MURA DEFECT DETECTION IN LCD

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ABSTRACT

With the increase in the usage of LCD's. FPD (flat panel display) are becoming widely acceptable and popular as display devices growing at a rapid pace and making it a promising investment opportunity. In this paper, we propose a machine vision approach for automatic inspection of Mura defects. The proposed method is based on wavelet based multiresolution structure and an efficient image restoration method for inspection of local defects present in LCD surfaces. The proposed method consist of selecting the low frequency and band frequency components or the combination of band frequencies at different resolution levels and giving weights to each band to enhance the threshold level for defect extraction.

Keywords: LCD, Mura Defect.

INTRODUCTION

Recently, TFT-LCD (thin film transistor liquid crystal display) devices have become a major innovative technology for FPD. FPD are found in a variety of military, industry and consumer applications, ranging from laptop computer to automobile and cockpit readout devices. Due to its high demand in market, the quality of the display becomes a more critical issue for manufacturers so Flat panels Display have become increasingly important in recent years due to their full color display capabilities, low power consumption and light weight. In order to ensure the display quality and improve the yield of FPD panels, the inspection of defects in FPD panels becomes a tedious task in manufacturing. Human visual inspection which is still used by the most manufacturers has a number of drawbacks including the limitations of human sensibility, inconsistent detection due to human subjectivity and high cost. However, manual inspection is a time consuming and tiresome assignment. It highly dependent on the experience of human inspectors. Automatic inspection using machine vision techniques can overcome many of these disadvantages and offer manufacturers an opportunity to significantly improve the quality and reduce cost. One class of defects includes Mura (The Japanese word for blemish) has been widely adopted by the display industry to describe almost all capricious stain variation defects in FPD. Mura defects are defined as areas of illumination (pixels on the substrate) which are different, or anomalous, from the neighborhood surrounding the defect, also termed Patterned Brightness Non-Uniformity (BNU). Mura defects are caused by process faults usually related to cell assembly, which affects the transmission of light through display. Any liquid crystal display having such problems of voids or gravity Mura is regarded as defect. Mura defects are caused by process flaws usually related to cell assembly, which affect the transmission of light through the display. The cyclical nature, randomness, and often, low contrast of Mura makes accuracy detection and classification extremely difficult for LCD. They are caused by a variety of physical

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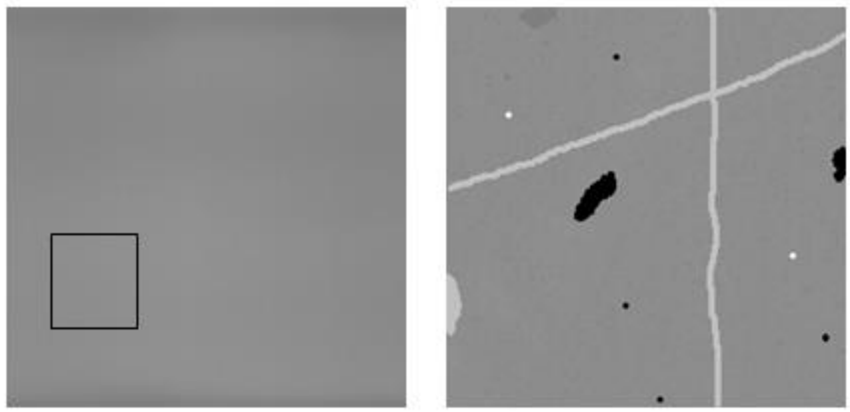
factor such as non-uniformly distributed liquid crystal material and foreign particles within the liquid crystal. Depending on the shapes and sizes, Mura defects may be classified into spot, line and Area Mura which are shown in Figure 1. As compared to spot and line Mura, area Mura is relatively difficult to identify due to its low contrast and no particular pattern of shape. In this paper we thus present the technique focused on all type of Mura by describing an automatic inspection method that reliably detects and quantifies FPD Mura defects by taking original image.



(a) Original image **(b) Mura defect**

Figure 1
ORIGINAL IMAGE AND MURA DEFECT

Many different technique of feature extraction using Fourier transform Liu & Jernigan (1990), Gabor Transform Daugman (1985), Singular value decomposition, some regression based diagnosing and threshold Niblack (1986), Jae & Suk (2004) were successfully applied. Fourier based method use the frequency spectra but not consider the information present in the spatial domain. Gabor filters Daugman (1985), have been well acknowledged as a joint spatial/spatial-frequency representation for analyzing images that contain highly specific frequency and orientation characteristics. Gabor filtering methods are very computational expensive as the mask moves like a sliding window on the entire image. The SVD technique is only efficient in pattern detection. In the recent past, wavelet transforms have been a popular alternative for the extraction of textural features. The 2D wavelet transform was defined by Lemarie & Meyer (1986), and the use of wavelets for texture analysis was pioneered by Mallat (1989). In this paper we propose a multiresolution based synthesis and analysis wavelet transform for inspecting the MURA defect incorporated in LCD panels. We have used different algorithms for small region Mura and belt or line defects. For small region Mura, after one level of wavelet decomposition we are left with one smooth subimage which is coarse approximation of the original image containing the low frequency component and three detail subimages which contain fine structures in horizontal, vertical and diagonal orientations having the information about the high frequency component of the image. With proper selection of a smooth subimage or the combination of detail subimages at different multiresolution levels for image reconstruction and giving proper weights to the band of frequency the local MURA defect can be effectively recognized. A simple binary thresholding is therefore used to separate the defective

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regions from the uniform gray-level background in the restored image and for the line or belt defect Mura we accumulate it along row or column and after applying one dimensional wavelet decomposition and reconstruction after selecting the band frequency components i.e. giving different weights to different bands then differencing give the defected area of the MURA.

The efficacy of the wavelet reconstruction scheme depends on the number of resolution levels and the decomposition selected for reconstruction. In this study, we develop a wavelet band selection procedure that can automatically determine the number of resolution levels and decomposed for the best discrimination of patterns in the image. This eliminates human intervention for the choice of best reconstruction parameters and has given better result in comparison to other algorithm for defect detection.

Defect Detection Using Wavelet Transform

Image Features

The Mura defect presence being random in nature have low contrast variation incorporated with high frequency noise content can be seen in Figure1, we have divided the Mura defects in three categories based on their pattern and have applied separate method for quantifying the defects present.

The categorization is

1. Small region Mura.
2. Line or belt type Mura.
3. Non uniform region Mura.

Small region Mura consists of defect like Stain, Scratch, Point, Sc and Particle defect. These are small in area and are due to band frequency. Line type Mura occurs in straight line or in form of belt can be horizontal or vertical in nature and the last Non uniform region Mura are Protrusion, Leak light, Pour radiation and others in Figure 2.

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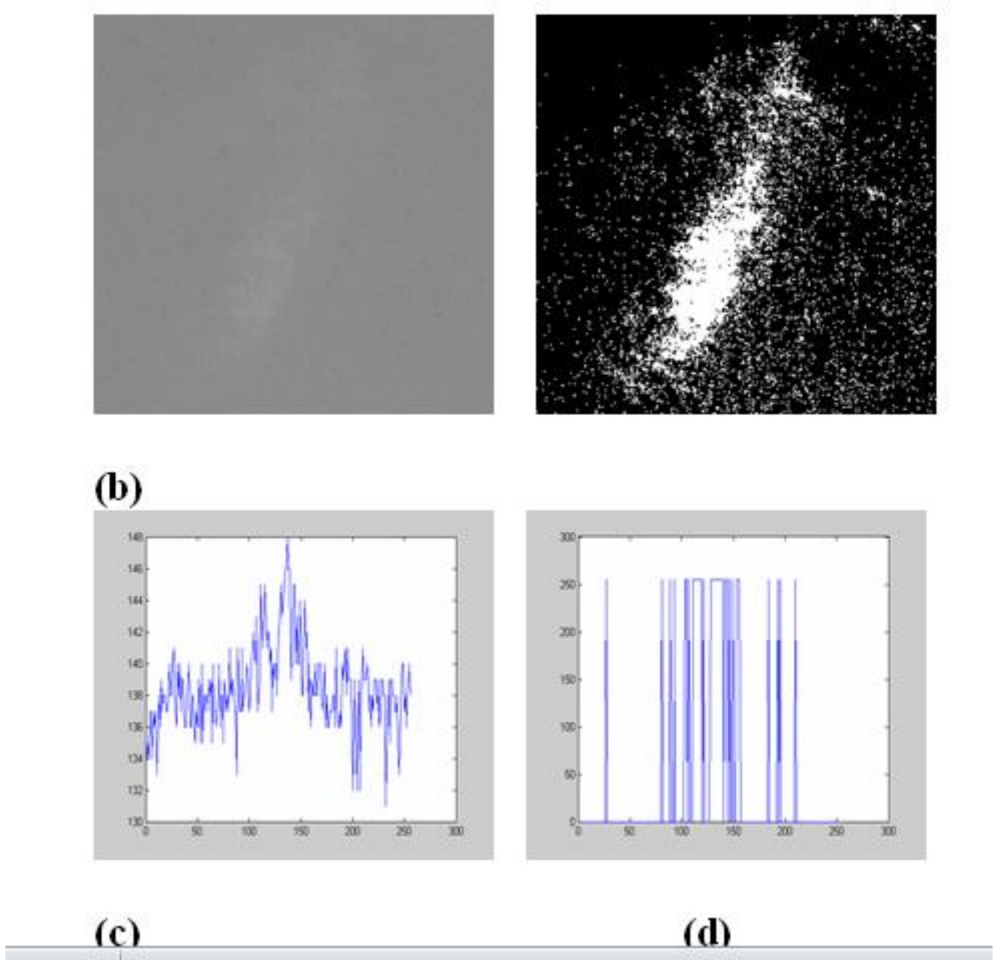

Figure 2
(A) SMALL REGION MURA (256X256) (B) SIMPLE THRESHOLDED IMAGE (256X256) (C) PROFILE OF 128TH ROW IN ORIGINAL IMAGE AND (D)THRESHOLDED IMAGE

Algorithm used for Small region Mura

After applying one level of wavelet based decomposition we are left with one smooth sub image which is the coarse approximation of the original containing low frequency information and three detail sub images contain fine structures in horizontal, vertical and diagonal orientation having the information about the high frequency component of the image With proper selection of a smooth subimage or the combination of detail subimages at different multiresolution levels for image reconstruction and giving proper weights to the band of frequency the local MURA defect can be effectively recognized. A simple binary thresholding is therefore used to separate the defective regions from the uniform gray-level background in the restored image in Figure 3.

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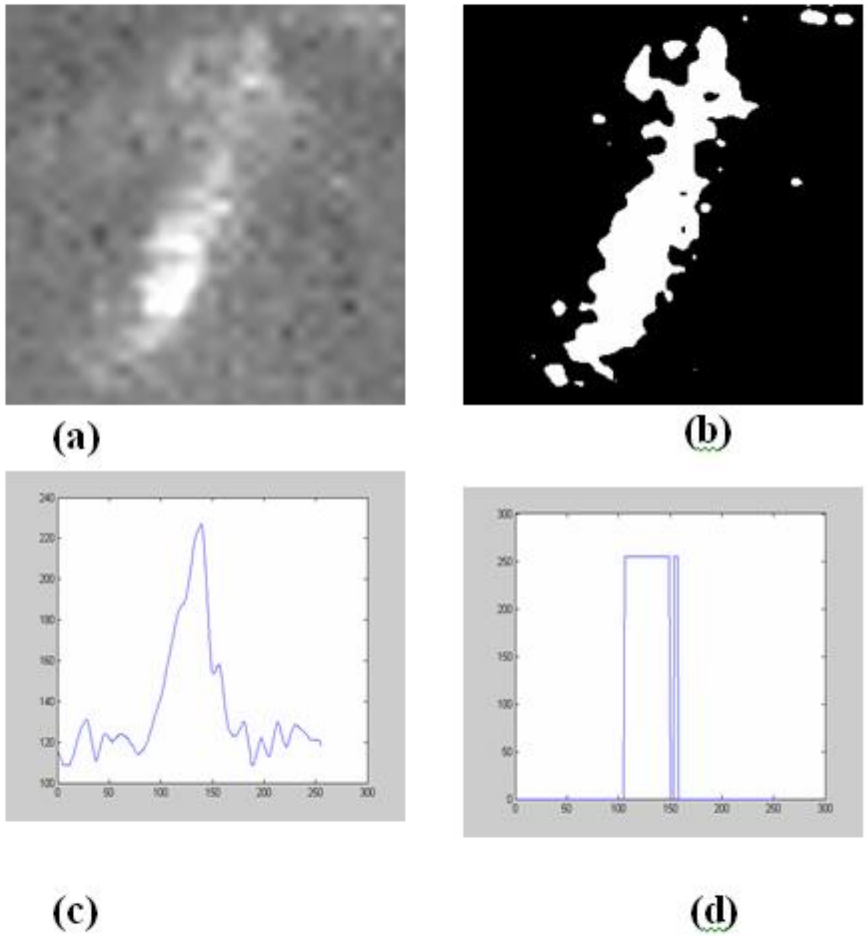

Figure 3
(A) TRANSFORMED IMAGE (256X256) (B) THRESHOLDED IMAGE (256X256) (C) PROFILE OF 128TH ROW IN TRANSFORMED IMAGE AND (D) THRESHOLDED IMAGE

The flow chart for the small region detection is shown as below in Figure 4.

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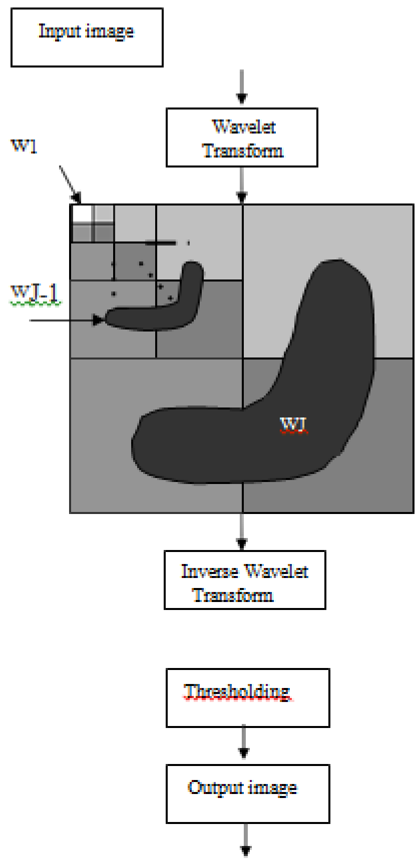

Figure 4
FLOW CHART FOR SMALL REGION DETECTION

Line or Belt Mura Defect

These types of defect occur in form of line or belt and may be horizontal or vertical in nature. As these defects are straight so if we accumulate the data along the row or column the variation along the belt or line can be easily detected after applying wavelet based decomposition then taking the difference from reconstruction after removing the high frequency part and reconstruction uses only low frequency part. The thresholding then gives the line or belt defect present in the image. The Figures 5 & 6 shows all about the detection using the give algorithm.

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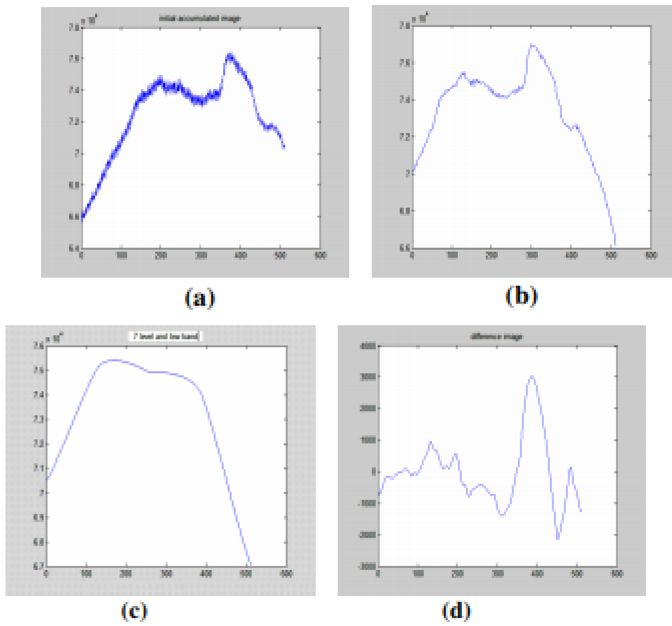

Figure 5
(A) ORIGINAL ACCUMULATED IMAGE (B), (C) RECONSTRUCTED DATA AFTER REMOVING HIGH FREQUENCY AND USING ONLY LOW FREQUENCY (D) DIFFERENCE OF (B) AND (C) DATA.

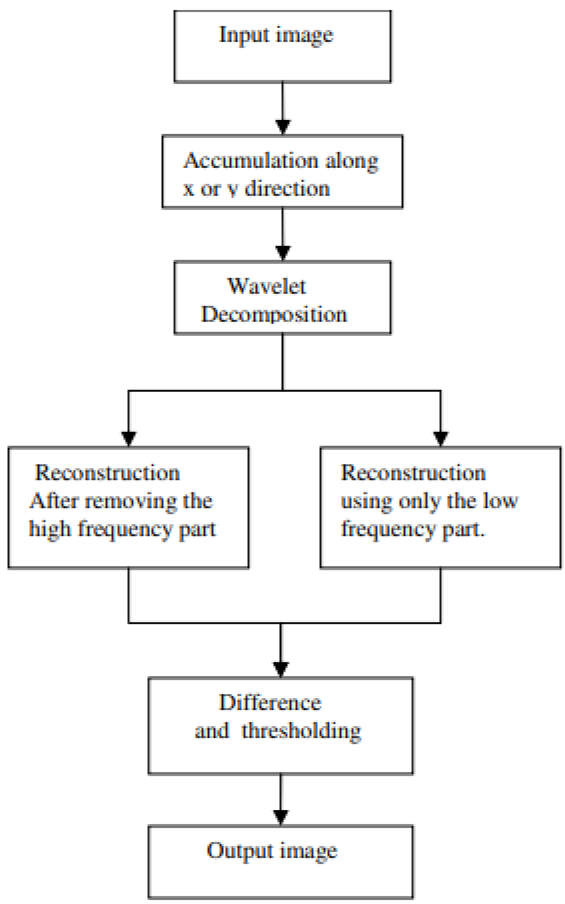

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Figure 6
FLOW CHART FOR LINE OR BELT TYPE MURA DETECTION

Experimental Results

The whole algorithm is using a LCD defect image of size 2048*2048 with 8 bit gray level of the various defects. Sources have been compiled using MATLAB 6.5 on an end work station. The runtime of proposed algorithm were measured on P4 1.7GHz and 1GB RAM. The outcome of the whole images took approximately 50s but in C coding it took near about 10ms. Through out the experiment all the test samples used the Debauchees 9/7 wavelet bases, we have applied 8 level wavelet transforms and have given weight w_1 $=w_7=w_8=0$ and rest weight being value 1. Figures 7-10 shows the sample of LCD images and the defect present in the image.

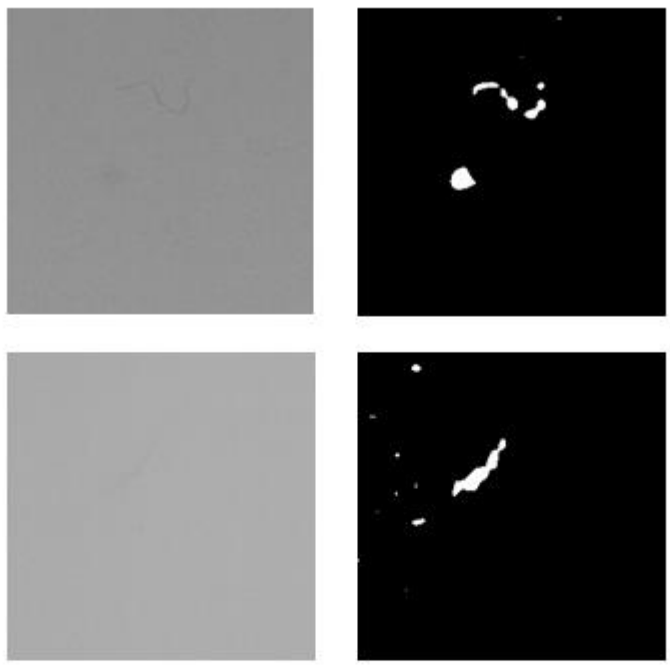
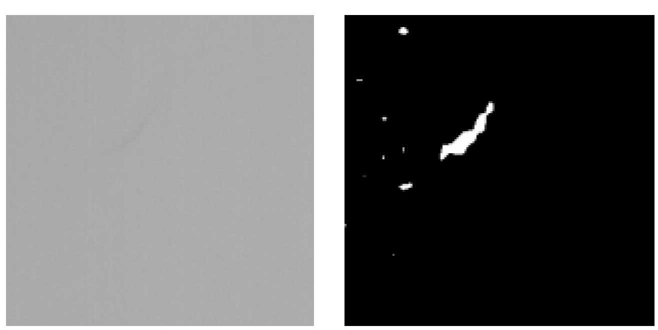


Figure 7
PARTICLE DEFECTED IMAGE AND PROCESSED IMAGE.



(a) (b)

Figure 8

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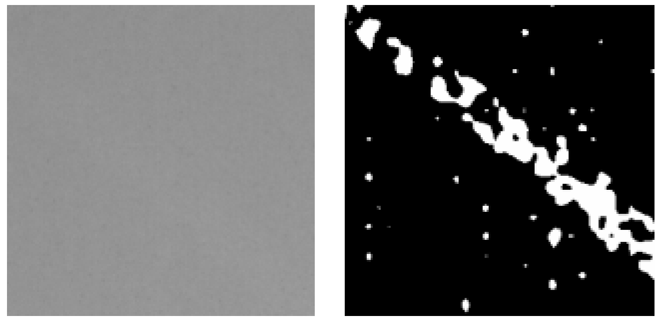
(a) SC defected image and, (b) Processed image



(a) (b)

Figure 9
(A) STAIN DEFECTED IMAGE AND, (B) PROCESSED IMAGE.

(a) (b)

Figure 10
(A) BELT DEFECTED IMAGE AND, (B) PROCESSED IMAGE.

CONCLUSION

In obtaining our results we first started with images having MURA defect. We then applied wavelet based decomposition and reconstruction method using Debauchees 9/7 filter to detect MURA filter. We have already discussed a number of examples in which our proposed method has proven to be valuable, band frequencies are seen to be responsible for the MURA defects. Our method is fast, robust and create surface of high quality. It is quintessential method for better detection of MURA defects in LCD panel. Direction of future work includes deriving efficient methods instead of Debauchees 9/7 which we have used in this paper.

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