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An Efficient Coin Recognition Technique using Rotational Invariance Approach

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Abstract: ***Coins are used in day to day life at various places like in banks, supermarkets, and automated weighing machines. These machines must recognize the coins accurately. In this work we concentrate on Image processing method based system for coin recognition. In presented system, initially coin image is acquired. Then image is given for segmentation. Here image is converted into grayscale image and then into binary image. Image is then given for radius calculation. Next, radial Blur technique is applied to that image. This image is then compared with database image. Finally we are showing the minimum value and the angle at which coin is detected. Our system provides better results within short period of time.***

Keywords: Coin Recognition, Segmentation, Radius Calculation, Radial Blur

1. Introduction

What is an image?

An image is 2D array of pixels. It is a matrix or array of picture elements arranged in columns and rows. So pixels are smallest addressable elements or picture elements. Pixels are stored as integers. The integers can be 8 bit, 24 bit or 32 bit depending upon image type. In our work we are dealing with images of Indian coin. Presented system detects Indian coins of different denominations. Basically three coin recognition systems are available which include [1]:

- Mechanical method based system
- Electromagnetic method based system
- Image processing method based system.

Mechanical method based system, considers the physical characteristics of the coins. If we gives 2 coins, out of which one is fake and another original, with different materials but having the same thickness then this system is fails to differentiate between these coins and treat these coins as original coins.

In electromagnetic method based system, an oscillating coil is used. Coins are passed through the coil at certain frequencies. Different materials bring different changes in amplitude and direction of the frequency. In this method the accuracy of recognition is better, but if a user passes coins used for gaming, then this system fails to recognize the coins [1].

We are using Image processing method based system, in which first image is acquired. Then Image Segmentation is carried out. Next, radius of the image is calculated. And it is matched with radius of test image which is stored in the database. Finally results are displayed.

2. Related Work

Harveen Kaur and Neetu Sharma (2014) developed a Rotation Invariant Coin Identification System along with pattern matching using a neural network. This system is capable of collecting data and extracting the features of coin. In the first step the RGB coin image is acquired. Then RGB image is converted into Grayscale image. They have used Sobel filter for detecting the edges from image and to find radius and centre. In the next step they have generated feature vector. This feature vector is then given for trained Neural Network. Neural Network then classifies the coins [2].

Sabita Pal, Gaurav Kumar, Sovan Raj Meher(2014) developed a simple automatic coin recognition system. This system checks the radius and Centroid of the coin image and then applies coarse and fine subtraction on input image. A subtraction between object image and database coin image is performed which provides fast recognition and good accuracy [3].

Saranya das.Y. M and R.Pugazhenthi (2013) used Harris-Hassian algorithm for detecting the coins of different denominations. In pre-processing step they have used Gaussian filter to smooth the image and then gray level thresholding is done to obtain binary image. For extracting the features they have used Harris-Hassian detector. Next, the threshold value of feature points of the coin is calculated. Circular Hough Transform is used for circle detection. After circle detection coins are classified according to radius and threshold value [4].

Tushar N.Nimbhorkar and M.M.Bartere (2013) presented a coin recognition using Artificial Neural Network. They have used Sobel Edge Detection for detecting Circular Boundary. For removing shadow from the coin image they have used Circular Hough Transform. After they applied Discrete Cosine Transform and Discrete Wavelet Transform to segment the image into small blocks. Then pattern averaged image is generated. In the last step feature vectors are generated and given as input to the Neural Network [5].

Dr. Seema Bawa and Shatrughan Modi (2011) have developed System for the recognition of Indian Coins. They have used Hough Transform and Pattern Averaging techniques for extracting the features from the image.97.74% recognition rate has been achieved using this network [6].

C.M.VELU and P.VIVEKANANDAN (2011) developed system for recognizing the coins and counting the total value of the coin. They have developed Multi-Level Counter Propagation Neural Network (ML-CPNN). The system mainly considers affine transformations which include, simple gray level scaling, rotation, shearing etc. They have used Robert Edge detection, LoG edge detection and canny edge detection and also shown the accuracy achieved with the three detection techniques [7].

J Prakash and K Rajesh (2009) proposed A Novel Approach for Coin Identification using Hough Transform ,Eigen values of Covariance Matrix, and Raster Scan Algorithms. Here coin image is converted into grayscale image and edge detection technique is applied on this image. Covariance matrix is then calculated. Now small and large Eigen values are obtained. Then sparse matrix technique is used for obtaining CHT for Eigen value images. Next, neighborhood suppression scheme is applied to find the meaningful set of distinct Hough peaks. Then they have obtained circumference pixel locations using Bresenham's Raster scan algorithm. After the extraction of circular objects coins get identified [8].

Ming Ma, Dong-Won Park ,Kulwinder Singh, Juno Chang (2005) developed region-oriented segmentation technique for coin recognition. They have used an improved K-means clustering algorithm, which speed up the automatic determination of the optimal number of classes, and all the gray-levels are grouped into several clusters. Then a label image is obtained. Then features are extracted from the label image [9].

Michael Nolle, Harald Penz and Michael Rubik (2003) developed a new coin recognition system called Degobert. This system consists of three parts namely Coin detection, Pre-selection and Coin verification. The main purpose of this system is to sort high volumes of coins [10].

Minoru Fukumi et al.(1992) developed a system which has a fixed invariance network and trainable multilayered network. 500 yen coin and 500 won coins were used in this system [11].

3. Methodology

We have developed Indian Coin Recognition System with rotation invariance approach. We are using Radial Blur Technique which reduces the processing time of the system.

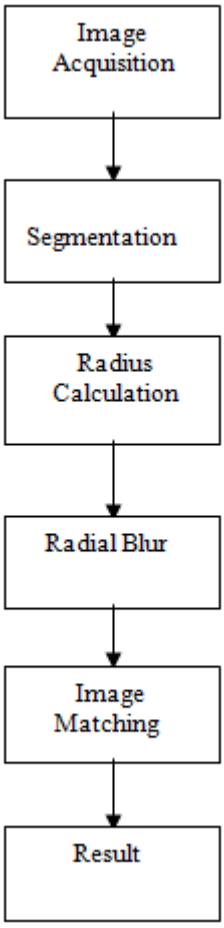

Figure 1: Developed Architecture

Figure 1 shows the developed architecture which consists of following components:

3.1 Image Acquisition

Here an image of the coin is acquired. This is an object image. This image is then converted into grayscale image and next into binary image for further processing. An image is 2D array of pixels in which each color pixel is described by the triple of intensities of Red, Green and Blue color. i.e. each pixel has three different intensity values. But in grayscale image these values are converted into single value.

Color image is converted into grayscale image using following formula [12]:

gray = (0.299*r + 0.587*g + 0.114*b)

3.2 Segmentation

It is a process in which an image is divided into segments. This process changes the representation of the image so that it is easier to recognize and analyze. Segmentation is used to locate boundaries in an image. Here we are separating the coin image from the background so that we can concentrate only on coin. In our work we are using Canny edge detector which involves:

- Noise Reduction
- Finding the intensity gradient of the image

- Non-maximum suppression [13].

In Noise Reduction phase Gaussian Filter is used to remove the noise. If there is a 5x5 Gaussian filter, used to create an image, with σ =1.4.

(The asterisk denotes a convolution operation.)

$$\mathbf{B} = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * \mathbf{A}.$$

In the second phase, four filters are used to detect vertical, horizontal, and diagonal edges in the blurred image. The edge detection operator now returns a value for the first derivative in the vertical and horizontal direction.

Horizontal direction = G_x
Vertical direction = G_y

Here edge gradient and direction is calculated as:

$$\mathbf{G} = \sqrt{\mathbf{G}_x^2 + \mathbf{G}_y^2}$$
$$\mathbf{\Theta} = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x),$$

atan2 is the arctangent function with two arguments.

Third phase is non maximum suppression which is used for thinning purpose. At every pixel, the edge strength of the center pixel gets suppressed if this magnitude is not greater than the magnitude of the two neighbors in the gradient direction [13].

Steps of Canny edge detection algorithm:

1. Acquire the source image. This image may be noisy. To reduce noise use Gaussian Filter.
2. Now take the blurred image and find the edge gradient and direction. Here value for first derivative in both axes is obtained.
3. Now non maxima suppression is done for thinning the edge. Only local maxima should be marked as edges
4. Final Edges are determined through tracing and hysteresis thresholding

3.3 Radius Calculation

Now we are having centre of the coin image so from that we can calculate the radius of the coin image. This object image is then given as input to radial blur technique.

3.4 Radial Blur

This technique blurs the image according to user defined angle and points. We are applying this technique on the object image. Here brightness value of each pixel is averaged with all pixels at the same distance. We are following rotation invariance approach, so it is not necessary to place the coin at certain angle.

3.5 Image Matching

Here object image is compared with test image present in the database. We csn see object image in image verification column. Only threshold value is considered in this step.\

3.6 Result

If coin is accepted then we are showing a result that coin is detected. Here we are also showing the value of minimum score and angle.

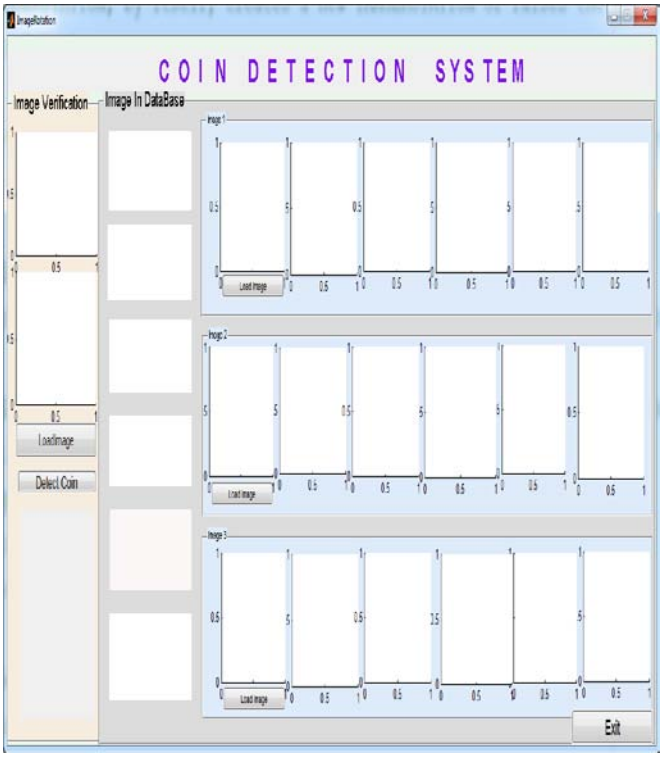

Figure 2: Coin Recognition System

Fig 2 shows our coin recognition system, in which we are loading the coin image in image verification column. This is an object image.

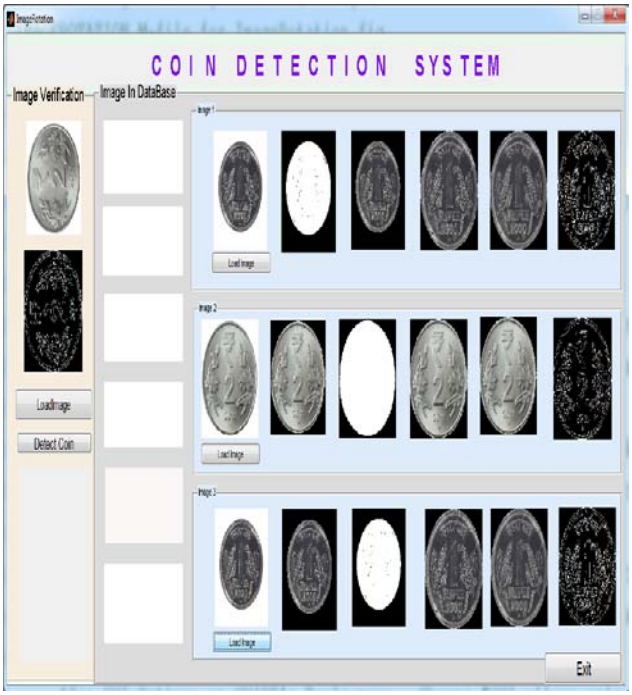

Figure 3: Loading object image

As shown in fig 3 object image gets loaded into verification column. The second coin image in the verification column is the result of edge detection technique.

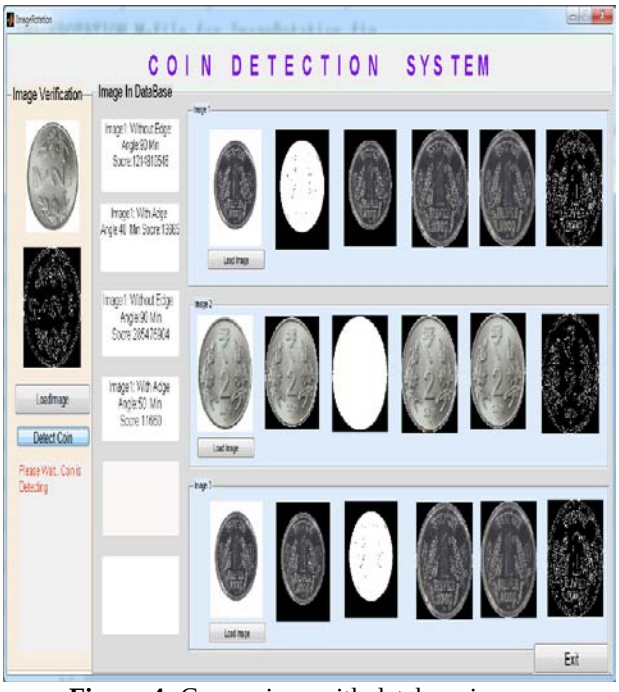

Figure 4: Comparison with database images

As shown in fig 4 now we are comparing object image with database images. In second column we are showing the minimum score and the angle. Here when we press Detect coin button, system gives the result whether coin is detected or not.

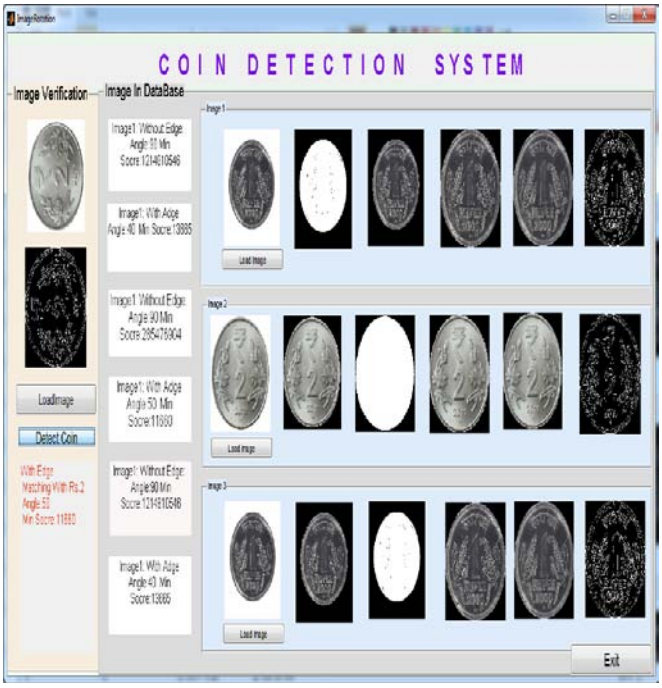

Figure 5: Final Result

Fig 5 shows the final result. Here we are showing the angle at which coin is matching with database coin and also the minimum score at which coin gets detected.

4. Conclusion

Our Coin recognition system takes an Indian coin of any denomination and detects whether the coin is original or fake. In our work we are following rotation invariance approach so it is not necessary to place the coin at specific angle. Image Segmentation is used as one important step which reduces the amount of data required for processing. Our system takes less time for processing and gives the best results.

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