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A Robust Rotation Invariant Coin Recognition System

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Abstract: Coins are frequently used in everyday life at various places like in banks, grocery stores, supermarkets, automated weighing machines, vending machines etc. So, there is a basic need to automate the counting and sorting of coins. For this machines need to recognize the coins very fast and accurately, as further transaction processing depends on this recognition. Three types of systems are available in the market: Mechanical method based systems, Electromagnetic method based systems and Image processing based systems. This paper presents an overview of available systems and techniques based on image processing to recognize ancient and modern coins.

I. Introduction

We cannot imagine our daily life without the use of coins. The usage of coins in our daily life is very common in places like bus tickets, super markets, banks, vending machines, post offices etc. coins have been a necessary of our daily life currency usage. Therefore the need of efficient and highly accurate automatic coin recognition systems arises. In addition to the daily usage, coin recognition systems were also a necessity for the research of ancient coins by various organizations. There are various systems for coin recognition in the market which can be subdivided into three types based on the method they used for the recognition:

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

In the recent years image processing based systems were also emerges as an option for coin recognition. These systems use camera or some scanning device processed by using various techniques (FFT, segmentation, DCT, neural network, Edge detection, full subtraction etc..,) of image processing and various features from the coin images are extracted based on which the recognition among different coins are done. We will mainly focus on image processing based coin recognition systems. Our project uses techniques like image subtraction, LBP and circular Hough Transform, which we are going to use in our system for implementation.

Processing of images that are digital in nature by a digital computer is known as Digital Image Processing [1]. A digital image can be viewed as a 2-D function $f(a, b)$, where a and b are plane coordinates and the amplitude of the function at any point a and b is called the intensity of the image at that point. A digital image is composed of finite number of elements called pixels, each having a particular value and location. The process of digital image acquisition is shown in Figure 1.3. The need of digital image processing is motivated by following major applications

- Improvement of pictorial information for human perception.
- Image processing for autonomous machine application.
- Efficient storage and transmission

Image subtraction (or pixel subtraction) is a process in which the pixel values of one image is subtracted with respect to the pixel values of another image at the same location. Image Subtraction is primarily done with two aims – to level uneven parts of an image (*e.g.* half image having shadow and half having the object), or for detecting difference between two images. This change detection is useful in determining whether something in the image is altered or moved. This is commonly used in fields such as in surveillance systems to detect intrusion, in astrophotography to assist with the computerized search for asteroids etc.

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Figure 1: Example of image subtraction (A) image 1 (B) image 2 (C) result image.

For subtraction images must be of same size and of same type. If the resultant image after subtraction is black then it indicates that both the images are similar else there‟s won‟t be a complete black image. The Figure 1 shows an example of image subtraction. In this subtraction is performed between image „A" and image „B" which is formed by rotating image „A" by few degrees. The resultant image „C" is not completely black which shows that both the images are not identical.

II. Rotational Invariance

Rotational invariance is used to found out if the image is rotated by a certain angle compared to an initial state. A zero value indicates no rotation and otherwise a rotation is there. An example showing rotation is shown in Figure 2. Finding rotational invariance is an important step because for the texture comparison our system requires the input image to be aligned at a specific angle. For rotational invariance multi-level image subtraction technique is used in our system.

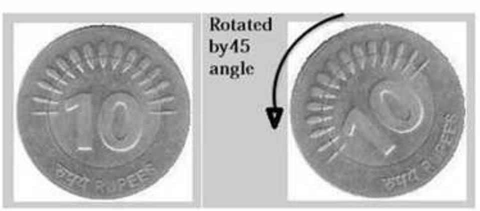

Fig 2: coin images indicating rotation invariance

III. Resolution

The images simply can be viewed as a matrix of N rows and M columns where each matrix element is known as a pixel. Each pixel is assigned a value that is the average brightness of its surrounding. Each pixel position can be given by a pair of coordinates (x, y). The resolution of a digital image is simply represented as the product of number of columns × number of rows. E.g. an image having a resolution of 800×600 indicated that it have 800 columns with each column having 600 pixels. Some other frequently used resolutions are 640×480 and 1024×728.

Resolution is a parameter commonly used to describe the quality of an image capturing device like digital camera. The resolution is described by the unit dots per inch. E.g. A display system having a resolution of 120 dots per inch (dpi). In our proposed system coin images of 200 dpi were used for the experiments.

IV. Problem Statement

The various existing techniques performs the recognition based on features like weight, thickness and diameter etc. which can be fooled by fake coins which have similar physical properties as of the original coins as they don’t take into consideration other features like color, texture etc. for the recognition. Therefore, to remove such discrepancies features such as color, radius, texture and rotation angle of the coin could be used so that more accuracy could be achieved in the recognition results.

V. Experimental Results

The system has been designed to perform the coin recognition based on multiple features like: radius, color, rotation invariance and texture.

Result for a Coin of Rs.10

The coin image of Rs.10 is taken as input. The dimensions of the input were 320×320. The sequence of results that produced by the system to provide our final recognition is as follows.

RGB to Grayscale conversion:

The input image is a true-color image. For processing we take a copy of the image and convert it to the grayscale image as shown in Figure.

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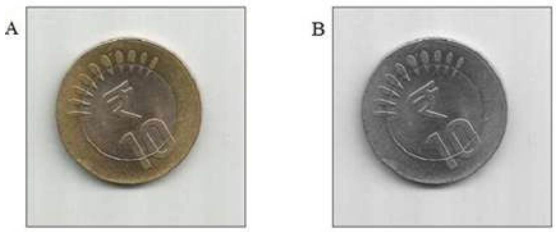

Figure 3: (A) colored image and its (B) gray-scale version.

1) Preprocessing and Radius Calculation results

The grayscale image is further preprocessed using the Hough transform to remove the unwanted background from the image and to know the radius of the coin. After the removal rest of the background is converted black as shown in Figure.

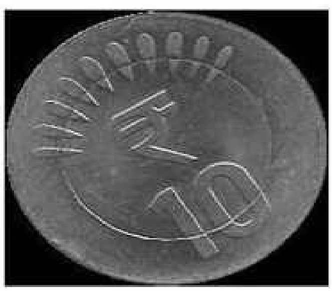

Figure 4: Image after pre-processing

Radius of the coin type is found out to be 106. Radius for all coins type used are as shown in Table.

Table 1: Radius of different coin types

Coin Type		Radius
1	Type(i)	86
	Type(ii)	95
	Type(iii)	95
2	Type(i)	95
	Type(ii)	106
	Type(iii)	106
5	Type(i)	89
	Type(ii)	89
10		106

2) Rotation invariance results

For the rotation invariance multi-level image subtraction technique is applied and the input is found out to be rotated by 26 degrees. The image after finding out the rotation invariance is rotated back to be in a desired position as shown in Figure.

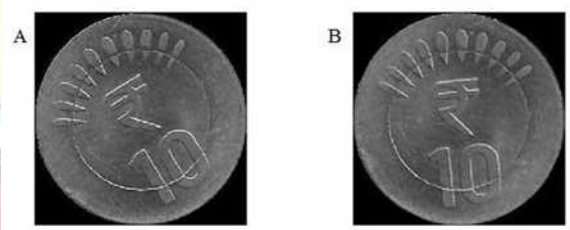

Figure 5: (A) Image before rotation (B) Image after rotation.

3) Texture comparison results:

After rotating the image to our desired position we apply LBP on the image to perform our texture comparison. The LBP output of the image is shown in the Figure.

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Figure 6: LBP output of the input image

The coin satisfies the threshold values for the Rs.10 coin. The table with various threshold values for LBP comparisons was shown in Table.

Table 2: Threshold values for the texture comparisons.

Coin Type		$LBP_{database}$-LBP_{input}
1	Type(i)	$\leq 5.69\times10^5$
	Type(ii)	$\leq 6.73\times10^5$
	Type(iii)	$\leq 7.62\times10^5$
2	Type(i)	$\leq 7.74\times10^5$
	Type(ii)	$\leq 6.74\times10^5$
	Type(iii)	$\leq 6.70\times10^5$
5	Type(i)	$\leq 6.63\times10^5$
	Type(ii)	$\leq 5.7\times10^5$
10		$\leq 7.9\times10^5$

Recognition based on results:

As the coin satisfies all the parameters for the coin of Rs.10, therefore it is a coin of Rs.10.

Overall Recognition results

We have used 5 samples of each type i.e. 5 samples of Rs.1 type(i), 5 samples of Rs.1 type(ii) and similarly for other coin types. Then we have rotated each sample coin by 1^{o}, so the total samples were 9×5×360=16200. All the coins used in the experiment are new with clear surface. The results are summarized in Table 5.4. The reason for less accuracy in case of Rs.2 Type (ii) coin is due to less accuracy in case of our rotational invariance due to which our texture comparison result values don't satisfy our threshold values.

Table 3: Final results showing accuracy achieved.

Coin Type		Recognition
1	Type(i)	97.74%
	Type(ii)	96.53%
	Type(iii)	93.37%
2	Type(i)	94.43%
	Type(ii)	78.89%
	Type(iii)	95.54%
5	Type(i)	96.81%
	Type(ii)	95.76%
10		98.56%
Avg. Accuracy		94.18%

Coin recognition using our approach shows positive signs for coin recognition. As all the three properties i.e. radius, color and texture are under consideration when we perform our experiments, the experiment results in an promising approach for coin recognition Future works will include modifications of the technique and also merging of other image processing techniques, such as, Neural Networks training for rotational invariance and using our approach on old coins. The snapshot of the graphical user interface of our system is shown in Figure.

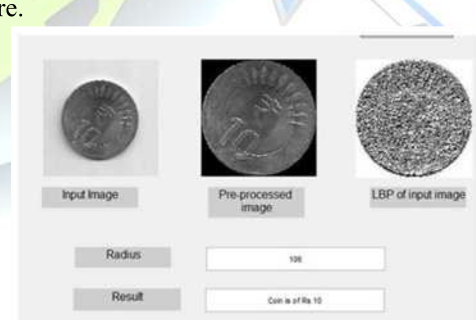

Figure 7: Snapshot of GUI of the Coin Recognition System.

VI. CONCLUSION

In this thesis a Robust Rotation Invariant Coin

Recognition System is implemented using PYTHON that considers various features of the coin image to perform the recognition. The process of coin recognition covers all the necessary feature by using various techniques, e.g. for radius Hough transform is used, for color comparison RGB channel values were compared, for rotation multi-level image subtraction is used and texture comparison is done by using the LBP operator. The recognition is based on the results of all the features. If the coin satisfies all feature tests, then only it stands recognized. The multi-level image subtraction technique used is better and a faster alternative for finding the rotation of the coin. The recognition rate of 94.18% is achieved during the experiment that proves the better quality of the system.

VII. Future Work

The system covers the features of an image only, by combining it with an electromagnetic system will further increase its capabilities. Also the existing techniques like neural network, spiral decomposition, Fourier coefficients etc. can be merged into the system to improve results. A dataset of coin images of other countries can be used to check the effectiveness of the system methodology.

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