Global Journal of Computer Science & Technology
Volume 11 Issue 6 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Accurate Corner Detection Methods using Two Step Approach

By Nitin Bhatia , Megha Chhabra
Thapar University

Abstract- : Many image features are proved to be good candidates for recognition. Among them are edges, lines, corners, junctions or interest points in general. Importance of corner detection in digital images is increasing with increasing work in computer vision in imagery. One of the most promising techniques is the one based on Harris corner detection method. This work describes different approaches to detect corner in efficient way. Based on the works carried out by Harris method, the authors have worked upon increasing efficiency using edge detection methods on image, along with applying the Harris on this pre-processed image. Most of the time, such a step is performed as one of the first steps upon which more complicated algorithm rely. Hence, good outcome of such an operation influences the whole vision channel. This paper contains a quantitative comparison of three such modified techniques using Sobel–Harris, Canny-Harris and Laplace-Harris with Harris operator on the basis of distances computed by these methods from user detected corners.

Keywords: *Corner Detection, Harris, Laplace, Canny, Sobel.*

Classification: *GJCST Classification: I.4.6*

ACCURATE CORNER DETECTION METHODS USING TWO STEP APPROACH

Strictly as per the compliance and regulations of:

Accurate Corner Detection Methods using Two Step Approach

Nitin Bhatia[α], Megha Chhabra[Ω]

Abstract- Many image features are proved to be good candidates for recognition. Among them are edges, lines, corners, junctions or interest points in general. Importance of corner detection in digital images is increasing with increasing work in computer vision in imagery. One of the most promising techniques is the one based on Harris corner detection method. This work describes different approaches to detect corner in efficient way. Based on the works carried out by Harris method, the authors have worked upon increasing efficiency using edge detection methods on image, along with applying the Harris on this pre-processed image. Most of the time, such a step is performed as one of the first steps upon which more complicated algorithm rely. Hence, good outcome of such an operation influences the whole vision channel. This paper contains a quantitative comparison of three such modified techniques using Sobel–Harris, Canny-Harris and Laplace-Harris with Harris operator on the basis of distances computed by these methods from user detected corners.

Keywords- Corner Detection, Harris, Laplace, Canny, Sobel.

I. Introduction

The concept of interest points connects to the idea of corner detection, where corner features are detected with the primary goal of obtaining robust, stable and well-defined image features for object tracking and recognition of three-dimensional CAD-like objects from two-dimensional images etc. The use of interest points also connects to the notion of regions of interest, which have been used to signal the presence of objects like edges or circles etc. Corner in an image is significantly spotted feature. Conventional corner detection, is one of the common non-destructive testing which employs manual image interpretation. This paper describes a system to detect corners that are present in the given image as a point for which there are two dominant and different edge directions in a local neighbourhood of the point. The system utilizes together two different algorithms, which are distinctively filtered by edge detection method to identify the best object candidate and then Harris as corner detection method to detect the presence of corner in a more efficient way.

About [α]- Assistant Professor, Department of Computer Sciecne, DAV College, Jalandhar-144002, Punjab, INDIA.
(Telephone: +91 9872 799 797 email: n_bhatia78@yahoo.com)
About[Ω] - M.Tech. (Student), Computer Science and Applications, SMCA, Thapar University, Patiala, INDIA.
(email: megha.chhbr@gmail.com)

The result of the experiment shows a promising output in recognition. In comparison to other recognition features, the edge and corner detection have a great advantage that there is huge variability of the pattern, meaning that large databases can be searched without going into details of stored data about image if appropriate search detection methods are utilised.

Corner detection comes within reach of computer visualization systems to extract certain kinds of characteristics and understand the contents of an image.

Corner detection is frequently used in motion detection, image matching, tracking, image mosaicing, panorama stitching, 3D modelling and object recognition.

Corners in images represent a lot of important information. Extracting corners accurately is significant to image processing, which can reduce much of the calculations. Paper aims at comprehensively using Harris after reading the study made on two widely used corner detection algorithms, SUSAN and Harris corner detection algorithms. Literature proves that both methods based on intensity, when compared in stability, and the runtime of each algorithm, concluded that Harris corner detection algorithm is superior to Susan corner detection algorithm on the whole. The technology is exploited to further sharpening the skills of detecting the corners with the help of edge detection operators. Methods used for edge detection as pre-processing are:

- Sobel Operator
- Canny Operator
- Laplace Operator

Research Literature serves the purpose of improvement desires in context of corner detection .as found in many of research works, a great deal of efforts has been done by computer vision community in solving the problem of efficiently detecting corners and edges. To start with, R. Deriche, R. and Giraudon, G. (1993) present the idea of corner detection by designing a new scale-space based approach by combining properties from the Laplacian and Beaudet's measure for correcting and detecting exactly the corner position. An extension of this approach is then developed to solve the problem of trihedral vertex characterization and detection. Another study is done by Lee, K. & Bie, Z. (1996) in which the gray-level corner detection problem is formulated as a pattern classification problem to determine whether a pixel belongs to the class of corners or not using the concepts of Bayesian classifier and fuzzy logic. Wang, M. J. et al. (1995) presented the idea of corner detection as that the directions of the forward and backward vectors of a non-corner point will cancel each other to detect corners. The bending value is used to assess the degree of possibility of a point being a corner. A paper by Seeger, U. & Seeger, R. (1994) states that only few locally parallel integer operations on 3×3 pixel matrices and on six-membered strings of edge elements are required. Within a given direction quantization, local curvature is approximated by finite differences. The extrema of curvature are classified and subsets are selected as corners. Trajkovi, M. & Hedley, M. (1998) present a corner response function (CRF) is computed as a minimum change of intensity over all possible directions. To compute the intensity change in an arbitrary direction an interpixel approximation is used. A multigrid approach is employed to reduce the computational complexity and to improve the quality of the detected corners. Another approach is presented by Freeman, H. & Davis, L. S. (2006), in which a method for detecting sharp corners in a chain-coded plane curve is described. A measure for the prominence of a corner is introduced. Ryu, H. et al. (2007) give a method that proposes that The Hessian matrix has information of ellipse with intensity variance, and corner can be detected by using the eigen-value and eigen-vector analysis and decided weight value. Li, X. et al. (2007) present a method that proposes a hierarchical corner detection framework based on spectral clustering (SC). The framework consists of three stages: contour smoothing, corner cell extraction and corner localization. Alvarez, L. et al. (2001) propose a method using Affine Morphological Scale Space (AMSS) to corner detection with sub-pixel precision.

Many authors have worked on Susan and Harris method of corner detection as well. As presented by Smith, S. M. & Brady, J. M. (1997), concept of each image point having associated with it a local area of similar brightness is the basis for the SUSAN principle. From the size, centroid and second moments of the USAN two dimensional features and edges can be detected. Harris detector is another approach towards the aim.

II. Existing Methods

Corner detection is used as the first step of many vision tasks. Hence, a large number of corner detectors exist in the literature. With so many already available it may appear unnecessary to present yet another detector to the community. However, we have a strong interest in producing a suite of high-speed detectors with the help of combination of edge detection operators. Our work present edge detection operators like Sobel, Canny, Laplace used each with Harris corner detection.

Many diverse interest point detectors have been projected with a wide range of definitions for what points in an image are interesting. Corner points are interesting as they are formed from two or more edges and are generally more abundant in real images than straight edges and are considered to be the most important features. They are striking due to their high information content and hence they are ideal features for tasks such as camera calibration, object tracking or fast interpretation of a robot's environment. Therefore, we present a comparative study of Harris applied with different edge detection methods as pre-processing on input gray-scale images.

The work of this paper can provide a direction to the improvement and the utilization of these corner detection algorithms.

a) *Harris Corner Detection*

Moravec's algorithm is one of the earliest corner detection algorithms. The algorithm tests each pixel in the image to see if a corner is present. It considers a local window in the image, and shifts the window in various directions. This results in changes in image intensity when intensity changes three cases are considered to be important:

- Windowed image pattern is flat as a result no change in intensity takes place in window shifts.
- In case of an edge in image shift along the edge will result in small change whereas perpendicularly shifting the window results in large change.
- If considering a corner or an isolated point ,all shifts will result in large changes

The corner is detected when the smallest SSD (sum of the squared differences) of intensities between the pattern and its neighbours is detected. If this number is locally maximal, then a feature of interest is present.

b) *Sobel Edge Detection Operator*

The Sobel operator performs a 2-D spatial gradient measurement on an image. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image.

Steps:

- The Sobel edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows).
- A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time.

- If we define A as the source image, and G_x and G_y are two images which at each point contain the horizontal and vertical derivative approximations, then the masks are as follows:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

- The magnitude of the gradient is then calculated using the formula:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

- An approximate magnitude can be calculated using:

$$|G| = |G_x| + |G_y|$$

c) *Canny Edge Detection Operator*

Canny edge detector discovers the optimal edges. In this situation, an "optimal" edge detector means it should mark all possible edges .marked edges are visited only once and possibly are the only edges not any false data.

Steps:

- The Canny edge detector uses a filter based on the first derivative of a Gaussian.
- It is prone to noise present on raw unprocessed image data, so to begin with, the raw image is convolved with a Gaussian filter.
- Result is a slightly blurred version of the original which is not affected by a single noisy pixel to any significant degree. Smaller filters cause less blurring, and allow detection of small, sharp lines.
- An edge in an image may point in a variety of directions, so the Canny algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image.
- The edge detection operator (Sobel for example) returns a value for the first derivative in the horizontal direction (Gy) and the vertical direction (Gx). From this the edge gradient and direction can be determined:

d) *Laplacian of Gaussian*

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image spots the regions of rapid intensity change and is therefore often used for edge detection.

III. Proposed Work and Experimental Analysis

Corner detection puts effort on time and accuracy calculation. Proposed work accepts the fact and uses it as the basis of enhancement in corner detection by Harris method. In this method, edge detection is performed over the image sequence before corner detection can be preformed. Instead of using data of whole of the image, edges are detected and that data is only required out of the whole image for detecting corners.

Processing steps for achieving results:

- EDGE DETECTION:

Sobel edge detection, canny edge detector and laplacian operator are applied to detect edges in an image.

- CORNER DETECTION:

Harris is then utilised on various images to detect corners from this reduced amount of data. To make the process more clear, images are of human faces with various expressions.

Experimental analysis: experiments have been performed on image data set of some common human face expressions [11].

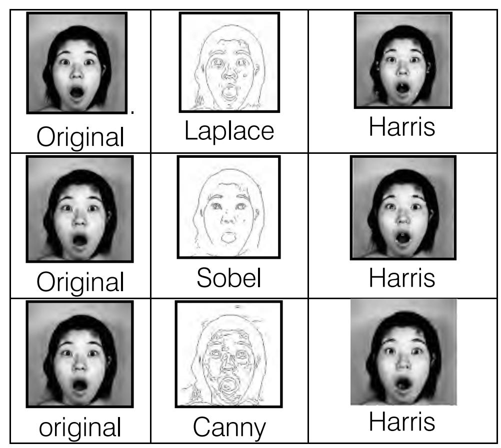

Fig.1. Comparison between outputs of images applied with various edge detectors and then Harris.

In Experiments, user selects a corner point on the image. After this, distances of corners detected by Sobel-Harris, Canny-Harris, and Laplace-Harris is compared with distance calculated by Harris from the point detected by user. This affirms the accuracy of these proposed three ways of fast detection of corners in terms of fact that these methods give better results than Harris. The results are shown graphically as well as tables demonstrating all the fields used to determine the fast methodology of proposed methods than original.

Table 1 show various feature points in a facial image along with the respective co-ordinate values of corners as selected manually. The results of Harris corner detector, various proposed detectors are also given in the same table. Each of the corner detectors have the Euclidean distance computed from the actual corner point.

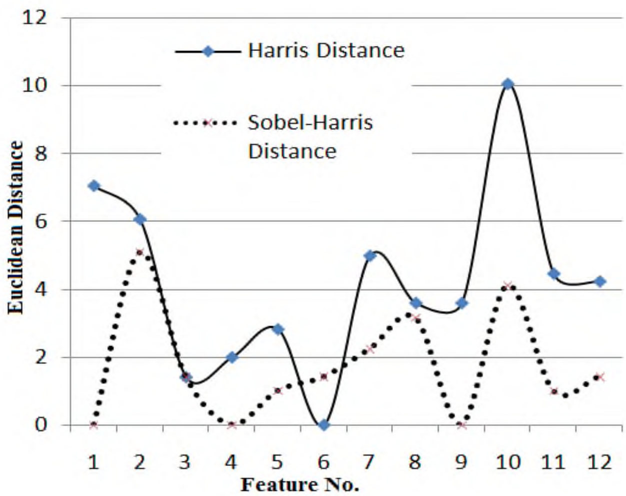

Fig. 2. *Harris vs. Sobel-Harris Corner Detector*

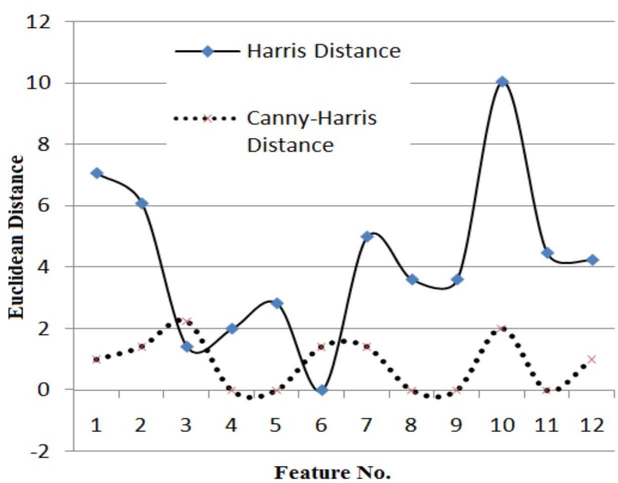

Fig. 3. *Harris vs. Canny-Harris Corner Detector*

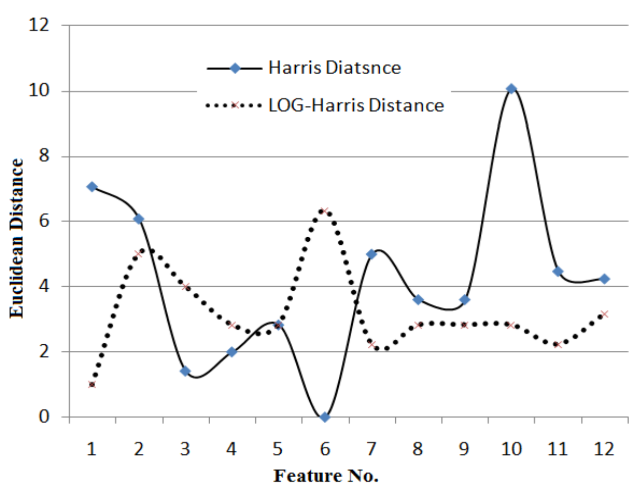

Fig 4. *Harris vs. LoG-Harris Corner Detector*

Figure 2 shows a graphical comparison of Harris method and Sobel-Harris method. In this case proposed Sobel-Harris detector outperforms Harris detector in case of all features except feature number 6, i.e. extreme right corner of left eyebrow. Similarly, figure 3 presents a comparison of Harris method and Canny-Harris method. In this case proposed Canny-Harris detector outperforms Harris detector in case of all features except feature numbers 3 and 6, i.e. extreme left of right eyeball and extreme right corner of left eyebrow. In fig 4, we present comparison of Harris method and LoG-Harris method. In this case proposed Log-Harris detector outperforms Harris detector in case of all features except feature numbers 3, 4 and 6, i.e. both extremes of right eyeball and extreme right corner of left eyebrow. But it is interesting to note that wherever the proposed methods are outperforming the well established Harris method, the accuracy is achieved with a great margin, for example, feature numbers 1 and 10, i.e. extreme left of left eyeball and right nostril.

IV. Conclusion

Experiments show that enhancement in Harris detection of corners in terms of pre-processing and hence reducing data has increased accuracy in terms of less distance detection from user detected corner points. This is proved that Laplace-Harris operator is best suitable enhancement in such a case. This determines even those corners and with good amount of precision, which Harris or other enhancements are not able to discover. Paper presents a stable and accurate corner detection algorithm, which is simple and an efficient means of producing input points of interest for feature-based approaches.

References Références Referencias

1. Alvarez, L., Cuenca C. & Mazorra, L. (2001). Morphological Corner Detection. Application to Camera Calibration. IASTED International Conference on Signal Processing, Pattern Recognition & Applications.
2. Li, X., Hu, W. & Zhang, Z. (2007). Corner Detection of Contour Images using Spectral Clustering. IEEE International Conference on Image Processing, 2007. ICIP 2007.
3. Lee, K. & Bien, Z. (1996).A gray-level corner detector using fuzzy logic. Pattern Recognition Letters, Volume 17, Issue 9, 1 August 1996, Pages 939-950.
4. Seeger, U. & Seeger, R. (1994). Fast corner detection in grey-level images. Pattern Recognition Letters, Volume 15, Issue 7, July 1994, Pages 669-675.
5. Smith, S. M. & Brady, J. M. (2001). SUSAN—A New Approach to Low Level Image Processing. International Journal of Computer Vision, Volume 23, Number 1, 45-78, DOI: 10.1023/A:1007963824710.
6. Wang, M. J., Wu, W. Y., Huang, L. K. & Wang, D. M. (1995). Corner detection using bending

value. Pattern Recognition Letters, Volume 16, Issue 6, June 1995, Pages 575-583.
7. Deriche, R. & Giraudon, G. (1993). A computational approach for corner and vertex detection. International Journal of Computer Vision archive, Volume 10 Issue 2, April 1993.
8. Trajkovi, M. & Hedley, M. (1998). Fast corner detection. Image and Vision Computing, Volume 16, Issue 2, 20 February 1998, Pages 75-87.
9. Freeman, H. & Davis, L.S. (2006). A Corner-Finding Algorithm for Chain-Coded Curves. IEEE Transactions on Computers, DOI: 10.1109/TC.1977.1674825.
10. Ryu, H., Lee, J., Hwang, E., Jing, L., Lee, H. & Choi, W. (2007). A new corner detection method of gray-level image using Hessian matrix. International Forum on Strategic Technology, 2007. IFOST 2007. DOI: 10.1109/IFOST.2007.4798654.
11. Lyons, M.J., Akamatsu, S., Kamachi, M., Gyoba, J., (1998). Coding Facial Expressions with Gabor Wavelets. Third IEEE International Conference on Automatic Face and Gesture Recognition, April 14-16 1998, Nara Japan, IEEE Computer Society, pp. 200-205.

April 2011

29

Global Journal of Computer Science and Technology Volume XI Issue VI Version I

Table 1: Comparison of Proposed Methods with Existing Harris Corner Detection Method

Feature Points	Manually Selected Corner Points		Existing Method Harris			Proposed Methods Sobel-Harris			Canny-Harris			L.O.G-Harris		
	X	Y	X	Y	Dist	X	Y	Dist	X	Y	dist	X	Y	Dist
Left eyeball extreme left	86	130	87	123	7.0711	86	130	0	86	131	1	86	131	1
Left eyeball extreme right	102	128	108	129	6.0828	107	127	5.09902	101	129	1.41421	107	128	5
Right eyeball extreme left	148	127	147	128	1.4142	147	128	1.41421	147	129	2.23607	148	131	4
Right eyeball extreme right	170	128	170	130	2	170	128	0	170	128	0	172	130	2.82843
Left eyebrow extreme left	70	114	72	112	2.8284	71	114	1	70	114	0	72	116	2.82843
Left eyebrow extreme right	111	109	111	109	0	112	108	1.41421	110	108	1.41421	117	107	6.32456
Right eyebrow extreme left	140	109	145	109	5	142	108	2.23607	141	110	1.41421	142	110	2.23607
Right eyebrow extreme right	180	112	182	109	3.6056	181	109	3.16228	180	112	0	182	114	2.82843
Left nostrils	111	170	113	167	3.6056	111	170	0	111	170	0	113	168	2.82843
Right nostrils	140	170	130	171	10.05	136	169	4.12311	138	170	2	142	168	2.82843
Left mouth corner	102	191	100	195	4.4721	103	191	1	102	191	0	104	190	2.23607
Right mouth corner	150	191	147	194	4.2426	151	190	1.41421	151	191	1	149	188	3.16228