Improved Disparity Map Estimation from Multiple Images on Hybrid Method

Chhatrala Nayankumar D. Bhalodiya Kelvin J. Doshi Kaushal J.

Abstract: Stereo vision systems aim at reconstructing 3D scenes by matching two or more images taken from slightly different viewpoints. The main problem that has to be solved is the identification of corresponding pixels, i.e. pixels that represent the same point in the scene In this paper, a stereo matching algorithm based on image segmentation is presented. We propose the hybrid algorithm based on k-means segmentation and refine the disparity map of the stereo image by SSD (sum of squared difference).Firstly, a color based k-means segmentation method is applied for segmenting the stereo images. segmentation is used to represent, locate and analyze the image. Segmented images are used as input to the local correlation based method for finding the disparity estimation .Experimental results show that our proposed algorithm gives good performance

Key Words: Stereo Matching, Disparity Map, RMSE Error, Segmentation, k-means

I. INTRODUCTION:

Stereo matching is one of the most active areas in computer vision because it is the basis for the accurate acquiring of image depth, which is important to applications in vision systems, such as obstacle avoidance, object recognition, and aerial photography, etc. Although lots of algorithms have been proposed for stereo matching, especially for disparity map calculation, there are still many challenging works needed to be done caused by texture less, occlusion, etc. Bela Julesz was using computer synthesized stereoscopic pairs to explain binocular depth perception in the 1960's [10]. Some of the first computer algorithms to find depth from an arbitrary stereoscopic pair were devised in the 1970's [11], [12], [13], when researchers developed coop-erative algorithms to investigate stereopsis. Stereo matching algorithm are mainly classified into two categories: global and local algorithm.[1] Global algorithm are based on iterative scheme that minimize the window cost. This algorithm have highly accuracy in computation of the disparity map but computation speed is very high. Local algorithm are also called area based algorithm, it calculate the disparity at each pixel on the basis of the neighbor pixel, the disparity map quality of the local algorithm is less than global algorithm but computation time is less. So it can be applied in real time application. The correspondence problem consists in finding correct point-to-point correspondences between images or models. Accurately solving the correspondence problem is the key to accurately solving the Stereo Vision problem.

Manuscript published on 28 February 2014.
* Correspondence Author (s)
Chhatrala Nayankumar D. Student, Dept. Of Electronics & Communication Engineering/ Marwadi Education Foundation Group Of Institution/ Rajkot/ Gujarat/India.
Bhalodiya Kelvin J. Student, Dept. Of Electronics &Communication Engineering/ Marwadi Education Foundation Group Of Institution/ Rajkot/ Gujarat/India.
Doshi Kaushal J. Asst. Prof./, Dept. Of Electronics & Communication Engineering/ Marwadi Education Foundation Group Of Institution/Rajkot/ Gujarat/India.

The correspondence problem (stereo matching), has had a more or less continuous evolution with its ups and downs. From the beginning, the difficulty of the matching problem was recognized and a set of constraints and rules were proposed to limit the number of possible matching [13]. The simple procedure steps to find the disparity map of the stereo images is shown in figure 1.

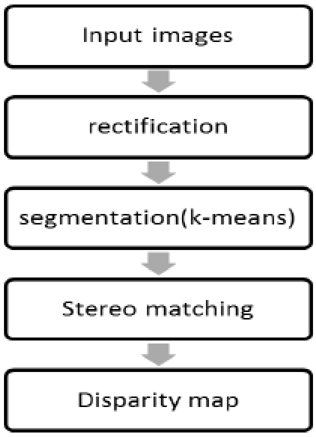

Fig. 1 proposed algorithm steps

II. IMAGE RECTIFICATION

The image rectification is necessary for reducing the complexity of calculation for stereo images. Image rectification is necessary in finding the epipolar lines .This operation is performed by linear transformation, translate the camera images [3].

III. IMAGE SEGMENTATION

The K-means Algorithm is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. K-means is Hard Clustering. Here data is divided into a number of distinct clusters, where each data element belongs to exactly one cluster. The algorithm Assumes that the data features form a vector space and tries to find natural clustering in them. The points are clustered around centroids $\mu_i \forall_i = 1......k$ which are obtained by minimizing the objective

$$v = \sum_{i=1}^{k} \sum_{x_j \in s_i} (x_j - \mu_i)^2 \frac{\Delta y}{\Delta x} \qquad (1)$$

where there are k clusters Si, i = 1; 2,….., k and μ_i is the centroid or mean point of all the points $x_j \in s_i$

*Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)*

As a part of this project, an iterative version of the algorithm was implemented. The algorithm takes a 2 dimensional image as input. Various steps in the algorithm are as follows:

1. Compute the intensity distribution (also called the histogram) of the intensities.
2. Initialize the centroids with k random intensities.
3. Repeat the following steps until the cluster labels of the image does not change Anymore.
4. Cluster the points based on distance of their intensities from the centroid intensities.

$$c^{(i)} := \arg\min_j \| x^{(i)} - \mu_j \|^2 \quad (2)$$

5. Compute the new centroid for each of the clusters.

$$\mu_i = \frac{\sum_{i=1}^{m} 1\{c_{(i)} = j\} x^{(i)}}{\sum_{i=1}^{m} 1\{c_{(i)} = j\}}$$

Where k is a parameter of the algorithm (the number of clusters to be found), i iterates over the all the intensities, j iterates over all the centroids and μ_i are the centroid intensities [16][17].

IV. STEREO MATCHING

The matching of image points is performed by comparing a region in one image, referred to as the reference image, with potential matching regions in the other image and selecting the most likely match based on some similarity measure. The resulting scene estimate is then invariably represented using a depth-map relative to the reference camera.

As an example of the stereo matching process, consider estimating the three dimensional position of a point shown in Fig. 2. By correctly matching this point between the two images, the relative shift or displacement of the point can be used to calculate the depth of the point.

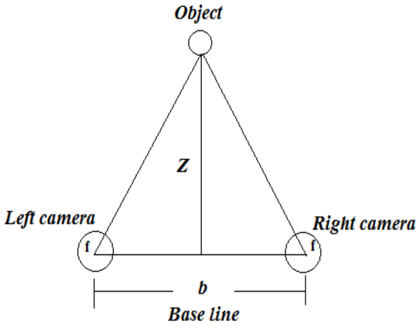

Fig. 2 Demonstration of disparity

As an example consider the object in Fig. 2. This has image coordinates (x, y) as viewed from camera 1 and image coordinates (x+ d, y) when viewed from camera 2.

By correctly matching this point between the two images the relative shift, or disparity d, of the point can found. This can then be used to calculate the depth of the point. If all cameras have the same focal length, are parallel to each other, and located on the same plane, the magnitude of this disparity is related to the depth, Z,

$$D = \frac{b * f}{z} \quad (3)$$

Where B is the baseline distance between two cameras and D is the distance of the image plane behind the principal point. One problem with this approach is that it is difficult to determine matches reliably because of ambiguities and occlusions. To reduce the number of ambiguities, regions in the image are matched in order to improve the reliability of matching, instead of individual pixels. This is based on the assumption that nearby pixels are likely to have originated from a similar depth.

However, difficulties arise in regions which do contain several depths, because the observed region will appear different between the various cameras.

Another difficulty with traditional stereo matching is which surfaces that are visible within the reference image may be occluded or hidden from view in one or more of the other images. In this situation false matches will occur as a true match does not exist. To avoid these problems occluded regions must be identified. Matches must then only be formed with images where the corresponding surfaces are visible. Identifying these surfaces is difficult with traditional stereo matching, since the matching is performed directly in 2D image space where occlusions cannot be properly modeled.

A. STEREO MATCHING ALGORITHMS

Stereo matching algorithms calculate disparity map based on matching window of pixel by using sum of squared difference(SSD) and sum of absolute difference(SAD). This algorithm measure the similarity between the images. It takes the window of pixel in original image and compare that window with the corresponding image being compared

The computation window cost can be given by the formula SSD:

$$SSD = \sum_{i=1}^{w_x} \sum_{j=1}^{w_y} [f_L(X+i, Y+j) - f_R(X+i+d, Y+j)]^2 \quad (4)$$

SAD: $$SAD = \sum_{i=1}^{w_x} \sum_{j=1}^{w_y} |f_L(X+i, Y+j) - f_R(X+i+d, Y+j)| \quad (5)$$

V.EVALUATION METHODOLOGY

Quality measures are computed with known ground truth data: RMS (root-mean-squared) error (measured in disparity units) between the computed disparity map dC(x, y) and the ground truth map in fig (C) dT (x, y)

$$RMSE = \frac{1}{N} \sum \left[|d_c(X,Y) - d_t(X,Y)|^2 \right]^{\frac{1}{2}}$$

Where *N* is the total number of pixels.

Results of RMS Error is shown in Table-1 and 2.

VI.OBSERVATION & RESULTS

Results of Algorithms introduced in the paper for the test images were given below.RMS Error is used for comparison of algorithm shown in table 1.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

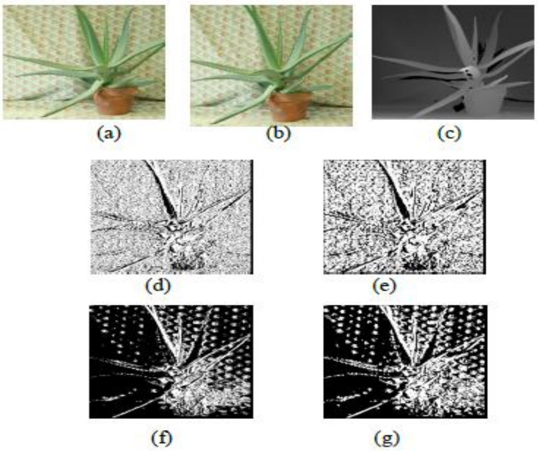

Fig. 3 (a) & (b) Stereo Image pair. Fig (c) is the ground truth image, (d) and (e) are the result of the SSD method with window size 1 and 3, (f) and (g) are the results of hybrid method

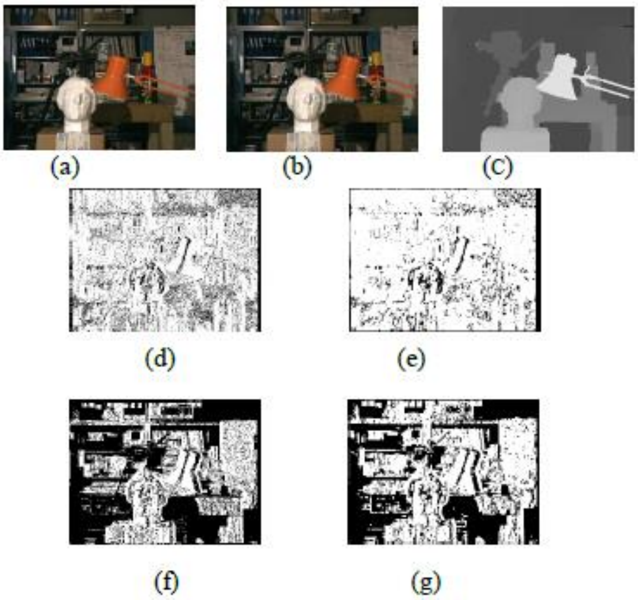

Fig. 4 (a) & (b) Stereo Image pair. Fig (c) is the ground truth image, (d) and (e) are the result of the SSD method with window size 1 and 3, (f) and (g) are the results of hybrid method

Table 1 RMS Error Comparisons Window size=1

Sr. no.	Image	Performance parameter	Sum of square differe-nce	Hybrid Sum of square differen-ce
1.	Tsukuba image	RMSE	148.43	114.85
2.	Aloe image	RMSE	166.94	102.99

Table 2 RMS Error Comparisons Window size=3

Sr. no.	Image	Performance parameter	Sum of square differen-ce	Hybrid Sum of square differen-ce
1.	Tsukuba image	RMSE	153.51	125.11
2.	Aloe image	RMSE	163.63	104.61

VII.CONCLUSION

Matlab R2013a has been chosen for implementing different Stereo Matching Algorithms. Stereo Matching Algorithms like sum of squared difference and sum of absolute difference have been implemented to generate disparity map, which gives displacement between two images used to estimate depth. From the figure 3,4 and comparison table shows that hybrid algorithm gives good result then SSD method. The proposed method also gives high performance.

VIII.FUTURE SCOPE

Disparity Maps are successfully generated by implementing Stereo Matching Algorithms, but still there is a scope for improvement. Performance of the Stereo Matching Algorithms is affected by the illumination conditions, shape and the camera characteristics. Effects of these three on Disparity Map. Depth Map can be Generate. Height and Width of an object can also be tried to be calculated. 3D view can also be generated by using Disparity Map and Depth Map.

REFERENCES

[1] A New Approach for Disparity Map Determination M. Mozammel Hoque Chowdhury and Md. Al-Amin Bunyan Daffodil International University Journal of Science And Technology, Volume 4, Issue 1, January 2009
[2] A New Stereo Matching Algorithm for Binocular Vision. Tao Hu and May Huang, International Journal of Hybrid Information Technology Vol.3, No.1, January, 2010
[3] SHIMIZU, M., OKUTOMI, M. Calibration and rectification for reflection stereo. In IEEE Conference on Computer Vision and Pattern Recognition CVPR.
[4] B Anchorage (USA), 2008, p. 1 - 8.. Julesz, Foundations of Cyclopean Perception. Chicago and London: The
[5] W. E University of Chicago Press, 1971.. L. Grimson, From Images to Surfaces. Cambridge, Massachusetts: MIT Press, 1981.
[6] H. L. F. V. Helmholtz, Treatise on Physiological Optics. New York: Dover, 1925.
[7] B. K. P. Horn, Robot Vision. Cambridge, Massachusetts: MIT Press, 1986.
[8] O. Faugeras, Three-Dimensional Computer Vision: A Geometric Viewpoint. MIT Press, 1993.
[9] R. N. Klaus Voss and M. Schubert, Monokulare Rekonstruktion Fur Robotvision. Verlag Shaker, 1996.
[10] B. Julesz, "Binocular depth perception of computer-generated patterns," Bell System Tech., vol. 39, pp. 1125-1161, September 1960.
[11] J. I. Nelson Journal of Theoretical Biology, vol. 49, pp. 1-xx, 1975.
[12] P. Dev International Journal of Man-Machine Studies, vol. 7, pp. 420-xxx, 1975.
[13] D. Marr and T. Poggio, "Cooperative computation of stereo disparity," SCIENCE, pp. 283-287, 1976.
[14] S. T. Barnard and M. A. Fischler, "Computational stereo," Computing Surveys, vol. 14, no. 4, pp. 553-572, 1982.
[15] U. R. Dhond and J. K. Aggarwal, "Structure from stereo - a review," IEEE Transactions on Systems, Man, and Cybernetics, vol. 19, no. 6, pp. 1489-1510, 1989.
[16] An Adaptive K-means Clustering Algorithm for Breast Image Segmentation, Bhagwati Charan Patel Dr. G.R.Sinha International Journal of Computer Applications (0975 – 8887) Volume 10– N.4, November 2010
[17] COLOR IMAGE SEGMENTATION USING K-MEANS CLUSTERING, Chinki Chandhok, International Journal of VLSI & Signal Processing Applications, Vol 2, Issue 3, June 2012, ISSN 2231-3133 , (241-245)
[18] http://vision.middlebury.edu/stereo/data/scenes2005/FullSize/Dolls/disp1.png

Mr. Chhatrala Nayankumar D. received his B.E. Degree from VTU in 2011 and is currently P.G. student in department of E&C, M.E. in electronics and communication at Marwadi education Foundation's Group of Institutions, Research interest in Image Processing

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Mr. Bhalodiya Kelvin J. received his B.E. Degree from Saurastra university in 2010 and is currently P.G. student in department of E&C, M.E. in electronics and communication at Marwadi education Foundation's Group of Institutions, Research interest in Image Processing

Mr. Kaushal J.Doshi received his M.Tech degree from Dhirubhai Ambani Institute of Information and Communication Technology,India, in the filed of Information and Communication Technology in 2008. The author is Associate Member of Institute of Engineers since 2008 and has been awarded with second prize in an All-India Innovative design Idea Competetion held by Institute of Electronics and Telecommunication Engineers IETE in 2003

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)