A High Sensitivity Shape Measurement Method of Minute Object by Using Laser Projection and Microscope

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1 Introduction

Recently, 3-D shape measurement of minute objects is becoming increasingly important. And with the development of technology, there are some 3-D measurement methods by using microscope was proposed, the widely used method was called Shape-from-Focus. However, the method is insensitive in the depth direction. In order to meet the demand of high precision measurement, we introduced 3-D image measurement technique based on laser pattern projection [1] into microscope system.

2 Measurement System

The measurement system we proposed consists of a conventional optical microscope equipped with camera, a semiconductor line laser projector and a computer. Fig.1 shows the schematic diagram of measurement system. In the

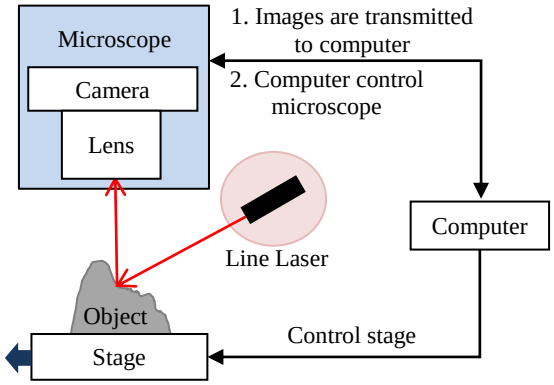
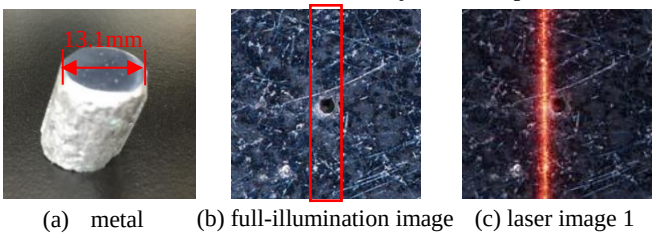


Fig.1 The schematic of the measurement system

system, firstly, we capture the full-illumination image of object. Then, scanning the object by using the line laser. Next, calculate the moving distance between full-illumination image and laser images, and combine the laser scanning result into one image by using moving distance. Then, calculate the 3-D information of the surface. Finally, obtain the 3-D shape measurement results.

3 Experiment

To test the measurement sensitivity in the depth direction of the proposed method, we aimed to measure the shape information of the hole. Fig.2 shows the original measurement images. And (a) is the measurement object, (b) is the enlarged image of the part of the metal surface, and it is also the full-illumination image. And the red area (width is 70 microns) is the measurement area. In this experiment, each movement distance of stage is 2 microns, and a total of 70 laser pattern images were taken, from (c) to (f) shows a part of 70-sheet laser pattern images.

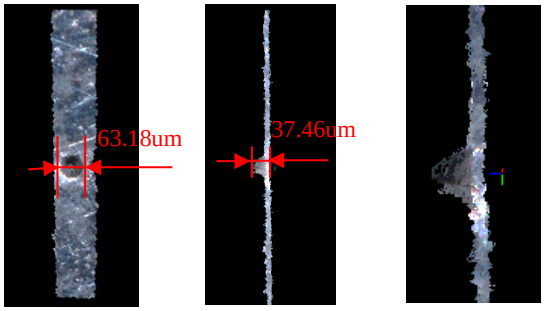


(a) metal (b) full-illumination image (c) laser image 1

(d) laser image 2 (e) laser image 3 (f) laser image 4

Fig. 2 Original measurement images

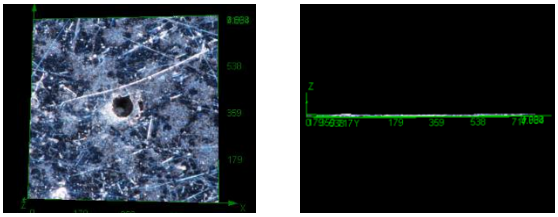
Fig.3 shows the measurement results of the proposed method, (c) is the enlarged image of (b). From the results we



(a)front view (b)right view (c)magnification of (b)

Fig. 3 The 3-D view of experiment results

can obtain the 3-D coordinate of each point. For example, (a) and (b) shows the diameter and the depth of the hole. Fig.4 shows the result of Shape-from-Focus method. We can see



(a)front view (b)depth of right view

Fig. 4 The 3-D view of Shape-from-Focus method

that it hasn't been able to measure the shape of the hole, and it measured the hole into a plane. Therefore, the proposed method is higher than the Shape-from-Focus method of measurement sensitivity in the depth direction.

4 Conclusion

In this study, in order to overcome the limitation of the Shape-from-Focus method, we developed a 3-D shape measurement system by using a line laser projector and microscope. We have verified that the proposed method can realize a higher sensitivity shape measurement in the depth direction than the Shape-from-Focus method by the experiments of the small hole of a metal surface.

References

[1] Xueli Zhang, Kazuhiro Tsujino, Cunwei Lu: "A high-sensitivity 3D shape measurement method using a microscope", Artificial Life and Robotics, Volume 17, Issue 3-4, pp.336-341, 2013.