MEDICINE TABLET IDENTIFICATION USING FEATURE EXTRACTION BASED ON NEURAL NETWORK

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ABSTRACT

The purpose of this research is to develop medicine tablet identification method by using an image recognition system. The algorithm consists of three main stages: (i) preprocessing and segmentation (ii) feature extraction (iii) image classification. In the first stage, the images of the medicines are cropped. Then, we use Canny's algorithm to detect edges from the images. After that in the second stage, 3 groups of features: shape features (perimeter, area, compactness, radius, standard derivation of radius), color features and internal tablet features are extracted from the medicine tablet images. In the last stage, we apply feed-forward backpropagation neural network to classify different groups of shape features. With these outputs, we compare and select the group of features that give the best classification. Finally, medicine tablet images are identified by using output from the neural network and observing color and internal tablet features.

In the experiments we used 33 types of medicine, 20 tablets for each type which were digitized in 2 dimensions: front and back for each tablet. Each type of medicine was divided to 2 groups: training and testing groups equally. The proposed method yields maximum 99.39% total accuracy.

KEYWORDS: Medicine Tablet Identification, Feature Extraction, Neural Network

1. INTRODUCTION

Medicine tablets are most popularly used in medicinal therapy. According to Thai Drug Control Division in 1999, it showed that 43% of registered drugs are of the tablet forms [1].The reason for this because of its convenience in production storage and administration. Furthermore, tablets can be printed with logo or number so that each tablet will be different for various companies. However, identification of medicine tablets is not easy especially if an identifier is not an expert or a pharmacist because of its variety. Therefore if the medicine has no label, the experience of the pharmacist is required for identifying its type.

Drug distribution and control is one of duties, assigned to follow the pharmacy care standard in hospital [2]. According this duty, pharmacists have to check the accuracy of medicine before dispensing. Thus if we can develop an automatic system that helps identify medicine tablet, it may reduce the inspection time of the tablets and reduce human error by using this system for a preliminary check. Moreover, this system can be used for predicting the name of unknown medicine tablets where the system may have known before. We believe that, using image processing knowledge and pattern recognition may be a good solution for developing this system.

In general, our pattern recognition process consists of three major phases [3]: (i) preprocessing and segmentation (ii) feature extraction (iii) classification. For the first phase, many researches have tried to detect edges using various methods such as Sobel, Prewitt, Robert, Canny and Lapracian of Gaussian [4, 5, 6, 7]. But most of their conclusions indicate that the optimal edge detection depend on the type of applications. In this experiment, Canny's edge detection was used because it gives thin edges and has smoothing process by Gaussian filter.

Although, there are many researches that are proposed about image recognition method in several areas, among these, none of the work that proposed the method for identifying medicine tablet

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image, directly. There is only a research that was related to logo on drug tablets. This research evaluated contents based on image retrieval methods for a database of logo on drug tablets [8]. The result of comparing different retrieval methods shows that color and shape of logo features give good outputs in term of ranking and speed. The color features appeared to work well. However, these features are not useful if light conditions are varied. Then, the shape features are the most optimal features in this experiment. Besides, there are many researches that give good results from using shape and color features for classifying object, for instance, a research by Solomon,C.Arulraj and Dinesh Somasundaram which used a feature extraction module for classifying the type of white blood cell[9]. The other one, a research by Intharasombat, Ouychai which proposed a method for classifying mammographic masses based on shape features [10]. The above researches illustrate that shape color and internal tablet properties will be the good features for classification.

In the classification phase, the neural network is used in classifying shape and after that we use the other features to help identify tablet images. Although, there are many types of neural network such as Self Organizing Map (SOM), Adaptive Resonance Theory (ART), and Bidirectional Associative Memories (BAM), we choose to use the feed-forward multilayer perceptron with backpropagation learning since it has been popularly used in for classification. For instance, Langner, Jens classified the leave species based on its token by using neural network[11], Mitzias, Dimitris A. and Basil G. Mertzios evaluated a neural multiclassifier system for object recognition in robotic vision applications [12] and Zhang, Mengjie developed a pixel-based neural method to recognize small objects in large picture[13].

2. MATERIALS AND METHODS

This research consists of three main stages: (i) preprocessing and edge detection (ii) feature extraction (iii) classification as shown in Figure 1.

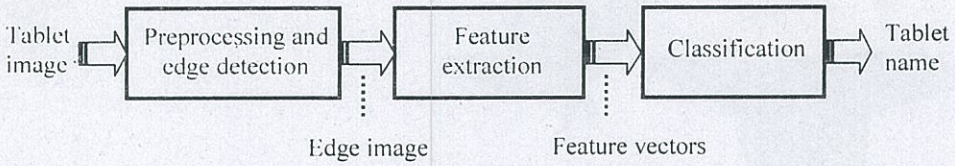

Figure 1.The stages of identification.

2.1 Preprocessing and edge detection

In the first stage, each tablet will be digitized in 2 dimensions: front and back. The digitizing environment was controlled to use the same condition of light and digitized distance throughout all experiments. After that, the images that are in JPEG format are preprocessed by cropping their sizes into 50 x 50 to 150 x 150 pixels. Then, the tablet's edge is detected using Canny's edge detection. The whole process is as shown in Figure 2 [14, 15, 16, 17]. The Gaussian filter is used to smooth images before finding the edges by the gradient method. After that, nonmaxima suppression is used to thin the ridges found by thresholding. Finally, using double thresholding algorithm reduces the false edge fragments.

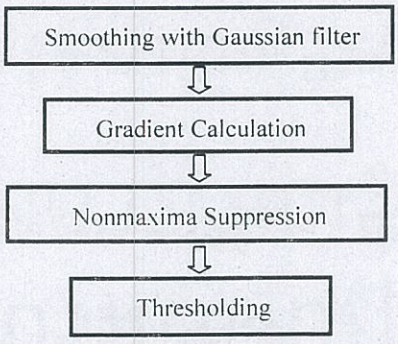

Figure 2.The processes of Canny's edge detection.

After the above processes, we select only outer edge of the object. The resulting edge obtained by this method will be connected if the gap is only one pixel. This outer edge will help divide the image itself in the logo part and the tablet part that would be used in the next process.

2.2 Feature extraction

The medicine tablets have varieties of size, shape, color and imprinted logo. Therefore, all of these properties are used for classification and are divided into 3 groups of feature as follows:

2.2.1 Shape features

We selected 5 features of shape [17, 18] that characterize the appearance of an object as follows:

- Perimeter

The perimeter of an object is the number of pixels in the boundary of an object. If $x_1, x_2, \ldots, x_n$ is a boundary list, then the perimeter is given by Equation 1.

$$perimeter = \sum_{i=1}^{N-1} d_i = \sum_{i=1}^{N-1} |x_i - x_{i+1}| \quad (1)$$

The distances d_i are equal to 1 for a 4-connected boundary and 1or $\sqrt{2}$ for an 8-connected boundary

- Area

The area of an object is the number of pixels inside the shape.

- Radius

The radius of object is measured from an average value of the distance between the center of the object and pixels on its boundary.

$$R = \frac{1}{n}\sum_{i=1}^{n}|C - V_i| \quad (2)$$

where C : center of the object (x_{center}, y_{center}), V_i : boundary pixel (x_i, y_i).

The distance between center point and V_i, $|C - V_i|$, can be computed using Equation 3

$$|C - V_i| = \sqrt{(x_{center} - x_i)^2 + (y_{center} - y_i)^2} \quad (3)$$

- Standard derivation of radius
- Compactness

The compactness is defined as the ratio of the area of an object to the area of a circle with the same perimeter. The measure takes a minimum value of 1 for a circle. Objects that have complicated, irregular boundaries will have larger compactness.

$$compactnes\,s = \frac{perimeter^{\,2}}{4\pi a} \quad (4)$$

where a is area.

2.2.2 Color features

The most straightforward way is to use the red, green, and blue brightness values, scaled between 0 and 255, called the RGB format [3]. In this research, we used the chromaticity which exclusively contains information about color, ignoring the intensity. The chromaticity is obtained by normalizing the RGB components of the image. The average intensity and chromaticity components of each color can be calculated by using Equations 5 and 6 respectively.

$$average\ intensity(R) = \frac{\sum_{i=1}^{n}(r[i]\times i)}{\sum_{i=1}^{n} i} \quad (5)$$

$$average\ chromaticity\ component = \frac{R}{R+G+B} \quad (6)$$

where i : intensity level
n : maximum level of intensity
$r[i]$: Number of pixel that have level of intensity = i
R, G and B are average intensity for each color: red green and blue respectively. These equations are example of R component.

2.2.3 Internal tablet features

The imprinted logo or any mark on the tablet is useful for identifying the medicine types due to its difference. Thus, the extraction method for these features was evaluated based on the distance between each edge pixel of the logo part and the center pixel of tablet as in the equation 7. The algorithm is to calculate the distance and store its output in a matrix. Then, we compare this output with the database that was previously collected as the output matrixes of the training images. A type of tablets that gives minimal difference between testing image and training image is a choice for prediction.

$$distance\ from\ center\ (D) = \sqrt{(x_i - x_c)^2 + (y_i - y_c)^2} \qquad (7)$$

where x_i, x_c : indicate rows of the logo part's edge pixel i and central pixel c
y_i, y_c : indicate columns of the logo part's edge pixel i and central pixel c

2.3 Classification

This section is divided in 3 parts. Consider the overall process in Figure 3. First, feed-forward backpropagation neural network is used for classifying the shape. Second, the possible tablet type is predicted based on color features. At last, internal tablet features is used together with the neural network results and color features to identify types of tablet.

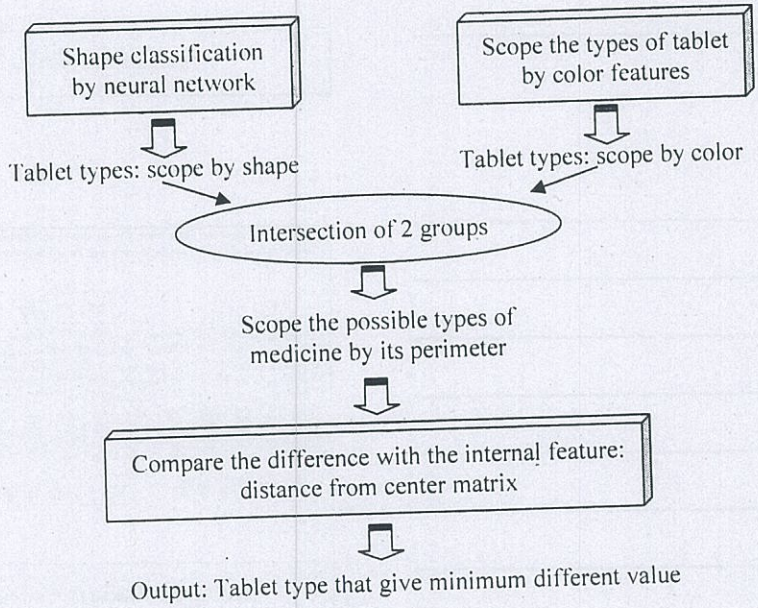

Figure 3.Classification process.

2.3.1 Neural network classification

We use feed-forward back propagation neural network for classified shape into 5 groups: circle, ellipse, square, hexagonal, and parallelogram as shown in Figure 4. By using 4 groups of shape features: (i) compactness and standard derivation (ii) perimeter, area and standard derivation (iii) perimeter, radius and standard derivation (iv) area, radius and standard derivation. The architectures of neural networks are different from each other. We will present the details in the next section.

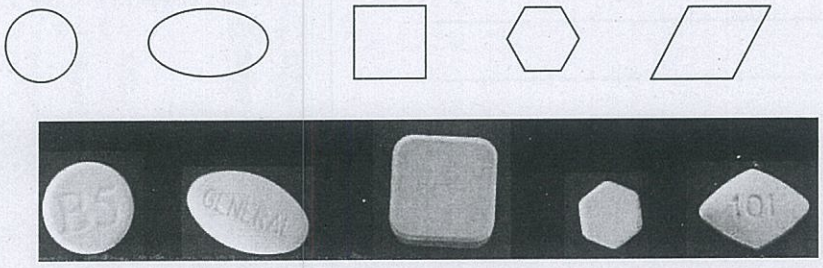

Figure 4.The 5 groups of shape and sample images.

2.3.2 Scope the types of tablet by color features

The average chromaticity components are then compared among testing and training groups. The average chromaticity components of a testing tablet are used to calculate minimum and maximum values of chromaticity components for scoping possible tablet types. The training tablet types that have average chromaticity components within this range will be selected.

2.3.3 Identification

The output from neural network, color features and perimeter is used to scope the possible types of tablet that should match with the tablet image. Then, the internal tablet feature is used to identify medicine type. A predicted medicine type will be the type which gives the minimum different of internal tablet feature. In order to get appropriate identifying tablet type's method, we compare 4 different methods of using internal tablet feature:

Method A combines the sum of different in D (distance from center) value both side of each tablet before selecting the minimum output

Method B, C and D calculate and select the minimum of D difference between front and back side, separately

Method B: using only output from front side of tablet

Method C: using only output from back side of tablet

Method D: using output from front or back side that gives the better order of difference in D value in the other side

The experimental results shown in percentage of total accuracy are calculated by Equations 9. For example, there are 50 testing tablets that give 45 correct outputs and 5 incorrect outputs. The percentage of total accuracy will be equal to ninety

$$\%\ total\ \ accuracy\ \ = \frac{Total\ \ number\ of\ \ correct\ ou\ tputs \times 100}{Total\ \ number\ of\ \ testing\ ta\ blets} \qquad (9)$$

3. RESULTS AND DISCUSSION

The samples of 33 medicine types that have variety in shape color and imprinted logo were used. Each type of medicine was divided into 2 groups: training and testing groups. Ten tablets in each group were digitized in 2 dimensions: front and back by digital camera with resolution value of 640 x 480 pixels. The captured images were processed by using a desktop computer, Pentium IV1.8 GHz and 384 MB RAM. Matlab 6.1 and Microsoft Access were used for programming and managing database, respectively.

We perform four parts of experiments. In the first part, the results of shape classification based on neural network by using different groups of shape features are shown in Table 1. The table shows 2 groups of shape features: (i) compactness and standard derivation of radius (ii) perimeter area and standard derivation of radius. Both give the same good results. From these results, we suggest that the

compactness value be calculated by using perimeter and area so it gives the result similar to the one that the perimeter and area yields.

Features*	Network	Layer	Transfer function	Nodes	% Total accuracy
C,stdr	1	1	-	2	100%
		2	Log-Sigmoid	5	
		3	Linear	5	
	2	1	-	2	95.76%
		2	Log-Sigmoid	4	
		3	Linear	5	
P,A,stdr	3	1	-	3	100%
		2	Log-Sigmoid	5	
		3	Linear	5	
P,R,stdr	4	1	-	3	94.39%
		2	Log-Sigmoid	5	
		3	Log-Sigmoid	3	
		4	Linear	5	
A,R,stdr	5	1	-	3	99.70%
		2	Log-Sigmoid	5	
		3	Linear	5	

*P=perimeter, A=area, R=radius, stdr=standard derivation of radius

Table 1. The results of neural network shape classification compared in 4 groups of features.

In the second part, we compare 4 different identifying tablet type's methods by using only internal tablet feature. As shown in Table 2, Column "Method" refers to type of method that use to identify tablet type (See details in classification part). Column "Use perimeter or not" indicates the cases where perimeters are considered as well. Column "% Total accuracy" shows the number of medicines that is identified correctly. The percent is calculated based on Equations 8.

Method	Use perimeter or not	%Total accuracy
A	no	74.24%
	yes	88.18%
B	yes	69.09%
C	yes	80.91%
D	yes	87.27%

Table 2. The results of identification using internal tablet feature by various methods

According to Table 2, method A gave the best result when considering the perimeter. Method D gave similar result to method A. Method B and C that use only one side of tablet gave bad results especially method C because the front side of tablet has fewer numbers of inner edges than the back side. Thus we select method A and combine with other features for tablet identification in the next stage.

In the third part, the color features that are extracted from testing image were used for categorizing the types of medicine. After that, the intersection of outputs from 2 feature groups (color and shape features) are considered together with the perimeter value. In the last part, the results of identification when using different groups of feature were compared in Table 3.

Features	Use perimeter or not	%Total accuracy
Shape and internal tablet	no	87.58%
	yes	96.36%
Color and internal tablet	no	95.15%
	yes	99.09%
Shape, color and internal tablet	no	98.48%
	yes	99.39%

Table 3. The results of identification by using different groups of features.

In Table 3, Column "Feature" lists features that are considered in the experiments. According to Table 3, the group of shape, color and internal tablet features gave the best result. The results from using color and internal tablet features were better than using shape and internal tablet features because the color feature can be used to identify the possible tablet types in more specific group than the shape features do. Similar to color features, perimeter of the tablet was used to identify the possible output for better results. Considering the best result achieved from using all features in identification, there is only one tablet type that gives some incorrect outputs since it is similar to the other one in shape, size, and color. It has only a little one difference in imprinted logo so the system gives the incorrect result in some sample cases.

4. CONCLUSIONS

In this research, we use different features to identify the medicine tablets. The shape features: perimeter, area, and standard derivation of radius results in the maximum accuracy as the result from using compactness instead of perimeter and area. The compactness may be a good choice since fewer features were used. The chromaticity components that were used in color features appeared to work well in the testing group. However, if the testing tablets have the same color these features may be useless. The most accuracy outputs are from using the combination of shape color and internal tablet features.

The results of this research are limited to the five different shapes and the amount of sample medicine types. In the future research, the unknown tablet types that the network never learned before may be used.

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