Medicine Recognition Using Intrinsic Geometric Property from Pill Image

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Abstract. It is often the case that prescription pills do not come with blister or alu alu packaging where the identity of the pill is available, rather it comes in air-tight plastic bottles or labeled Ziploc bags. Problem with such bottle or pack is that, if the label is removed then it becomes difficult to tell what the pill is. Moreover, there is the issue of visually impaired people having difficulty identifying pills outside the pack. There are such many scenarios where it is good to have an automated pill recognition system. Due to the large variety of size, shape, color, texture it is a difficult task for human to tell about the identity of any individual medical pill. To localize a pill from a given dataset using computer vision techniques requires multiple steps. This paper will describe how to split a dataset according to the shape of pill. To find the shape information we used intrinsic geometric properties such as: eccentricity, extent and narrowness of pill which can be extracted from image using carefully selected image processing techniques. Reference values of discriminative parameters are determined using 'RxIMAGE', National Library of Medicine, USA database. The overall shape discrimination accuracy of the proposed system is 93.75%.
Keywords: Medical Imaging, Pill Image, Eccentricity, Extent, Narrowness

1 Introduction

Prescription pills are available in blister, alu-alu or container (bottle) pack and Ziploc pack. When a medical pill is out of its pack, it is almost an impossible task to recognize. It is also possible that in any way the label can be damaged. In many cases someone has to take two or more pill at a time, so it is hard to find the correct pill from several where the label is damaged or all of them are out of designated containers. Older people will face even more difficulty identifying pills out of its container.

For a visually impaired person this problem is even worse. As the printed labels are of no help to them. Though sometimes they can identify some pills by touching the embossed imprints on the surface of a pill. However, this works with some tablet form of pills, as in the capsule form of pill it is not possible to emboss any text. Moreover, sometimes the pills may not even have any imprint on them. However, sometimes here may be some imprint on the surface of a capsule but that is not sensible by touching. All of these issues may leads to wrong medication. Which may cause an unwanted serious health hazard.

adfa, p. 1, 2011.

Automated recognition of medicine is relatively a new concept though there exists a few work on this issue. Lee et al. [8] developed an application that is able to automatically identify illicit drugs. Hartl et al. [4], and Hartl [5] in their work tried to recognize medical pills using mobile device. However, their proposed method is limited to find shape and color of the pills.

In this paper we propose a method to provide an initial sorting of pill images based on proper measurement of their intrinsic geometric parameters values.

2 Proposed Method

The usual approaches to find features in image for object recognition are the use of, Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Pyramid Histogram of visual Words (PHOW) [6,7, 9-11].

Above mentioned feature descriptors perform excellent with objects that contains variations within the object under consideration. However, medical pill does not contain enough texture or corner features thus SIFT or SURF cannot extract enough discriminating features to separate pills from each other. The most dominant features for pills are size, shape and color. Hagedoorn [2], and Veltkamp and Hagedoorn [3] in their work provide a detailed survey about shape recognition techniques or algorithms. Such as tree pruning, Hough transform, Fourier descriptor, statistics, wavelength transform, deformable templets, curvature scale space, relaxation labeling, and neural network.

Because only features available for discrimination are shape, size and color; the proposed method intends to extract values of intrinsic geometric property of medical pills from image by using image processing techniques for a set of training image and then determine a threshold of those parameters and use it on differentiate pills.

2.1 The NLM Dataset

It is common practice to use standard datasets [1, 12] for developing and testing a new idea. On January 2016, NLM open a challenge under a federal notice "Pill Image Recognition Challenge [1]". NLM's purpose of this Challenge is to find a set of algorithm and software that can rank an input pill according to the similarity to images of unknown prescription pills to known prescription pill images in the NLM RxIMAGE dataset. There is two image-set one for consumer quality image and other for reference image and a ground truth table.

The RxIMAGE dataset contains 5000 images of 1000 different pills in the consumer quality image-set. To mimic the quality of image in consumer level the photos were taken with digital cameras built in to mobile devices. Fig. 1 shows some sample images from the database.

Fig. 1. Sample images from the reference set of the NLM RxIMAGE dataset

2.2 Image Processing Steps

Ones the images are collected next task is to measure the geometric properties of the main object (pill) in an image. However, before we can do so, series of image processing steps are required to acquire the shape of the pill in the image. Consider the image in Fig 2(a). It is not possible to measure the intrinsic parameters values directly.

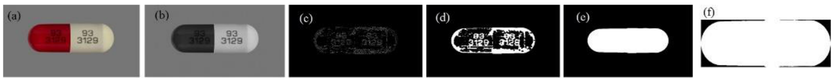

Fig. 2. (a) 24-bit Color pill image from the reference database, (b) 8-bit Gray pill image for the image from color image, (c) Detected Edges of the pill image for the Gray image, (d) Edge image after application of closing morphological operator, (e) Image after application of fill morphological operation, (f) Segmented pill region from pill image.

Converting RGB image to Grayscale image: Every reference image in the database is a 1600 X 2400 X 3 matrix. For farther processing the color image is converted into a 1600 X 2400 8-bit grayscale image (Fig. 2(b)).

Edge Detection: Ones the images are converted into an 8-bit gray image Canny edge detection algorithm is applied on it to acquire edge in the image (Fig. 2(c)).

Closing Morphological Operation: To segment out the pill from image it is necessary to find the boundary of pill. Morphological closing operation is used with disk shape structuring element to connect any edge pixel that is missed in the Canny edge detector during edge filtering process (Fig. 2(d)).

Fill Morphological Operation: Note that the image in Fig. 2(d) contains many smaller components, however we are interested in a single object representing the pill. Thus we apply fill morphological operator to finally acquire a single object (Fig. 2(e)).

Detecting the Pill in the Image: Now apply boundary enclose on the whole image the pill will be detected in the image (Fig. 2(f)).

2.3 Metric for Shape Measurement

Now that we have the pill image in more suitable form for measuring geometric parameter values. Depending upon the types of measurements used in image processing or analysis it is possible to split and categorize any dataset in various way. One can categorize the measurement types based on scale. Roundness, which can express the radius of curvature of the object corners in the next smaller scale measurement. The types of measurement can also be categorized based on the assumption level and the degree to which the results are calculated. In this case linear results such as area, perimeter can be calculated from the pixel map of the image. By these other results such as spherical equivalent volume and the circular equivalent diameter are calculated.

Finally, using several relations and ratios of the mentioned factors, metrics such as the aspect ratio, circularity, convexity, solidity, spherical equivalent volume, eccentricity, extent, elongation, convex hull area etc. may be calculated.

To categorize the RxIMAGE dataset we used Eccentricity, Extent and Narrowness (using aspect ratio) to separate the dataset into four categories. These are, Circular, Oval, Oblong, and Special (Fig 1).

Eccentricity: The ratio of the distance between two focal of the ellipse and its major axis length is known as eccentricity. Fig. 3(left) illustrates, how eccentricity can be a measure of shape. Its value is between 0 and 1. The shape with 0 (zero) eccentricity is actually a circle and eccentricity 1 (means) it's a line or line segment. It is a rotation and scale invariant property.

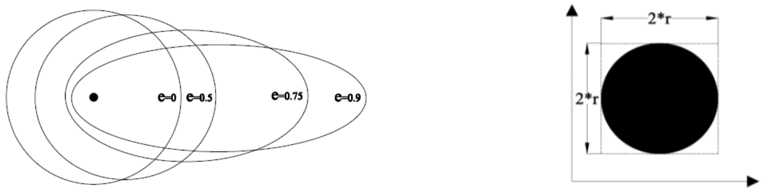

Fig. 3. (left) A perfect circle has an eccentricity of 0, while an oval or ellipse has 1, (right) Dimension of bounding box for a circle

Extent: It is the ratio of the area of the region to the total area of its bounding box (bounding box: the smallest rectangle containing the region) Fig. 3(right) illustrate and Eq. 1 gives the formula to measure extent of an image object. Though it scale invariant, however not rotation invariant. Thus we have to rotate the image according to its major axis to measure the correct value of extent. In theory if the extent is 0.7854 it's a circular shaped object.

$$Extent = \frac{Object\ Area}{Bounding\ Box\ Area} \quad (1)$$

Narrowness: It is defined as the absolute difference of aspect ratio and inverse of aspect ratio. The ratio between major axis and minor axis length is the measure aspect ratio (Eq. 2). If the narrowness is 0 (zero) the shale is circular. A higher value of narrowness (Eq. 3) will means the object is narrower.

$$aspectRatio = \frac{majorAxisLength}{minorAxisLength} \quad (2)$$

$$narrowness = abs\left(aspectRatio - \frac{1}{aspectRatio}\right) \quad (3)$$

3 Experimental Results and Discussion

We did all our experiments using the reference image-set from the RxIMAGE dataset. Table I provides distribution of data according to class.

TABLE I. Distribution of training and testing image

Type	Training Set	Testing Set
Circular	814	90
Oval	188	20
Oblong	722	80
Special	78	8
Sub-total	1802	198
Total	2000	

For all the images of the train dataset we had calculated the values for Eccentricity, Extent and Narrowness and empirically measured the minimum and maximum values for all three features such that we can differentiate four shapes from each other. The maximum and minimum values for three features is given in Table II. Here note that, it is possible to find in theory one precise value for each of the features, however in reality the value is rather a range not a single floating point number. We believe this is happening because, during the image processing steps, information lose occurs and shapes does not appear as strict and structured they should be. Moreover, the shapes of the pills are most of the time circle like, oval like, oblong like, triangle like, trapezoid like not exactly the geometric shape they are supposed to be.

TABLE II. Shapes vs minimum and maximum value of the features

		Circular	Oval	Oblong	Special
Eccentricity	Min	0.0107	0.7212	0.7637	0.0298
	Max	0.2104	0.8938	0.9496	0.8522
Extent	Min	0.7713	0.7598	0.8003	0.6050
	Max	0.7935	0.8013	0.9732	0.9439
Narrowness	Min	0.00011471	0.7509	0.9034	0.0008874
	Max	0.0453	1.7818	2.8779	1.3883

Based on the minimum and maximum values of all three feature values of Table II test dataset was tested. Value of Table II can group the test dataset into four shape category with 93.75% accuracy. Detailed result of this testing is given in Table III.

TABLE III. Detailed test results for all shapes of the test dataset

	In Test Image Set	Correctly Identified	Accuracy
Circular	90	90	100%
Oval	20	20	100%
Oblong	80	80	100%
Special	8	6	75%
Total	198	196	99%
Average Accuracy			93.75%

Fig. 4. Two pill images that were classified as oval shaped image instead of being classified as special type

Here note that, except the special shaped pills all others are correctly grouped according to their shapes. The two pills that are not correctly identified are classified as Ovals. In Fig 4 we are providing the pill images that are not correctly identified. It can be said that this particular morph is from an oval shaped object roughly we may call it oval. Intrinsic value suggest that it is an oval however visually they are not.

4 Conclusion

In this paper we have proposed an intrinsic geometric feature based approach to discriminate pill images into four categories: Circular shaped, oval shaped, oblong shaped and special shaped. The proposed method can discriminate them with 93.75% accuracy. However, it might appear in mind that size and color should be more dominant feature to discriminate prescription pills from their images. However, taking size as a feature to discriminate pills from images is a difficult one, as size is not scale invariant and photo is taken from two different height, so pills will have different size in the image. The goal of this work is to provide an initial screening of the pill images into smaller groups and then next we are working on how to farther split the dataset according to the color of the pill. Moreover, we intend to incorporate OCR techniques to farther refine the search. Such that we can determine the text or symbol inside the interior of a pill, and that will help us more to accurately identify what kind of medicinal pill is that.

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