Quick image stitching algorithm based on template matching for Mask defect detection

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Abstract. With the computer technology and image processing technology gradually applied to the mask detection system, computer vision detection method has become the mainstream way of automatic mask inspection. Masking is usually a large area, and in order to ensure detection accuracy, the camera's field of view is small, and the panorama stitching of mask images has become an essential image processing link in defect detection. In the mask image acquisition system, the precision workbench is in the working mode of horizontal vertical translation, and the adjacent two images have horizontal and vertical offsets. In view of the characteristics of big data volume of mask image, cell repetition, small variation of rotation scale, this paper proposes a fast multi-mask image stitching algorithm based on template matching. The template matching algorithm is optimized, compared with the traditional image stitching algorithm, which greatly improves the stitching speed, avoids the problem of feature matching repeated graphics mismatch, and the stitching effect is good.

1. Introduction
Mask image stitching refers to the process of stitching together multiple overlapping masked area images of a scene into a panoramic image [1]. Due to the limitations of image acquisition equipment, it is impossible to obtain a panoramic image of a scene [2], in order to get a complete view of the same scene, people try a lot of different methods, people consider using image stitching method, the captured image, the appropriate matching algorithm, Seamless stitching of multiple images with software to produce high-definition images with full viewing angles [3].

Figure 1. Mask defect schematic
Improving the calculation speed has become an important research content of late researchers. Later researchers Bergen and Irani, Shmuel Peleg, etc. have improved the speed of the panoramic image stitching model, and further promoted the development of panoramic image stitching technology by proposing adaptive image stitching models [4,5]. Image stitching algorithm based on feature point matching is popular in the study of image stitching algorithm [6]. Because feature-based image stitching algorithm has a series of advantages, there are many international studies of algorithms for such features.

However, because of the large amount of mathematical calculation of the algorithm, which is also inherent in the algorithm itself, it affects the overall speed of the algorithm. Image stitching technology has made great progress after a long time, but image stitching technology still has some difficulties and shortcomings, image stitching technology is mainly due to the following factors: 1) image stitching technology of various methods, usually have certain restrictions and specific application scenarios. 2) How to ensure that the fusion method adopted can make the fusion image eliminate the difference between the two original images, and it is also a worthy of strengthening the problem in the field of image stitching algorithm. 3) The issue of the extraction and efficiency of matching information.

2. Method

2.1. Math

Template matching is one of the important parts of digital image processing. Simply put, a template is a small known image [7]. Template matching is the search for a target in a large image, which is known to have the target to be sought, and the target has the same dimensions, directions, and images as the template, and can be found in the graph by a certain algorithm to determine its coordinate situ position [8].

\[ R(x, y) = \left( \frac{\sum_{x',y'} T(x', y') \cdot I'(x + x', y + y')} {\sqrt{\sum_{x',y'} T(x', y')^2} \cdot \sum_{x',y'} I'(x + x', y + y')^2} \right) \]

In the formula

\[ T'(x', y') = T(x', y') - 1/(w \cdot h) \cdot \sum_{x'',y''} T(x'', y'') \]

\[ I'(x + x', y + y') = I(x + x', y + y') - 1/(w \cdot h) \cdot \sum_{x'',y''} I(x + x'', y + y'') \]

As we can see from above, as we go from simple measurements (square differences) to complex measurements (correlation coefficients), we get more and more accurate matches, which of course come at an increasing cost. So in practical applications, these matching algorithms should be tested, and then choose the best solution that takes into account both speed and precision.

2.2. Optimization

In mask defect scenarios, we need to process a lot of image data, and there are many similar graphics in different images, as shown. SURF/SIFT feature point detection method requires large area of image overlap, slow processing speed, and easy mismatch of mask unit.

We propose optimization based on the basis of the original template match.
1) Rough fit matching combination Looking at the results of the actual template matching operation, we can find that the matching error near the match point drops rapidly, which is obviously different from other locations. In view of this feature, the algorithm of crude matching combination can quickly lock the approximate area of the match point, which can greatly reduce the number of overall matches.

2) Limit maximum matching error. Because only the location of the minimum matching error needs to be found, it is not necessary to fully calculate the absolute matching error for each position, but to use the calculated minimum matching error as the maximum allowable error.

![Template match diagram](image)

**Figure 2.** Template match diagram

2.3. Image stitching algorithm process
Dozens of images stitched apart from two or four images, and as the number of stitched images increases, one is that the amount of data to be processed increases, which can lead to data overflow. Second, the corresponding characteristic relationship is more difficult to determine, easy to appear by mistake match. Third, stitching takes longer and longer. In this paper, in order to avoid the above problems, we propose an algorithm that can be used for masking multi-image stitching, according to the distance preset image overlap area as the ROI area, determine the correspondence of the front and back two images in order to stitch together the two images, this image as the original image, the latter image as the image to be matched, re-demarcated the ROI area, Each stitching only transforms the ROI region and the next image of the fixed amount of data, avoiding a series of problems caused by the increase in the number of images.
Figure 3. Image stitching algorithm flowchart

3. Experiment

3.1. Experimental platform:
In the camera and lens selection, this paper selects the face array CCD camera, the camera resolution of 2048 x 1536, the mask image by 10 times the scale of the objective, the workbench scanning mode to choose the laboratory's existing arch glyph scanning device, horizontal step distance of 500 pixels, vertical step distance of 400 pixels. The defect template is drawn by Klayout and is finished with a 4-inch mask and a minimum line width of 2um. The software platform is a mixed compilation environment for VS+OpenCV.

3.2. Results:

Figure 4. Part of the original image

Figure 5. Stitched image
As can be seen from the figure, the stitching effect is good, no obvious distortion deformation, no obvious stitching seam, the image effect can be followed by the two-value step, and then through the split comparison to detect the defect location. When the image to be processed is more than 15, the optimized image stitching algorithm is more than 5 times faster than the pre-optimization processing speed, and the feature point algorithm is more than 20 times faster.

4. Conclusion
The image stitching algorithm proposed in this paper can realize the stitching of mask images well, the experimental verification stitching effect is good, this method solves the problem of mismatch and slow stitching speed in mask image stitching, and can also be applied in other multi-repeating graphics printing defect detection.

References
[1] Luo Jingjing, Han Baoan. Image matching based multi ship image mosaic method [J]. Ship science and technology, 2019,41 (16): 61-63.
[2] Cheng Xixi, Zhang Yanling, Tian Junwei. A new fast corner detection method based on template matching [J / OL]. Computer Engineering: 1-6 [2019-10-22]. Http://kns.cnki.net/kcms/detail/31.1289.tp.20190719.1724.010.html.
[3] Zhang Jinrong, Chen xunlin, Luo Yanqi, Zhang Panfeng. Fast template matching of integrated circuit online detection based on bicubic interpolation algorithm [J]. Science and technology and engineering, 2019,19 (19): 185-189.
[4] Sheng Mingwei, Tang Songqi, Wan Lei, Qin Hongde. Overview of 2D image mosaic technology [J]. Navigation and control, 2019,18 (01): 27-34 + 96.
[5] Yang Fan. Research on real-time image acquisition and splicing technology of industrial online visual inspection system [D]. China University of science and technology, 2018.
[6] Gong miaolian. Research on image registration and splicing technology based on feature points [D]. Beijing University of Posts and telecommunications, 2018.
[7] Jia Di, Yang Ninghua, sun Jingguang. Template selection and matching of image pair matching [J]. Chinese Journal of image graphics, 2017,22 (11): 1512-1520.
[8] Wang Juan, Shi Jun, Wu Xianxiang. Overview of image mosaic technology [J]. Computer application research, 2008 (07): 1940-1943 + 1947.