유리패널검사를 위한 고속 고해상도 이미지 생성 기술

A novel fast super-resolution image construction technique for glass panel inspection

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1. Introduction

The level of repeatability of a critical dimension (CD) measurement, which is the measurement of the distance between two edges of a sample image, affects the quality and performance of a glass panel, so CD measurements should have an accuracy of the order of nanometers[1]. High magnification microscope objectives can be used for CD measurements. However, the higher the magnification of the microscope objective, the smaller its working distance; therefore, it can cause scratches on the glass panel. In addition, the higher the magnification of the microscope objective, the smaller its aperture, thus, requiring a longer exposure time which can reduce measurement quality because of the noise on the captured image. Therefore, using a low magnification microscope objective is required to measure a small distance of a very large glass panel with high-level repeatability in a short time. To improve the performance of a low magnification microscope objective, a sub-stepping[2] system, as shown in Fig. 1, is used to increase the current image resolution.

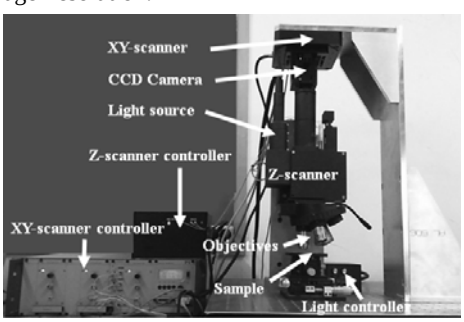

Fig. 1 Sub-stepping system configuration

Low resolution (LR) images are obtained when the camera is moved in steps smaller than a normal pixel. An XY piezo scanner is used to for precise movement of the camera, so that the LR images can be interlaced to generate the desired high resolution (HR) image. A new scanning path is proposed in this paper to reduce the number of LR images. A fast interpolation algorithm based on the local pixel gradient is used to construct an HR image. Then, the CD measurement method[1] is applied to the HR image.

2. A new camera scanning path for the fast image enhancement

In this research, the camera is moved in nine steps in two directions (about 1/3 camera pixel size per step), as shown in figure 2(a). The LR images can be interlaced to generate the desired HR image, as shown in figure 2(b). However, the more number of sub-step images used, the longer the required capture time. In fact, the capture time is about 50% of the whole processing time. Therefore, a new scanning path, as shown in Fig. 2(c), is proposed to take fewer LR images than those taken by using the normal moving path. The pixels at positions that are indicated by symbols in Fig. 2(d) are unknown. These pixels are calculated by using an interpolation-based algorithm3. Neighboring pixels contributes to the interpolated pixel in a way which is based on the local gradient. The smaller the local gradient of a neighboring pixel, the more influence it has on the interpolated pixel. The following equations are used.

$$f(i,j)=\frac{\sum_{k=0}^{4} I(x_k,y_k)\times W(x_k,y_k)}{\sum_{k=0}^{4} W(x_k,y_k)} \quad (1)$$

$$W(x_k,y_k)=\frac{1}{d_k}\times inv\,G(x_k,y_k)^m \quad (2)$$

where $I(x_k,y_k)$ (k=0~4) is the gray value of the neighboring pixel; d_k is distance from the considered unknown pixels to its neighbor; m is a positive integer.

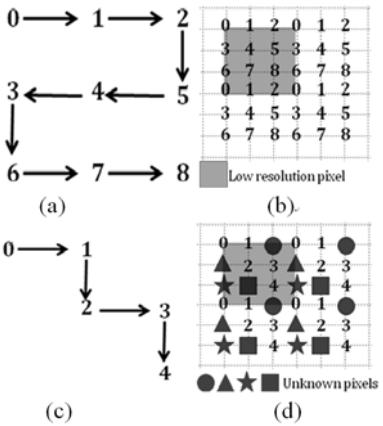

Fig. 2 The camera scanning path and position of the interlaced images: (a) (b) For the normal path; (c)(d) For new path

3. Result and discussion

Fig 3(a) and (b) show LR image and the HR image result of the proposed method. The constructed HR image includes more edge information, less blurring and aliasing effect.

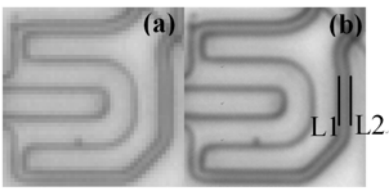

Fig. 3 Comparison result: (a) LR image, (b) Resulted image after applying 5(-) step interpolation

Fig. 4 shows the comparison of the CD measurements (between L1 and L2 as shown in Fig. 3) for the image of microscope objective 10x with image resizing, the HR image after applying sub-stepping with the normal and new scanning paths, and the image of higher magnification microscope objectives 20x and 50x. As shown, the repeatability of CD measurements is improved remarkably after using the proposed method. The result is even better than the result obtained with the high magnification microscope objectives.

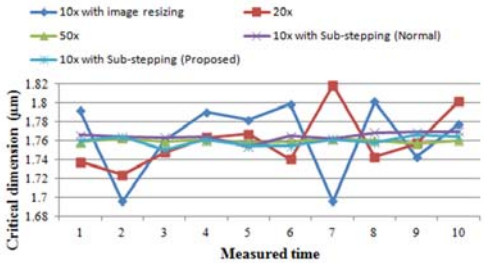

Fig. 4 CD measurement comparison results

4. Conclusions

A fast SR image construction technique for glass panel inspection was developed in this paper. Our experimental results proved that the proposed path can replace the usual 9-step path with faster processing time and acceptable repeatability.

Acknowlegement

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