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A Review on Stereo Image Matching Using, Corner Detection Algorithm

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Abstract: In computer vision applications feature detection algorithm plays a very important role. Widely used features in many stereo vision work, are robust against the change of perspective like edge elements, corners, line segments, and curve segments. The major types of stereo image matching are Intensity-based stereo matching and feature-based stereo matching. The intensity based stereo matching requires depth calculation and this might get complex and costly. While the feature based stereo image matching is easier than depth calculation. This review paper describes the method to match stereo image with the help of Harris corner detection algorithm. Algorithm contains Gaussian smoothing filter for noise reduction so that false corners can be avoided. The architecture contains flexible threshold operator for corner detection and it requires less time. The system will be implemented on System Generator to reduce the bulkiness of the system and to maximize the speed of operation.

Keywords: Harris corner detection, stereo matching, Gaussian smoothing, System Generator.

I. INTRODUCTION

Many computer vision based systems require sensible features for the purpose of identification and classification of environments. One of the distinguishable features used by these systems is corners. Extracted corners help to differentiate patterns, detect objects and they also guide algorithms to make decisions. There are two groups in which corner detection algorithms are classified [5]. The first group has contour-based algorithms in which curvature spaces are formed to classify edges and corners in the images. The other group has intensity-based algorithms, which are computationally less expensive but also sometimes less successful than the former ones. Among the intensity-based algorithms, Harris [17] algorithm is the most common one. Some Different studies [11, 13, 15, 16] argue that the Harris algorithm has superior performance than the other intensity based algorithms.

In this paper, the aim is to introduce stereo image matching with the help of Harris corner feature detection algorithm. Generally, when stereo images matching is done with the help of area based method it becomes complex and time consuming. To make easy method for stereo image matching Harris corner detection algorithm is used. Corners of the input stereo images are detected and accuracy is improved with the help of thresholding and non maxima suppression. After this step the corners from both the images are matched and matched stereo image is formed.

In section II of this paper, related work on recent corner detection and stereo image matching implementations are discussed. Also a brief overview of the Harris corner detection algorithm is discussed in this section. In section III the system block diagram is presented. In section IV expected results are discussed. We conclude this paper with section V.

II. RELATED WORK

In recent years, there have been studies to accelerate corner detection algorithms. A feature can be a line, corner, or any noticeable region which can be extracted from an image. Chris Harris et. al. To provide image regions which are containing texture and isolated features, a combined corner and edge detector is used. It is based on the local auto-correlation function [17]. Many other feature detectors have been developed after that with different qualities. Most detectors are designed with keeping different properties in mind, properties such as speed, accuracy, repeatability etc. As important property keeps on changing based on the requirement the implementation of algorithm is also having different methods.

In [12], it develops an affine invariant feature detector which uses too many look up-tables which can only fit into expensive high end FPGA devices. Power consumption of such devices may increase. Some systems [3,5] uses a fixed threshold to obtain the Harris score only. Fix threshold may lose control on the total amount of features in an image. Dr. Marsha [14] this paper presents an overview of digital stereo image matching techniques. Discussed techniques primarily use area-based measures.

J. Joglekar [9] et.al. this paper presents area based image matching algorithm which offers a dense disparity map. In the paper the composite technique of image matching is discussed. This technique is a combination of three methodologies which are used for refining the accuracy of the match. 1.The normalized cross correlation coefficient is used for selecting best five matches and scores are given to them according to correlation coefficient value. 2. Further the scores of the matches are improved by Hausdorff distance technique. 3. The third method that does texture analysis of template window and corresponding search sub window, improves the score of the matches.

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In this paper the aim is to introduce stereo image matching with the help of Harris corner detection method and this is easier than the area based stereo matching technique.

1) Harris Corner Detection Algorithm

1. Input image and convert it to gray scale image $I(u, v)$: the intensity of pixel at row u and column v
2. Calculate $I_x(\ldots)$ and $I_y(\ldots)$ the partial derivatives of $I_x(\,)$ in x and y direction

$$I_x = \left(\frac{\partial I(u,v)}{\partial x}\right)$$

$$I_y = \left(\frac{\partial I(u,v)}{\partial y}\right)$$

Where, $\partial_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$ and

$$\partial_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

3. The Harris algorithm takes a small window of an image (e.g. 3×3 pixels) and with this it determines whether the window contains corner feature or not Calculate the gradient matrix M,

$$M = \begin{bmatrix} \sum_{u,v}^{W} I_x{}^2 & \sum_{u,v}^{W} I_X \times I_y \\ \sum_{u,v}^{W} I_X \times I_y & \sum_{u,v}^{W} I_y{}^2 \end{bmatrix}$$

where u, v are pixel indexes of a window of range W.

4. If two eigen values of M are high, it is a corner feature point. Finding the eigenvalue may be time consuming, so that a approximation formula is used:

$$R = \mathrm{Det}(M) - k * \mathrm{Trace}(M)^2$$

where k is a value nearby 0.04 – 0.06. If R is bigger than a threshold, the center pixel in the window is a corner feature candidate.

All feature candidates can be found , by scanning the windows at different positions of the entire image.

Generally too many corner features are detected in a local window which may cause confusion to some vision algorithms.

5. Non maximum suppression is the solution for the problem of too many corner features detection in a window.

   Here the system should allow one corner feature for a local window.

Then detected feature candidates are sorted by the Hrris score (value of R), here the N highest score candidates are the best N corner features.

This is how the Harris corner detection algorithm works.

III. PROPOSED SYSTEM

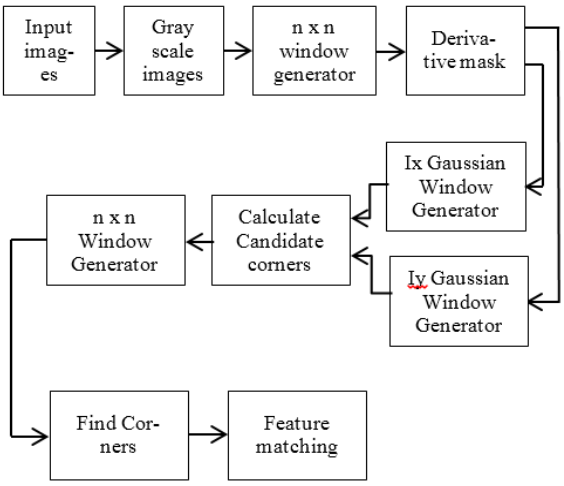

Fig. 1 Block Diagram Of System

In the feature based stereo image matching system, the features which are stable under the change of viewpoint are extracted with the help of first preprocessing image pair by an operator. After that the matching process is done with the detected features. Edge, corners, line segments, and curve segments these features are robust in contrast to the change of perspective, and because of that they have been widely used in many stereo vision work. Generally edge and corner elements which are easy to detect as compare to that of line and curve segments as they requires extra computation time. The system to be implemented uses Harris corner detection algorithm for feature detection and pair image matching.

1. Input Image

In the FPGA implementation of the Harris corner detector the first step is to convert RGB color standard into grayscale image where representation of each pixel is done by 8-bit samples which are carrying the pixel's intensity. This step is performed by the Gray scale image block which computes the average intensity of the three colors (red, green, and blue) in each input pixel.

2. Gaussian Smoothing

The smoothing stage is based on a Gaussian low-pass filter. The Gaussian filter requires a 3 x 3 pixels window as shown in Fig.1 and that is multiplied with fully parallelized linear filter operator. This operator firstly multiplies all the elements of the input window by the corresponding kernel coefficients. Then, these intermediate results are summed up in an adder tree. This thing is done to obtain smooth , error free image

3. Sobel Filtering

The sobel filtering is done for edge enhancement. In this step, a single 3×3 neighborhood extractor (NE) block is necessary and the computation is similar to the Gaussian filter, based on linear filtering.

The two Sobel kernels work in parallel processing the gradients Ix and Iy.

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4. Non Maximum Suppression

The Non-Maximum Suppression (NMS) step eliminates pixels with gradient magnitude smaller than adjacent pixels in the gradient direction. This step is itself having special purpose, this reduces the chance of fault feature detection. For this the partial derivative is calculated.

5. Hysteresis Thresholding

The final step is the hysteresis thresholding where two different thresholds, Thigh and Tlow are applied to the input image. Thigh saturates every pixel with a gradient value greater than its threshold value. Tlow bypasses every pixel with a gradient value greater than its threshold value. The output of these two blocks are added up, resulting in a stream where the saturated pixels are considered part of the corner and the other pixels different than zero are considered corner candidates.

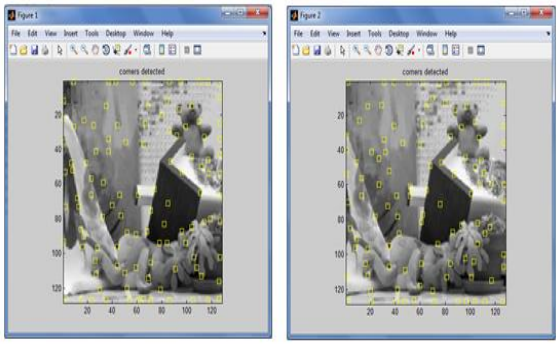
6. Feature Matching

Detected features in both images are matched with the help of feature matching block. As compare to the area based stereo image matching this technique is better.

IV. EXPECTED RESULTS

This system is to be implemented with the help of MAT-LAB and Xilinx System Generator. Here the expected results are shown. As the aim is to detect the corners in the input image, we can test the validity of proposed algorithm by simulating the estimated result before actually implementing it to the hardware, for this purpose the MATLAB simulation tool is used. Expected results are shown with the help of some sample stereo images.

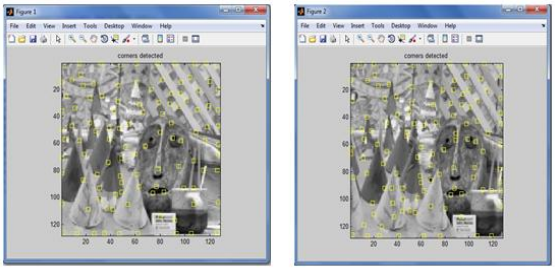
A) Left Image b) Right Image



c)Corners in the left image d) Corners in the right image

Fig. 2 Corner detection for Teddy Image Data Set

A) Left Image b) Right Image



c)Corners in the left image d) Corners in the right image

Fig. 3 Corner detection for Cones Image Data Set

V. CONCLUSION

In this paper a review of the feature based stereo image matching method is given. Here the Harris corner detection algorithm is used for the detection and matching of the stereo image features. Matching ambiguity can be eliminated and speed can be maximized by using this algorithm. The selected feature points are Harris corners, which can be quite easily computed. Furthermore, the algorithm works on image blocks and each block is processed almost independently. Because of that the proposed framework seems suitable for implementation on the FPGA technology.

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