Morphological based Segmentation and Recognition of Indian Coins

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***Abstract*:**
Coins have very much importance in human's day to day life, which are used in everyone's daily routine like banks, super markets, vending machines etc. So, there is a basic need to automate the counting and sorting of coins. Coin recognition applications play an important role in industry and computer vision. Many approaches developed for the coin detection and calculate its corresponding values. This paper recognizes Indian coins of different denomination The recognition process consists of three steps, 1) we present a simple and fast method for coin segmentation, based on morphological thresholding technique to remove noise and to enhance the quality of coin image, 2) we applied some simple descriptors like mean intensity, area, perimeter to extract the regional features of the coins used for recognition and sorting and 3) we performed edge detection using statistical operators. Only after detecting the edges in the image the number can be recognized. In this paper we describe the pattern recognition method used for identification of coins in the new coin recognition and sorting system.

Keywords— *Edge detection, features extraction, segmentation, thresholding, top-hat transformation.*

I. INTRODUCTION

The ability to recognize the value of different forms of currency is a necessary skill in the everyday life of most human beings. In order to automate monetary transactions, it is necessary to enable computers to perform such recognition as well. Towards this end, we created a system that could correctly identify coins.

In this paper we describe the pattern recognition method based on statistical approach used for the identification of coins. This paper presents an automatic method for taking measurements on coins by means of spatial features of a coin, like area, perimeter and mean intensity. The coin segmentation works for a wide range of coins and backgrounds and is independent of the position of the coin. Segmentation of Indian coins was achieved using morphological top-hat based thresholding technique. Coin segmentation deals with the division of the image into two regions: the region depicting the coin and the region belonging to the background. Segmentation of present day coins was done in various papers. However, all of them make special assumptions and applied the Hough transformation for circle detection [1]. By definition, this approach is not applicable on ancient coins which likely show no perfect circularity. The global thresholding methods presented in [2] and [3] are applied to images acquired under controlled conditions.

For the image-based recognition ancient coins, initially a segmentation of the coin region is of out-most importance. The initial step of object recognition will be discussed as the problem of detection, i.e. foreground-background segmentation [4]. From a numismatic point of view, the shape of a coin is a very specific feature. Thus, the shape described by the edge of a coin serves as a first clue in the process of coin identification and discrimination. A shape based method tuned to the properties of ancient coins was combined with matching of local features through Bayesian fusion [5]. Ancient Coin Classification Using Reverse Motif Recognition was proposed by adding spatial information to the Bag of Visual Words model, which is invariant to scale changes, image rotations, and translation [6]. Image rotation invariance is introduced by rotating the image at fixed angular interval thus providing us with the exact angle of difference between the coins on analyzing the plot of the subtracted values [7, 8].

Many pattern recognition systems insensitive to transformation of an input pattern have now been presented. P. Thumwarin [9] presented the rotation invariance feature by the absolute value of Fourier coefficients of polar image of coin on circles with different radii. Minoru Fukumi [10] had proposed a neural pattern recognition system, which is insensitive to rotation of input pattern by various degrees. Results show that the neural network approach works well for variable rotation pattern recognition problem. Linlin shen[11] proposed the Gabor feature for coin recognition. In this the centre of the coin is located and concentric rings are used to achieve rotation-invariance.

There are different algorithms for implementation of vending machine using microcontroller and FPGA board. FPGA based vending machine give fast response than the microcontroller based vending machine. FSM based Vending Machine with auto-billing features. The

machine also supports a cancel feature means that the person can withdraw the request and the money will be returned back to the user [13].
For these machines, need to recognize the coins very fast and accurately, as further transaction processing depends on the recognition of coins. In this paper, we proposed morphological based Segmentation and Recognition of Indian Coins.

The rest of this paper is organized as follows. Section 2 describes the proposed method, Section 3 describes the experimental results, and conclusions are presented in Section 4.

II. PROPOSED METHOD

The proposed approach of coin recognition system consists of six modules namely, image acquisition, pre-processing of an image, segmentation based on morphological thresholding, feature extraction, sorting of coins with relevant denomination and edge detection. The flow of the proposed coin recognition process is illustrated in figure.1

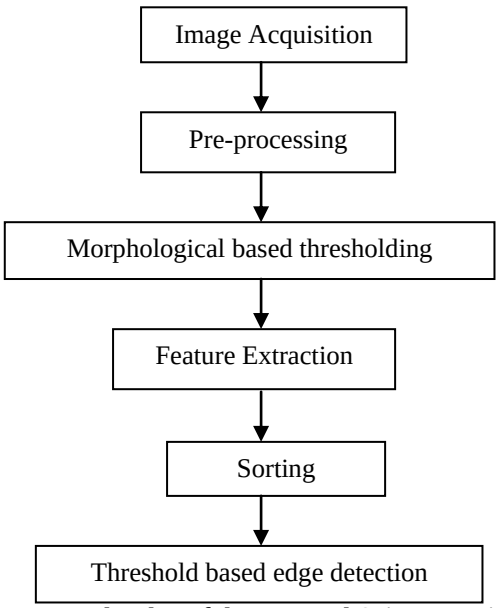


Figure -1: The Flow of the Proposed Coin Recognition Process.

Proposed Algorithm:

a. Image acquisition: We have captured the image of different Indian coins namely, Rs.10, Rs. 5, Re. 1, 25 np and 10 np, with resolution of 16 mega pixel under proper lighting conditions.
b. Pre-processing: We converted the RGB image into gray scale and size of the image is reduced to 1024 x 1024 using MATLAB.
c. Morphological based thresholding: We applied morphological based thresholding technique to segment the gray scale image. After applying threshoding, the gray scale image is converted to binary.
d. Feature extraction: We extracted the features, area, mean intensity, perimeter and centroid of the segmented coins. The centroid is considered to display the number on coin. The other three features, area, mean intensity, perimeter are used to sort out the coins. We have drawn boundary line of each coin on the image.
e. Sorting of coins: The coins are sorted out based on their features. Here, we have sorted out the coins of same denomination with good accuracy.
f. Edge detection: After separation, the images are converted back to gray scale. To make the coin denomination number visible, edge detection technique is applied.

A. Coin image Acquisition and Pre-Processing:

During the acquisition stage, coin image was acquired using a 16 Mega pixel camera with the specifications of the image such as Width and Height - 3263 x 2989 pixels, Horizontal resolution - 180 dpi, vertical resolution - 180 dpi and Bit depth - 24-bit. The original image is as shown in figure-2.

After image acquisition, preprocessing has been done. In pre-processing, we resized the image of size 1024 x 1024 pixels and the original colored image is converted to gray scale as shown in figure-3.

Figure-2: Original Image

Figure-3: Gray Scale Image

B. Morphological Based Thresholding:

Mathematical morphology act based on the structural properties of objects. These methods use mathematical principles and relationships between categories to extract the components of an image, which are useful in describing the shape of zones. Morphological operators are nonlinear, and two sets of data are their input. The first set contains the original image and the second one describes the structural element (mask). The original image is binary or in gray level and the mask is a matrix containing zero and one values [12].It is after applying the final image to the morphological operators that a new value for each pixel is obtained through sliding the mask on the original image. Value 1 in each mask indicates effectiveness and value 0 indicates ineffectiveness in the final image. Different formats can be selected to form a mask.

Selecting a mask in proper shape and size to take morphological actions has a key role in achieving desired results and reducing calculation time. In general, the shape and size of a mask are arbitrarily selected; however, the selected mask should be in appropriate shape and size for various diagnosis purposes. Morphological top-hat transform is used to enhance the contrast of the image.

Morphological Based Thresholding Algorithm:

i. Taking the input image and determining the shape and size of the mask. We use a disk-shaped mask with the initial. The size of the radius is increased arbitrarily according to the size of the original image
ii. Top-Hat transforms which first calculates the morphological opening and then subtracts it from the original image.
iii. Increase the Image Contrast using Enhancement technique
iv. Create a new binary image by thresholding the adjusted image

After applying morphological thresholding, the gray scale image is converted to binary as shown in figure-4.

C. Feature Extraction:

By extracting features from image processing sequence classification can be done by a discriminative classifier. To extract the features from an image, first we converted the image from gray scale to binary. Feature extraction is the process of generating a set of descriptors or characteristic attributes from a binary image. The strategy used for segmentation is boundary segmentation method which traces the exterior boundaries of objects, as well as boundaries of holes inside these objects, in the binary image. The features extracted from the coin image are mean intensity, area, perimeter and centroid.

The area can be formulated as the number of pixels in the object, or integration over an approximated continuous region. The perimeter can be formulated as the length of the boundary of a polygon, approximating the original object. The area and perimeter can also be determined faster by using an object representation that describes only the object boundaries. Almost all object measures are sensitive to the image resolution; the same image acquired at a different resolution will give different area and perimeter values. It is important to realize that the effect of changing resolution is different for different measures. For instance, the perimeter will generally increase with increasing resolution, while the area will converge to a stable value. The area and the perimeter of a planar object are two useful features to describe the shape of the object. This paper deals with the estimation of the features from a discrete binary image.

D. Edge Detection Based on Thresholding:

Many edge detectors are available in image processing literature where the choices of input parameters are to be made by the user. In this article, an edge detector is proposed where thresholding is performed using statistical mean and median operators. The ideal result of edge detection can trace the boundary of the object as well as the curves of surfaces. And edge detection is used for image segmentation registration and object identification. There are many approaches for edge detection, such as model-based approach, first-order derivative edge detection, second-order derivative edge detection and canny edge detection. The edge detector is very

sensitive to noise; the image should be pre-processing as well as post-processing to get a better result of edge detection. The median and mean filter is normally used to reduce noise in an image. Median filter often does a better job than the mean filter of preserving useful detail in the image. The mean filtering is simply to replace each pixel value in an image with the average value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean. Median value must actually be the value of one of the pixels in the neighborhood; the median filter does not create new unrealistic pixel values. For this reason the median filter is much better at preserving sharp edges than the mean filter. Median filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise.

Algorithm for threshold based edge detection:

1. Read the sorted image.
2. Convolve the sorted image with a suitable statistical *mean* or *median* operator
3. Subtract the original from the convolved image
4. Threshold the difference image with mean or median
5. Invert the thresholded image.

III. EXPERMENTAL RESULTS

The features extracted from the coin image are mean intensity, area, perimeter and centroid. The centroid is considered to display the number on coin. The other three features, area, mean intensity, perimeter are used to sort out the coins. We have drawn boundary line of each coin on the image which is shown in the figure 4.

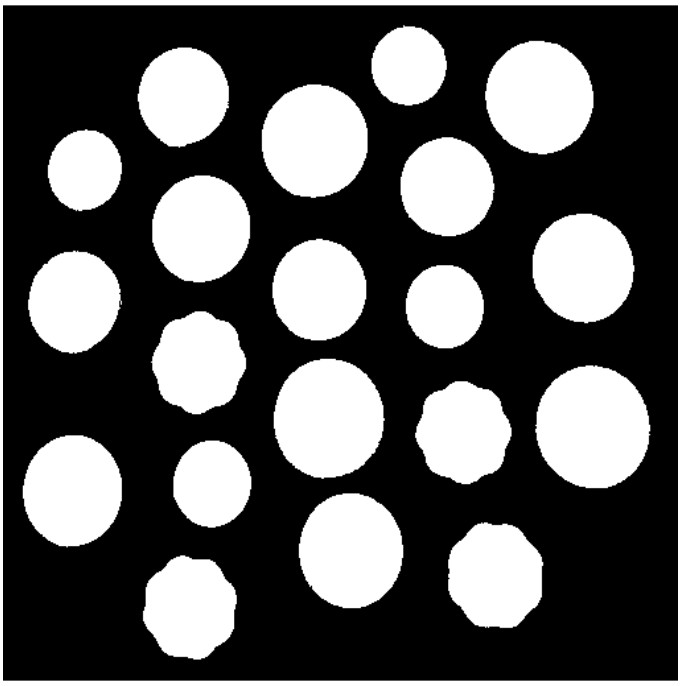


Figure-4: Result of Segmented Image (Binary)

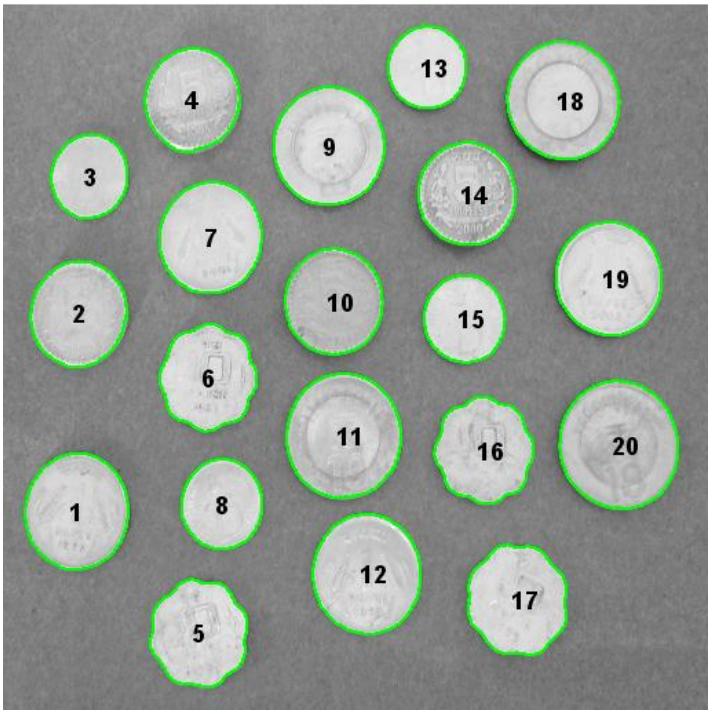


Figure-5: Gray Scale Image with Labeling

From Coin statistical Table:1, Compared to different denomination of coins, Rs. 10 coin has larger area and 25 paisa coin has smaller area. The area of Rs. 5 coin and 10 paisa coin is almost same, so that we compared with additional parameter mean intensity. Materials are different from coin to coin, so their mean intensities are changing. In this paper, 10 paisa coins are sorted out based on perimeter.

Table 1: Coins Statistical Table

S. No.	Coin	Mean Intensity	Area	Perimeter	Centroid(X)	Centroid(Y)
1	Re. 1	202.6430755	19951	530.2152955	108.4555661	737.1450053
2	Rs. 5	198.6689956	16746	518.2152955	110.9211752	450.3314224
3	25 NP	208.9722379	10662	385.747258	126.9020822	250.7977865
4	Rs. 5	198.4730793	16010	489.629509	276.0668957	139.2728919
5	10 NP	210.9613308	17042	497.8305192	286.1245746	914.4036498
6	10 NP	211.707806	16513	494.6589463	299.2880761	542.813662
7	Re. 1	214.1560888	19002	516.901587	302.9055363	339.8782233
8	25 NP	209.1535041	12143	410.8183259	319.416701	726.6178045
9	Rs. 10	211.7008861	21781	552.1147904	474.9150177	206.793857
10	Rs. 5	185.6895267	17177	492.7594514	481.9562205	432.7731269
11	Rs. 10	193.4117079	23796	611.7127702	496.0318541	627.5146243
12	Re. 1	204.1152831	21599	553.8721497	529.9504607	828.0006945
13	25 NP	222.2549222	10666	396.5756852	617.5740671	92.86508532
14	Rs. 5	191.0149621	16642	483.3452378	675.3692465	276.5144213
15	25 NP	216.0849801	11791	405.9898987	671.8807565	457.7748283
16	10 NP	203.4474845	16776	496.6589463	700.3315451	648.6751311
17	10 NP	210.7635735	18234	513.0437226	748.6669957	865.8904793
18	Rs. 10	202.1159381	21960	556.8427125	815.2581967	140.7555556
19	Re. 1	213.4781089	20031	528.2152955	881.4575907	399.1780241
20	Rs. 10	187.7350708	25286	600.884343	896.13549	640.701574

All the sorted out images of coins with different denomination and their respective edge detected images are shown in figure-6 to figure-10.

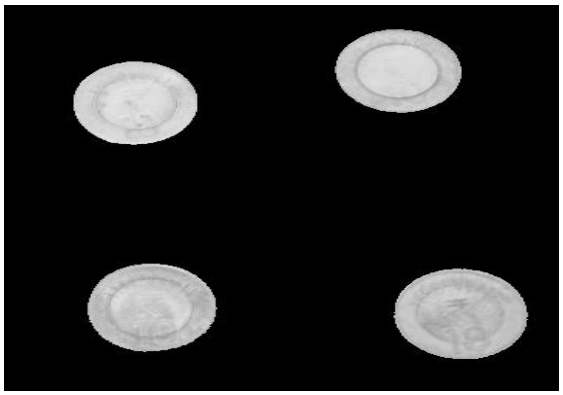


Figure-6(a): Sorted out Image of Rs. 10 coins.

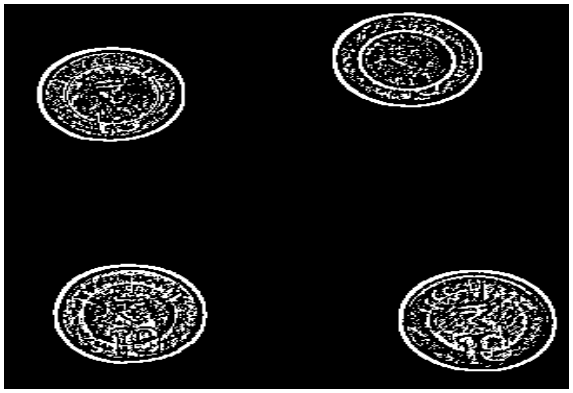
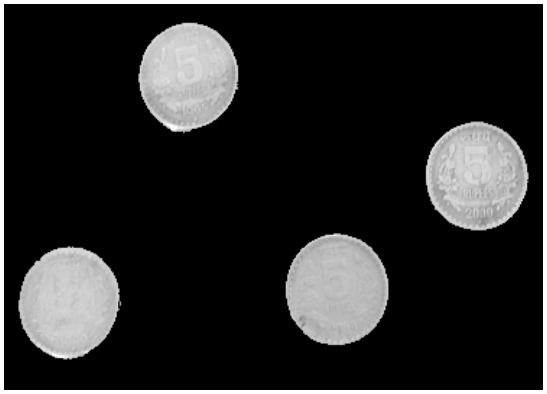


Figure-6(b): Edge Detected Image of Rs. 10 Coins



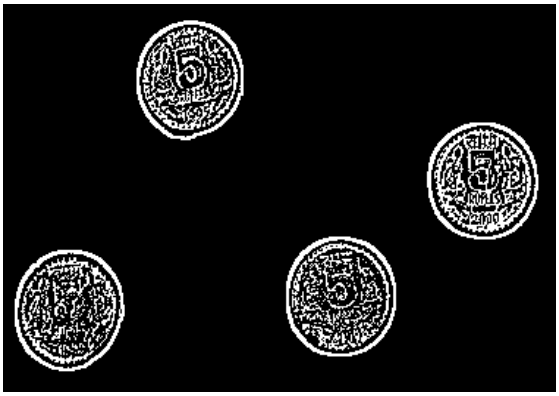


Figure-7(a): Sorted out Image of Rs. 5 coins.

Figure-7(b): Edge Detected Image of Rs. 5 coins

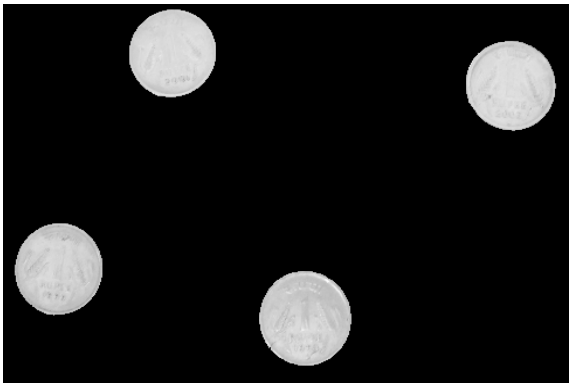


Figure-8(a): Sorted out Image of Re. 1 Coins.

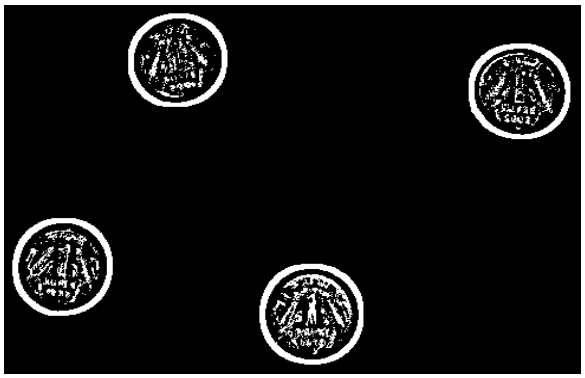


Figure-8(b): Edge Detected Image of Re. 1 Coins

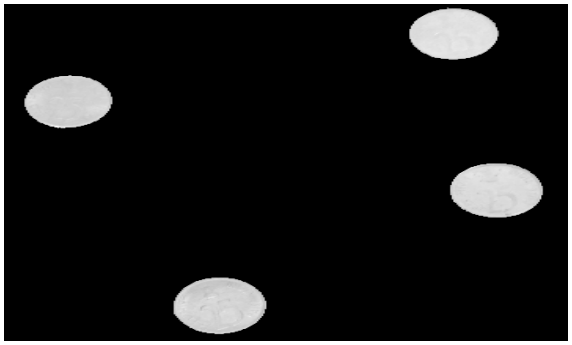


Figure-9(A): Sorted Out Image of 25 Paisa Coins.

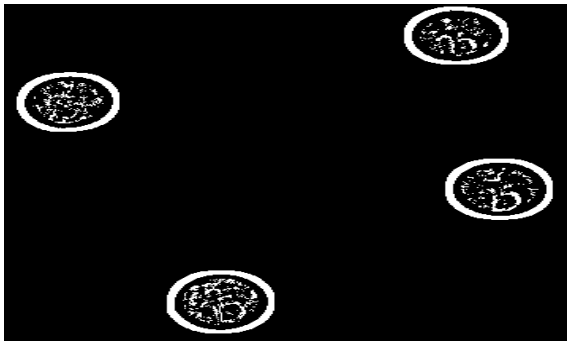


Figure-9(B): Edge Detected Image of 25 Paisa Coins

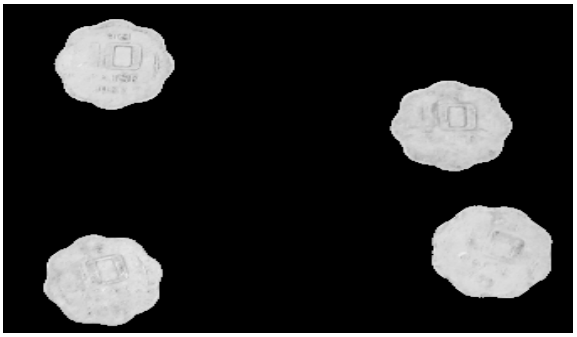


Figure-10(a): Sorted Out Image of 10 Paisa Coins.

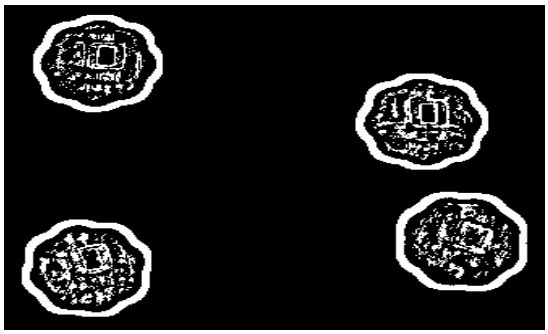


Figure-10(b): Edge Detected Image of 10 Paisa Coins

IV. CONCLUSION

By analyzing the experimental results, it is evident that, the proposed method yields the good result. This paper could classify coins released during various time periods based on the coin shape, metal of the coin. Moreover, the classification could be done based on the area, mean intensity and perimeter of the coin. In this paper, we have presented threshold based edge detection and morphological thresholding which are suitable for non-uniform illuminated and noisy images also. The position of camera may not be always stable, because of this; same type of coins may vary in size in case of Rs.5and Rs. 10 coins. Even though, we sorted out with good accuracy.

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