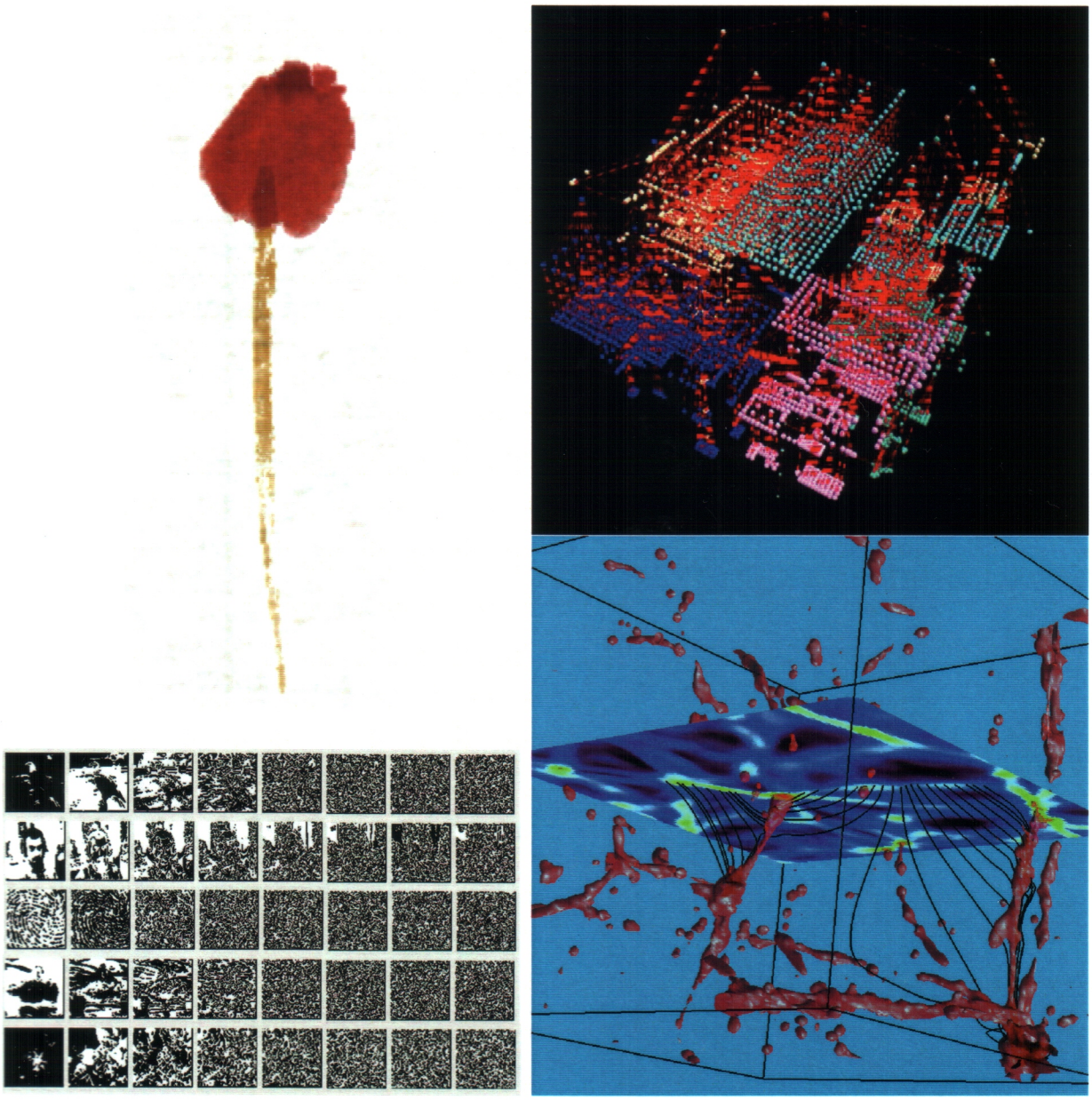
Computer Graphics, Imaging and Visualisation

New Advances

Ebad Banissi, Muhammad Sarfraz, and Natasha Dejdumrong (Eds.)



Bangkok, Thailand **13-16 August 2007**

IEEE COMPUTER SOCIETY

IEEE

Keypad Inspection System of Cellular Phone

Du Cheol Gang, Seung Il Han, Byung Gook Lee, Joon Jae Lee
Graduate School of Design & IT, Dongseo University
{ newsephiro@dongseo.ac.kr, tedl2@dongseo.ac.kr, lbg@dongseo.ac.kr, jjlee @dongseo.ac.kr}

Abstract

In this paper we describe a keypad inspection of cellular phones using image processing. Before keypad buttons are assembled, they occur problems such as surface chipping, color difference, and font errors under process. To solve these problems and to improve the quality of the products, automatic keypad inspection is required. This paper deals with development of inspection method so that objects are moved and rotated for matching to reference image, when objects are in random direction and location in images. And then, for inspecting defect of keypad button, all images of the same patterns of keypad buttons are sequentially matched by the proposed method.

Keywords--- Defect detection, segmentation, pattern matching, cellular phone, keypad

1. Introduction

This paper deals with a machine vision system designed to control and inspect defect of cellular phone keypad button. The defects in keypad button are due to surface chipped, color distorted, fonts errored, etc. It depends on human perception whether the defect is acceptable or not or how much it degrades the quality of the device, even though, manual control tasks are fastidious subjective and cost effective. Due to its high demand in market, the quality of the keypad button becomes a more critical issue for manufacturers. In order to ensure the quality and improve the yield of keypad button, the inspection of defects in keypad button becomes a indispensable task in manufacturing.

An automatic inspection using machine vision techniques can offer manufacturers an opportunity to significantly improve the quality and reduce cost. The reduction of defects in components level improves the quality of final products. But the existing automatic inspecting systems demand high cost, because they inspect keypads after assembling keypad buttons of 12 pieces. There are several works of defect detection on keypad button such as keypad's surface, pattern of background's color in keypad button, font disparity, and many different type of defect. In this paper we propose a single key button inspection method based on segmentation of fonts and keypad and PCA(principal component analysis) for registering the input image to reference one. In the image, the object of keypad button is in random direction and location. For correctly matching, it is rotated and translated to reference keypad position. We use the eigenvalue and eigenvector of PCA which are constructed by segmented object position information in image for rotating and translating the input image. After rotating and translating a input image, it is compared with the reference image which is a normal keypad button.

2. Inspection system

The proposed system is shown in Figure 1 to obtain and inspect defective patterns of keypad button in Figure 2.

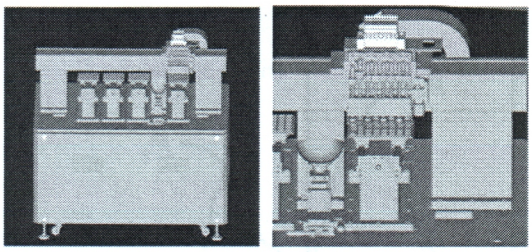


Figure 1. Inspection system

Figure 2. Defective pattern of keypad

The flow chart of this system is shown in Figure 3. First, the segmentation algorithm extracts a pad and font regions of keypad button, and then find a direction of keypad button using PCA. The reason

0-7695-2928-3/07 $25.00 © 2007 IEEE

of finding direction is because a rotation requires standard direction by font and pad features. If correct pad and font area are detected, we can translate a location of object and rotate a direction of object to compare between reference image and input image. And then, we acquire a difference image to check the scratch and font error.

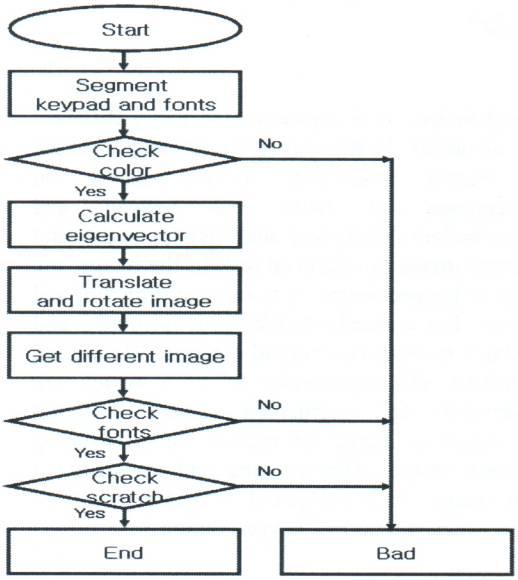


Figure 3. Flowchart

2.1. Segmentation of pad and font regions

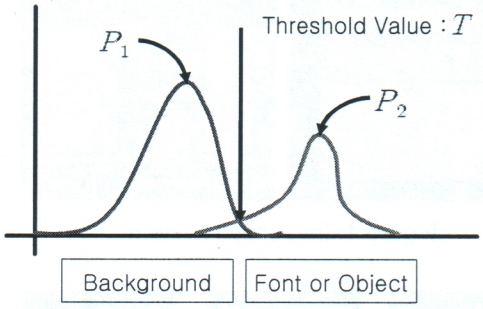
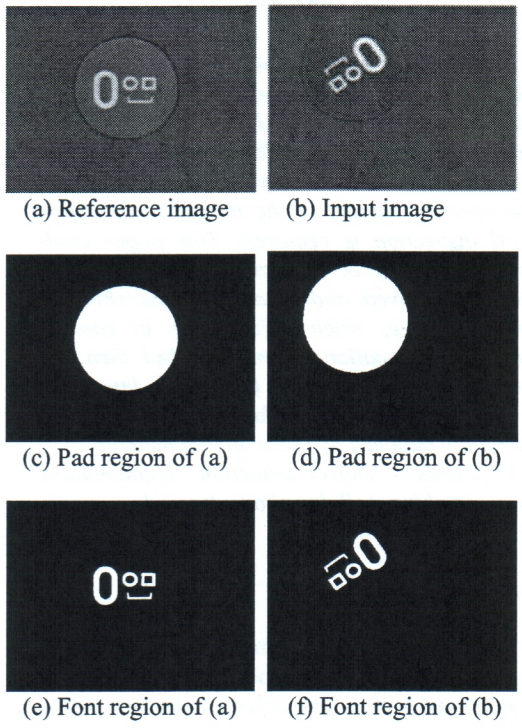


Figure 4. Probability density function for threshold value

An image is segmented by classifying as pixels with gray levels greater than a threshold T(Figure 4) as background pixels. All other pixels are called object pixels. Our main objective is to select the value of T that minimizes the average error in making the decisions that a given pixel belongs to an object or to the background. The P_1 and P_2 are the probabilities of occurrence of the two classes of pixels. That is, P_2 is the probability that a random pixel with value z is an object pixel. Similarly, P1 is the probability that the pixel is a background pixel. We can find both areas which are a pad and font areas through the ratio of P_1 and P_2.

$$T = \frac{\mu_1 + \mu_2}{2} + \frac{\sigma^2}{\mu_1 + \mu_2} \ln\left(\frac{p_2}{p_1}\right) \quad (1)$$

Where μ_1 μ_2 and σ^2 are the mean and variance of the Gaussian density of one class of pixel.



(a) Reference image (b) Input image

(c) Pad region of (a) (d) Pad region of (b)

(e) Font region of (a) (f) Font region of (b)

Figure 5. Segmentation of a pad and font region

2.2. Registration of keypad

The centroid of object is calculated and its image is translated using Equation (2) for matching a input image to reference one. To inspect keypad button's defect, we store the reference image which is a normal keypad button and then compare to input image. When comparing images, the input image is rotated to same directions in image. In this paper we use the eigenvector of the PCA(Principal component analysis) to get the rotation angle(θ).

$$A = \begin{bmatrix} 12636549 & -3762543 \\ -3762543 & 5893278 \end{bmatrix} \quad (2)$$

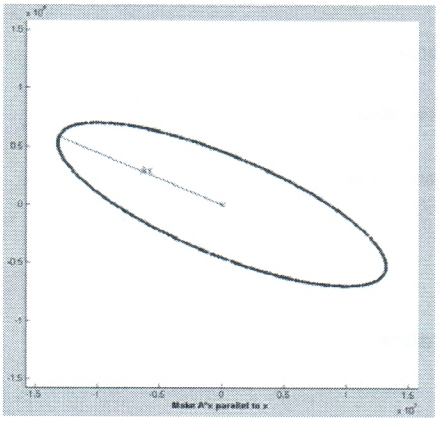


Figure 6. Eigenvector in the keypad image

$(A-\lambda I)X=0$ uses a characteristic equation to get eigenvalue.

$$\lambda=\begin{bmatrix}14317107 & 0\\ 0 & 4212720\end{bmatrix} \quad (3)$$

Eigenvalue uses $AX=\lambda X$ to get eigenvector.

$$X=\begin{bmatrix}0.913061 & -0.407823\\ 0.407823 & 0.913061\end{bmatrix} \quad (4)$$

It decides which is bigger among the two eigenvalue corresponding to the selected eigenvector to get the rotation angle(θ).

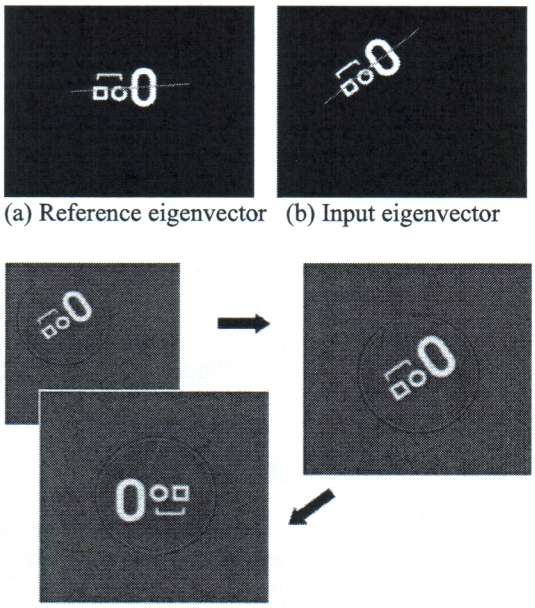
$$\theta=\operatorname{actan}\left(\frac{0.913061}{-0.407823}\right) \quad (5)$$

2.3. Font inspection and scratch detection

After registering input image to reference one, the difference image as shown in Figure 8 (a), Then the font error and scratch is detected by simple threshold in Figure 8 (b) .

2.4. Color inspection

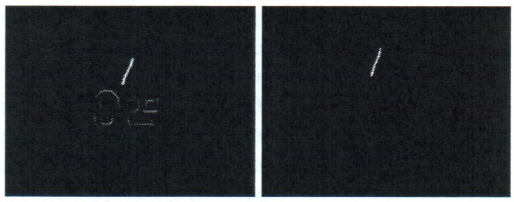
To check color difference, the color of keypad is extracted only in keypad region excluding font regions as shown in Figure 9.



(a) Reference eigenvector (b) Input eigenvector

(c) Steps for registration

Figure 7. Registration of the keypad image



(a) Difference image (b) Detected scratch

Figure 8. Detected scratch of keypad

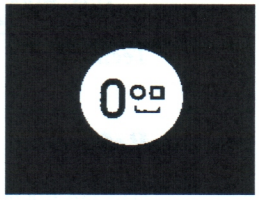


Figure 9. Region for color comparison

The average color values of all pad regions are used for distance between input and reference images. As shown Figure 10, RGB coordinate is used for illustration, but different color model can be used instead.

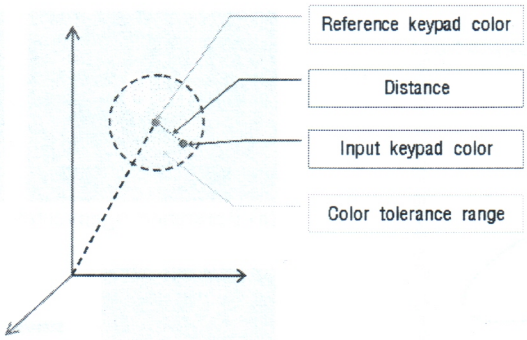


Figure 10. A model of color difference

3. Conclusions

This paper presents a inspection method before assembling the buttons to reduce the cost, which is based on PCA on a single keypad button. Eigenvectors of the PCA which are constructed by pixel position in input image are used. After rotating and translating images, it is compared with reference image which is a normal keypad button. In this way, user can inspect the defection of keypad button, even if a image is in random direction and location. The system can perform efficiently in real-time environment because it is detecting and transforming image using eigenvalue and eigenvector calculated by only the position of the thresholded objects.

Acknowledgements

This work was supported by grant No. R01-2004-000-10851-0 from Ministry of Science & Technology

References

[1] Sang Ji Kim, Nam Yoo Kim, Byung Gook Lee, and Joon Jae Lee, "FPD Defect Detection Using B-Spline for Uneven Illumination Variation Compensation", *Proc. of Conference on Korea Multimedia Society,* May 2006.

[2] Sang Ji Kim, Nam Yoo Kim, Byung Gook Lee, and Joon Jae Lee, "Wavelet Based Uneven Illumination Compensation for Defect Detection of Flat Panel Display", *Proc. of 4th IASTED International Conference on Signal Processing, Pattern Recognition, and Applications,* February 2007.

[3] Hui-Fuang Hg, "Automatic Thresholding for Defect Detection," *Proc. of Third International Conference on Image and Graphics*, IEEE, 2004

[4] Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing 2nd Edition*, Prentice Hall, 2002.

Digital Art, Animation, & Multimedia

Augmented, Mixed, and Virtual Reality