An Image Processing Algorithm Based on Multiple Wavelet

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***Abstract* — To extract foreground area is a shallow depth of field image smoothing depth of the problem of the great error, to modify the depth value based on pixel classification, put forward a kind of based on multi-scale wavelet clues, but at the same time for arrangement of the depth of the shallow depth of field image and wide-angle image extraction algorithm. The first to use wavelet analysis to extract the image depth information in multiple scales; and then put forward an adaptive classification and according to the scale and depth change rule of pixel depth correction, get depth map; finally combining region growing and edge segmentation algorithm on depth map area optimization. In order to speed up the depth calculation, also put forward the rapid zero-count method and multi-scale method to meet the standard definition video real-time processing requirement. The experimental results show that the proposed algorithm to obtain the depth of the figure relative depth right, foreground and background area depth good consistency.**

Keywords - wavelet analysis; multi-scale; depth map; pixel classification; region grow

I. INTRODUCTION

Through 2D to 3D technology converts the original 2D video can be used for stereo display of 3D video, is the effective way to solve the 3D film sources scarce, the technology is one of the key issues in how to extract depth information from 2D images[1]. In the process of 2D film there are 2 types of images: 1) describe a panoramic background wide-angle image significantly. Ma and so on put forward a kind of based on feature analysis in depth of the vanishing point figure depth extraction and optimization method, but the uncertainty of the vanishing point position makes its application limited[2]. Jung based on relative height is put forward, such as clues to depth information estimation method, but the relative height leads to the depth value according to the bottom of the image, the image at the top of the nearly far rule arrangement, the input image was limited[3]. 2) in order to highlight the protagonist with long focus of shallow depth of field image. Zhuo, etc. point spread model based on the analysis on the edge of the fuzzy degree of layered and combined with marginal distribution probability estimate relative depth value[4]. The method of texture and noise has strong robustness, but because of its mainly depends on the edge information, so the prospects do not apply to the texture of single or fuzzy image. Valencia such as using wavelet analysis and boundary estimation based on lee's index, from a single image to obtain the relative depth, but a d lee index boundary analysis result in vertical depth map information isolation, streaks, greatly reduces the depth map quality[5]. Such as Guo on the basis of Valencia was improved, using two-dimensional lee index analysis, and introduced based on color segmentation, significantly improve the effects of depth map, but its effect is easily affected by light, at the same time a longer calculation time consuming[6].

Above the depth of the 2 kind of image information extraction research have achieved certain results, but can also apply the less depth of 2 class image extraction algorithm. Aiming at this problem, this paper tries to explore a general 2D to 3D algorithm, make it can't only applicable to the shallow depth of field image, consider the wide-angle image at the same time. In the literature inspired, this paper puts forward the depth extraction algorithm based on multi-scale wavelet clues[7]. The idea is multi-scale wavelet method were used to detect the image area significantly to extract depth information, through the analysis of the same area musicale dynamic correction and significant strength change rule to depth information. Experiments show that this algorithm can apply to more than 2 at the same time the depth of the image information extraction, and can effectively solve the foreground area is a shallow depth of field image blur caused by the depth value deviation problem, so as to get a higher degree of uniform depth prospects. In addition, accelerate the optimization algorithm is proposed in this paper can well meet the standard definition video real-time processing requirements.

II. MULTI-SCALE DEPTH EXTRACTION ALGORITHM OF 2D IMAGES

From the point of view of the local, shallow depth of field image with wide-angle image has a obvious similarities, which details more significant area is generally smaller values of the depth of foreground object or edge; Rather than a significantly larger regional general value for the depth of background objects. The wavelet analysis method can get local high-frequency component image, its signal strength can accurately reflect the image detail change, is effective means of significant test. Therefore, regional image can be high frequency wavelet coefficients of China-Africa zero element number and the scene depth value relevance as a

depth cue[8]. However, it must be noted that the above method is a method of local affected by scale. Small scale, lack of texture information of foreground area is smooth strength significantly smaller, will lead to the depth of the wrong results.

From the global perspective, the same area of its significance is different in different scales, and there is regular contact. As shown in figure 1 to 4 kinds of testing scales have significant image, it is not difficult to find some laws. For the image edge, significant and decreases with the scale; for the area of foreground area is lack relatively smooth texture, significant as the scale increases.

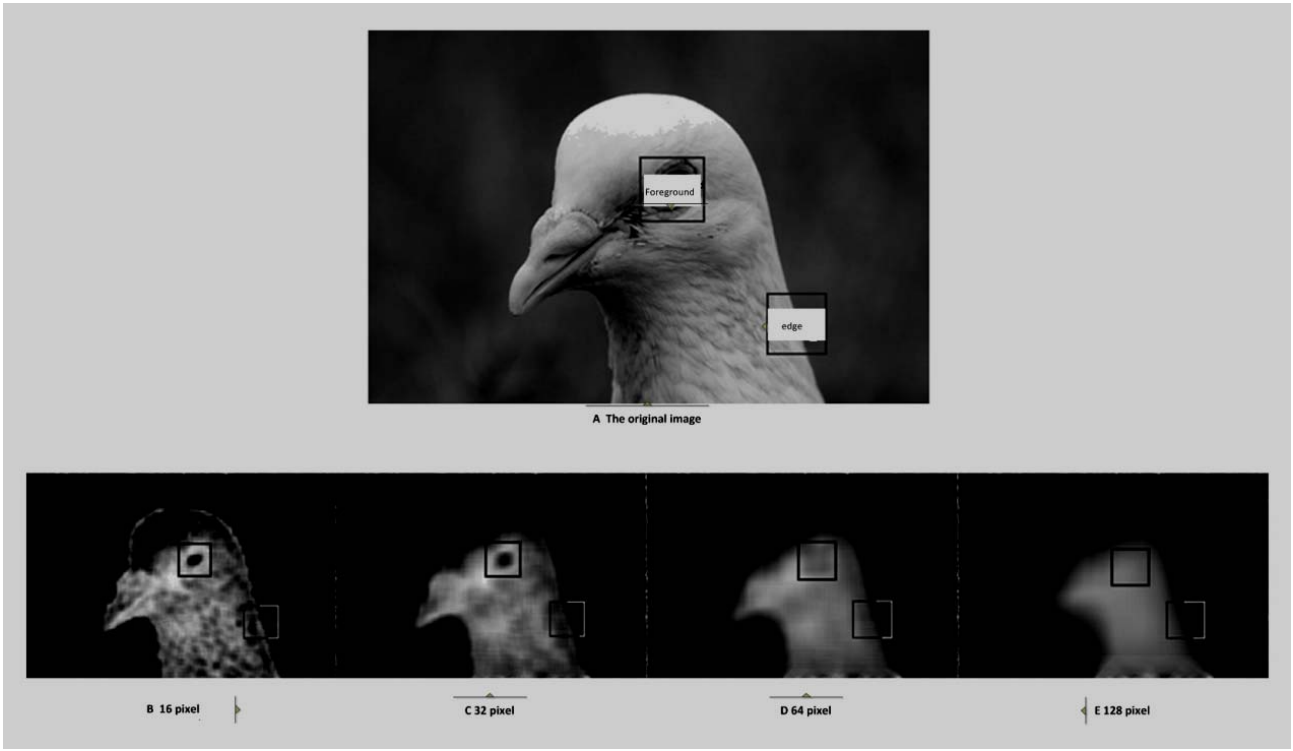


Figure 1. The figures under the different scales of significant

The algorithm of adaptive wavelet multi-scale analysis is presented, under the multi-scale detection image is significant to extract depth information, and according to the same area musicale and significant strength change law adaptively adjust the depth information. Then put forward the combination of region growing and edge segmentation image segmentation algorithm, in order to optimize the depth map. Compared with other algorithms, this algorithm has the depth information correction ability; making it can be applicable to the shallow depth of field image at the same time with wide-angle image, and can effectively solve the prospects for regional gray little change in the high frequency of non-zero elements less caused by small depth value. In this paper, a 2 d image depth extraction algorithm is shown in figure 2, the specific steps are as follows:

Step 1: input 2 d image into a gray image.

Step 2: Using adaptive wavelet multi-scale analysis depth map is generated, and using the method of rapid Zero-count to accelerate calculation process.

Step 3: Using the combination of wavelet edge region growing image segmentation algorithm of image segmentation, and using the method of multi-scale acceleration to accelerate computation.

Step 4: According to the values to deep depth map image segmentation region optimization to get the final depth map.

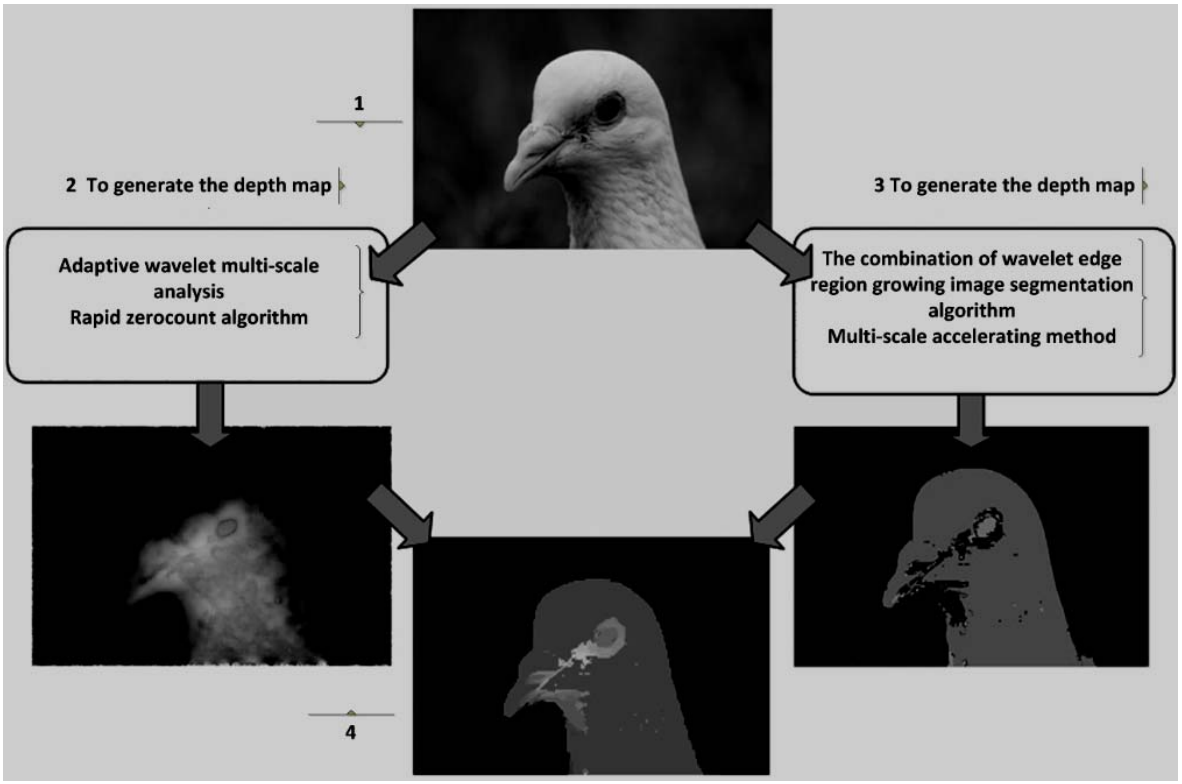


Figure 2. 2D image generation depth map algorithm step

III. ADAPTIVE MULTI-SCALE WAVELET ANALYSIS ALGORITHM

The musicale will directly affect the choice of the wavelet analysis method for significant test result. Through the experiment, analysis scale will reduce the accuracy, bring about background and foreground edge blur; Scale is too small, the depth value accumulation on the edge, and there will be a prospect for large prospect area target center area small relative depth problems. Therefore, adaptive wavelet multi-scale analysis is put forward, its core idea is to analyze the regional multi-scale wavelet coefficient variation law under, USES the adaptive threshold value method will pixels according to classify foreground, edge, background; Then according to the pixel category to modify the depth value. This algorithm can effectively solve the prospects for regional gray little change in the high frequency of non-zero elements less depth value caused by small problems, in order to gain higher consistency prospect depth values.

Rapid Zerocount method in this paper on 4 kinds of scale statistical pixel area high frequency number of nonzero wavelet coefficients, s depth as a significant strength, define the pixel values (x, y) depth as:

$$y = 255(\frac{s}{0.75N^2})^4, s \in [0,...,\frac{3}{4}N^2] \quad (1)$$

Four dimensions depth map is obtained S16, S32, S64, S128 as shown in figure 1, from figure 1B to 1E corresponding scale N = 16, 32, 64, 128 pixel depth map.

If the area is divided into foreground, edge and background 3 class, pay attention to the regions to belong to the same class, its scale - fitting line depth values present similar laws. Figure 3 a on the right shows the three pixel scale as the abscissa, depth values for the vertical linear fitting characteristics of classification figure. About the prospect area pixel, fitting line (green) slope value is positive and intercept larger for larger positive. For the edge of the fitting line (blue) slope value is less negative and intercept for larger positive. The fitting line of background region pixels (red) values of the slope and intercept is somewhere in between. As a starting point, linear fitting for all pixels, and structural slope, intercept distribution histogram respectively; Of pixels are classified, and then use the threshold method classification results as shown in figure 3 b, the white part on behalf of the future, the need to strengthen the depth, the black part on behalf of the background, it needs less. Depth correction results as shown in figure 3 c. After comparing figure 1 and the depth of the revised figure can be found, prospects of eyes depth is worth to correction.

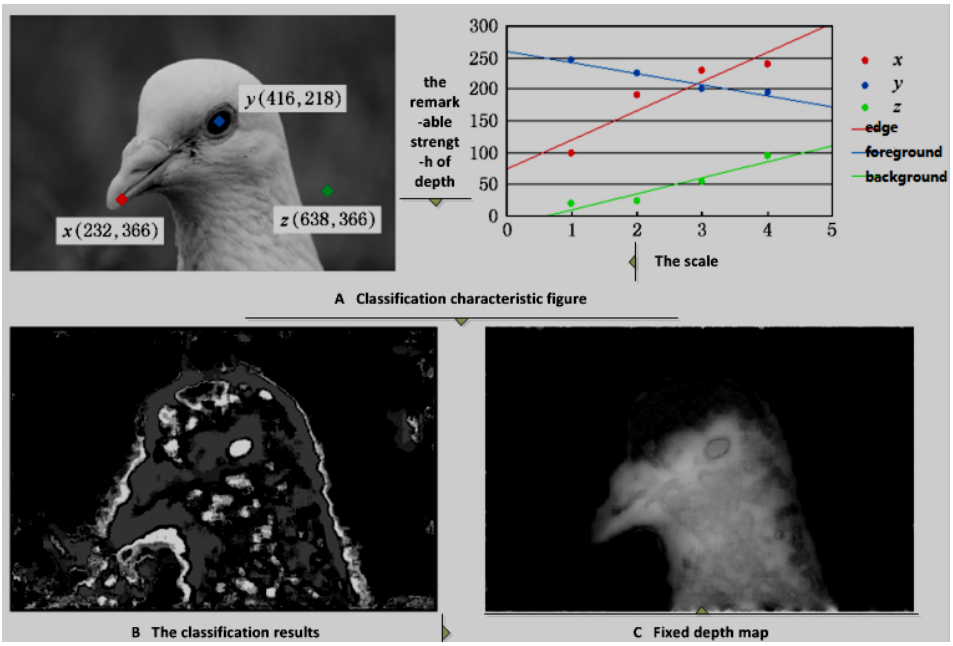


Figure 3. Adaptive pixels classification

For pixel rectangular area where the high frequency wavelet coefficients of the sliding window scanning method is conventional. The method USES the size of a given rectangle window by scanning the whole image pixels, for each scan area do a layer of two-dimensional wavelet decomposition are shown in figure 4 a four frequency subband LL, LH, HL, HH. Of LL subband is composed of low frequency coefficient, reflect the image in a certain scale after filter the high frequency signal overview; And LH, HL, HH subband contains all the high frequency coefficients, respectively reflect the horizontal, vertical and diagonal direction of image detail. Need four scales of the wavelet coefficients are computed scan images 4 times again and again to do wavelet transform, its time complexity is too high, not suitable for real-time multiscale computation.

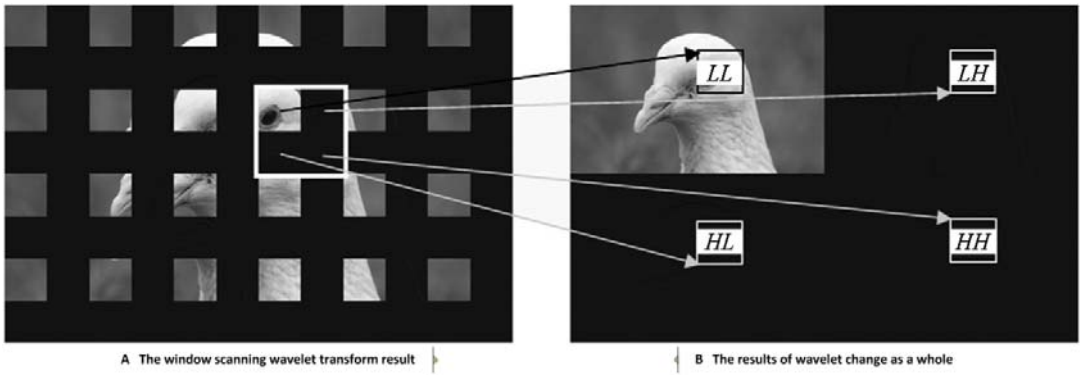


Figure 4. Window scanning wavelet transform and the overall position diagram after wavelet transform

In fact, is the result of two-dimensional discrete wavelet decomposition and local computational, sliding window scanning algorithm, in the image horizontal axis x, y coordinate y pixel as the center of the N * N rectangular W wavelet decomposition of matrix, the four subsystems with LL, LH, HL, HH and artwork as a whole do a layer of wavelet decomposed matrix H corresponding frequency domain with corresponding relation, and the corresponding position within the subband coefficients equal. As shown in figure 4 do window scanning wavelet transform for the image respectively with integral wavelet coefficient after wavelet transform of the relative position relations, in figure 4. A window in the centre of the image wavelet coefficients matrix W 4 sub-niches belt respectively located in figure 4 b integral wavelet coefficient matrix H 4 is a central location. If you can get location mapping formula, can pass the whole

image wavelet coefficient matrix H immediately gain coefficient of the wavelet coefficient matrix W all, eliminate repeat wavelet transform time overhead. As a starting point, this paper designed a statistical pixel area high frequency number of nonzero wavelet coefficients s accelerated algorithm. The algorithm based on the window with the wavelet coefficient map location map linear wavelet coefficient formula of the zero element based on integral figure statistical algorithms calculation of whole image depth strength significantly. On time efficiency, the algorithm in this paper wavelet transform of calls from M*N times into four times, so greatly accelerated.

In general, it Doesn't break for a m*n image, a sliding window h long, Hk (k = 1, 2, 3, 4) is a graph will shift to the left, right, up, and after the shift to the left first, then move up four wavelet decomposition coefficient matrix, mobile distance is 1 pixel; With image pixels (x, y) as the center of the sliding window wavelet decomposition coefficient matrix W/position can be according to the formula (2) corresponding to the Hk, among them, the $x = 2(i-1)+h/2+1+p_k$, $y = 2(j-1)+h/2+1+q_k$, $M(a,b,c,d)$ said the boc matrix M, column number for a to b to c to d submatrix(v formula 3);

$$\begin{cases} W(2(i-1)+1:2(i-1)+h/2, 2(j-1)+2:2(j-1)+h/2+1)+(p_k,q_k) \\ \Rightarrow H_k(i:i+h/2-1, j:j+h/2-1):(LL) \\ W(2(i-1)+1:2(i-1)+h/2, 2(j-1)+h/2+1:2(j-1)+h+1)+(p_k,q_k) \\ \Rightarrow H_k(i:i+h/2-1, n/2+j:n/2+j+h/2-1):(LH) \\ W(2(i-1)+h/2:2(i-1)+h, 2(j-1)+2:2(j-1)+h/2+1)+(p_k,q_k) \\ \Rightarrow H_k(m/2+i:m/2+i+h/2-1, j:i+h/2-1):(HL) \\ W(2(i-1)+h/2:2(i-1)+h, 2(j-1)+h/2+1:2(j-1)+h+1)+(p_k,q_k) \\ \Rightarrow H_k(m/2+i:m/2+i+h/2-1, n/2+j:n/2+j+h/2-1):(HH) \end{cases} \tag{2}$$

$$(p_k,q_k) = \begin{cases} (0,0): k=1 \\ (0,-1): k=2 \\ (1,-1): k=3 \\ (1,0): k=4 \end{cases}, \begin{cases} i = 1,2,...,m/2-h/2+1 \\ j = 1,2,...,n/2-h/2+1 \\ k = 12,3,4 \end{cases} \tag{3}$$

Thus each pixel corresponding W by the number of high frequency zero element calculation to convert to H_k. On this basis, put forward based on the integral map accelerating algorithm. The idea is to integrate computing, reduce duplication of computing, accelerate the purpose in order to achieve. Algorithm steps are as follows:

Step1: Structural integral figure. Hk for wavelet decomposition coefficient matrix (m, n), the integral figure Ik (m + 1, n + 1) of any point (i, j) value refers to the upper left corner from Hk to the point of the rectangular area number, the sum of all the high frequency zero elements to Ik (i, j) is based on formula 4, Structural integral figure. In which $I(i,0)=0, i=1,2,...,m,\ I(0,j)=0,\ j=1,2,...,n.$

$$I(i,\ j) = \begin{cases} I(i-1,j)+I(i,j-1)-I(i-1,j-1)+1, H(i,j)=0 \\ I(i-1.j)+I(i,j-1)-I(i-1,j-1), H(i,j)!=0 \end{cases} \tag{4}$$

Actual calculation process, remember H_k R matrix anyon area ($x_1 : x_2, y_1 : y_2$) in high frequency zero element number for z, its calculating formula for

$$z = I(x_2+1, y_2+1) - I(x_1+1, y_2+1) \\ -I(x_2+1, y_1+1) + I(x_1+1, y_1+1) \tag{5}$$

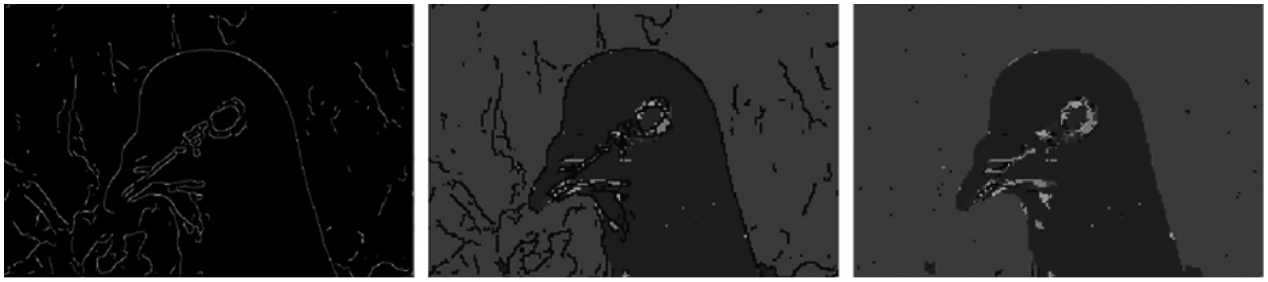
İn this formula, $x_1, x_2 = 0,1,...,m-1; y_1, y_2 = 0,1,...,n-1.$

Step2: Calculation depth values significantly. Window dimension h (pixels), the pixel points (x, y) window three high frequency subband of wavelet coefficient matrix by (2) mapped to Hk three areas A, B, C. according to type (3) can get high frequency zero element number three area a, b, c; The depth of the pixels (x, y) significant value s = a + b + c; s generation into (1) pixel depth values are obtained.

III. COMBINED WITH REGION GROWING IMAGE SEGMENTATION ALGORITHM OF EDGE DETECTION

Adaptive multi-scale wavelet analysis to get the depth of the figure boundary is fuzzy, the information need to be further optimized. Image segmentation technique is widely used in image analysis and optimization, a region growing image segmentation algorithm commonly used and edge segmentation algorithm.

Region growing is the basic ideas of qualitative similarity to the pixel, together constitute the area that is looking for a seed pixels in each division area, according to the pre-determined growth or similarity criterion, the neighborhood search within and around seed pixel, pixels with the same or similarity and merged into the seed area. This method can fine image segmentation, and the calculation is simple, reliable, but it is easy to image segmentation (on the edge or noise produced in area). The basic idea of edge segmentation is the division between image edge as regional boundaries, used in a variety of operator get the image edge, then connect the refine edge, and use the regional flood fill algorithm. The method to calculate speed, stability calculation, edge information is also very good, but its depend heavily on edge detection and the connection algorithm, the closed boundary error can lead to segmentation.



A The original image edge B Region segmentation image C final segmentation image

Figure 5. Combined with edge detection region growing image segmentation

Therefore, in this paper, combined with the region growing image segmentation algorithm of edge detection for depth map optimization, divided the edge advantages and region growing fast accurate advantage, combining the effect of the speed and balance; at the same time can effectively overcome the image segmentation problem. The specific steps are as follows:

Step1: Using the method of literature edge of original image are extracted, connecting refining after edge figure as shown in Figure 5 a.

Step2: Definition to remove edge pixels after the rest of the pixel region area to meet the conditions, use of growth criterion formula:

$$P(R_i) = \begin{cases} TRUE: \ if \mid f(p) - f(p') \mid \leq T & p, p' \in R_i \\ FALSE: else & p' \in N_G(p) \end{cases} \tag{6}$$

Region to region growing image segmentation to satisfy the condition, get the results as shown in Figure 5 b. The Ri said a start-point, $N_G(p)$ said all the adjacent pixels pixel point p, p and p' for the grey value respectively with f (p) and f (p').

Step3: The edge pixel in the picture, check its 8 neighborhood pixels, according to the rule of growth to be incorporated into the surrounding's area, as shown in Figure 5 c.

Due to regional growth area in addition to the edge, the rest of the region is more background or grayscale change little prospect, thus greatly reducing the number of segmented regions. At the same time of preventing the over-segmentation, this method also improves the calculation speed; region growing, on the other hand, fix the segmentation error, as a result of the closed boundary.

In response to the high resolution image segmentation speed real-time demand, should be combined with edge detection region growing image segmentation algorithm was improved. Inspired by the literature (Wang X. et al, 2006), in this paper, multi-scale acceleration method; Its core idea is to reduce the image on the low resolution first coarse segmentation, and then by scale up fine segmentation, and algorithm steps are as follows:

Step1: a layer of wavelet decomposition of the original image to get low frequency subband as to the reduced image segmentation; Then USES the combination of region growing image segmentation algorithm of edge detection Step1 ~ Step2 to image segmentation, A segmentation algorithm.

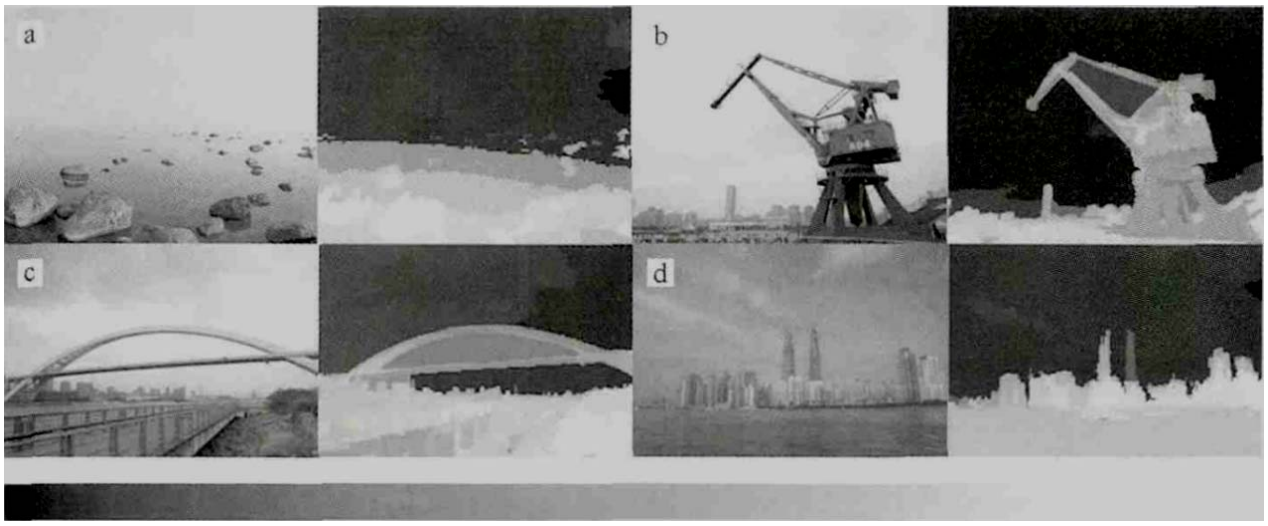
Step2: Define the edge area B for A zoom in double after growing area of complement; Then USES the combination of region growing image segmentation algorithm of edge detection Step3 will edge pixels into the surrounding area B's area for image segmentation.

Step3: The algorithm has two advantages: 1) the coarse segmentation region for the wavelet low frequency part, texture smooth, less noise, can effectively suppress the image segmentation. 2) fine segmentation region contains only edge area, at the same time will get the new segmentation region merge into the growing point the original area; So the segmentation area number remains unchanged, while greatly reduce amount of calculation also restrain the over-segmentation phenomena occur.

IV. THE EXPERIMENTAL RESULTS

In this paper, the shallow depth of field image and wide-angle image respectively, the depth of extraction experiment for 2 kinds of images to show that the algorithm is adaptive. On the depth of the article extraction algorithm on different resolution images again the operation time of statistics, to prove the effectiveness of the algorithm is accelerated.

The experimental configuration for the desktop computers (AMD Quad Core 3.9 GHz Quad CPU, 8 GB DDR1333 RAM); C + + is the programming language; Test environment for Windows 7 64 - bit operating system, compile environment for vs2010, c + + code failed to do optimization.



Far nearly
Figure 6. Wide Angle type figure image depth extraction results

The first is to extract the depth of the wide Angle type image experiment, to verify the validity of the algorithm in this paper. The input image containing the proportion is set background. As shown in figure 6 for the extraction of algorithm in this paper the depth of the figure, results show that the depth map to accord with the real scene structure. The depth of the lakeshore information in figure 6. A consistent with actual situation, and the transition, proves that the algorithm can be applied to the depth of the wide Angle type image extraction.

TABLE 1. DEPTH EXTRACTION ALGORITHM BASED ON MULTI-SCALE WAVELET CLUE IS THE AVERAGE TIME CONSUMING (MS)

The testing image size	Multi-scale wavelet analysis		Depth map optimization	Total time
	Rapid Zerocount	Depth correction		
640*480	9	<1	25	34
800*600	11	<1	34	45
1024*768	15	<1	52	67

It Can be seen from table 1, 640 * 480 sd size 34 ms, the average total time to achieve the real-time processing requirements; Under the size 1024 * 768, the average total time to rise to 67 ms, including depth map optimization module available gain 27 ms, accounting for 80% of the total increment. The main reason is the scale enlarges leads to segmentation area to flourish, and multi-scale wavelet blocks when rose only 6 ms, proved the validity of the algorithm is fast Zero count.

Experiments show that this algorithm can simultaneously meet the depth of the shallow depth of field image with wide-angle image extraction, and the depth of the layer in good consistency and relative depth of the relationship between layer accuracy is high, the light and texture has strong robustness. In addition, in this paper, the algorithm with high calculating speed, can meet the real-time processing requirements.

V. CONCLUSION

In this paper, the single image explores the general 2 d to 3 d algorithm, this paper proposes a at the same time for the depth of the shallow depth of field image and wide-angle image extraction algorithm. Experiments show that the proposed adaptive wavelet multi-scale analysis and combined with edge segmentation region growing image segmentation algorithm can obtain accurate relative depth information, and the depth of the foreground and background have been higher. The same, in this paper, the fast speed of zero count method and multi-scale method can meet the standard definition video real-time processing requirements. Although this article had some effect on the depth of wide-angle image extraction algorithm, but the structure of the input image scene in requirements, require a certain proportion the same texture background image. Therefore, the next step work will focus on providing indoor type wide-angle image depth extraction support; In addition, will also consider using CUDA parallel programming technology to further improve the computing speed depth optimization processes.

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