Evolutionary Computing Techniques in Off-Line Handwritten Character Recognition: A Review

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***Abstract*- Handwritten character recognition is always a frontier area of research in the field of pattern recognition and image processing and there is a large demand for OCR on hand written documents. This paper provides a comprehensive review of existing works in handwritten character recognition based on Evolutionary computing technique during the past decade.**

Keywords- Handwritten Character recognition, On-Line and Off-Line Character Recognition, Neural Network, Fuzzy-Logic, Evolutionary Computation Technique.

I. INTRODUCTION

The advancement of digital computer, machine simulation of human function has been a very challenging and fascinating research area in the field of image processing and pattern recognition[1],[2].In this paper, all types of machine recognition of character in various application domain has been covered by character recognition (CR).The intensive research in the field of CR is not only because it helps in postal address, bank check amount reading but also because it automates processing of bulk amount of papers, transfers data into machines and web interface to paper document. CR has been classified based upon the two important aspects:

- According to the manner in which data has been acquired (On-line and Off-line).
- According to the text type (machine printed and handwritten).

This paper focuses only on the offline handwritten recognition systems developed in the past few years. Generally there are six major steps in the character recognition system which has been shown in fig.1.

1) Data acquisition 2) Pre-processing 3) Segmentation
4) Feature extraction 5) Classification 6) Post-processing

This paper is arranged as follows: In Section II, history of evolution of CR system is given, CR methodologies have been discussed in Section III, techniques used for off-line handwritten character recognition based on Evolutionary computing is given in section IV and the paper is concluded in Section V.

II. HISTORICAL EVOLUTION

Systems for recognizing machine printed text originated in the late 1950s and have been in widespread use on desktop computers since the early 1990s. In [3], historical review of off-line character recognition research and development is mentioned. In the early 1990s, image processing and pattern recognition are efficiently and effectively combined with artificial intelligence and statistical technique (HMM) [4],[5].

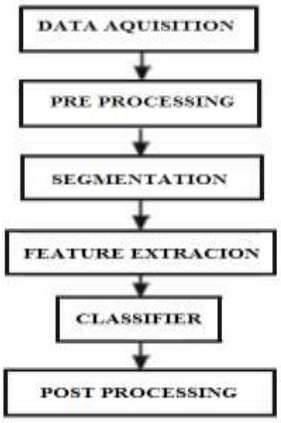

Fig.1. Typical flowchart for CR methodology

Now a day's Evolutionary Algorithm (EA) have been successfully applied to find the solution of numerous problems from pattern recognition domain. It uses biological evolution viz. reproduction, mutation, recombination and selection. The commonly used Evolutionary Algorithms are Genetic Algorithm, Evolutionary Programming, Evolutionary Strategy, Genetic Programming, Particle Swarm Optimization, Artificial Immune, Ant Colony Optimization and Invasive Weed Optimization and Bee's Optimization [17]-[29].

III. CR SYSTEM METHODOLOGIES

In this section the available methodologies to develop the stages of the CR system are presented. Fig.1. shows the typical flowchart for CR methodology and is discussed below:

A. Data Acquisition:

The progress in automatic character recognition systems is evolved in two categories according to the mode of data acquisition:

- On-line character recognition systems
- Off-line character recognition systems

Off-line character recognition captures the data from paper through optical scanners or cameras whereas the on-line recognition systems utilize the digitizers which directly captures writing with the order of the strokes, speed, pen- up and pen- down information.

B. Pre-processing:

A series of operations have to be performed during the pre-processing stages. The main objective of the pre-processing is to organise the information so that the subsequent CR task become simpler. It essentially enhances the image rendering it suitable for segmentation. The various Techniques performed on the image during pre-processing stage are shown in fig.2.They are discussed below:

- Noise removal: Optical scanning devices introduces some noises like, disconnected line segments, bumps and gaps in lines, filled loops etc. It is necessary to remove all these noise elements prior to the character recognition process starts. Various noise reduction techniques have been developed by various researchers [6],[7].

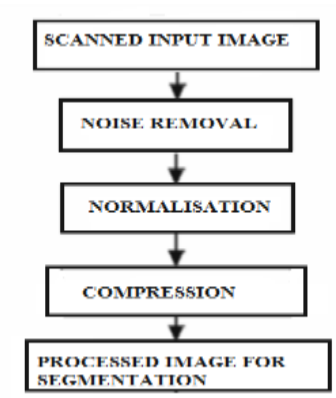

Fig.2. Flowchart for pre-processing.

- Normalisation: The main component of the pre-processing stage is normalization, which attempts to remove some of the variations in the images, which do not affect the identity of the word. Handwritten image normalization from a scanned image includes several steps, which usually begin with image cleaning, skew correction, line detection, slant and slope removal and character size normalization [8].
- Compression: Space domain techniques are required for compression. Two important techniques are thresholding and thinning [9],[10]. Thresholding reduces the storage requirements and increases the speed of processing by converting the gray-scale or colour images to binary image by taking a threshold value. Thinning extracts the shape information of the characters.

C. Segmentation

Segmentation is an important stage in CR system because it affects the rate of recognition. Segmentation can be external and internal. External segmentation is the isolation of various writing units, such as paragraphs, sentences or words. In internal segmentation an image of sequence of characters is decomposed into sub-images of individual character [11], [12].

D. Representation or Feature extraction

The feature extraction step selects and prepares data which is used by a classifier to achieve the recognition task. Feature extraction involves representing a handwriting text by a set of discriminative features. The feature representation is based on extraction of certain types of information from the image .A survey on feature extraction methods can be found in [13],[14].

E. Classification

The classification stage is the decision making part of the recognition system. The performance of a classifier relies on the quality of the features. There are many existing Classical [15] and soft computing techniques for handwriting identification. They are given as:

(a) Classical Techniques:

- Template matching
- Statistical techniques
- Structural techniques

(b) Soft Computing Techniques:

- Neural networks (NNs)
- Fuzzy- logic technique
- Evolutionary computing techniques

F. Post Processing

Post-processing stage is the final stage of the proposed recognition system [16]. It prints the corresponding recognized characters in the structured text form.

IV. CLASSIFICATION TECHNIQUES

In this section the handwritten character recognition based on Evolutionary computing approach is presented. The discussion is based on the research methodology used during the last decade.

A. Evolutionary Computing Techniques

Bio-inspired evolutionary algorithms are probabilistic search methods that simulate the natural biological evolution or the behaviour of biological entities. All Evolutionary computing techniques can be implemented independently or hybridization of these techniques is also possible [28].

De Stefano, A. Della Cioppa and A. Marcelli [17] presented a learning system that uses genetic programming as a tool for automatically inferring the set of classification rules

to be used during a pre-classification stage by a hierarchical handwritten character recognition system. Starting from a structural description of the character shape, the aim of the learning system is that of producing a set of classification rules able to capture the similarities among those shapes, independently of whether they represent characters belonging to the same class or to different ones. In particular, the paper illustrates the structure of the classification rules, the grammar used to generate them and the genetic operators devised to manipulate the set of rules, as well as the fitness function used to drive the inference process. The experimental results obtained by using a set of 10,000 digits extracted from the NIST database show that the proposed pre-classification is efficient and accurate, because it provides at most 6 classes for more than 87% of the samples, and the error rate almost equals the intrinsic confusion found in the data set.

A.D. Parkins and A.K. Nandi [18] applied genetic programming to the recognition of hand written digits from the USPS data set. Genetic programming is the implementation of the paradigm of the survival of the fittest from the natural world in the world of computation. Genetic programming is used to automatically create solutions to problems where the governing mechanisms are unknown. There have been no results presented on this data set using genetic programming. The authors introduced some variations on the selection and evolution methods normally used in genetic programming systems, in particular: aged members, directed crossover, inter-output crossover and node mutation.

A new Arabic character recognition system has been proposed by Muhammad Sarfraz1 and Ali Taleb Ali Al-Awami[19] using Moments as features. The proposed scheme works in such a way that the features are selected as well as weighted using a swarm-based optimization technique. For the sake of simplicity, it has been assume that the Arabic text has already been pre-processed and segmented. Recognition results have been achieved up to 82% of accuracy.

M. Hanmandlu at al. [20] introduced a new recognition scheme which employing a new learning technique. It uses the box approach for feature extraction. The authors presented the bacterial foraging for learning the parameters in the recognition of Hindi numerals by the use of the test function. A set of optimization function and test functions has been explored leading to the particular combination that gives an overall 96% recognition rate which is obtained with Shannon entropy function and other entropy functions have failed to yield good results.

Nasser Omer Sahel Ba-Karait and Siti Mariyam Shamsuddin [21] exploited Particle Swarm Optimization (PSO) based method to recognize unconstrained handwritten digits. Each class is encoded as a centroid in multidimensional feature space and PSO is employed to probe the optimal position for each centroid. The algorithm evaluates on 5 folds cross validation of handwritten digits data, and the results reveal that PSO gives promising performance and stable behaviour in recognizing these digits.

In order to eliminate the shortcomings such as pre mature convergence of traditional neural networks in handwritten Chinese characters recognition, a novel intelligent method is presented in the study [22] which uses the particle swarm optimization (PSO) algorithm with adaptive inertia weight to train the neural networks. The main idea is that the optimum weights and thresholds of the neural networks is acquired by the iteration and updating of the swarms, in this process ,the inertia weight of the swarm iteration is improved to be adaptive in this paper. In the experimentation, the quantity and distribution information of the strokes of the Chinese character is extracted as the features ,then the Chinese characters is classified by the improved PSO neural networks based on these features. Comparing with the BP neural networks, the improved PSO neural networks can avoid the premature convergence and achieve higher precision, in handwritten Chinese characters recognition, the application effect is very notable.

M. Keyarsalan at al.[23], proposed a method based on Particle Swarm Optimization to obtain the presentation order of training Persian fonts for improving the performance of Simplified Fuzzy ARTMAP. This method uses generalization error as a criterion to specify the best order of training patterns in this problem. The new method has the advantage of improved classification performance compared to the random ordering. The achieved average recognition rates were 91.24% for twelve popular Persian fonts.

Yuefeng Chen at al. [24] proposed a method in which the handwritten character recognition (HCRA) algorithm simulates the immune memory mechanism of biology immune system. After the immune training and learning, it evolves memory immune cells, and significantly improves speed and accuracy of recognition. The algorithm is a supervised classification learning methods. Co-stimulation means recognizing handwritten characters by the user's habit, and which will also be added to the set of memory cells, which will ensure the flexibility of recognition. Simulation results show that the HCRA algorithm has a higher recognition speed and accuracy than the neural network model in handwritten character recognition.

Arijit Sarkar at al.[25] described the application of Artificial Neural Network in Numerals recognition especially from handwritten documents for both the Bengali as well as English Numerals. The paper also deals with the computational analysis on the recognition output obtained from the neural network with the help of particle swarm optimization technique. The contribution to the research area from this paper is that, the proposed algorithm with PSO depicts that the normal training and testing efficiency obtained from the existing dataset is higher than the training testing efficiency with neural network based approach. It also focuses the PSO with mutation concept.

Handwritten Russian uppercase character recognition strategy using artificial immune system was proposed [26] and carefully experimented. With 36 feature coefficients extracted from 36*36 handwritten Russian uppercase character image using 6*6 sub-meshing and 14 contour coefficients as its feature vector, 33 antibody libraries for 33 character category were trained and built to recognize

handwritten Russian uppercase characters with artificial immune algorithm. The contrast experiment was done using BP neural network. The experimental results indicated that the artificial immune system model has more advantages than BP neural network in handwritten Russian uppercase character recognition.

Handwritten Nepali character recognition strategy using artificial immune system and wavelet packet transform was proposed by Yu Yang [27]. The preliminary experiment has been done on the consonant character using artificial immune system. With 116 feature coefficients extracted from 32*32 Nepali character images as its feature vector, which 84 were from wavelet packet transform and 32 achieved by horizontal and vertical histogram, consonant antibody libraries for its character categories were trained and built to recognize handwritten Nepali consonant characters with artificial immune algorithm. The contrast experiment was done using three-tiered feed-forward, back-propagation neural network model with 116 feature coefficients as input, 36 hidden nodes and 31 output nodes for consonant category, sigmoid transfer function. The experimental results indicated that the artificial immune system model has more advantages than Back Propogation neural network in character recognition.

Saurabh Shrivastava and Manu Pratap Singh[28] describe the performance evaluation for the feed forward neural network with three different soft computing techniques to recognition of hand written English alphabets. Evolutionary algorithms for the hybrid neural network are showing the numerous potential in the field of pattern recognition. The authors have taken five trials and two networks of each of the algorithm: back propagation, Evolutionary algorithm, and Hybrid Evolutionary algorithm respectively. They analysed that the feed forward neural network by two Evolutionary algorithms makes better generalization accuracy in character recognition problems. The problem of not convergence the weight in conventional back propagation has also eliminated by using the soft computing techniques. It has been observed that, there are more than one converge weight matrix in character recognition for every training set. The results of the experiments show that the hybrid evolutionary algorithm can solve challenging problem most reliably and efficiently.

G. Pirlo and D. Impedovo [29] presented a new class of membership functions, which are called Fuzzy-membership functions (FMFs), for zoning-based classification. These FMFs can be easily adapted to the specific characteristics of a classification problem in order to maximize classification performance. In this research, a real-coded genetic algorithm is presented to find, in a single optimization procedure, the optimal FMF, together with the optimal zoning described by Voronoi tessellation. The experimental results, which are carried out in the field of handwritten digit and character recognition, indicate that optimal FMF performs better than other membership functions based on abstract level, ranked-level, and measurement-level weighting models, which can be found in the literature.

V. CONCLUSIONS

Evolutionary Computing technique used in the field of handwritten character recognition during the last decade has been surveyed in this paper. Different Pre-processing, segmentation techniques and various classifiers with different features are also discussed. We described many methods, some of which are somewhat related to each other and some of which are more or less independent. The important point is that we should make these methods more precise in the sense of an exact science, not a mere accumulation of empirical knowledge. Neural Network and Fuzzy Logic methods of optimization are not robust to the dynamic changes in the problem of the environment and often require a complete restart in order to provide a solution (e.g. dynamic programming). To overcome these problems, researchers have proposed evolutionary computation for searching near optimum solutions to problems. We are intending to develop new technique with the help of literature review. We believe that our survey will be help full to the researcher in this field.

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