COMPUTATIONAL COMPLEXITY ANALYSIS OF COIN RECOGNITION SYSTEM FOR REAL TIME IMPLEMENTATION

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Abstract

Accurate characterization and speed of reorganition is an important issue in coin identification and counting system. In this paper various techniques for coin detection are analyzed and compared which gives insight to design real-time coin detection on embedded platform. Based on these results the system designer gets the brief idea about the computational complexity involved in various algorithms. Here there are three techniques, Euclidean distance transform based, region property based and Hough transform based are analyzed.

Index Terms Edge detection, Morphological process, Euclidean distance transform, regional properties, Hough Transform.

I. INTRODUCTION

Automatic Methods for coin detection are required in many applications such as automatic selling-goods, vending vehicles and in counting coins in temples. In business transaction to recognize coins and other different forms of currency has been an essential process. Today in many parts of India, one rupee coin telephone booths are widely used. Any metal like that of original coin dimension can be inserted and the purpose can be solved. The image processing based (vision based) algorithm used in coin recognition system identifies the difference between coin and other metals, thus stopping telephone fraud. This technique can be used in machines that recognizes several coins simultaneously and do related work according to the instructions specified in the application [1].

Coin recognition is a difficult process in machine intelligence, because of its various rotations and widely changed input patterns. The coin reorganition problem can be considered as pattern recognition or pattern matching. Pattern recognition is a study based on mathematically derived conclusions. The technique of pattern matching is applied on set of images and extraction of sufficient mandatory characteristics is done for coin reorganition. Extracting sufficient monetary characteristics from the coin image is essential for accuracy and robustness of the automated system. This is challenging issue to the system designers. The existing coin recognition in the literature mainly involves image processing techniques. In this paper we discuss the coin classification based on Euclidean distance transform and regional properties and Hough transform and the comparison of the computational complexity is presented.

II. BLOCK DIAGRAM

The classification of the three systems is shown in the block diagram. As the image is changed to RGB image is common for all the three classifications. The right most classification follows Edge detection of the RGB image following morphological processes and Euclidean distance transform. And the middle classification follows binary image following

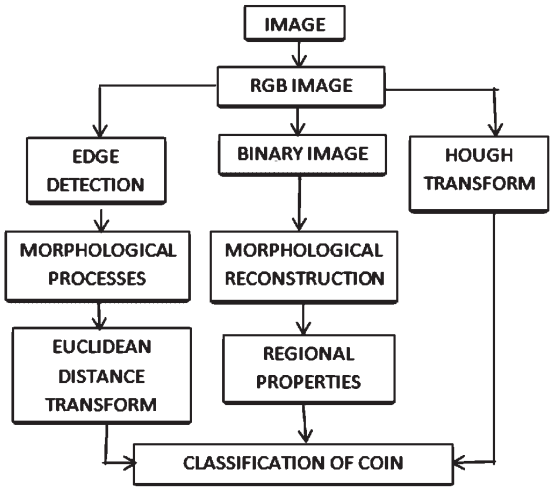

Fig. 1. Block diagram showing three classification systems

morphological reconstruction and regional properties. The last classification is based on Hough transform.

In all the three image processing systems we use various pre-processing filters to reduce the noise and extra computation complexity required for that is also analyzed, tabulated in table number-1. Median and Weiner are the two pre-processing filters used

In this paper we compare three coin classification systems. They are coin classification based on Euclidean distance transform, based on regional properties and classification based on Hough transform.

In this paper we describe Euclidean distance transform as system1, regional properties as system2 and Hough transform as system3. Here we give a brief outline of advantages and disadvantages of three systems and their computational complexity and thus giving a clear view for the designer to design a real time embedded system.

III. CLASSIFICATION BASED ON EUCLIDEAN DISTANCE TRANSFORM

Euclidean distance is widely used in pattern recognition it is based on a simple mathematics.

A. Edge Detection

Edge detecting is the first step in Euclidean distance based coin reorganition system. Edge detection is often used to identify objects and regions of interest in an image where there can be significant variation in size and colours of the objects of interest or the colours of the objects of interest are not known. In this paper edge detection is used to identify edges of the coins in the image. Here we are using canny edge detection We also analyzed various edge detectors like canny, sobel, prewitt, roberts, laplacian, zero-cross. Their computational complexities are tabled in table number-1. From the table is com complexity wise zero crossing, laplacian is good but it is not in the sense of accuracy. Canny is best one for the accuracy as well as for computational complexity.

Canny edge detection was developed by John F. Canny (JFC) in 1986. Even though it is quite old, it has become one of the standard edge detection methods and it is still used in research [2].

B. Morphological Processes

Morphology is a technique of image processing based on shapes. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors [3]. By choosing the size and shape of the neighborhood, we can construct a morphological operation that is sensitive to specific shapes in the input image. Morphology is involved in two basic operations of dilation and erosion.

Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image [4] [5].

In Fig. 4,5. It is shown the output of morphological operations in system-I.

C. Euclidean Distance Transform

Distance transforms are an important tool in computer vision, image processing and pattern recognition. A distance transform of a binary image specifies the distance from each pixel to the nearest non-zero pixel [6] [7]. Distance transforms play a central role in the comparison of binary images, particularly for images resulting from local feature detection techniques such as edge or corner detection [8][9].

Fig. 2. Gray scale input image

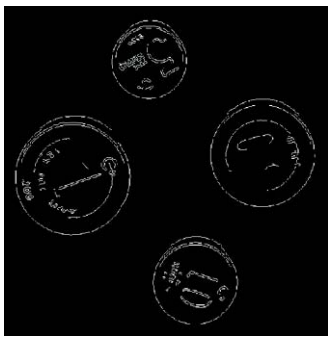

Fig. 3. Results of canny edge detection

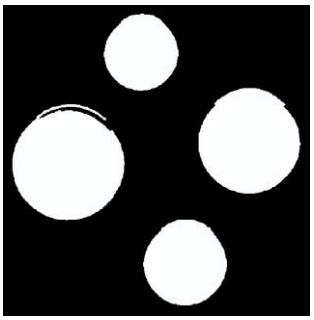

Fig. 4. Results of morphological processes

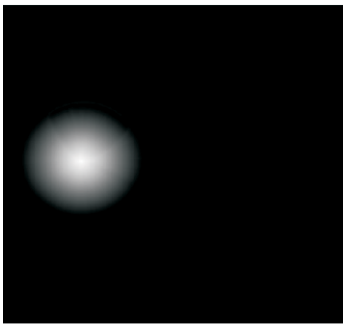

Fig. 5. Hole filled morphological output.

After morphological operation and hole filling the output of the image will be as shown in the Fig. 4.

Table 1. Computational Complexity of Edge Detection

Edge detection type	Total time (median filter)	Total time (wiener filter)
Canny	4.202	4.535
Sobel	6.658	7.591
Prewitt	5.14	7.076
Roberts	6.34	6.583
Laplacian	3.33	3.546
Zero-cross	3.38	3.765

The Euclidean distance from the centroid of the hole in the input image after the morphological operation (Fig. 5) is calculated. Then based on the Euclidean distance the coins are classified into various denominations.in our case the coins of denomination 100, 50, 10, 5 (turkey currency).

The below Table 1 shows comparison of different edge detection

Techniques when two pre-processing filters used.

IV. CLASSIFICATION BASED ON REGIONAL PROPERTIES

The difference between this system and previous one is that, here we use area of the coins to classify coins. The disadvantage of this system is it cannot classify images of same area as this classification is based on regional properties [12]. This system is very good for the images of different sizes.

Regional properties include area and centroid of the image taken. This system finds the area and centers of the images and compare with the original image and classify the images [13]. Area of the

Table 3 shows the area of each coin using regional properties and radius of each coin using Euclidean distance transform.

From the results obtained which are shown in table 2 we can conclude this system is very good in computational complexity sense.

V. CLASSIFICATION BASED ON HOUGH TRANSFORM

A. Hough Transform

Hough Transform (H.T) is a classical tool for multiple alignment detection in image processing, based on the property that Aligned Points are transformed into Intersecting Curves (APIC) [11].

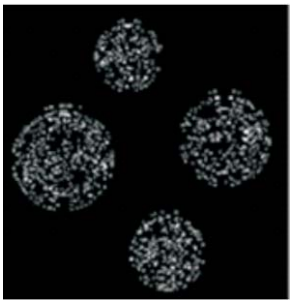

Fig. 6. Simulation result of zero-cross edge detection

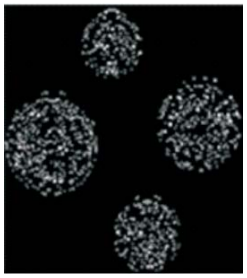

Fig. 7. Simulation results of laplacian edge detection.

Detection of different kinds of shapes, i.e. lines, circles, hyperbolas etc., in varying kinds of images arises in diverse areas such as signal and image processing, computer vision or remote sensing. The generalized Hough Transform is a traditional approach to detect a specific shape in an image by transforming the problem into a parameter space representation. In this paper we use the observation that the number of shapes in an image is much smaller than the number of all possible shapes [12]. This means the shapes are sparse in the parameter domain.

The Hough transform of the edges is performed on each object separately. This reduces the computational complexity of the algorithm as interactions between the objects are not added to the parameter space model, reducing the interference effect between the different lines in the image.

The below Table 2 shows total time taken by three systems without pre-processing filters and with pre-processing filter.

Table 2. Computational Complexity

System classification	Total time (no filter used)	Total time (Median filter)	Total time (wiener filter)
System -1	6.480	6.763	6.921
System -2	0.13	0.283	0.291
System -3	9.634	10.646	10.786

From the Table 2, it is very clear that coin classification based on regional properties is good for real time embedded systems.

Table 3. Area and Radius Values for Various Denominations

Denomination	Area of coin for regional properties (pixels)	Radius of coin for Euclidean distance transform (pixels)
100	32660	102
50	27700	94
10	18130	76
5	14520	68

VI. CONCLUSION

In this paper we compared three coin classification systems with two pre-processing filters. We found that coin classification based on regional properties is good for real time applications. But these systems cannot classify coins of similar area. This will be our focus in future.

VII. FUTURE WORKS

In the future we would like to extend this work to currency detection and detection of fake currencies with more accuracy .we would also like to extend this work for all the possible coin and currency. Usually coin detection system will not be able to handle different scaling of images that is captured with different distances and zoom scaling. So our work in future will be to develop a system with incorporating the capabilities. We would develop a program that will capture images at a constant distance based on algorithm requirement.

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