ISSN: 2349-6495

Calculation for Efficient Circular Window Based Disparity-Map by Stereo Matching

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Abstract—*Stereo matching is the fundamental problem to achieve human like vision capability to machines and robots. Stereo vision researches during last two decades have produced many local and global algorithms for stereo correspondence matching. Circular window -based cost aggregation methods for solving the correspondence problem have attracted researches as it can be implemented in real time using parallel processors. In this paper a circular window stereo algorithm has been proposed to solve correspondence problem efficiently. Motivated by human stereo vision, the technique uses a circular window to enhance the strategy of finding a best match to compute dense disparity map. Performance of the proposed method is compared with the rectangular window method for benchmark images. Significant improvement has been achieved.*

I. INTRODUCTION

It has been established that the depth can be recovered from two (or more) images of the scene taken from slightly different known viewpoints using principle of triangulation. However, in terms of speed and performance no conclusive solution has been developed yet. The fundamental basis for stereo vision is the fact that a single visible three dimensional physical location of a scene is projected to a unique pair of image locations in two observing cameras. As a result, given a stereo pair images, if it is possible to locate the image points that correspond to the same physical point in the scene, then it is possible to determine its three dimensional location[1]. The recovery of image points depth permit the recreation of a three dimensional model of the scene from 2-D images.

The depth of various scene points may be recovered if the disparity of the corresponding points can be calculated from rectified stereo images. Rectification means to transform and rotate the images so that the epipolar lines are aligned horizontally. This reduces the search of corresponding pixel in 2D image to 1D i.e. in rectified images the corresponding points will always lay on the same horizontal scan line. The disparities of all image points of stereo images is called disparity map which can be stored and displayed as an image.

Stereo correspondence algorithms are classified as local, global methods and hybrid methods. In local methods pixels

in a small Circular window surrounding pixel of interest are used whereas global methods use complete scan lines or the entire image. In case of hybrid methods local or global method is used at various stages. Global methods offer excellent performances but are computationally expensive and do not meet real time requirements and cannot be implemented on parallel computers. On the other hand, the local methods are simple and fast but do not produce good results.

Local stereo matching typically operates on a rectangular Circular window that is shifted on the corresponding scan-line in the right image to find the point of maximum correspondence. The choice of an appropriate Circular window size and correlation functions are important for accurate disparity determination. Small Circular window do not capture enough intensity variation to give correct result in less-textured regions. On the other hand, large Circular window tend to blur the depth boundaries and do not capture well small details and thin objects.

Motivation of the present paper is the process of image formation in actual pinhole camera. The aperture size of an actual camera is of some finite circular window size contrary to the ideal pin-hole camera. Due to this noise and error are projected as a circular window spot instead of a rectangular region on image plane. Since effect of aperture is circular window it is proposed to use circular window Circular window in place of rectangular Circular windows as used by the previous researchers. Further, biological model of stereo vision seems to be better approximated by using circular window shaped Circular window[6].

In this paper a local method that uses a circular window Circular window surrounding the pixel of interest is proposed. This method significantly improves the computation time and

ISSN: 2349-6495

results compared to the rectangular Circular window based algorithms.

II. RELATED WORK

The local rectangular Circular window based method for disparity computation has been extensively researched for the last few decades. Fusiello *et. al*.[2] used rectangular Circular window of fixed size with different centers with an assumption that one of them will cover a constant depth area. They performed the correlation with nine different Circular windows (i.e. in every corner, in the middle of every side and in the centre) and retain the disparity with the smallest SSD error value. This method produced improved result at depth discontinuity. Hirschmuller *et. al*.[3] divided the search Circular window into set of subCircular windows. The subset of those Circular windows that show the highest correlation Circular window was used for matching cost computation. To get accurate results at depth discontinuity as well as in homogeneous regions some methods assigned or adjusted the weights to each pixel of the rectangular Circular window by using photometric and geometric relationship[7,8,9].

The weight assigned to each neighbouring pixel decreases with both the distance in the image plane (the spatial domain *S*) and the distance on the intensity axis (the range domain *R*) i.e., geometric and a color proximity constraint of each pixel is jointly and independently enforced[5,8]. One thing is common in above mentioned methods was the use of rectangular Circular window for disparity calculation. Nalpantidis and Gasteratos[6] discussed the benefits of circular window Circular window over the rectangular Circular window. Firstly it better approximate the human stereo vision. Circular window has advantage of isotropic effects in all the directions to the pixel of interest. No work has reported the comparative analysis of effect of various shapes of Circular windows. Experimented result presented in this paper shows distinct advantage of circular window over rectangular Circular window.

Disparirty Computation

The left image is taken as a reference image and circular window is shifted over the disparity range in the right image. The aim is to find out the best match for the left image coordinate *(x,y)* in the right image over the disparity range. The computation of the disparity using circular window uses intensity values of the images within a finite Circular window. For the matching procedure, various block

$$c(x, y,d) = \sum^{n/2} \sum^{n/2}(I_l (x +i, y + j) - I_r (x +i - d, y + j))^2$$

Where I_l and I_r are the left and right image intensities respectively, d is the disparity,it ranges from d_{min} to d_{max} in the right image. The computed disparity D at *(x,y)* is given by equation (3) .

$$D(x, y) = \min (c(x, y,d)) \quad (3)$$
$$d = d \min, d \max$$

III. METHOD OVERVIEW

Circular window Creation

In local method the search for pixel correspondence between the two images of a stereo pair is normally done by comparing the surrounding regions of the examined pixel in place of pixel alone[6]. Normally a Circular window of fixed size (also called support Circular window) and a similarity criterion, a measure of the correlation between Circular windows in the two images, are used and the corresponding element is given by the Circular window that maximizes the similarity criterion within a search region. The correspondence problem may be solved by selecting a support Circular window that vary in shape, size and could be either fixed or adaptive.

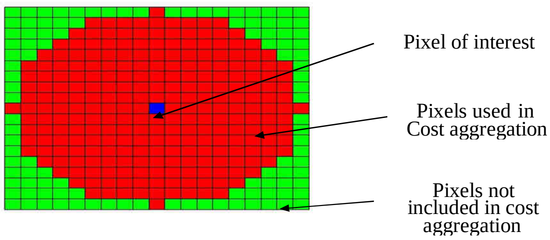

Fig 1 Circular window

The square Circular window is most commonly selected support Circular window by researchers because of its easy implementation. In the proposed method the correspondence problem is solved by considering a circular window for cost aggregation in two rectified image pair. An inscribed circular window with diameter n is made out of *n* x *n* square Circular window as shown in figure (2). The center of the circle is the pixel of interest and only pixels inside the circle are used for the cost aggregation.

(a) (b)

(c)

Fig. 2: (a) Tsukuba left image (b) disparity map using rectangular Circular window (c) disparity map using rectangular Circular window

IV. DISPARITY COMPUTATION ALGORITHM

The input to the algorithm is a rectified stereo images I_l and I_r, circular window Circular window size and disparity range d. The algorithm performs the following four steps.

a. Matching cost computation-The matching cost is the squared difference of intensity values at a given disparity

b. Cost aggregation- aggregation is done by summing matching cost of all the pixels within circular window Circular window.

c. Disparity computation- disparity is computed by selecting the minimum aggregated value at each pixel in the disparity range.

V. RESULT & EVALUATION

The disparity obtained for all the points of the left image can be displayed as an image. This disparity map is a 3D image. All the pixels in the disparity image which appear brighter have higher disparity and are nearer to the camera, dark points have lower disparity and are farther from the camera. The disparity map for Tsukuba image using rectangular Circular window and circular window Circular window for Circular window size 19 x 19 is shown in figure (3). Table1 tabulated the comparative improvement in result of circular window Circular window based method in comparison to traditional rectangular Circular window based method

Table 1: Calculate disparities on Tsukuba Image using Circular based Method

Size	5*5	7*7	9*9	11*11	13*13	15*15	17*17
Total time	21.36	27.94	35.02	43.16	48.93	62.31	77.44

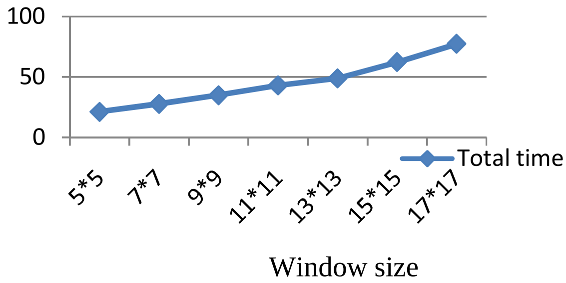

Fig. 3: The error in disparity calculated using circular window for Tsukuba image or various Circular window sizes

VI. CONCLUSION

In this paper a new Circular window based approach has been presented that uses circular window Circular window to compute dense disparity map. The algorithm has been tested on benchmark stereo images that show that the circular window Circular window based disparity computation outperforms than rectangular Circular window based disparity computation. The proposed method reduces computation by 27% for the same level of quality.

REFERENCES

[1] Brown M. Z., Burschka D. and Gregory d. Hager, ‘Advances in Computational Stereo’, IEEE Trans. *Pattern Analysis and Machine Intelligence, Vol.* 25(8), pp 993, 1008, (2003).

[2] Fusiello, A., and Roberto, V., ‘Symmetric Stereo with Multiple Circular windowing’, International Journal of Pattern Recognition and Artificial Intelligence, 14, (8), pp. 1053-1066, (2000).

[3] Hirschmuller, H., Innocen, P.R. and Garibaldi, J., ‘Real-Time CorrelationBased Stereo Vision with Reduced Border Errors’, Int. Journal Computer vision, 47(1/2/3), pp 229-246, (2002).

[4] Jain, R. , Kasturi, R.and, Schunck, B. G.:, ‘Machine Vision’, MIT Press, McGraw Hill Inc., International Edition (1995).

[5] Mattoccia, S., Tombari, F. and Stefano, L. D., ‘Stereo Vision Enabling Precise Border Localization Within a Scanline Optimization Framework’, Asian conference on Computer Vision, pp 517-527, (2007).

[6] Nalpantidis L. and Gasteratos A., ‘Biologically and psychophysically inspired adaptive support weights

algorithm for stereo correspondence', Robotics and Autonomous Systems, 58, pp. 457-464, (2010).

[7] Paris, S. and Durand, F., 'A Fast Approximation of Bilateral Filter using a Signal Processing Approach'. Int. Journal Computer vision, 81,(1), pp. 2452, (2009).

[8] Porikli, F. M., 'Constant Time O (1) Bilateral Filtering', Proc. Computer Vision and Pattern Recognition, pp 18, (2008).

[9] Yoon, K. and Kewon, S. , 'Adaptive Support-Weight Approach for Correspondence Search', IEEE Trans. Pattern Analysis and Machine Intelligence, 28, (4) , pp 650-656 (2006).

[10] Scharstein D. and Szeliski R., 'A Taxonomy and Evaluation of Dense two Frame Stereo Correspondence Algorithms', Int. *Journal Computer*.