The Fourteenth International Symposium on Artificial Life and Robotics 2009 (AROB 14th '09),
B-Con Plaza, Beppu, Oita, Japan, February 5 - 7, 2009

Crack detection method using rotational morphology

M. Yoshioka
Osaka Pref. Univ.
Sakai, Osaka 599-8531

S. Omatu
Osaka Pref. Univ.
Sakai, Osaka 599-8531

Abstract

Recently, in the factory, it becomes very important to detect cracks on products automatically. In order to achieve this purpose, auto crack detection systems using photo images from digital camera have been proposed. However, in conventional methods using detected edge lines extracted by such as Sobel filter, it is di cult to distinguish between the original lines on the product surface and those of cracks in the case of noisy images. In order to overcome this di culties, we have proposed the new method using rotational morphology. The rotational morphology is a kind of mathematical morpholgy with structuring element rotation. Finally, some simulations are carried out for confirming the effectiveness of our proposed method.

1 Introduction

In these latter years, in the factory, it becomes very important to detect cracks on products automatically, because cracks on products reduce the lifetime of them and it costs much time to detect small cracks by human check. In order to achieve this purpose, auto crack detection systems using photo images from digital camera have been proposed. However, in conventional methods using detected edge lines extracted by such as Sobel filter, it is di cult to distinguish between the lines from the product surface texture and those from cracks in the case of noisy images(Fig.1,5,7). For example, Fig.1 is the sample image which has the noisy surface texture, and Figs.2 and 3 are the results of vertical and horizontal Sobel filter from it. Figs.2 and 3 are filtered with different threshold values th. In this case, it is di cult to find cracks by using Sobel filter and its threshold value optimization because the intensities of image in crack and product texture are almost same. In order to overcome this di culties, we have proposed the new method using rotational morphology. The rotational morphology is a kind of mathematical morpholgy with the rotated structuring element. Finally, some simulations are carried out for confirming the effectiveness of our proposed method.

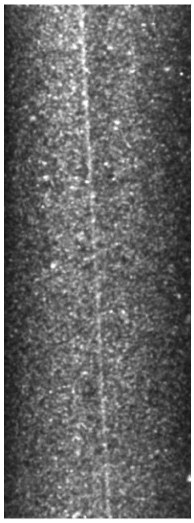

Figure 1: Sample image 1.

2 Proposed method

In order to improve the crack detection in noisy images, we have proposed the new crack detection method using rotational morphology. At first, we introduce rotational morphology briefly and mention about our proposed method.

2.1 Rotational morphology

Mathematical morphology [1] is one of the well known methods for image processing. It has many operators which are dilation, erosion and etc. Particularly in edge detection from noisy images, mathematical morphology is used with the top-hat operator. Rotational morphology [2] is the expansion of the mathematical morphology with rotated structuring elements. By using rotated structuring elements, it fits not only one direction but also the other directions.

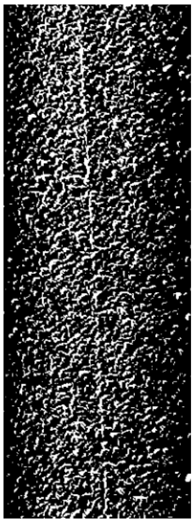

Figure 2: Filtered image 1 (th=10).

Figure 3: Filtered image 1 (th=20).

2.2 Flexible structuring element

In conventional mathematical morphology, structuring elements need to be selected along the target edges for detection. However, it is di cult to select suitable one because there are many kinds of cracks in length, width and depth. In order to resolve this point, we have proposed the flexible structuring element instead of conventional one (Fig.4), where L, K and D in Fig.4 are parameters for determining the size of the structuring element. By using this as a structuring element and fitting it to intensity surface, the fitting error is able to be used for the criterion whether there is crack. The fitting error is defined as following equations:

$$E = \sum_{x,y \in A_1} (D - I(x,y) - \alpha)^2 + \sum_{x,y \in A_2} (I(x,y) + \alpha)^2 \quad (1)$$

where the area A_1 and A_2 indicate the top and bottom surface of the structuring element, and E and $I(x,y)$ indicate the fitting error and the intensity of images at position (x,y). The α is the optimized parameter which minimizes the fitting error E.

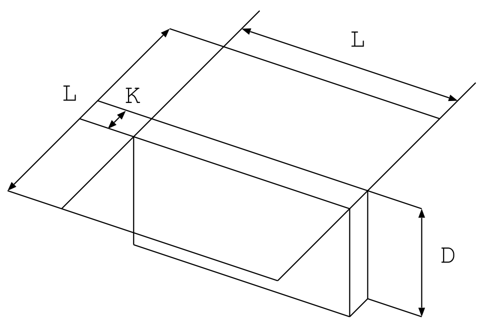

Figure 4: Structuring element.

3 Simulations

In order to confirm the effectiveness our proposed method, simulations for crack detection are performed using Figs. 1,5 and 7. Results of simulations are shown in Figs.8-13. Parameters determining the structuring element size and used for simulations are indicated in the figure captions, and θ and th are the rotation angle of the structuring element and threshold value of cracks respectively. As the results of simulations, cracks are clearly detected from noisy images, and the effectiveness of our proposed method is confirmed.

4 Conclusions

In order to develop the crack detection method in noisy images, we have just proposed the new method using the rotational morphology. As the result of simulations, the effectiveness of our proposed method is confirmed. As the future work, we need to develop automatic parameter optimization and reduce computation time.

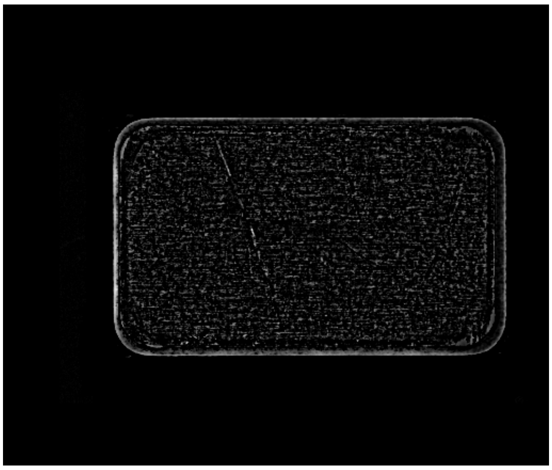

Figure 5: Sample image 2.

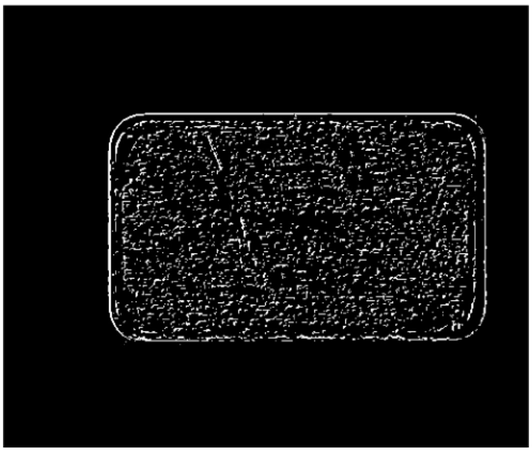

Figure 6: Filtered image 2(th=20).

References

[1] Jean Serra, *Mathematical Morphology volume II*, Academic press, London, 1988.

[2] K. Yoshitaka, O. Yosuke, I. Norihiko, B. Norio and K. Eisaku, "A procedure to analyze surface profiles of the protein molecules visualized by quick-freeze deep-etch replica electron microscopy", *Ultramicroscopy*, Vol. 107, No. 1, pp 25-39, 2007.

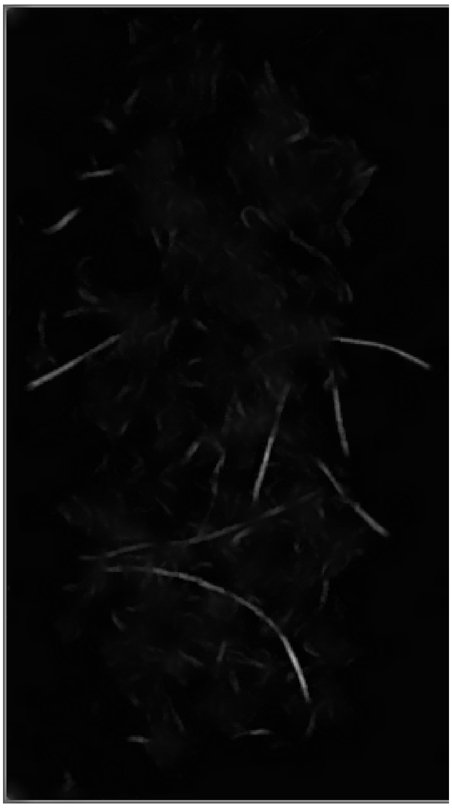

Figure 7: Sample image 3.

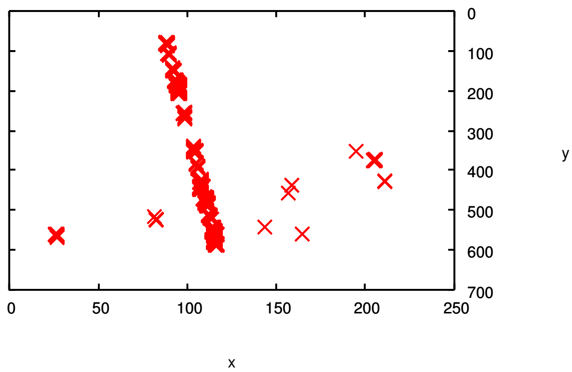

Figure 8: Detected crack in Image 1 ($\theta = 85, L = 20, K = 4, D = 100, th < 500000$).

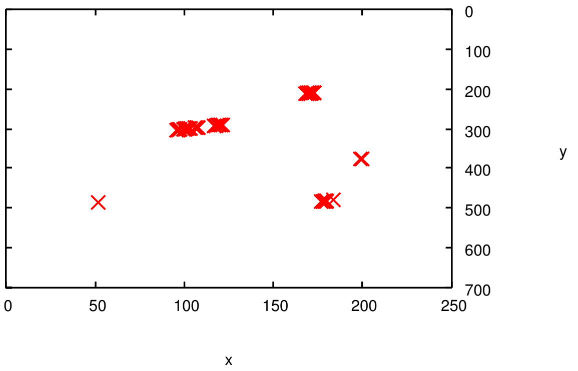

Figure 9: Detected crack in Image 1 ($\theta = -30, L = 20, K = 4, D = 100, th < 500000$).

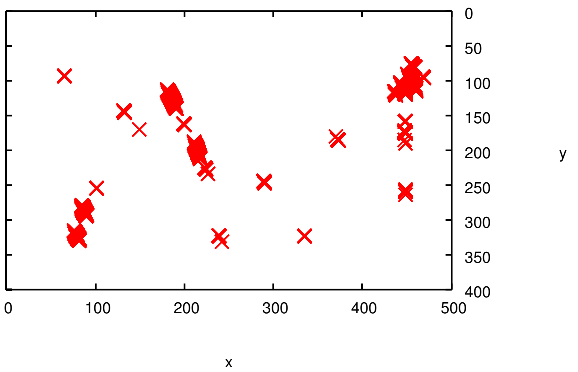

Figure 10: Detected crack in Image 2 ($\theta = 70, L = 20, K = 3, D = 200, th < 1800000$).

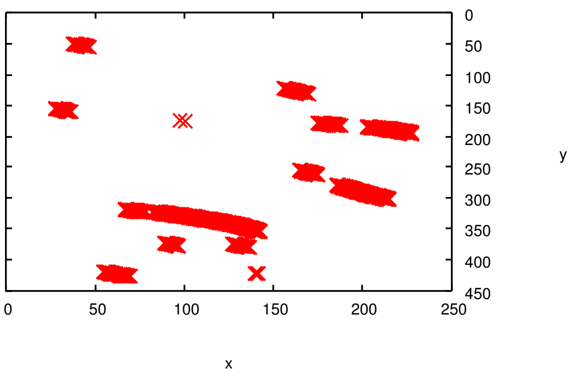

Figure 11: Detected crack in Image 3 ($\theta = 30, L = 20, K = 4, D = 100, th < 550000$).

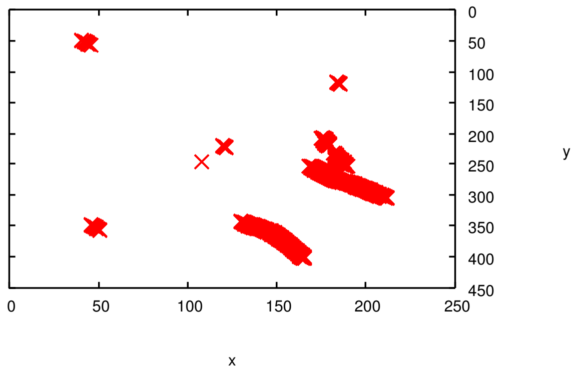

Figure 12: Detected crack in Image 3 ($\theta = 60, L = 20, K = 4, D = 100, th < 550000$).

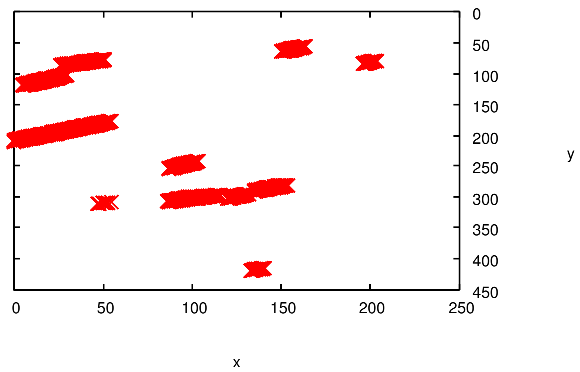

Figure 13: Detected crack in Image 3 ($\theta = -30, L = 20, K = 4, D = 100, th < 550000$).