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DEVELOPMENT OF SURFACE INSPECTION MACHINE FOR ORGANIC PHOTO CONDUCTOR(OPC)

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ABSTRACT

The OPC is one of the most important component in the electrophotography process. So far its surface defects which degrade print quality were inspected by human-eye. We have developed the OPC surface inspection system employing an image processing technique. In this paper, we describe (1) an optical system to get the OPC surface image, (2) its analysis algorithm to specify the various defects and (3) the hardware/software implementation to reduce the processing time. As a result, the OPC inspection system was realized with high performance and flexibility.

1. The OPC and OPC defects

The OPC's we are working on have three layers, i.e. UL, CGL, and CTL, on the metal base, as shown in Fig. 1.
The defects in each layer have different characteristics in terms of size and category (Table. 1).

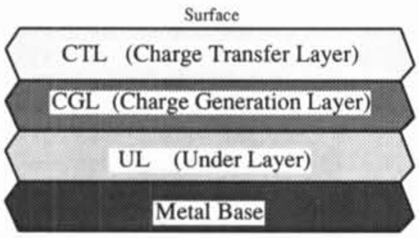

Fig. 1 The OPC

Table.1 OPC detects

	Category	Size(mm)
CTL	Hillock in CTL Layer Black Dot with Hillock Foreign Substance	0.1 - 1.0
UL,CGL	Blcak Dot White Dot Uneven Shade	0.1 - 100
Metal Base	Break	1 -

Hillock defects is the most fatal defect of the OPC, because it does not only degrade the print quality but also can cause the damages to other components. For the reason, it is important to detect the small hillock defects at the size of 0.1 mm.

2. The construction of optical system to detect OPC surface intensity

The OPC is illuminated by a light source with cut off filter which removes all the light having the wavelength less than 420 nm to avoid optical damage to the OPC. The reflected light is detected by a camera installed with one dimensional 2048 pixel CCD line sensor. The OPC is rotated at such speed that we can get the image of 2048x2048 pixels with 8 bit gray scale for one turn. The size of each pixel or the resolution of the image is about 0.19 x0.19 mm. The relative position of the light source, the OPC and CCD camera is optimized to get a part of dispersion reflection. As we chose the construction , the optical system was able to detect all the surface defects. Fig.2 shows the construction of optical system to detect the OPC surface intensity. Fig.3 shows the relative position of the light source, the OPC and the CCD camera.

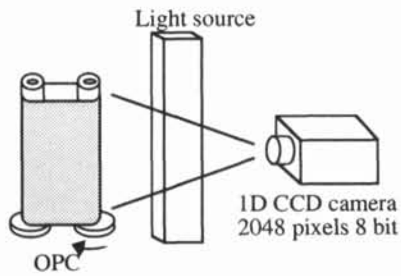

Fig. 2 The optical system

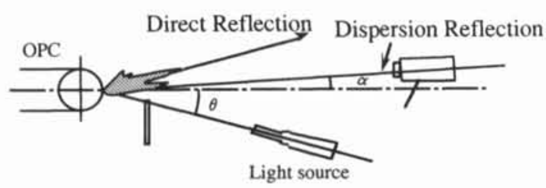

Fig. 3 The relative position of the light source, the OPC and the CCD camera

3. Inspection algorithm

Conventional methods of the inspection using image processing are usually to binarize images and estimate the features. The OPC have some defects that are broad and slight intensity change,so its not good to binarize images. We call such a defect low frequency defect. There are also high frequency defects that have a remarkable intensity change. In our algorithm, the defects are separately detected according to their spatial frequencies. Fig.4 shows the schematic illustration of this algorithm.

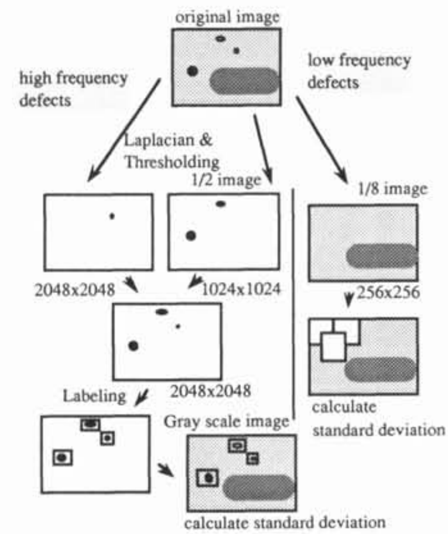

Fig.4 The schematic illustration of this algorithm

Inspection algorithm for high frequency defects have three steps. First step is getting block with defects. This step contains edge detection (Laplacian filter), thresholding, noise removal (expansion two times, contraction two times, isolated pixel removal one time), and labeling. Before thresholding, original and 1/2 size images are used to detect wide frequency. An object of Labeling is a synthesized image from logical OR of original and 1/2 size bit images. Second step is calculating feature value that is standard deviation of gray scale(8 bit) of the block with defect. Third step is judging whether the block is GOOD or NO GOOD by comparing with the feature value and fixed parameter. Detailed procedures of inspection algorithm for high frequency defects are shown in Fig.5 .

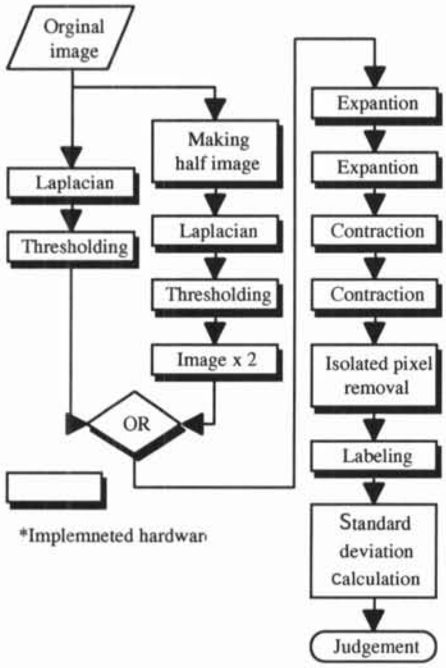

Fig.5 The iInspection algorithm
for high frequency defects

Inspection algorithm for low frequency defects deals with broad and slight intensity change, so it dose not require such fine image as original image(2048x2048 pixels-8 bit). Therefore, we reduce the original image to 1/8 for saving the time and calculation resources. For the detection, we divide the 1/8 small image(256x256 pixels-8 bit) into blocks having the size of 32x32 pixels, because the low frequency defect is not assumed to be specific points but it has broader area. The every neighboring blocks are overlapping with each other as shown in Fig.4 to eliminate the boundary of the blocks. Then, we calculate standard deviation of each block as the feature value of low frequency. Finally, the comparison of the feature value and fixed parameter makes a judgement whether GOOD or NO GOOD block. Detailed procedures of inspection algorithm for low frequency defects are shown in Fig. 6.

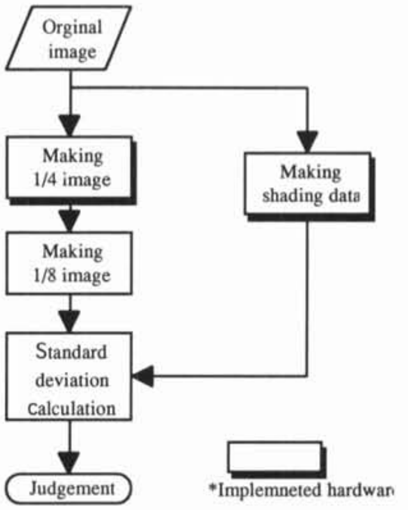

Fig.6 The inspection algorithm
for low frequency defects

4. Implementation and experimental results

We designed special hardware to execute the inspection algorithms and reduce the processing time drastically. This special hardware executes pipe-line process as follows.

1) Inputting image
2) Making 1/4 size image (L
3) Making 1/2 size image (H
4) Edge detection from original and 1/2 size images (H
5) Thresholding for original and 1/2 size images (H
6) Noise removal for original and 1/2 size images (H
7) Making the logical OR image from original and 1/2 size images (H
8) Labeling (H

(L:For the detection of low frequency defects
(H:For the detection of high frequency defects

Table.2 shows the processing time of the algorithm for high frequency defects with/without the hardware and Table.3 shows the processing time of the algorithm for low frequency defects with/without the hardware. To keep flexibility of the system, standard deviation calculation and judgment are executed by software.

Table.2 The processing time of the algorithm for high frequency defects (sec)

	without hardware	with hardware
Image input	10	10
Laplacian	16	
Thresholding	9	
Noise removal	41	
Labeling	10	4
Standard deviation calculation	2	2
Total	88	16

Table.3 The processing time of the algorithm for low frequency defects (sec)

	without hardware	with hardware
Image input	10	10
Make 1/8 image	4	1
Standard deviation calculation	2	2
Total	16	13

*Target image data have 250 label (20x 10)
*Motorola MVME-167(68040,25 MHz,OS-9)
*without I/O time

We install the two sets of special hardware board for one CCD camera so that while one board is executing to get a image and the hardware image processing, the CPU board can use the data of the other board for the software image processing. This alternate inspection technique shortens the system cycle time. Fig.7 shows the construction of processing board.

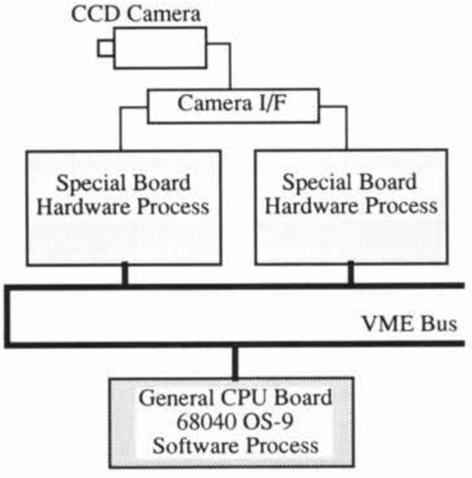

Fig. 7 Construction of processing board

The inspected results of this system was confirmed to be in good agreement with the conventional human-eye inspection results.

5. Conclusion

We have developed an OPC surface inspection system which employs optimized optical system and image processing technique. The optical system was optimized to detect all kinds of defects as intensity differences in the image. Two different inspection algorithms were used; one is for high spatial frequency defects and the other is for low spatial frequency defects. The inspection algorithm was realized by the combination of hardware and software implementation, thereby lessen the processing time while maintaining the flexibility of the system. All kinds of defects on an OPC surface were detected efficiently by this system, so that it can substitute conventional human-eye inspection method.

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1. Shinji Kobayashi, Image Sensing Symposium of Industry(1994), Development of surface inspection method for OPC,105-109