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# Hybrid Feature Extraction for Character Recognition using Genetically Optimized Neural Network

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*Abstract* –**The selection of features is an important step in any pattern recognition system. This selection of features is considered a combinatorial optimization problem and made the object of research in many disciplines. The main objective of the selection of features is to reduce the number of them by eliminating redundant and irrelevant features recognition system. The second objective of this feature selection is also to maintain and / or improve the performance of the classifier used by the recognition system. In this paper, Genetically Optimized Neural Network (GA-NN) algorithm is used to solve this type of feature selection problem in the recognition of character. The results in the selection of features have reduced the complexity of using GA-NN approach.**

*Keywords* –**Genetic Algorithm, Neural Network.**

## I. INTRODUCTION

The handwriting recognition is not a new topic. It dates back more than thirty years. The handwriting recognition proves an extremely complex problem that has no satisfactory solution to date. So quickly, the researchers restricted their studies to specific problems in connection with defined applications. Among them is quoted applications of handwriting recognition: automatic sorting of mail, the automatic processing of administrative files, forms, surveys, or the registration of bank checks.

In the field of handwriting recognition, features can be described as a way to distinguish an object (word, letter, number) of a class of another object (word, letter, number) of another class. Therefore, it is necessary to define meaningful feature when developing a system of recognition. Features are generally defined by experience or intuition. Several features can be extracted. Representation features used is a vector representation. The vector size may be wide if a large number of features is extracted. It has been observed that some extracted features are irrelevant or redundant in recognition system. The selection of relevant features is against a complex issue and is the subject of much research.

We propose an optimization method in the context of this work for the selection and weighting of features of a system of recognition of isolated handwritten character.

The optimization method used is based on the theory of Genetically Optimized Neural Networks. In this work, the optimization of the recognition system is advanced. The first criterion is to reduce the number of entries (feature) of the neural network, while the second criterion should improve or maintain the performance of the recognition system. When applying genetic algorithms, the inputs of the neural network are reduced. The problem is to perform the learning of the network for each found solution. To avoid re learning network and to minimize the computation time, the technique of sensitivity analysis is significant in this case. This technique is to replace the entries or features deleted from the neural network by the mean calculated of all features of the entire training set.

A second step adds to this work is the weighting of features. The weighting of the feature is to classify according to their respective importance. It identifies the most important features' recognition system. This approach is very delicate and cannot reach a solution because the neural network has already generated weight of each input during learning. However, we suggested to perform the weighting of feature once the selection is completed. This is to recover the feature selected by the genetic algorithm using the technique of sensitivity and boost learning network with this solution. And the weight matrix is generated again with a reduced number of network inputs. The weighting of the feature by the genetic algorithm is performed on the new network of neurons.

In this paper, we present framework for the character recognition based on neural networks and genetic algorithms. It then outlines the approach to

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optimize the character recognition system. Finally it illustrates the results of experiments we analyze.

## II. Character Recognition

Historically, man has been fascinated by the machines. The first controllers having fun and were performing repetitive tasks. Nowadays they are endowed with sensory organs allowing them to see, hear and even taste. Among the most sophisticated robots, there are those which are able to decipher the human writing. This field of writing still remains to be explored given its complexity and diversity. There are two areas of research: recognition of printed characters and handwriting recognition.

In the case of handwriting recognition, there are two fields of applications following the entry mode. If the input mode is dynamic, we talk about recognition in real time called online or on-line. In the case of the static entry is called deferred-time recognition called offline or offline [1]. The offline recognition applies once the writing is on paper that is scanned and saved to an image format. This image contains pixels either binary (black and white pixels) or integer (grayscale picture). This offline recognition includes two themes: the recognition of isolated handwritten characters (numeric or alphanumeric) and word recognition. Current applications are aimed more automatic reading of handwritten documents of the type checks or postal mail. Case studies focus on the recognition of handwritten characters from the segmentation of figures such as the digital amount of a check or postal code for an address or segmentation lowercase letters and / or capital in the case of such literal amount of a check or city name on an address. These isolated characters exhibit strong variations primarily caused by the position of the letter in the word.

In general, the objective of the handwriting recognition is to develop a system that is closest to the human being in his ability to read. However, the handwriting recognition is to extract an unknown form (word, letters, numbers) a simpler description and build on it a decision. This decision is usually made by measuring the similarity of an unknown form with a set of references stored in memory and described in a similar representation. The references are obtained from a qualified earlier phase of learning. This phase is very important in any system of handwriting recognition. In other words it is a passage of the observable space to a decision space of belonging to a class.

Building a handwriting recognition system comprises several distinct stages. The steps that are described by Duda et al. [2] are shown in Figure 1:

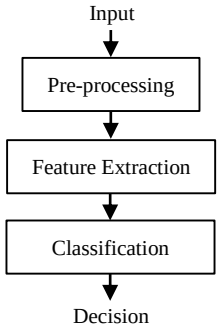


Figure 1: The steps of character recognition

The system acquires an input form or a signal from a sensor (camera, scanner, tape recorder, etc.). This input can be a scanned image or a voice signal to be stored in a file. Subsequently several processes are made on these images and files. The purpose of these pre-processing is to eliminate the phenomena which cause degradation of system performance, reduce quantization noise (binarization) and preserve the connectivity of the connected components in the image. The result of this phase will extract or highlight local or global features. This step will generate for each image, a vector features that serves as input to the head of the classification module.

In the next section we discuss the state of the art of each phase of recognition, namely: pre-processing, extraction of features and classification.

## III. Proposed Method

***Pre-Processing***

The goal of the pre-processing is to facilitate the characterization of the form (character, number, word) or entity to recognize either by cleaning the picture of the form or reducing the amount of information to process only keep only the most relevant information. The image cleaning is basically to eliminate residual noise from the binarization. Reducing the amount of information to be processed can be obtained from operations to bring the line thickness to a single pixel or by monitoring feature or from extractors of upper contours, lower and / or interiors.

Note that some forms (characters, numbers, and words) are inclined or bent so it is necessary to normalize slope this form to segment the form (E.g. segmentation of a word in letters). This standardization is to correct the slope of a word or correct the inclination of the letters in a word to facilitate segmentation.

Segmentation is a phase of pre-processing. Its purpose is to locate and extract as precisely as possible the information to recognize. It includes two stages: binarization and location information to recognize. Binarization is to reduce the amount of

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information to be processed when the image is grayscale and location of entities to recognize concerns shapes like lines, words, letters or groups of letters. The result obtained in this pre-processing phase will allow passage to the extraction phase. For details, structures Abhijit et al. [3] deal with this phase.

***Feature Extraction***

The purpose of feature extraction in the field of recognition is to express the feature in numerical or symbolic form called encoding. Depending on the case, the values of these features can be real, integer or binary. The vector composed of feature n represents a point in the new space of n dimensions. This stage of the recognition is to extract features to describe unequivocally the forms belonging to the same class of characters while differentiating them from other classes.

Trier et al. [4] indicated that the selection and definition of feature during extraction is the most important part of the recognition system, because the choice of these depends on the type of problem to solve.

There are different features extraction methods cited in the literature. Trier et al. [4] describe extraction methods based on the representation of the character. This extraction is done on images in grayscale, binary, binary contour and as a vector representation. Features are classified into two categories: [5] structural features (or local features) based on a linear representation of the character (decomposition of character in straight lines and curves, contours of the character, skeleton) and feature statistics (or feature global) based on the distribution of points, transformations and physical measurements on the character (space, time, projections). These two types may be combined forming a feature vector.

*Local Features:* These features are objects of the form such that the ends, crossings traits, loops and curls. The disadvantage of these features is that their extraction requires prior skeletisation character, since the thickness of the line does not contain any information. Nevertheless these are very feature robust with respect to the rotation, translation, scaling. In this category, there are 4 families of characteristics: intersections with straight, concave arches and occlusions, extrema and junctions [5]

*Global Features*

These features are derived from the distribution of pixels. There exist 3 families of characteristics such as moment invariants, projections, and profiles. They are extracted by considering the distribution of black pixels of the object (character, word, numbers).

The process of identifying the best method of feature extraction is not obvious. For example, Trier et al. [6] reported that Zernike moments apply well on grayscale images and the projection is often applied on characters segmented to solve their handwriting recognition problem.

However, it is necessary to perform for each recognition problem experimental evaluation of some methods for extracting the most promising features. These experiments will make a wise choice features to extract as often, the use of a single method of feature extraction is not sufficient to achieve good performance of the recognition system.

The obvious solution is to combine several extraction methods to give a better description of the form (character, number, word) to classify.

***Classification***

The classification is developing a decision rule that transforms attributes characterizing the forms in class membership (transition from code space to space-making) [2]. Before a decision model is integrated in a handwriting recognition system, you must have also previously two steps: the learning step and the test step.

The learning step is to characterize the shape classes so as to distinguish the homogeneous families of forms. This is a key step in the recognition system. There are two types of learning: supervised learning and unsupervised learning [2].

In the case of supervised learning, a representative sample of all forms recognition is supplied to the learning module. Each form is labeled by an operator called teacher, this label to specify the learning module the class in which the teacher wants the form of either row. This learning phase is to analyze the similarities between elements of the same class and differences between different classes of items to derive the best score of the space of representations. The parameters describing this partition are stored in a learning table when the decision module will then refer to classify the forms submitted to it.

In the case of unsupervised learning, there is provided to the recognition system a large number of unlabeled forms. The classification step will load automatically identify the forms belonging to the same class. In the field of handwriting recognition, these are the methods based on a supervised learning that are most frequently used; and especially for isolated handwritten characters because natural classes are known and limited.

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The test step evaluates the performance of the classifier for a given learning. This is an important step because it can involve the selection of features or the choice of learning method. Indeed, it is difficult to find a priori relevant feature and the most appropriate learning method to the problem of where the utility to proceed by successive iterations. These iterations are to extract features deemed useful to the recognition problem solving and test the system's performance with this set of features. As and when the desired system performance are not achieved then simply find again a new family of feature or combine features extracted with new features.

These learning and testing phases are carried out prior to the integration of the decision module in the recognition system. In any case, we can allow the iterate recognition system learning and test phases as we did not achieve the desired performance. The calculation of this performance is the result of the classifier used.

As part of our project, genetically optimized neural network is the method of classification of character recognition system which is described in the following headings.

***Genetic Algorithm***

Genetic algorithms (GA) are a fairly wealthy family and very interesting stochastic optimization algorithms based on the mechanics of natural selection and genetics. The choice of GA among other methods is justified based on the following four properties [6]:

- The GA use encryption settings and not the settings themselves.
- The GA are working on a population of points, rather than a single point.
- The GA use only the values of the studied function, not its derivative or other auxiliary knowledge.
- The GA use probabilistic transition rules, not deterministic.

In addition, the GA using two major strategies to find a solution or set of solutions. These strategies are: exploration and exploitation. They allow to find the global maximum (solve the problem) because they are complementary [7]. If the exploration is investigating all solutions of the search space, the operational phase in turn uses the found knowledge to previously visited solutions to help find better solutions. The combination of these two strategies can be quite effective but the difficulty is to know where the best solution is.

The GA operate with a population comprising a set of individuals called chromosomes. Each chromosome is composed of a set of genes. Each individual is assigned a value calculated by a function called adaptive or fitness. In practice, from a population of chromosomes is generated in a random manner during initialization. To set the size of the population, Xavier Hue [7] reported that this size varies from one problem to another. In each cycle of genetic operations, a new population called generation is created from the chromosomes of the current population. Why some chromosomes called 'parents' are selected to develop the genetic operations. The genes of these parents are mixed and recombined to produce other chromosomes called 'children' forming the new generation. The steps of the GA are repeated in cycles *t*, the judgment of the algorithm is fixed according to a stopping criterion. There can be several stopping criteria:

- The number of generation originally set has been reached.
- The value of the adaptation function has reached a set value a priori.
- The absence of changes in the value of the fitness function of individuals in a population to another.
- The chromosomes have reached a certain degree of homogeneity.

Figure 2 shows the steps of a simple GA:

***Simple Genetic Algorithm***

```
{ t = 0;
        Initialization (P (t));
        Evaluation (P (t));
        While not end to t =
        t+1;
            P'= select (P (t));
          Recombining (P'(t);
          Mutation (P'(t));
          Evaluation (P '(t));
             P = Survival (P, P'(t));
}
```

Figure 2: Steps of a simple GA

Figure 3 shows the evolutionary cycle for Genetic algorithm

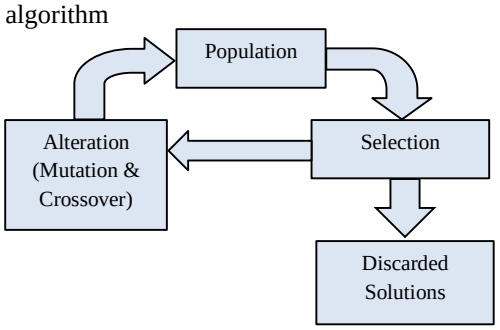


Figure 3: Genetic algorithm evolutionary cycle [8]

*A. Selection*

In biological evolution, only the fittest survive and their gene pool contributes to the creation of the

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succeeding generation. Selection in GA is also based on a similar process. In a common form of selection, recognized as fitness proportional selection, every chromosome's likelihood of being selected as a decent one is proportional to its fitness value.

*B. Alteration to improve good solutions*

The alteration step in the genetic algorithm refines the good solution from the current generation to produce the next generation of candidate solutions. It is takes place by acting out crossover and mutation.

*C. Crossover*

Crossover may be regarded as artificial mating in which chromosomes from two individuals are combined to create the chromosome for the next generation. This is carried out by splicing two chromosomes from two different solutions at a crossover point and swapping the spliced parts. The fact is that some genes with good characteristics from one chromosome may as a result combine with some good genes in the other chromosome to create a better solution represented by the new chromosome [8].

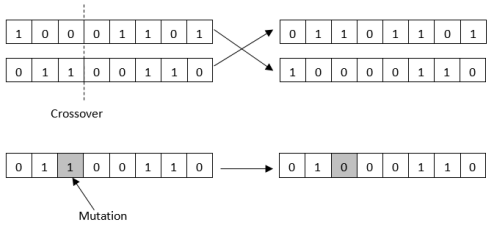


Figure 4: block representation of Crossover and Mutation [8]

*D. Mutation*

Mutation is a random adjustment in the genetic composition. It is beneficial for announcing new characteristics in a population – something not achieved through crossover alone. Crossover only reorders prevailing characteristics to give new combinations. For instance, if the first bit in every chromosome of a generation happens to be a 1, any novel chromosome created through crossover will also have 1 as the first bit.

The mutation operator changes the current value of a gene to a different one. For bit string chromosome this modification amounts to flipping a 0 bit to a 1 or vice versa. Mutations can be counterproductive, and applied only randomly and infrequently.

The steps in the typical GA for finding a solution to a problem are listed below:

1. Generate an initial solution population of a certain size randomly.
2. Calculate each solution in the current generation and assign it a fitness value.
3. Select "good" solutions based on fitness value and discard the rest.
4. If satisfactory solution(s) found in the current generation or maximum number of generations is exceeded then stop.
5. Change the solution population using crossover and mutation to create a new generation of solutions.
6. Go to step 2.

***Neural Network***

The methods of neural network based recognition have been studied for several years in order to achieve performance close to those observed in humans. Such neural networks are composed of several elements (or cells) for calculating operating in parallel and arranged in the manner of biological neural networks. The strength of neural networks is their ability to generate a decision region of any shape required by a classification algorithm, the price of integration of additional cell layers in the network type multilayer perceptron with learning by back propagation of the error gradient.

The general Neural Network approach contains following steps:

- Neural network creation.
- Configuration
- Training
- Simulation

Neural Network accept the features of training signals and test signal as an input a predefined target value has been set to perform feed forward neural network with gradient descent back propagation neural network algorithm in the presence of supervise learning, this algorithm is used to reduce the overhead and increase the accuracy of network and we use sigmoid transfer function to perform calculation at output layers. With the help of these all function desired output is generated. The functionality of Artificial Neural Network is performed is explained as follows:

Artificial Neural Network (ANN) is dealt with as an intelligence data processing framework that is motivated by the method for working of biological nervous systems of human, for example, mind and process data. The structure of data processing framework made out of countless interconnected processing components called neurons constantly in attempting to take care of particular issues. ANNs, is much the same as individuals, learn by case. There are numerous application region of ANN, for example, pattern recognition or information arrangement, through a learning procedure. Adapting in biological nervous systems includes alterations of synaptic associations

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that work between the neurons. This is valid for ANNs too that Neural networks, with their wonderful capacity to extract meaning from convoluted information, can be utilized to concentrate and despise examples and patterns that are so complex to be perceived by either ordinary people or other traditional computerized methods. A trained neural network can be dealt with as a master framework in the class of data it has been given to analyze to give suitable outcome [9].

***Neurons***

A class of statistical models is generally recognized as "Neural" if they possess following characteristics:

a. Consisting the set of adaptive weights or numerical parameters tuned by learning algorithm
b. Capable of approximating non-linear functions of their inputs.

The training mode of neurons (Figure 5) sources n number of inputs in parallel manner. The teaching input provides sufficient arguments to a neuron for generating specific output. In this mode the neurons are trained to fire for particular fashion. In case if input pattern does not resemble the taught list of patterns, firing rules takes the decision of firing or holding the inputs.

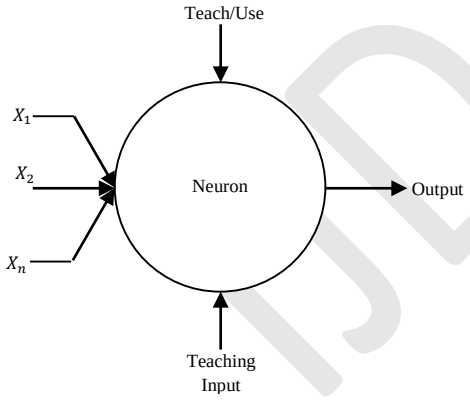


Figure 5: A simple Neuron [9]

***Layers***

The organization of Neural Network is a pattern of interconnected nodes that contain 'activation function'. The patterns are provided to 'input layer' that communicates with one or more hidden layers (Figure 6) for processing via weighted connections.

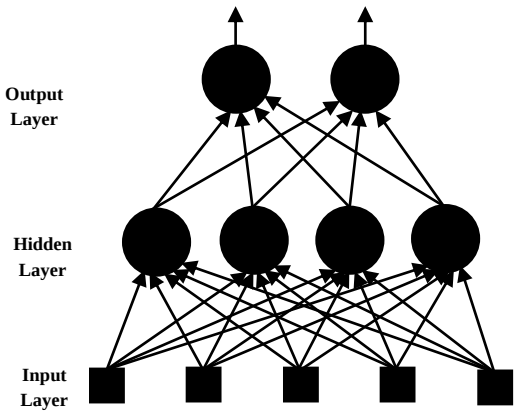


Figure 6: An example of a simple feedforward network [9]

The connection among the hidden layers and output layer delivers the required answers. The functions of three layers in NN can be defined in following statements:

- *Input Layer:* This layer accepts the patterns as input. The firing decision for further process is positive if the test input match with the training input.
- *Hidden Layer:* Dependent on the weights of connection with input and the related activities the operations at hidden layer are determined.
- *Output Layer:* The behaviour is directly proportional to hidden layer(s) activity and weight of connections among both output and hidden layer(s).

## IV. Simulation And Results

The performance of proposed algorithms has been studied by means of MATLAB simulation.

**Test-1:**

Figure 7: Original image

Figure 8: Grey image

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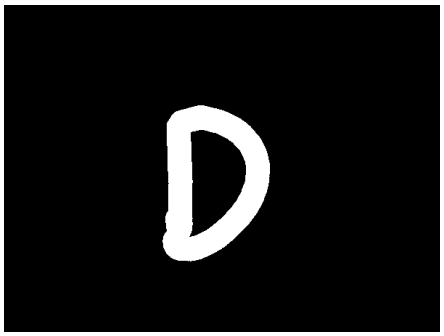

Figure 9: Binary image

Figure 10: Horizontal Crop

Figure 11: Vertical Crop

Figure 12: Resized binary image (80×50)

Figure 13: Thin image for feature extraction

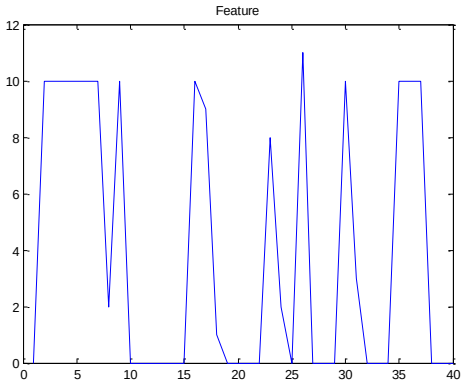


Figure 14: Extracted feature (input to the classifier)

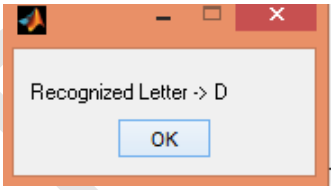


Figure 15: Recognized letter

**Test-2:**

Figure 16: Original image

Figure 17: Grey image

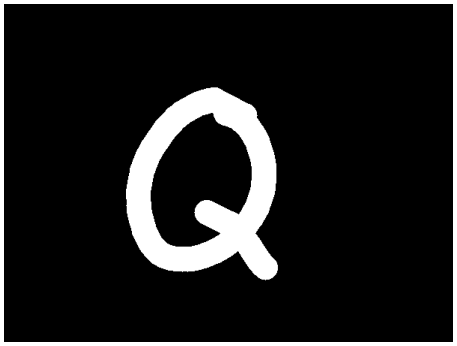

Figure 18: Binary image

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Figure 19: Horizontal Crop

Figure 20: Vertical Crop

Figure 21: Resized binary image (80×50)

Figure 22: Thin image for feature extraction

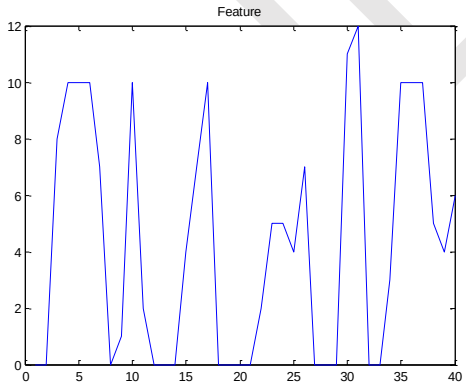


Figure 23: Extracted feature (input to the classifier)

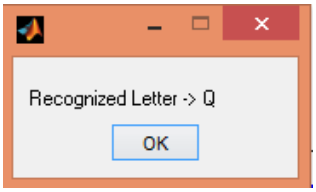


Figure 24: Recognized letter

## V. CONCLUSION

The work presented in this paper address the steps necessary to build a system of character recognition. For each of these stages are: pre-processing, extraction of features and classification, we have tried to propose an optimization method for the selection of features relevant figures recognition system.

Thus, from the extraction step of the feature, the selection of relevant and non-redundant system is performed features. This selection is to reduce inputs of the classifier (Neural Network) while improving or maintaining the classification recognition rate. Our main contribution is the study of the implementation of the Genetic Algorithm to select discriminant features. The results of this selection is satisfactory. The overall accuracy achieved by simulation is **98.32 %** which is higher than the previous work (93.23%) done by Gauri et al. [10].

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