LCD MURA DETECTION WITH MULTI-IMAGE ACCUMULATION AND MULTI-RESOLUTION BACKGROUND SUBTRACTION

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ABSTRACT. We integrated the techniques of multi-image accumulation and multi-resolution background subtraction to detect mura defects in low-contrast and high-noised TFT-LCD images. First, several images of an LCD on a moving product conveyer are contiguously captured and then a synthesized LCD image is used to calibrate the non-uniform illumination of these images. Second, the images are aligned in position to accumulate the gray levels of the pixels which all correspond to a point on the LCD. The multi-image accumulation process enhances the contrast between the mura defects and the background; moreover, visible mura problems due to the view angle and the uneven illumination are also mostly resolved. Third, the multi-resolution backgrounds of the accumulated image are progressively estimated based on the discrete wavelet transform (DWT) and the defect candidates are extracted coarse-to-fine and accumulated by subtracting the background from the accumulated image. The multi-resolution background subtraction strategy speeds the detection process and solves the problem of different sizes of mura defects without reducing the detection rate. Finally, a standard thresholding method is used to “threshold out” the mura defects. The stability and effect of the proposed method are demonstrated in experiments.

Keywords: Automatic optical inspection, Mura detection, Multi-image accumulation, Multi-resolution background subtraction, TFT-LCD

1. Introduction. Currently, thin film transistor liquid crystal displays (TFT-LCDs) are the most popular flat panel display devices. A critical task for TFT-LCD manufacturers is to control their visual quality, that is, to quickly inspect the TFT-LCD for outward appearance and mura defects. The outward appearance defects are generally made from the existence of foreign bodies in flat panel units, non-uniform color filters, non-uniform gap in glass bases, ill-functioning polarizers, or poorly backlit units [1,2]. These kinds of defects generally appear microscopically, but can still be detected successfully [3-7]. In contrast, macro-scope mura defects are difficult to perceive with the human eye, due to their properties of low contrast and non-uniform brightness as shown in Figure 1. Moreover, non-uniform illumination makes the mura harder to detect and some mura defects can only be detected at a special angle, also shown in Figure 1.

There are many types of mura defects: lines, black spots, white spots, black regions, white regions, and rings [8]. Many methods have been proposed to detect mura defects, which can be categorized into three classes: spatial-domain [8-22], frequency-domain [23,24], and feature-based [25] methods. The spatial-domain methods directly process image pixels to detect mura defects. Those methods can be categorized into three sub-classes: thresholding, template matching, and background estimation. In the thresholding sub-class, Chen and Chiang [9] proposed a threshold method to detect mura defects; the method is very fast but is not accurate for non-uniform backgrounds. Nakano and Mori