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Image 3d Adaptive Algorithm Based on Graph Cut

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Abstract

As a key step in the visual inspection, image to appear particularly important. Compared with the traditional algorithm, graph cut algorithm overall high precision and faster convergence speed in discontinuous area. Based on adaptive algorithm on the basis of in-depth study, this paper proposes a three-dimensional adaptation algorithm based on graph cut theory in order to realize the image matching. Experimental results show that this algorithm can well meet the requirements of high precision and high real time capability, solve the problems such as large amount of calculation in the traditional algorithm.

Keywords*: Image segmentation; Graph cut algorithm; Three-dimensional adaptation*

1. Introduction

Image adaptation is a key step in the visual inspection technology. Three-dimensional adaptation is by looking for the same space objects under different viewpoints corresponding relation between the projection of the image pixels, finally get the parallax of the scene graph. Adaptation is an essential part of the computer vision image. For many algorithms, if the images are not used to that, they lose the basis of analysis of the algorithm. If in the optical flow method to adapt to the accuracy is not high, will be a huge influence on the subsequent processing. For guidance system, if used to precision is not high, can lead to false judgment of guidance system. In industrial inspection, if the image adaptive precision can reach sub pixel accuracy, so the precision of image measurement and detection method can also achieve sub pixel level. In the industrial automation installation, adapt to the precision of the image is directly related to the installation of the system precision. At the same time, in the environment observation, image adapt to and is an important method of observation environment changes. As the environment is becoming more and more attention, therefore, the images have increasingly taken seriously [1-3].

The distribution of data according to the parallax, adaptive algorithm to sparse parallax and dense parallax adapt to divides into two broad categories. Sparse parallax adapt to general image characteristics such as edge profile, line with primitive, and adapt to the characteristics of the two images only area. These methods are generally more robust, but get a sparse results general circumstances. Intensive parallax algorithm usually to as to adapt to the primitive image grayscale or other properties, by the correlation degree between the candidate neighborhood as discriminant basis, the commonly used methods are: regional correlation method, dynamic programming, and based on the optical flow field, and the method based on graph cut.Its advantage is to give all pixels of parallax information, but will have some mistake. By building energy function to try to get the image of some global properties, widely used in the early vision.But, unavoidably, it's often difficult to obtain global minimization of energy function.Compared with the traditional algorithms,

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graph cut algorithm not only overall accuracy is high, and in discontinuous regions and the precision of low texture area also is higher than other algorithms. Not only that, even if some algorithm accuracy and the precision of the graph cut algorithm, close to the graph cut algorithm convergence is faster in the process of optimization.

2.Related Works

2.1. The Image Adaptation

Image adaptation is a very important subject in image processing, the moving object tracking, recognition, motion compensation in time sequence image compression, medical image processing, and other fields have broad application prospects. Many scholars in the field of image to adapt to and motion detection to do a lot of work.Image to adapt to translation, rotation, scale difference allows the correction of the relative position and gray scale and geometry changes, *etc*. Paper introduced under the face of the present status of the adaptive algorithm and traditional algorithm are given in detail the implementation of traditional algorithm combined with wavelet filtering.

In the practical application often need to each image from the image sensor. Multisensor image to adapt to the technical difficulty is greater, especially to realize automatic image bands are far apart, because of the small image correlation between, is even more difficult. Image to adapt to a lot of methods, according to the adaptive algorithm of image pixel values include global related algorithm, fast Fourier algorithm, *etc*., this method is simple, easy to implement. At present, also has a lot of research in this field at home and abroad.By means of projection, such as normalized function and so on. According to the image characteristics of adaptive method refers to the original image and the image is extracted after the transformation of proportion, scaling, rotating, gray level transformation adaptive method has the characteristics of immutability. In the original image, the characteristics of the commonly used include edge, region, line endpoint, line intersection, regional center, the curvature of discontinuous points, *etc*. The most commonly used edge and regional boundaries, they can be made by edge detection method and region segmentation method. In the transform domain, can use Fourier transform, discrete cosine transform and Walsh transform transform the image into a set of coefficients, such as feature points. As a general rule, the method based on feature because they are not directly dependent on the pixel values, so often need to be more complex image processing to extract feature, thus for hardware implementation. Image adaptive process mainly involves to adapt to the characteristics, the determination of constraint condition, *etc*. They determine the success of the image to adapt [4-5].

To adapt to the first step is to select is used to describe the template image and to adapt to the characteristics of the image. To adapt to the basic features and transformation characteristics usually includes two kinds big.

The basic characteristics; The basic features of images including the gray levels of pixels in the image, image feature points, the edge and texture, *etc*. The grayscale characteristics is the image of the original information, is also the most accessible. Feature points is in the image pixels to meet certain requirements, such as line intersection, *etc*. Edge refers to the image by gray scale and color change of discontinuity and formation of the border.

Texture is a structure for repeat arrangement and form on a wide range of features. To analyze the basic characteristics, can be found grayscale characteristics while the most accessible, but also the most easily by the influence of various factors and the larger change. The feature points, the edge and texture, although is not sensitive to image gray level of the overall changes, but their extraction effect relies on access to their various operators as well as the different parameters set by the operator. And decide to choose which kind of operator as well as the corresponding operator of parameter Settings, is a very difficult job. In addition, these characteristics of tilt, scaling, rotating, displacement and deformation are no

fault tolerance.

Transform characteristic; If these basic features for various transformation, new features are available with special performance. The most typical transformation are: Fourier transform, K - L transformation, Hough transform and other coordinate transformation and so on.The characteristics of the image after Fourier transform can obtain a series of spectrum F (u, v), their low frequency part contains the main part of the image. According to the spectrum of the low frequency part of image adaptive can eliminate noise caused by the inconsistent. But it is hard to the spectrum that is associated with the actual graphics, therefore not suitable for the image for further analysis.

Through the K-L transform can obtain information about image of each component. In the process of typical transformation we will first gray image represented as n * n phalanx. And then obtains the phalanx of F characteristic matrix X and the corresponding diagonal form the characteristic value of matrix E, have FX = XE. Finally, according to E part of the eigenvalues for image to adapt. In this case the characteristic value is reflected in the level of the strength of the component function on the image so it is invariance for rotation and is not sensitive to slight deformation, and the changes of zoom multiples, *etc*. But it is worth noting that the K-L transformation is often reflected by the results of information is not adapt to the main consideration of a key information, for example, it can describe the effects of light as the main characteristics of the image, and to increase or reduce the number of involved in adaptive eigenvalue not to adapt to the inevitable impact on the success rate.In addition, by using the transform image to adapt to another big problem is that existing: it requires large-scale matrix operations.

In 3d in the process of adaptation, in order to be able to properly adapt to point to, the following a few basic constraints to reduce the conjugate point by mistake.

Uniqueness constraints;At any point on the surface of an object of a given point in space has the only place only, so generally adapt primitives that only suit with another image of a primitive.In this way, only a parallax images of each adapt to primitive values. The constraint requirement being filmed opaque objects, in the forest environment, the constraint can be satisfied.In the actual image of the trees, because most of the feature points is not obvious, especially the repetition of the texture trunk, often can produce corresponding polysemy, namely an image on a feature points corresponding to the image of the other image multiple points, the same name one of the points is the real name, and other points are false name.

Compatibility constraints; Compatibility constraint refers to the two 3d like to adapt to the primitive should be produced by the same object. When judge whether two to adapt to the primitive compatible according to the similarity between two to adapt to the primitive. There are two kinds of description to adapt to the primitive similarity measure.One is based on the nature of the photometric invariant, the left and right are similar as the corresponding changes in gray area. It is mainly used in the scene of depth changes in the surface is flat, and at the same time two cameras distance is not big, such as aerial photography measurement system.But in the application of 3d visual in forestry survey, scene depth distribution often have changed dramatically, in such areas prone to corresponding to the left in the area near obscured in the right, or with corresponding areas of the right in the left obscured. The photometric invariant measure it will be difficult to maintain.Another kind of similarity metric geometry invariability, the two images is described in the same object at the same geometry.The constraint of 3d vision system for forestry three-dimensional adaptation is very important [6-8].

Continuity constraints; And surface compared to the distance of the camera, caused by the surface concave and convex or by an observer to the distance on the surface of the object changes caused by the difference is very small, under this precondition, continuity constraint is to adapt to the changes in the parallax value almost everywhere in the image smooth. For the crown part, due to keep out, crown, on top of each other between so you can't satisfy the continuity constraint. The current experiment when shooting generally

consider avoiding barrier between the trunk, so in the same tree trunk or satisfy the continuity constraint on the crown of a tree, but does not meet the between overlapping canopies.

Outside the polar constraints; For two to obtain the same scene images from different angles, the traditional feature point search method is first on an image to select a feature point, and then search the corresponding point on the second image. Is clearly a two-dimensional search problem, its computation is palpable. Even so, also hard to guarantee the correctness of the search to the conjugate points. According to the principle of perspective imaging geometry, an image of the feature points must be located on another image corresponding to the outer line, so for the polar equation of only the outer pole online search to adapt to the point and don't need to the whole image search, this adaptive two-dimensional search into the one-dimensional search, not only greatly reduces the amount of calculation, also increases the reliability of the adapt to the point. These constraints using can improve to adapt to the accuracy, reduce to adapt to the workload, increase the speed of adaptation.

2.2. Image Segmentation

Image segmentation is the image into each area and extract the characteristic of technology and process of interested target. This feature can be gray, color, texture, *etc*., the target can correspond to a single region, can also correspond to multiple regions. Image segmentation is the key of automatic target recognition and the first step, is also a kind of basic computer vision technology. Image segmentation accuracy will directly affect the subsequent work. Therefore, the method of segmentation and accuracy is very important.

In image processing, an image can be light intensity of the objects in the natural scenery, can also be a body organs absorption characteristics of the quantitative; The radar cross section of objects or targets; Or a region of temperature field, gravity field. Generally any said a two-dimensional function of information can be regarded as an image. Such as using two-dimensional intensity function $f(x, y)(0 \le f(x, y) \le L-1)$, where x, y space point coordinates, L to grayscale. F gray image. Color images can be respectively using the three primary colors gray image addition of R, G, B.Over the years, people put forward different definitions of image segmentation, generally refers to: separate image has a special meaning in the different areas, these areas are mutually disjoint, each region to satisfy consistency in a particular area. The following is the aid of more formal definition of the concept of set is given:

To set R represents the entire image, region segmentation of R can be seen as R can be divided into N the loophole that meet the following five conditions set $R_1, R_2 \ldots R_N$

$$\bigcup_{i=1}^{N} R_i = R ; \quad (1)$$

If $i \neq j$, $R_i \bigcap R_j = \varnothing$ (2)

If $i = 1, 2, \ldots, N$, $P(R_i) = TRUE$; (3)

If $i \neq j$, $P(R_i \bigcap R_j = FALSE)$; (4)

If $i = 1, 2, \ldots, N$, R_i is connected area. (5)

$P(R_i)$ is the set of all R_i the logical predicate.Conditions (3),(4) refers to the segmentation results belong to the same area of the pixel should have some of the same features, the opposite should have different characteristics. After the split regions should satisfy the consistency principle.

In practice, not only to divide an image into image segmentation to satisfy the above five conditions of each region and the characteristic of need them interested in the detection of target area. Only in this way in order to be completed the task of image segmentation. In addition, the research on image segmentation and can be divided into three levels: the first is the study of segmentation algorithm; Followed by the study of segmentation evaluation method, namely, describe and compare the performance of segmentation technology, it helps to grasp the characteristics of different segmentation algorithms, this is the division of research at the second level; Finally, people have realized the system was studied for the segmentation evaluation method and evaluation criterion, to ensure proper evaluation method and evaluation criterion is used to study segmentation technology, it is considered to be a third level of image segmentation research.

3d adaptive algorithm can be roughly divided into two categories: algorithm based on region, this algorithm can easily restore the high texture area parallax, but low in texture area can cause a lot of adaptation, which can lead to fuzzy boundaries, and at the same time to keep out area is hard to deal with;Algorithm based on global, compatibility and smoothness constraints is commonly used in the algorithm to form an evaluation function, and through a variety of optimal algorithm to get the minimum value in the evaluation function, especially the idea of minimum cut algorithm has obtained the very good effect on accuracy. However, the traditional algorithm based on global one of the biggest problems is the amount of calculation is too large, in the case of high real-time demand is not suitable for use.

Use of image segmentation based on graph cut theory of 3d adaptive algorithm, the basic ideas of Tao algorithm framework for reference, the template calculation and selection of evaluation function is improved. First of image segmentation, and extract the parallax template, the traditional global algorithm based on distribution of each point optimal parallax problem into distribution of optimal template for each area. In the algorithm of Tao, template parameter for direct to calculate income for all areas after segmentation, because after some reliable segmentation points less area, so these areas calculated template parameters are not accurate. The algorithm to calculate its only for reliable points more regional template parameters, and the template, using the method of regional integration, to enhance the calculation the robustness of the template. Also in the process of global optimization, the algorithm adopts a new evaluation function, make the template to adapt to the cost of the regional similarity calculation it only once and further reduce the computation of the algorithm, which greatly improve the real-time performance of the algorithm [9-11].

3. Image Three Dimensional Adaptive Algorithm Based on Graph Cut Theory

This paper presents a use of image segmentation based on graph cut theory of 3d adaptive algorithm. The algorithm framework based on the smooth surface of the assumption that in the single color area parallax change is smooth, so that you can pass a $d(x, y) = a + bx + cy$ plane template formula to describe the area $[a \quad b \quad c]^T$ as a template parameter, calculated by the formula of the parallax parallax is called a template.Based on this assumption, can the traditional algorithm of each point in the global distribution, the optimal parallax problem into distribution of the optimal template for each area. To construct a global energy function, measured in pixels and the distribution of the integral level of quality.Robust to minimize the energy function is achieved by optimization based on graph cut. The algorithm greatly improve the real-time performance of the algorithm.

The algorithm to learn from the basic ideas of Tao algorithm framework, and the template calculation and selection of evaluation function is improved. In the algorithm of Tao, template parameter for direct calculated for all areas after segmentation, because after

some reliable segmentation points less area, so these areas calculated template parameters are not accurate. The algorithm to calculate its only for reliable points more regional template parameters, and the template, using the method of regional integration, to enhance the calculation the robustness of the template. Also in the process of global optimization, the algorithm adopts a new evaluation function, make the template to adapt to the cost of the regional similarity calculation it only once and further reducing the amount of calculation of the algorithm.

Image segmentation is the basis of the whole algorithm, this algorithm adopts the Pedro and Daniel and efficient image segmentation algorithm based on graph theory, the algorithm has high accuracy and good real-time performance characteristics. In general, in order to make the smooth surface of the hypothesis is more reliable, should make the regional single color as far as possible, to regional colour difference threshold parameter properly cut, divided area slants small.

3.1. Graph Cut Theory Analysis

If G is a connected graph, delete one of the nodes after G into a connected, so, the deleted node is called the cut point of G.If G is a connected graph, delete a node can increase the number of connected components of G so the deleted node is called a connected graph G cut point.If you delete an edge complex by the number of connected components will increase, we are called the side of the bridge or cutting edge.

N is a two terminal network consists of a connected weighted directed graph, and a definition on the arc of the nonnegative real function of c, which directed graph to specify the two special node s and t, called side, is the source node s, the in-degree 0, it is in directed graph emitter;Node t to send, its degree of 0, it is the receiver in the directed graph. The rest of the nodes is the middle of the network.In general, the network may not have a terminal, can also have many terminal, but we only discuss the two terminals of a source, collect. For each of the arc e, giving rights c (e) is called the capacity of the edge.Of source for a s a N t network, cut is a collection of arc s, satisfy each path from s to t at least through an arc of s.Another way, if the arc S have been deleted, there are no directed path from S to t.Cut cut capacity refers to all the capacity sum of the arc.Network N minimum cut is a minimum capacity of cut.Minimal cut S refers to all e ∈ S, S - e is not cut, is to delete any of the S, S, has been cut, we also say that there is no redundant arc in a tiny cut.

3.2. The Template is Calculated

Outside to discuss convenient, assumes that the two images of polar has been calibrated, if the reference point (x,y) and adapt to the figure of the point (x', y'), you should meet the following corresponding relation:

$$x' = x + s \cdot d(x, y), y' = y \quad (1)$$

Type $s = +1$, for guarantee the parallax d (x, y) is not always negative.In this article are to choose the left view for reference, right view with figure, so take $s = -1$.This algorithm first uses the different SAD calculation of each pixel in parallax in adapt to the price.If calculated, using the large window in low texture area will get more reliable results of initial adaptation prospects but also inevitably expansion effect, so all the points in this algorithm to adapt to the cost is calculated using 3×3 small window.Parallax of the accuracy of the initial value of the estimate of the template effect is very big, in addition to the usual using cross validation, and joined the similarities filter processing, thus enhanced the reliability of the initial value.If a point of reference in the adaptation in the figure is reliable to adapt to the point, which is known as a reliable points, otherwise is not reliable.

3.3. The Grid Structure

Network flow can be used to solve the problem of image to adapt easily.A given image G, divided into two parts, A and B.By adding two new node s and t, N, founded by G network from s to each node to add an arc, A all the edge to the arc, from A to B from B of each node to add A t arc.Then all the arc capacity is set to 1.On the N application - maximum flow minimum cut theorem, when calculating maximum flow, from A to B of saturated arc G the biggest adaptation.

3.4. Adaptive Strategy

To adapt to the request for best results, as a result of image content without prior cognitive, in order to get accurate adaptation as a result, often need a global search in the image.In theory, of course, the introduction of polar constraints can search range from 2 d to one dimensional search, greatly reduces the operation time, but still can't meet the requirements.To in order to improve the speed, adapt to the accuracy and dense depth information, this paper applied in full to constraints on the basis of the following strategies:

(1) The first reference graph is divided into multiple regions, in a split with plane formula based parallax, extract parallax from initial parallax segmentation template, template is calculated, and optimize regional optimization and templates.

(2) And then build the energy function, the algorithm is commonly used in the algorithm based on global energy function.To minimize the energy function, build an undirected network N, the label set of functions and network N figure cut a bijection, and for each label f, the energy E (f) to its corresponding cutting capacity.

(3) In the N application again - maximum flow minimum cut theorem, when using the maximum flow algorithm, at the time of the maximum flow of saturated arc that is from A to B G the biggest adaptation.

(4) To adapt to the uniqueness and combining the corresponding feature compatibility.The uniqueness of the right to adapt to the point, no doubt, but the image pixel feature rich and not very clear, in the process of adapt to inevitable many ambiguous points, is in the right to adapt to the point and many ambiguous points to select the right to adapt to the point [12-13].

4. The Simulation Experiment and Result Analysis

In this paper, the experimental data processing under the environment of Matlab. According to the graph cut algorithm and adaptive strategy design of the use of image segmentation based on graph cut theory of three-dimensional flow chart of adaptive algorithm. Further on the basis of image segmentation using graph cut theory, combining with the knowledge of network flow, to adapt to image process simple and clear, high precision and fast speed.Its algorithm process is shown in Figure 1.

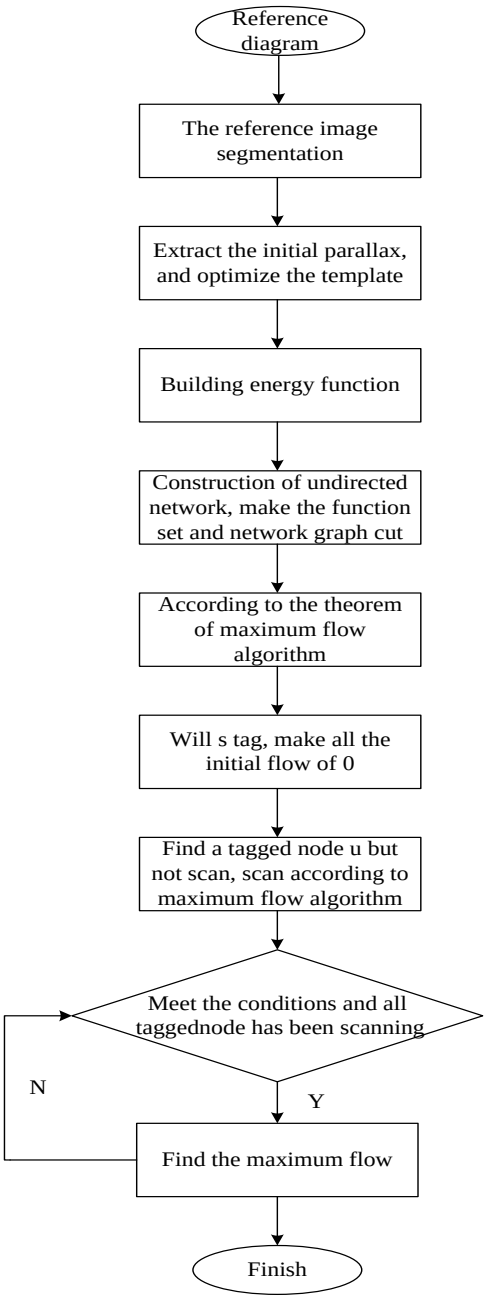


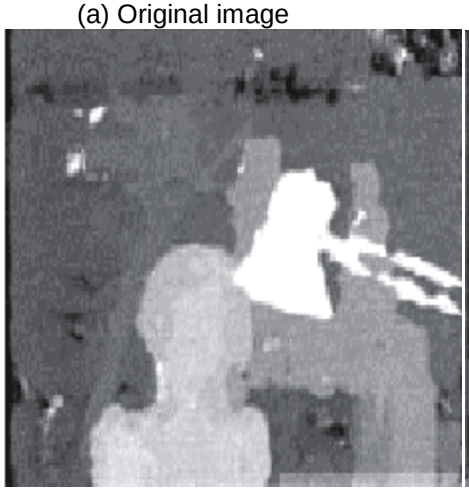
Figure 1. Algorithm Flowchart

In order to verify the advantages of 3d adaptive algorithm based on graph cut, we in Tsukuba image on the application of various algorithms, such as: dynamic programming algorithm, graph cut and occlusion detection algorithm, 3d adaptive algorithm based on image segmentation, and in this paper, the 3d adaptive algorithm based on graph cut, has carried on the experiment to reference images, it is concluded that the parallax figure, and the experimental results of each algorithm are compared, and are compared with those of the standard parallax figure also [14-15].

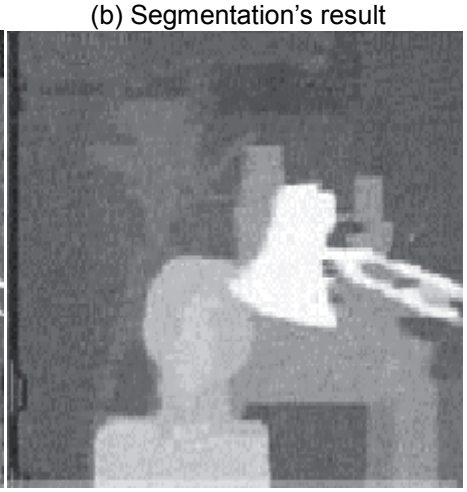
As shown in Figure 2, Tsukuba image for all kinds of algorithms of the comparison results.

(a) Original image

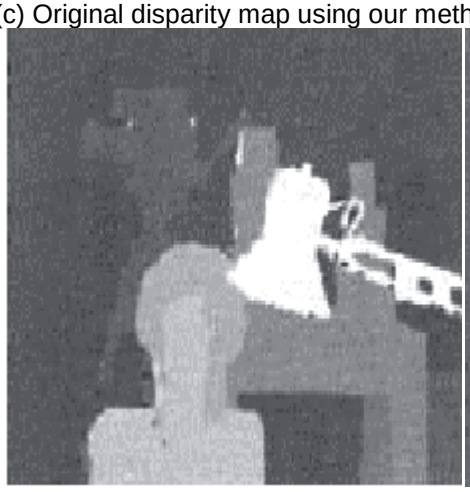
(b) Segmentation's result



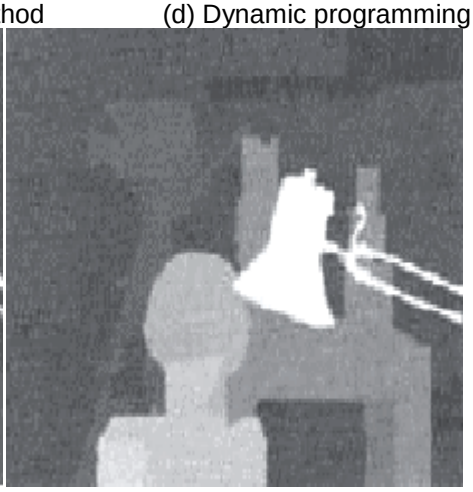
(c) Original disparity map using our method



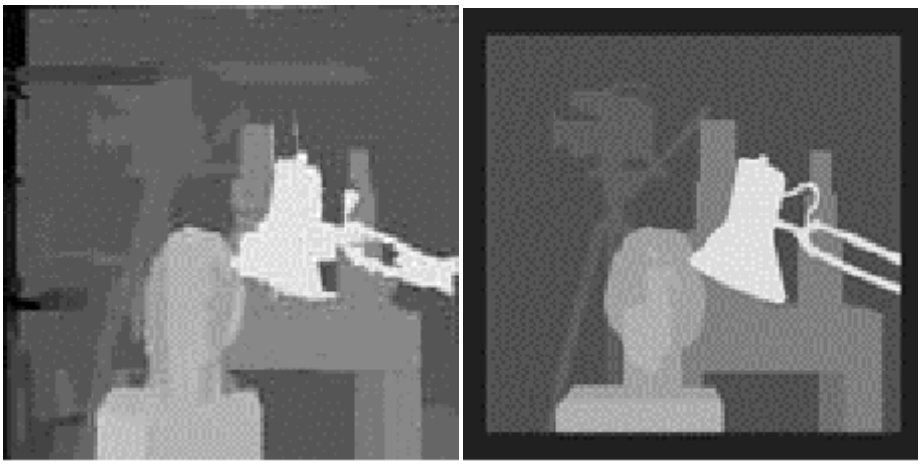
(d) Dynamic programming



(e) Algorithm with Occlusions using graph cuts



(f) Algorithm using image segmentation



(g) Our method (h) Ground truth disparity map

Figure 2. The Disparity Maps' Comparison of Various Algorithms on Tsukuba

As can be seen from the Figure 2, the basic target of the image is segmented, segmentation edge character location accurate, after major basic shape remains the same.Because this algorithm is based on region segmentation parallax change will not appear in the region is flat and parallax leap on the basis of the initial color segmentation error, so if will affect the later adapted to the results.Through the analysis can be found, if appear over-segmentation, namely the same area is divided into multiple regions, figure cutting optimization can still be correctly allocated each parallax of pixels in the area;If owe segmentation, in which multiple regions are divided into a region, will likely loss phenomenon of the parallax boundary.So in segmentation parameters when the choice, should choose as far as possible little window width.This algorithm is superior to the dynamic programming algorithm.In graph cut algorithm, compared with the dynamic programming algorithm, this algorithm at the same time of parallax smooth constraint preserves the details information, and more conducive to handle big low texture area.Compared with the 3d adaptive algorithm based on image segmentation, this algorithm can make some area again according to the pixel distribution of parallax error segmentation, reduce energy further, so as to better estimate parallax boundary, can adapt to get higher accuracy.

5. Conclusion

Based on adaptive algorithm is made on the basis of in-depth study, put forward a kind of use of image segmentation based on graph cut theory of three-dimensional adaptive algorithm.Reference graph is divided into multiple regions first, and then in a split with plane formula based parallax.Parallax template is extracted from the initial parallax segmentation.Each partition is assigned to precise parallax template.To construct a global energy function, measured in pixels and the distribution of the division level of quality, the adaptation into energy function minimization problem.And then using the knowledge of network flow, by constructing the network, make the cutting energy and the network capacity.After using adaptive algorithm based on graph cut theory, through - maximum flow minimum cut theorem to minimize the energy function, so as to realize the image of adaptation.Experiments show that this algorithm is of low texture area and close to the parallax effect of border area has good adaptation, at the same time, and solution to the traditional global large amount of calculation of the algorithm, which based on real-time performance is bad.Thus, the algorithm can well meet the requirements of high precision and high real time capability.

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