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Edge distance extraction and orientation invariant transform for object recognition

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ABSTRACT

This research finds the distances between the edge and the centroid as the parameters to do the pattern recognition. The entire edge distances are recorded in a vertical strip. The "vector magnitude invariant transform" technique is used to transfer the distance quantity to an invariant vector magnitude quantity for object identification. The "vector magnitude invariant transform" technique can solve the image rotation problem. Various distance vertical magnitude quantity strips are generated to cope with the image-shifting problem. In this research, one hundred and five comparisons are conducted to find the accuracy-rate of the developed algorithm. Within those one hundred and five comparisons, fifteen comparisons are conducted for self-comparison. The other ninety comparisons are conducted for comparisons between two different object images. The algorithm developed in this research can precisely classify the object image.

1. Introduction

In the past thirty years, researchers invested a lot of effort to do the object identification. The technique used is – directional signal (Bazen & Gerez, 2002), line shape analysis (Chang & Fan, 2002; Han, 2004; Ma, YingLiang, Pollick, Frank, & Hewitt, 2004; Sun & Qiu, 2004), Gabor filter (Lee et al., 2001), singular point detection (Ramo & Tico, 2001), Wavelet transform (Hsieh, Lai, & Wang, 2003), dilate enhancement (Ikeda & Nakanishi, 2002; Randolph & Smith, 2001), *r*-theta transformation (Chen, 1996), thermal sensor technique (Lin & Fan, 2004), and two band decomposition (Shah & Sastry, 2003). In this research, the distances of the edges to the centroid are found. These distances are recorded in the vertical strip and these distances are used as the variables to perform the pattern recognition. The "vector magnitude invariant transform" technique is used to transfer these distance-quantities to another invariant vector magnitude quantities – by which one can identify different object images. The algorithm developed in this research can precisely recognize the object image. This paper consists of six sections. Section 2 extracts the essential part of the object image. Section 3 shows the mechanism of the "vector magnitude invariant transform". Section 4 extracts the edge distances. Section 5 copes the image-shifting problem and performs the signal comparison. Section 6 concludes this paper.

2. Extract the essential part of the image

Fig. 2.1 shows the image extracting process. The original image, which taken by the SONY DCR-PC 110, is the 240 by 352 image. The following technique is applied to the original 240 by 352 image to extract the essential part of the image – Sobel operator, three by three cross medium filter, and edge searching and thinning operator. In Fig. 2.1, the original 240 by 352 image is expand to the 380 by 380 – RGB image. Consequently, one can obtain the 128 by 128 – grayscale images and the 128 by 128 – edge thinned image by processing the 380 by 380 – RGB image. Fig. 2.1 shows the extracted images.

3. Vector magnitude invariant transform

Fig. 3.1 shows the edge-signals of x_0, x_1, $x_2,\ldots,x_{127}$. In Fig. 3.1, every two signals and the centroid has the angle of 2.81° – i.e. $\angle x_4$ *Centroid* x_3 is 2.81°, $\angle x_3$ *Centroid* x_2 is 2.81°, $\angle x_2$ *Centroid* x_1 is 2.81°, $\angle x_1$ *Centroid* x_0 is 2.81°,..., and $\angle x_0$ *Centroid* x_{127} is 2.81°. Eq. (3.1) calculates the location of the centroid (x_c, y_c) of the object. In Eq. (3.1), the term $g(x,y)$ represents the gray level of the pixel on location (x,y). In this research, the values of N and M are 128. In Fig. 3.1, the distance between x_4 and (x_c,y_c) is r_{x_4}, the distance between x_3 and (x_c,y_c) is $r_{x_3},\ldots,$ and the distance between x_0 and (x_c,y_c) is r_{x_0}. Eq. (3.2) shows the function of "vector magnitude invariant transform", which will transform the signals x_0, x_1, $x_2,\ldots,x_{127}$ in Fig. 3.1 to various vectors $f(x_0)$, $f(x_1)$, $f(x_2),\ldots,f(x_{127})$, – by which to generate the terms of $F_1(u_0)$, $F_1(u_1)$, $F_1(u_2),\ldots,F_1(u_{127})$. Actually, in Eq. (3.2), $f(x_0) = r_{x_0}$, $f(x_1) = r_{x_1}$, $f(x_2) = r_{x_2},\ldots, f(x_{127}) = r_{x_{127}}$. In Eq. (3.2), the parameter ρ is set to 2.81. Fig. 3.2 shows an object

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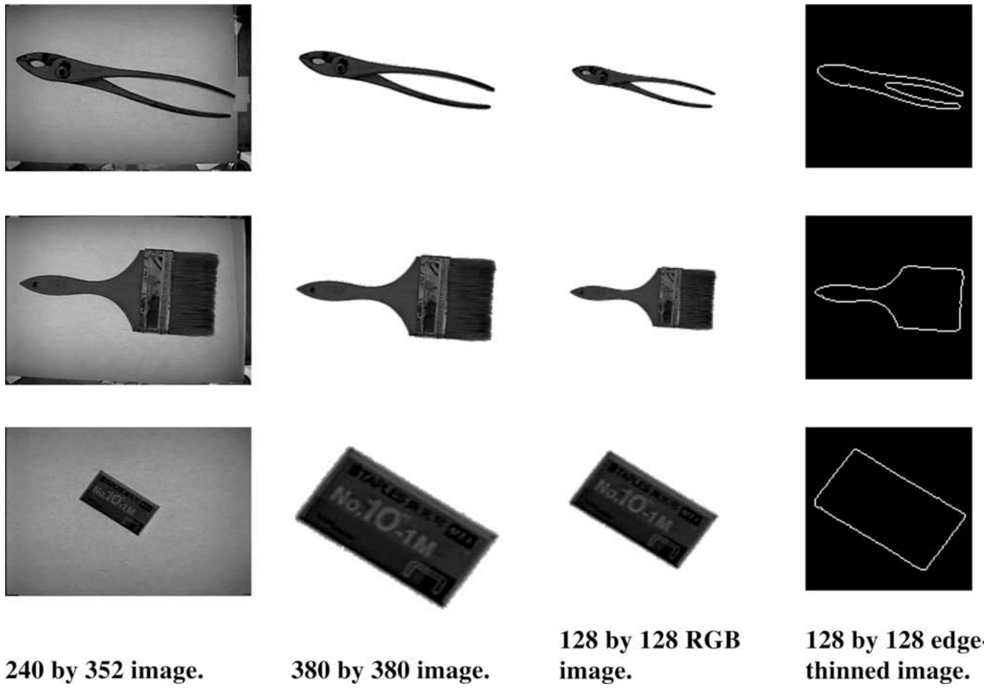

Fig. 2.1. The extracted images.

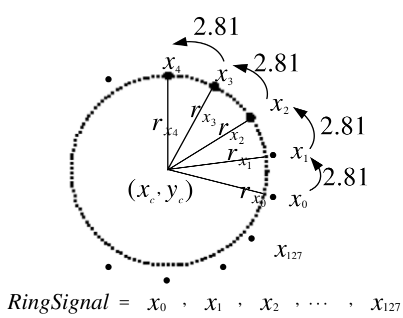

Fig. 3.1. The original signal.

with three different orientations and they are represented by *RingSignal*$_1$, *RingSignal*$_2$, and *RingSignal*$_3$, respectively. One can perform the "vector magnitude invariant transform" to these three thinned-edge signals – *RingSignal*$_1$, *RingSignal*$_2$, and *RingSignal*$_3$ and one can obtain the following results:

$$\|F_{RingSignal_1}(u_0)\| = \|F_{RingSignal_2}(u_0)\| = \|F_{RingSignal_3}(u_0)\|$$
$$\|F_{RingSignal_1}(u_1)\| = \|F_{RingSignal_2}(u_1)\| = \|F_{RingSignal3}(u_1)\|$$
$$\vdots \qquad \vdots \qquad \vdots$$
$$\|F_{RingSignal_1}(u_127)\| = \|F_{RingSignal_2}(u_127)\| = \|F_{RingSignal_3}(u_127)\|$$

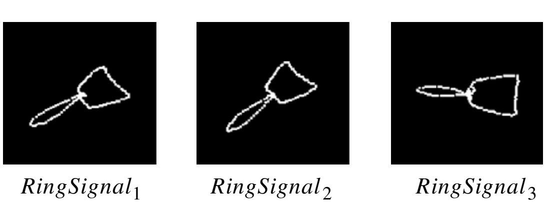

Fig. 3.2. Different ring signals.

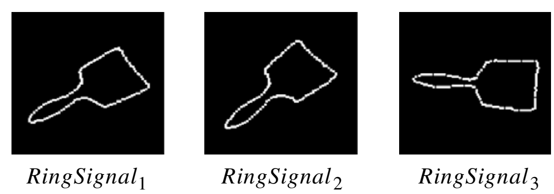

Fig. 3.3. Different ring signals.

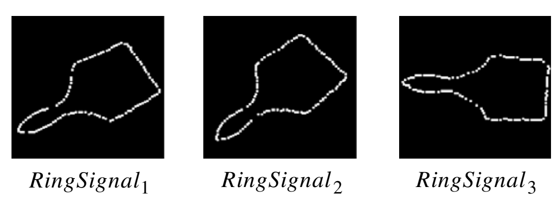

Fig. 3.4. Different ring signals.

Figs. 3.3 and 3.4 also show the same object as in Fig. 3.2 and the object in Figs. 3.3 and 3.4 also has three different orientations. The thinned-edge signals are also represented by *RingSignal*$_1$, *RingSignal*$_2$, and *RingSignal*$_3$, respectively. The radiuses of the thinned-edge signals – *RingSignal*$_1$, *RingSignal*$_2$, and *RingSignal*$_3$are greater than the radiuses of the thinned-edge signals – *RingSignal*$_1$, *RingSignal*$_2$, and *RingSignal*$_3$ in Fig. 3.2. The "vector magnitude invariant transform" technique is used to transfer the thinned-edge signals to an invariant vector magnitude quantity. After performing the "vector magnitude invariant transform" to the thinned-edge signals in Figs. 3.3 and 3.4, one also can obtain the following results:

$$\|F_{RingSignal_1}(u_0)\| = \|F_{RingSignal_2}(u_0)\| = \|F_{RingSignal_3}(u_0)\|$$
$$\|F_{RingSignal_1}(u_1)\| = \|F_{RingSignal_2}(u_1)\| = \|F_{RingSignal_3}(u_1)\|$$
$$\vdots \qquad \vdots \qquad \vdots$$
$$\|F_{RingSignal_1}(u_127)\| = \|F_{RingSignal_2}(u_127)\| = \|F_{RingSignal_3}(u_127)\|$$