Marbling Stone Slab Image Segmentation Based on Election Campaign Algorithm

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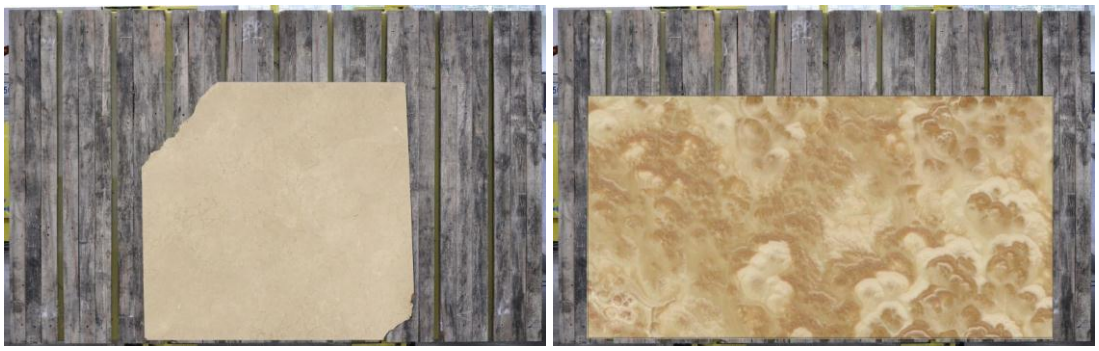
Abstract. Detecting irregularly shaped raw material is the most rudimentary problem of cutting and nesting process in natural stone production plant. The threshold segmentation and background subtraction method could achieve the segmentation of stone slab on the wooden platform in most of the cases. But when the stone slab is marbling, these methods do not work. Based on the grey scale feature analysis and Election Campaign Algorithm, optimization mathematical model is used to detect the threshold in small area. Segmentation find out the edge of each areas, connect all these edge and the edge of whole stone slab will be find. This new detection method is proposed and gets the better utilization rate method for production. The results show that the method has a good applicability to the irregularly shape, and has a high operational characteristics to achieve the object of shaping the stone slab with high precision.

Introduction

Stone slab is directly cut from the natural rock blocks. The irregular profile and various surface defects, such as the gall stone, holes, cracks and other defects are usually found on stone slabs [1]. Fig. 1 shows the stone slabs on the wooden platform, all are taken in the natural stone production plant. Because the wooden platform is not fixed invariant, background of every image taken in plant is a little different [2-6]. If every stone slab image and the background image are taken in a very short time, the background subtraction method is efficient in most of cases, such is show in Fig. 2.



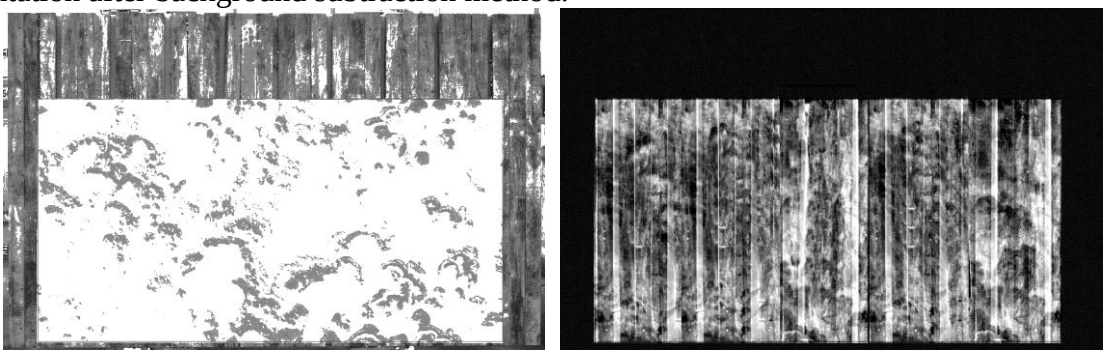
(a) (b)

Figure 1. Stone Slab on the Wooden Platform

Figure 2. Stone Slab Segmentation from the Background

In the case of Fig. 1 (b), the shape of stone slab is easy to detect by the human eyes, but the threshold segmentation and background subtraction method is hardly to get the shape correctly. In

human eyes, the stone slab has different color than the background and easy to get the shape, but actually the segmentation algorithm must be adapted to a variety of colors [7]. And then digital image has three channels, every channel is actually a grey image. So, the segmentation using color feature to get shape is still the threshold method. With the other method, the marbling on the stone slab also effect the result of segmentation. The marbling always has some area similar between the foreground and background. This area will be considered as the defects, such as holes, the next step of cutting and nesting will be incorrect and bad utilization. Fig. 3 (a) shows the result of threshold segmentation. Some background and some foreground areas are incorrectly segmented. Fig. 3 (b) shows the result of background subtraction method. The background is easy to be segmented but some areas of the marbling on the stone slab are also segmented. Because the marbling is not the same, different marbling has different segmentation result; it is hard to find assured method to continue the segmentation after background subtraction method.



(a) (b)

Figure 3. Results of Segmentation

In this paper, we use grey scale feature to detect the similarity of the areas. The author uses the election campaign algorithm to find out the grey scale feature of random position [8]. As an optimization process, the similarity of the areas could be detected and the areas could be easily segmented. This process finds out the edge of shape in the image after the background subtraction method.

Grey Scale Feature of Images

Detecting of gray scale feature is not sensitive to the deformation and rotation of the target position in the image, and has good stability [9].

Set the image grey scale level is *L (0 ~ l)*, the general *l* is 255. In order to speed up the computing and improve the real-time performance, the grey scale level is mapped to *m* level, such as *m=8*, which is divided into 8 levels. So, the grey scale level of point is calculated by the Eq. 1.

$$G(r,c) = | x*m/l | \tag{1}$$

Corresponding, assuming that the grey scale level of surrounding points at the center point *P(r,c)*, the objective function can be expressed as *S(r,c)*, the sum of levels of points. As is show in Eq. 2.

$$S(r,c) = \underset{i=1,2,\cdots,n}{sum}(| x_i*m/l |) \tag{2}$$

So, the target localization problem in the process of comparing is transformed into the problem of the candidate target region which is the minimum value. When *P(r,c)=S(r,c)-I(r,c)* is close to 0, said the target and candidate regions are more similar; when *P(r,c)>R*, *R* is the evaluation criterion and in this paper we set *R*=n/2, n is the number of comparing points, said the target and candidate region are dissimilar.

Fig. 4 shows the model of target and candidate regions, point (1, 2, 3, 4, 6, 7, 8, 9) is the points surrounding point 5, all together the sum of 9 points gray scale level, such as Eq. 3, is used as the evaluation criterion of the center point.

$$S(r,c) = \underset{i=1,2,\cdots,9}{sum}(| x_i*m/l |) \tag{3}$$

1	2	3
4	5	6
7	8	9

Figure 4. Surrounding Points of Point 5

Election Campaign Algorithm

Election campaign algorithm (ECA) is an optimization algorithm simulating election process [10]. Election candidates influence the voters round them, the voter's support is in proportion to the distance between the candidates and the voters. The voter will vote to the candidate which he pefer the most. The sum of location coordinates of every voters supported the candidate powered by its contribution is a new location coordinates, which is named support focus, it is the next position of the candidate. Such computational cycle is done continually until the function finds the position of the highest support, which is the global solution of the optimization problems.

Set the Algorithm Parameters. Main parameters of Election campaign algorithm are:

- The number of candidates.
- The number of voters.
- The number of floating voters.
- Target accuracy.

Generate the Candidates and Calculate the Prestige of Them. Generated the define number of candidates in feasible solution field on the uniform distribution. Use the objective function to calculate the prestige of each candidate.

Generate the Voters. The uniform distribution is employed to generate the voters in feasible solution field.

Compute the Investigate Mean Square of Candidates. Higher prestige of a candidate, smaller the mean square deviation of local voters, so that ECA is able to converge to local optimization solution rapidly and steadily.

Calculate the Supported of the Voters. The support of a voter is proportional to his prestige, and then the proportional constant will be reduced, so the prestige of a voter can used to denote the support of a voter directly. A voter may be influenced by several candidates; the voter should distribute his support to candidates proportionally on the magnitude of effect from candidate to voter.

Find the Support Focus of Candidates. A new position coordinate will achieve by means of summing the products of the support from the voters to the candidate and the position coordinate of the voters. It is named the support focus.

$$x_{C_i}^{*} = \frac{\sum_{j=1}^{n} S_{C_i V_j} x_{V_j}}{\sum_{j=1}^{n} \max(S_{C_i V_1}, S_{C_i V_2}, \cdots, S_{C_i V_j}, \cdots S_{C_i V_n})} \tag{4}$$

$x_{C_i}^{*}$ is the support focus of the candidate C_i. The support focus of a candidate is obtained by investigating, which depends on those voters whose distances to the candidate are nearer and the prestige is higher relatively. The next post of the candidate should be the support focus, where the candidate will have the higher support.

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Calculate the Prestige of the Candidates and Compare the Prestige of the Voters with the Candidates. In order to jump out of local optimization solution and increase search rate, the prestige of candidates are compared to that of voters, if the prestige of a voter is higher than that of a candidate,

the voter with higher prestige will substitute for the candidate and the that candidate of lower prestige will be eliminated in election.

Check Whether the Condition Is Reach. Check whether the condition is reach, otherwise return to start step to execute the period. Here, the condition could be the relative position relation in target image. Do that circularly until the highest support is not change.

$$\begin{cases} |\underset{i=1,2,\cdots,n}{sum} S_c(r_i^r, c_i^r)| > |\underset{i=1,2,\cdots,n}{sum} S_x(r_i, c_i)| \\ |\underset{i=1,2,\cdots,n}{sum} S_c(r_i^r, c_i^r)| \leq |\underset{i=1,2,\cdots,n}{sum} S_x(r_i, c_i)| \end{cases} \tag{5}$$

S_c represents the position of random point in the effect range; S_x represents the position of focus center. The threshold is find when the points are Feature points of template $P_r(r_i,c_i)$ and points of target image region $P(r_i,c_i)$ have the same relative position relation. As is show in Eq. (5), two types of image region are defined. When the focus point does not change, the highest support is not change, and the computation stop. When ECA stop, the edge point of stone slab is found.

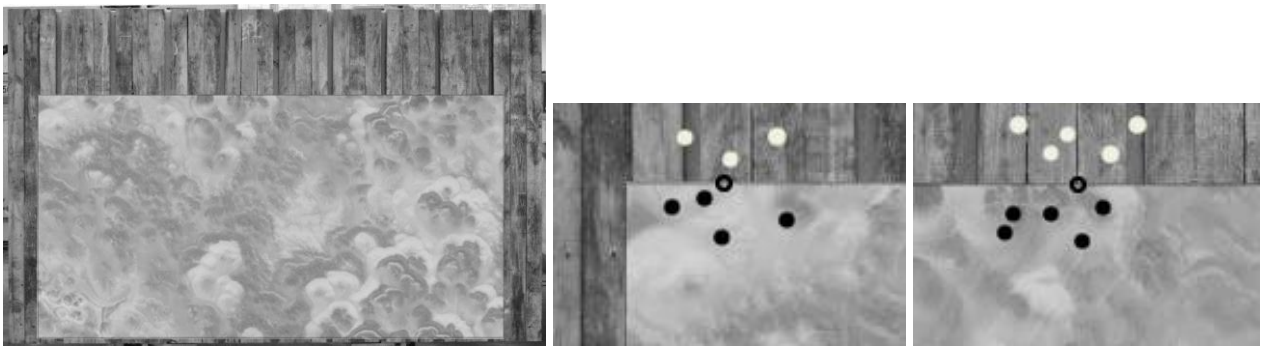

Figure 4. Image Set for Comparing

In image set of Fig. 4, the first image is the grey scale image, others are the focus point locations.

Using Election campaign algorithm, the number of candidates define as 5, the number of voters is 10, the number of floating voters is 5, and the target accuracy is set as 2.5. When all the edge points are found, the border of stone slab is found.

Figure 5. Stone Slab Segmentation from the Background

Conclusions

With the method of comparing the gray scale feature levels, the dissimilar two types of segmentation area can be detected. Election campaign algorithm optimization program detect the focus point of the gray scale image, which is the border of the stone slab. Election campaign algorithm has the advantages of parallel computing and good performance to avoid the solution trapped in local optima. This is suitable method to find the border of two types of numerical value. For future work, another feature and different comparing function will be used in the detecting of focus points of features.

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