A New Algorithm to Stereo Correspondence Using Rank Transform and Morphology Based On Genetic Algorithm

Razagh Hafezi, Ahmad Keshavarz, Vida Moshfegh

Abstract—This paper presents a novel algorithm of stereo correspondence with rank transform. In this algorithm we used the genetic algorithm to achieve the accurate disparity map. Genetic algorithms are efficient search methods based on principles of population genetic, i.e. mating, chromosome crossover, gene mutation, and natural selection. Finally morphology is employed to remove the errors and discontinuities.

Keywords—genetic algorithm, morphology, rank transform, stereo correspondence

I. INTRODUCTION

WITH a pair of eyes, each eye records a slightly different image of the world due to separate position. The human visual system (HVS) is able to automatically detect disparity between the left and right scene. HVS can reconstruct three-dimension structure information from detection disparity [1],[2],[3]. That is depth information gained using two images taken from different views. Stereo vision systems try to emulate the depth extraction ability of the human vision system with the use of two cameras, and a computer.figure1 shows a parallel-axis stereo geometry that is used in the binocular stereo approach. The depth, x, of a point as seen in figure1 can be written as:

$$x = \frac{f(L+d_L+d_r)}{d_L+d_r} = \frac{f \times L}{d_L+d_r} + f \qquad (1)$$

Where f is the length of the camera and L is the baseline distance between the two cameras and d_L+d_R is the difference between corresponding points of the left and right images. Identifying corresponding points that exist in stereo images is called stereo matching.Sometimes ,disparity has the same meaning as depth because the depth can be simply obtained using disparity and basic depth information is existed in the disparity.Stereo matching has been an area of intensive research for decades because the disparity contains useful information for various image applications, including object recognition, inspection, manipulation, stereo sequence coding and intermediate view generation.

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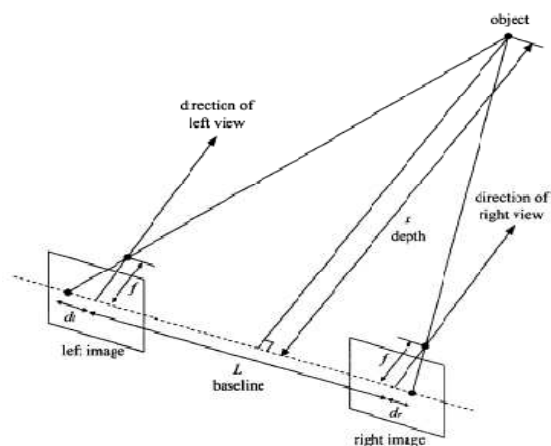
Fig. 1 Parallel axis stereo geometry

Approach to stereo matching can be roughly classified into the feature based methods and area-based methods. feature based methods use group of pixels with similar attributes normally either pixel belonging to low level features such as edges and corners. The features often sparse and interpolation process used to fill the gap later.

Area based stereo techniques use correlation between intensity patterns in the local neighborhood of a pixel in the other image. It is based on the assumption that disparities within a window centered at a pixel are constant.

The selection of suitable window size is a problem because a small neighborhood will lead to fewer correct disparity map with a short run time where as a large neighborhood goes to more accurate disparity map at the expense of run time. A lot of studied have been attempted to solve this problem such as shiftable windows[4], windows with adaptive size[5], windows using image segmentation[6], windows based on connected components[7], and windows based on disparity space[8].

For efficient select from so many candidates, genetic algorithm (GA) was employed to optimize the window size combination. GA is a global optimization technique based on randomize and iterative search.GA is often regarded as alternative methods to solving complex optimization problems whose derivatives cannot be computed normally.

In our algorithm: firstly, A rank Transform method are employed to acquire an initial disparity map and then calculate depth maps using the genetic algorithm.Finally, the morphology method used to achieve the accurate disparity map.

II. RANK TRANSFORM

Using a suitable correlation method can obtain a more credible initial disparity map. In our technique, we select the rank transform. Rank transform is insensible to image noise and brightness differences of stereo images.

The process of rank transform is described as follows: The window of rank is lied on through of the image and calculates the number of pixel of the window of rank what their luminance is less than the centre pixel. The gray level of image is transformed to an array of numbers [9].

The rank transform can be expressed by eq1:

$$R(x,y)=R-\sum u[s(x + i, y + j) - s(x, y)] \quad (1)$$

Where u(t) is the unit step; R is the number of pixels in the window of rank; (i,j) is a neighbour of the window.

III. GENETIC ALGORITHM

Each disparity is obtained by calculating the sum of squared differences between a pair of stereo image with the following equation:

$$s_R(x, y, z) = \sum_{x=-w/2}^{w/2} \sum_{y=-w/2}^{w/2} \left\{ \begin{array}{l} I_R(x + x', y + y') - \\ I_L(x - d + x', y + y') \end{array} \right\} \quad (2)$$

Where s(x,y,z) represents the SSD of pixel (x,y) in the image, d is the window shift in the left image , w is the window size, and I_L and I_R are the gray-levels of the left and right images, respectively. Here, we have employed an epipolar line can be determined first. The value of d that gets the smallest $S_R(x,y,d)$ with different window sizes is considered to be the disparity at each pixel position (x,y).

The optimal disparity map is one of $W^{N \times M}$ combination, where W is the number of window sizes and $N \times M$ is the number of pixels for a $N \times M$ resolution image. To simplify the calculation, the disparity map is partitioned into little blocks. In our method, the block size set into 8×8 , giving a block comprised of a 8×8 characters with eight levels. To apply the Gas to determine the optimized disparity map from several possibilities, the map's accuracy must be evaluated. To do this, we employ:
1) The compatibility between matching pixels in stereo images.
2) The continuity of an obtained disparity map.

IV. MORPHOLOGY

The mathematical morphology as a toll for extracting image components that are useful in the representation and description of region shape, such as boundaries, selection, etc. in our algorithm, we used the morphological technique for post processing.

Morphology is formulated in terms of set theory. Sets present object in an image; for instance, the set of all white pixels in a binary image is a complete morphological description of an image.

In the binary image, the sets are members of the 2D integer space Z^2, where each element of a set is a 2D vector whose coordinates are the (x,y) coordinates of a white(or black) pixel in the image.

A. Dilation and Erosion

Dilation and erosion are basic morphological processing operation. They are defined in terms of more elementary set operations, but are employed as the basic elements many algorithms.

Both dilation and erosion are produced by the interaction of a set called a structuring element with a set of pixels of interest in the image.

The structuring element has both a shape and an origin.

Let A be a set of pixels and let B be a structuring element. Let $(\widehat{B_s})$ be the reflection of B about its origin and followed by a shift by s. Dilation, written

$$A \oplus B = \{s|((\widehat{B_s}) \cap A) \in A\} \quad (3)$$

And the erosion of A by B is defined as

$$A \ominus B = \{z|(B)_z \in A\} \quad (4)$$

B. Opening and Closing

Opening generally smoothes the counter of an object and eliminate thin protrusion. Closing also tends to smooth section of contours but fusing narrow breaks and long, thin gulfs and eliminating small holes and filling gaps in the contour.

The opening of a set A by structuring B is defined as

$$A \circ B = (A \ominus B) \oplus B \quad (5)$$

Therefore, the opening A by B is the erosion of A by B, followed by a dilation of the result by B.

Similarity, the closing of a set A by structuring B is defined as

$$A \cdot B = (A \oplus B) \ominus B \quad (6)$$

Therefore, the closing of A by B is the dilation A by B, followed by the erosion of the result by B.

V. EXPERIMENTS AND RESULTS

We applied our method to
1) Stereo images obtained synthesized by computer simulation.
2) Stereo images obtained from a CCD camera.

In our algorithm, image pairs Tsukuba was used to test the proposed algorithm. In order to testify the performance of our algorithm, its simulation result was compared with those gets by a regular window sizes. Figure 2(a), (b), (c) is the left and right images of stereo pair Tsukuba and rank transform of left and right image and ground truth of disparity map respectively.

Figure3(a) shows the simulation result using our algorithm from (b) to (d) are the result got with window size 3×3, 7×7, 13×13, respectively.
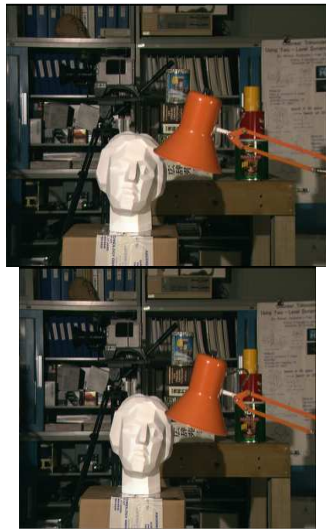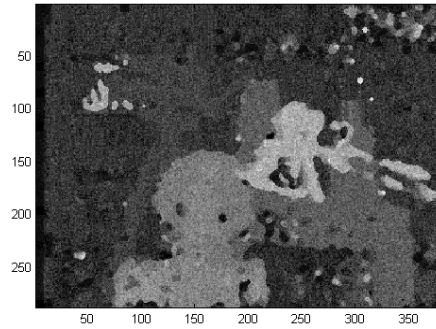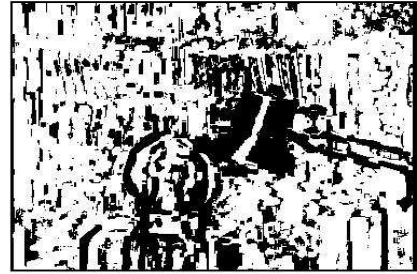

(a)
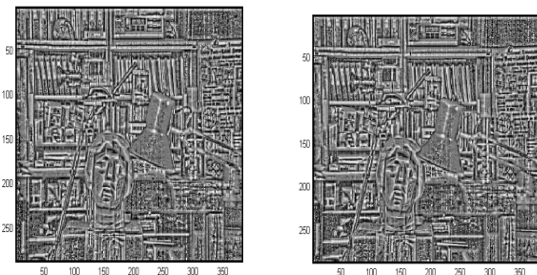
(b)

(c)

Fig. 1 (a) left and right image of Tsukuba (b)Rank transform of left and right iamges (c)Ground truth image

(a)

(b)

(c)

(d)

Fig. 3 Simulation result: (a) Our algorithm (b) 3×3 (c) 7×7 (d) 13×13

VI. CONCLUSION

Stereo correspondence is the central problem of stereo vision. In this paper, a method was proposed that employs Gas to determine a disparity map optimizing both the compatibility between stereo images and the continuity of the disparity map. This technique employs rank transform on image pairs. We used morphology to remove discontinuities. Our method generates the good simulation results compared to these obtained by correlation calculated with a fixed-sized window.

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