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# DESIGN OF A FUZZY INSPECTION AND RECOGNITION SYSTEM FOR BINARY IMAGE

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## ABSTRACT

In this paper, the system design includes the hardware implementation based on M6809 microcomputer and the application software for biomedical and industrial image recognition system. In order to get a high speed and clean image, a notchless and floating binarized circuit was used to make the conversion from the NTSC signal into 256 levels monochrome image (256 × 256 × 8) or bilevel Black/White image (256 × 256 × 1) within 1/30 second. We also use the window and/or feature extraction as the algorithm of pattern recognition and inspection according to the moment inertia ratio of the object. Based on the fuzzy set theory, fuzzy logic is used in decision-making for the recognition in accord with the rule of similarity and it's membership value.

## INTRODUCTION

The automatic inspection and recognition technique are very useful at robotic assembly process in the factory or biomedical image inspection in the hospital [1,2,3,4]. Though the human visual inspection system is adapted to performing in a world of variety and change, its performance is generally inadequate and variable. And the inspection quality decreases with dull and endless routine jobs. Above all, some environments such as high-temperature, air-pollution or noise -disturbance are hazadous to the operators. Obviously, automated visual inspection is the alternate to the human inspector, and it will increase productivity and improve product quality.

To find a quick and simple method for inspection and recognition of binary image to meet the speed and accuracy requirement in pratical use, this paper provides a method for momemt property analysis and a fuzzy decision rule to achieve the recognition goal.

## SYSTEM DESIGN

The fuzzy image processing system is shown as in Fig. 1. The picture of pattern is taken by a camera with 256 × 256 pixels of 256 gray level (8-bit) and stored in frame memory (FRAM) through a signal amplification and high speed A/D conversion. With a digital circuit threshold value

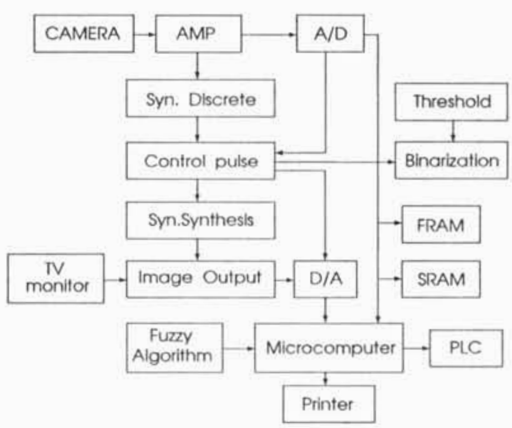


Fig. 1 The Fuzzy Image Recognition System.

setting, the image can be binarized to 256 × 256 × 1 image and stored in SRAM. Also the processed image can be displayed on a TV monitor for supervision. A software fuzzy inspection and recognition algorithm is excuted by the microcomputer. The result is printed out from a printer and sent to a PLC (programmable logic controller) in pratical use.

## MOMENT PROPERTIES

Moment can be given a physical interpretation by regarding gray level as mass, that is, regarding image of f as composed a set a point masses located at the point (x,y). And the (i,j) moment of image of f is defined by

$$m_{ij} = \sum\sum x^i y^j f(x,y)$$

Thus $m_{00}$ is the total mass of image pattern f and $m_{20}$ and $m_{20}$are the moments of inertia of f around the x and y axes respectively. For the binary-valued picture, the moment of f provides a useful information for recognition. Fig. 2 shows 10 simulated patterns. And table I shows the first few normalized fuzzy moment properties of these patterns as fuzzy similarity features.

The centroid of pattern f is the point $(\bar{x}, \bar{y})$ defined by

$$\bar{x} = m_{10}/m_{00}, \ \bar{y} = m_{01}/m_{00}$$

When we take the origin at the centroid, the central moment of the pattern f can be obtained as follows:

$$\mu_{pq} = \sum \sum (x-\bar{x})^p (y-\bar{y})^q f(x,y)$$

Table II shows first few normalized fuzzy centroid moment of simulated patterns. And $\mu_{pq}$ can be seen as the normalized pattern f with respect to translation and rotation. They can also be taken as the fuzzy similarity features for recognition.

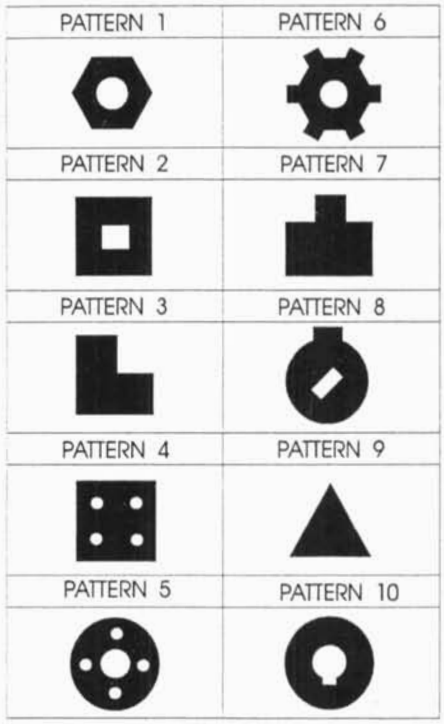


Fig. 2 Ten Simulated Patterns.

Table I Normalized Fuzzy Moment Property

| | $m_{11}$ | $m_{20}$ | $m_{02}$ | $m_{21}$ |
|---|---|---|---|---|
| pattern 1 | 0.55 | 0.71 | 0.55 | 0.72 |
| pattern 2 | 0.35 | 0.31 | 0.65 | 0.82 |
| pattern 3 | 0.68 | 0.69 | 0.82 | 0.62 |
| pattern 4 | 0.59 | 0.68 | 0.68 | 0.75 |
| pattern 5 | 0.69 | 0.83 | 0.71 | 0.56 |
| pattern 6 | 0.62 | 0.85 | 0.68 | 0.92 |
| pattern 7 | 0.50 | 0.61 | 0.45 | 0.45 |
| pattern 8 | 0.60 | 0.69 | 0.65 | 0.73 |
| pattern. 9 | 0.25 | 0.36 | 0.20 | 0.40 |
| pattern10 | 0.60 | 0.71 | 0.70 | 0.67 |

Table II Normalizaled Fuzzy Central Moment Property

| | $\mu_{11}$ | $\mu_{20}$ | $\mu_{02}$ | $\mu_{21}$ |
|---|---|---|---|---|
| pattern 1 | 0.35 | 0.54 | 0.38 | 0.33 |
| pattern 2 | 0.45 | 0.72 | 0.48 | 0.09 |
| pattern 3 | 0.40 | 0.73 | 0.50 | 0.38 |
| pattern 4 | 0.10 | 0.60 | 0.48 | 0.34 |
| pattern 5 | 0.64 | 0.54 | 0.44 | 0.45 |
| pattern 6 | 0.02 | 0.74 | 0.44 | 0.42 |
| pattern 7 | 0.23 | 0.33 | 0.24 | 0.31 |
| pattern 8 | 0.39 | 0.44 | 0.38 | 0.36 |
| pattern 9 | 0.55 | 0.12 | 0.25 | 0.12 |
| pattern10 | 0.28 | 0.78 | 0.50 | 0.35 |

## FUZZY DECISION ALGORITHM

To distinquish patterns with the same moment and central moment property, we apply a method of fuzzy similarity measurement as mentioned above [5]. Here we take the 8 moment values as $(m_{11},m_{20},m_{02},m_{21},\mu_{11},\mu_{20},\mu_{02},\mu_{21})$ as the characteristic value of patterns. Therefore a pattern can be respresented as a fuzzy vector as follows:

$$F(A)=(m_{11},m_{20},m_{02},m_{21},\mu_{11},\mu_{20},\mu_{02},\mu_{21})$$

Suppose

$$F(A) = (a_1,a_2,a_3,a_4,a_5,a_6,a_7,a_8)$$

and

$$F(B) = (b_1,b_2,b_3,b_4,b_5,b_6,b_7,b_8)$$

are two fuzzy vectors to represent patterns. We use the following equation for the similarity measurement.

$$D(A,B) = \frac{1}{8}\sum_{i=1}^{8} |a_i - b_i| \qquad (1)$$

we can find the following property of similarity measurement from above equation ,and have the following conclusions:

(1) D(A,B) = 0, it shows pattern A and B are identical.

(2) D(A,B)=D(B,A)

We setup the database by auto-learning mode and a adaptive compensation with 3% of displacemental tolerance in horizontal, vertical and rotational directions. Let $\{P_1, P_2,......,P_n\}$ represent the database of installed patterns and Q represent the fuzzy vector to be recognized. Let

$$D(Q,P_k) = \mathrm{Max}(D(Q,P_1), D(Q,P_2), \cdots D(Q,P_n))$$

and take the threshold value a=0.05. If $D(Q,P_k) \leq a$, then the corresponding pattern of Q is recognized as the installed pattern $P_k$; otherwise it is rejected.

## CONCLUSION

A fuzzy decision concept is adopted in our image system to inspect and recognize the machine patterns. We have conducted an experiment for recognizing 300 patterns of 24 × 48 pixel dimension. The rate of recognition time is less than 0.15 second to meet the requirement of inspection process. Also the centroid moment is taken into consideration as the fuzzy feature, therefore the variation in the coordinate will not significantly affect the recognition result.

To make the system more flexible, and to shorten the developing process, our system was designed to have the following functions:

1. Computer-aided auto-learning ability to simplify the try and error process.
2. Optical condition adjustment and calibration in the beginning of each inspection process.
3. Inspected pattern change without software development.
4. An adaptive compensation with 3% of displacemental tolerance in horizontal,and rotational directions.
5. Tracing and printing of all inspecting steps for analysis.

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