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A Novel Approach for Identification of Fake Indian Currency Using Genetic Algorithm

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Abstract

In any country, there is always arrival of different kinds of new currency from time to time. In India, the government applied demonetization in the year 2016, and later on, there was the arrival of new notes in the form of 10, 20, 50, 100, 500, and 2000 Indian rupees. Although it minimizes the use of fake currency in any Country but hackers and intruders generate the fake currency through a high-quality scanner and printer. In the present work, an application of the Genetic algorithm is used for the identification of fake currency based on feature extraction. An algorithm has been implemented for the identification of fake currency in the form of notes.

Keywords: *Genetic Algorithm, Currency, Security, Feature Extraction, Pattern Recognition.*

1. Introduction

In the year 1968, Charles Darwin developed a theory based on the biological evaluation that states the natural existence of the strongest species. This was based on the natural selection of small inherited variation for increasing the individual ability to compile, survive, and reproduce. Based on this theory, the concept of the genetic algorithm was developed by Goldberg. Since the present work is based on the application of a genetic algorithm for the identification of fake Indian currency notes, therefore, it is necessary to describe some of the important references related to the work.

Hermawanto [1] explained the concept of a genetic algorithm for solving the mathematical equality problem by taking the four variables. In the year 1997, Gen and Cheng [2] proposed the concept of the genetic algorithm to achieve crossover by a solution of irregular cut point and created the off-screen by a blend of one parent to one side cut point which section of the other parent of the correct slice point and applied it to the designing point. Bashkansky and Yaari [3] proposed a famous approach of a black box which is used for selecting the optimized chromosomes which is a very advantageous approach and simple to implement the genetic algorithm. One of the important paper introduces in the year 2012 which was Dharmistha and Vishwakarma [4] developed accuracy process model and further optimized the weights assigned on the internal layers' architecture of the Artificial Neural Network (ANN). Nanhao and O'Connor [5] described the genetic algorithm which is also used in the field of wireless sensor networks with which a method for finding the 100 possible solutions for a given task. In the year 2015, Bashir [6] explained the bit by bit mathematical calculation of hereditary calculation for addressing the Eggcrate work. The outcomes demonstrated that the Eggcrate work has a known worldwide least at [0, 0] with an ideal capacity estimation of zero. Bashir and Mahdi [7] explained Queen Problem which is a well-known optimization technique used for the genetic algorithm. Further, the application of generation is described by the solution of

fitness function by selecting the coordinated and fitness function [8, 9]. The other important references related to genetic algorithms are [10, 11, 12, 13, 14 and 15]. From the review of the literature, it is observed that there is little use of the genetic algorithm for solving the problem related to identifying spatial, transform, edge and boundary, color, shape, texture features of any kind of the Image.

In the present work, the concept of genetic algorithm is used for finding the generation of new chromosomes process till the matching of the result. Sufficient iterations have been performed by the use of Python programming language. Results are depicted on Indian currency of note of Rs 500.

2. Methodology and Implementation

For Implementation of the concept of genetic algorithm, the following steps are used:

1. *Input the image of the note of Rs 500 and compute the number of chromosomes generation, crossover rate, mutation rate values;*
2. *Divide the chromosomes into the number of blocks of the same size;*
3. *Initialize the number of chromosomes by taking the four variables;*
4. *Repeat the following sub-activities for identification of fake currency;*
   - *4.1. Compute the fitness value of the chromosomes of the objective function;*
   - *4.2. Compute the highest fitness function chromosomes and the selection of the chromosomes;*
   - *4.3. Compute the chromosomes along with probability values;*
   - *4.4. Mutate rate parameter by reproducing the genes at a random position;*
5. *Repeat step 4 till the finding of the best chromosomes.*

The genetic algorithm assesses the objective function to be upgraded at some arbitrarily chosen purpose of the domain definition. By the utilization of this strategy, another arrangement of focuses (another population) is produced. Steadily, the focuses in the population approach towards local maxima and minima of the function. The above technique has been implemented in the Indian currency of note of Rs 500 and steps are discussed below in brief:

Step1

Input the scanned Image of Rs 500, then apply image pre-processing and extract the feature of the most vulnerable parts of currency. For this purpose, MATLAB is used to get the feature vector as shown in figure 1.

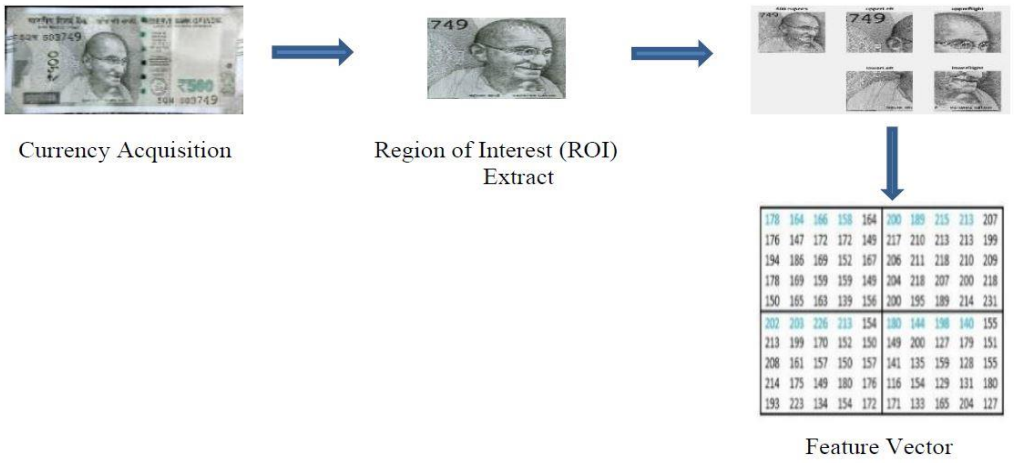

Figure 1. Feature Extraction of Rs 500

Step 2
Image is analyzed and divided into some blocks each with the same size and give a label to each block and save the pixels of each block in temporary storage to retrieve these Pixels as when constructing the original image matrix. The construction of the original matrix is represented in the following figure 2.

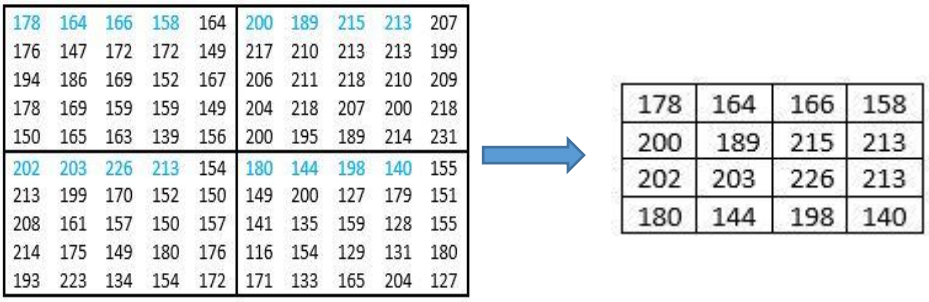

Figure 2. Construction of the Original Chromosomes Matrix

Step 3
Consider the initial population consisting of some chromosomes taken as Ch [ ] and each chromosome consists of some genes of a block in the blocks matrix that results from the first stage:

Ch [1] = [a; b; c; d] = [178; 164; 166; 158]
Ch [2] = [a; b; c; d] = [200; 189; 215; 213]
Ch [3] = [a; b; c; d] = [202; 203; 226; 213]
Ch [4] = [a; b; c; d] = [180; 144; 198; 140]

Step 4
Repeat the following sub activities for identification of fake currency:

Step 4.1
Compute the fitness evaluation taken as F_eval [ ] using objective function of each chromosome by taking fitness function as

$$f(x) = ((a + 2b + 3c + 4d) - 50) \quad (1)$$

F_eval [1] = Abs ((178 + 2*164 + 3*166 + 4*158) - 50) = 1586
F_eval [2] = Abs ((200 + 2*189 + 3*215 + 4*213) - 50) = 2025
F_eval [3] = Abs ((202 + 2*203 + 3*226 + 4*213) - 50) = 2088
F_eval [4] = Abs ((180 + 2*144 + 3*198 + 4*140) - 50) = 1572

Step 4.2
For finding the next generation, let us compute the highest probability of the fittest chromosome. To calculate the fitness probability, first, compute the fitness taken as fitness [ ] of each chromosome. To avoid partition by zero issues, the assessment of F_eval is added by 1 and represented below:

Fitness [1] = 1/ (1+F_eval [1]) = 0.00063011972
Fitness [2] = 1/ (1+F_eval [2]) = 0.00049358342
Fitness [3] = 1/ (1+F_eval [3]) = 0.00047869794
Fitness [4] = 1/ (1+F_eval [4]) = 0.00063572791

Total = 0.00063011972 + 0.00049358342 + 0.00047869794 + 0.00063572791
=0.00223812899

Step 4.3
The probability for each chromosome is to be computed by:

$$P[i] = Fitness[i] / Total \quad (2)$$

P [1] = 0.00063011972/0.00223812899 = 0.28153860784
P [2] = 0.00049358342/0.00223812899 = 0.22053394697
P [3] = 0.00047869794/0.00223812899 = 0.21388308812
P [4] = 0.00063572791/0.00223812899 = **0.28404435707**

Therefore, chromosome 4 has the most elevated the wellness esteem, this is the most noteworthy likelihood that to be picked for the cutting edge chromosome. For the computation of cumulative probability considered as Cum [ ], consider Roulette Wheel for the selection process as shown below:

Cum [1] = 0.2815
Cum [2] = 0.2815 + 0.2205 = 0.502
Cum [3] = 0.2815 + 0.2205 + 0.2138 = 0.7158
Cum [4] = 0.2815 + 0.2205 + 0.2138 + 0.2840 = 0.9998

Using Roulette-Wheel, to calculate the cumulative probability of selection process and generate the random number taken as Rand [ ] between 0-1 as given below:

Rand [1] = 0.201
Rand [2] = 0.284
Rand [3] = 0.099
Rand [4] = 0.822

If random number Rand [1] is smaller than Ch [1] then select Ch [1] as a chromosome in the new population for the next generation represented as New_Ch [ ].

New_Ch [1] = Ch [1]
New_Ch [2] = Ch [2]
New_Ch [3] = Ch [1]
New_Ch [4] = Ch [4]

Chromosomes Ch [ ] in the population are now represented below:

Ch [1] = [178; 164; 166; 158]
Ch [2] = [200; 189; 215; 213]
Ch [3] = [178; 164; 166; 158]
Ch [4] = [180; 144; 198; 140]

For interchanging the sub chromosome, used a one cut point to select a random point in the parent chromosome. Parent chromosome which will mate is randomly chosen and the quantity of mate Chromosome is controlled utilizing crossover rate taken as pc [ ] boundary. Chromosome k will be chosen as a parent if Rand[k] < pc. Assume one set that the crossover rate is 25% then chromosome number k will be chosen for crossover if a randomly created

an incentive for chromosome k underneath 0.25. Consider an irregular number taken as Rand [ ]:

Rand [1] = 0.191
Rand [2] = 0.259
Rand [3] = 0.760
Rand [4] = 0.006

For the random number above, parents are Ch [1] and Ch [4], will be selected for crossover:

Ch [1]> < Ch [4]
Ch [4]> < Ch [1]

After chromosome determination, the following cycle is deciding the situation of the crossover point. This is finished by producing a random number between 1 to (length of Chromosome - 1). For this situation, created random numbers ought to be somewhere in the range of 1 and 3. After that one get the crossover point, the parent's chromosome will be cut at the crossover point and its qualities will be exchanged. For instance, one produced 3 irregular number and get:

C [1] = 1
C [2] = 1
C [3] = 2

At that point for the main hybrid and second hybrid, parent's gens will be cut at gen number 1, Example

Ch [1] = Ch [1] > < Ch [4]
= [178; 164; 166; 158]> < [180; 144; 198; 140]
= [178; 144; 166; 140]
Ch [4] = Ch [4] > < Ch [1]
= [180; 144; 198; 140] > < [178; 164; 166; 158]
= [178; 144; 166; 140]
After the crossover process, compute the new chromosomes:

Ch [1] = [178; 144; 166; 140]
Ch [2] = [200; 189; 215; 213]
Ch [3] = [178; 164; 166; 158]
Ch [4] = [178; 144; 166; 140]

Step 4.4
After the change of chromosome dictated by the mutation rate boundary and mutation measure is finished by supplanting the gen at arbitrary situation with another worth. For this cycle, first process the complete length of gen (Tot_gen) in the populace as follow:

Tot_gen = Number_of_gen_in_Chromosome * Number of population
= 4*4
= 16

Therefore, in mutation measure, an arbitrary number is created between 1 to Tot_gen. To mark the position of gen in chromosome, whenever created arbitrary number is more modest than change rate (pm). Assume, characterize pm 10% it is normal that 10% (0.1) of total_gen in the populace that will be changed:

Number of mutations = 0.1*16
=1.6 = 2

Assume the age of irregular numbers yield as 8 and 14 then the chromosomes are Chromosome number 2 gen number 4 and Chromosome number 4 gen number 2.
Suppose generated random numbers are
Ch [1] = [178; 144; 166; 140]
Ch [2] = [200; 189; 215; **213**]
Ch [3] = [178; 164; 166; 158]
Ch [4] = [178; **144**; 166; 140]

For completing the change cycle, think about one emphasis or one generation of the genetic calculation. One would now be able to assess the target work after one generation as:

Ch [1] = [178; 144; 166; 140]
F_eval [1] = Abs ((178 + 2 * 144 + 3 * 166 + 4 * 140) - 50)
= Abs ((178 + 288 + 498 + 560) - 50) = 1474
Ch [2] = [200; 189; 215; **213**]
F_eval [2] = Abs ((200 + 2 * 189 + 3 * 215 + 4 * 213) - 50)
= Abs ((200 + 378 + 645 + 852) - 50) = 2025
Ch [3] = [178; 164; 166; 158]
F_eval [3] = Abs ((178 + 2 * 164 + 3 * 166 + 4 * 158) - 50)
= Abs ((178 + 328 + 498 + 632) - 50) = 1586
Ch [4] = [178; **144**; 166; 140]
F_eval [4] = Abs ((178 + 2 * 144 + 3 * 166 + 4 * 140) - 50)
= Abs ((178 + 288 + 498 + 560) - 50) = 1474

From the advancement of the new Chromosome, one can see that the objective function is diminishing, this implies that we have better chromosomes or arrangements contrasted and the past Chromosome age. New chromosome for the following emphasis are given beneath:

Ch [1] = [178; 144; 166; 140]
Ch [2] = [200; 189; 215; 213]
Ch [3] = [178; 164; 166; 158]
Ch [4] = [178; 144; 166; 140]

These new chromosomes will go through similar cycle as the past generation of Chromosomes, for example, evolution, selection, crossover and mutation and eventually, it creates another generation of Chromosomes for the following emphasis. This cycle will be rehashed until a foreordained number of generations.

Steps 5:
The above-said process is repeated until the finding of the best chromosomes.

3. Concluding Remarks

To execute the Simple Genetic Algorithm (SGA) code written in Python programming language, the fundamental three stages of the SGA, for example, select, crossover and mutation are manually determined. This method is called as generation and another populace creates at each progressive generation. Toward the finish of the run, rehashing the cycle until the best arrangement is resolved. After getting the best chromosome of acquiring, currency image is compared to a chromosome of reference currency image. To reduce the computation time, the proposed algorithm uses the currency. This paper is representing the calculation behind the genetic algorithm for paper currency detection.

The texture pattern of the genuine Rs 500 currency is exceptionally powerful in the process of information. The estimation of chromosome in the arrangement input utilizing the genetic algorithm technique can decide the exactness of the characterization procedure and identification of the realness of rupee currency. The genetic calculation finds close ideal outcomes rapidly subsequent to looking through a little segment of the hunt space. The calculation is not difficult to create and easy to comprehend and improvements effortlessly presented that show the viability of calculation. The computed results show that the genetic algorithm can find an optimal solution for currency identification problems.

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