pixel Comer Detection Algorithm for Chessboard Image," 2013 2nd International Conference on Measurement, Information and Control

[3] Jing Cui, Jianbin Xie, Tong Liu, Xiaoguang Guo, Zhangyong Chen," Corners detection on finger vein images using the improved Harris algorithm"

[4] Yong Zhang School of Computer and Communication, Lanzhou University of Technology Lanzhou, China," Adaptive Harris Corner Detection Algorithm Based on B-spline Function," 2010 Second International Conference on Intelligent Human-Machine Systems and Cybernetics.

[5] Yanshan Li1, Wei Shi1, Ailin Liu2 Affiliation1. ATR National Key Lab. of Defense Technology, Shenzhen University; Shenzhen 518060, China lys@szu.edu.cn Affiliation2. College of Information Engineering, Shenzhen University; Shenzhen 518060, China," A Harris Corner Detection Algorithm for Multispectral Images Based on the Correlation ," ICWMMN2015 Proceedings

[6] Hyun I. Kim, Sung Shin, Wei Wang Department of Electrical Engineering and Computer Science, South Dakota State University, Brookings, SD 57006, USA" SVM-based Harris Corner Detection for Breast Mammogram Image Normal/Abnormal Classification"

[7] Meng Liu, Chengdong Wu and Yunzhou Zhang School of Information Science and Engineering Northeastern University Shenyang Liaonin Province, China ," Motion vehicle Tracking based on Multi-resolution Optical Flow and Multi-scale Harris Corner Detection ," Proceedings of the 2007 IEEE International Conference on Robotics and BiomimeticsDecember 15 -18, 2007, Sanya, China.

[8] Tejendra Panchala,*, Hetal Patela, Ami Panchalb," License Plate Detection using Harris Corner and Character Segmentation by Integrated Approach from an Image," 7th International Conference on Communication, Computing and Virtualization 2016

[9] Moein Lak1, AmirMohamad Soleimani Yazdi2 1, 2 Islamic Azad University, South Tehran Branch, Technical & Engineering Faculty, P.O. Box: 11365-4435, Tehran, Iran,"Corner Sharpening With Modified Harris Corner Detection to Localize Eyes in Facial Images".

[10] Likai Chen, Wei Lu, Jiangqun Ni, Wei Sun, Jiwu Huang, "Region Duplication Detection Based on Harris Corner points and step sector statistics,".

[11] Ding Zhengj ian Lanzhou University of Technology LanZhou,China," Harris Comer Detection Based on the Multi-scale Topological Feature," 2011 International Conference on Computer Science and Network Technology

[12] Li Yi-bo, Li Jun-jun," Harris corner detection algorithm based on improved Counterlet Transform,"

[13] Liang Sun, Shuang-qing Wang, Jian-chun Xing College of Defense Engineering, PLA University of Science and Technology, Nanjing

210007," An Improved Harris Corner Detection Algorithm For Low Contrast Image,"

[14] Bo Yu, Li Wang, Zheng Niu "A novel algorithm in buildings/shadow detection based on harris detector,"

[15] AlakDasResearch Scholar, Dept. ofECE NationalInstitute of Technology, AgartalaAgartala, India," Human Eye Detection ofColor Images Based on Morphological Segmentation using Modified Harris Comer Detector".

[16] Andrea Kovacs', Tamas Sziranyi' "Harris function based active contor external force for image segmentation",Pattern Recognition Letters, Volume 33,Issue 9, 1 July 2012, Pages 1108-1187

[17] Shuhua Luo, Jun Zhang School of Information Science and Engineering, Central South University Hunan Engineering Laboratory for Advanced Control and Intelligent Automation Changsha, China," Accelerating Harris Algorithm with GPU for Corner Detection," 2013 Seventh International Conference on Image and Graphics.

[18] L. Gueguen , M. Pesaresi, "Multi scale Harris corner detector based on Differential Morphological Decomposition," Pattern Recognition Letters Volume 32,Issue 14,15 October 2011,Pages1714-1719

[19] Jiandong Su, Xiusheng Duan and Jing Xiao," Fast Detection Method of Checkerboard Corners Based on the Combination of Template Matching and Harris Operator," Third International Conference on Information Science and Technology March 23-25, 2013; Yangzhou, Jiangsu, China.

[20] G.A. Papakostas, E.D. Tsougenis, D.E. Koulouriotis , V.D. Tourassis,"On the Robustness of harris detector in image watermarking attacks," Optics Communications,Volume 284,Issue 91,1 September 2011,Pages 4394-4407

[21] Nilanjan Dey, Poulami Das, Anamitra Bardhan Roy, Achintya Das," Detection and Measurement of Arc of Lumen Calcification from Intravascular Ultrasound using Harris Corner Detection", 2012 National Conference on Computing and Communication Systems (NCCCS) 978-1-4673-1953-9/12/$31.00 ©2012 IEEE

[22] Na Yao, Tiecheng Bai, Xia Jiang, Haifang Lv, College of Information Engineering Tarim University Alaer, China," Improved Harris Corner Detection for Chinese Characters," 2013 Fourth World Congress on Software Engineering.

[23] M. Fatih Aydogdu, M. Fatih Demirci, and Cosku Kasnakoglu," Pipelining Harris Corner Detection with a Tiny FPGA for a Mobile Robot ," Proceeding of the IEEE International Conference on Robotics and Biomimetics (ROBIO)Shenzhen, China, December 2013

[24] Yijian Pei, Hao Wu, Jiang Yu, Guanghui Cai School of Information Science and Engineering, Yunnan University, No. 2, North Green Lake Road Kunming, P.R.China, 650091," Effective Image Registration based on Improved Harris Corner Detection," 201O International Conference on Information, Networking and Automation (ICINA)

[25] Xin Zhang1,2 Guojin He1Jiying Yuan1,2 Center for Earth Observation and Digital Earth, Chinese Academy of Sciences1Graduate University of Chinese Academy of Sciences2," A rotation invariance Image matching method based on Harris corner detection.

[26] Pei-Yung Hsiao, Member, IEEE, Chieh-Lun Lu, and Li-Chen Fu, Fellow, IEEE," Multilayered Image Processing for Multiscale Harris Corner Detection in Digital Realization ," IEEE Transactions On Industrial Electronics, Vol. 57, No. 5, May 2010.