Arabic Digit Recognition Using Genetic Algorithms

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تمييز الأرقام العربية باستخدام الخوارزميات الجينية

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الخلاصة

تعتبر المعالجة التمهيدية احد الخطوات المهمة في تمييز الأنماط، حيث انها تقوم باستخلاص الصفات الأساسية وتحسينها. يقدم هذا البحث فكرة جديدة لتميز الأرقام العربية دون الحاجة الى عمليات المعالجة التمهيدية. تستخدم التقنية المقترحة الخوارزميات الجينية لاستخلاص وتحسين الصفات في الأنماط غير المعروفة وتصنيفها بصورة متزامنة. ان عمليات الخوارزمية الجينية تمكن نظام تمييز الأنماط من اجراء عملية تحسين النمط واستخلاص صفاته إثناء عملية التمييز (التصنيف). يستطيع النظام القيام بعملية تمييز ناجحة بأقل ما يمكن من عمليات تحسين النمط.

تتكون التقنية المقترحة من جزئين: الأول يستخدم لتوليد النماذج الأساسية للأرقام العربية، في حين ان الجزء الثاني يستخدم الخوارزميات الجينية لاستخلاص الصفات وتمييز الأنماط غير المعروفة. النماذج الأساسية للأرقام تستخدم في تقيم أفراد مجموعة حلول الخوارزمية الجنية، حيث ان هذه العملية تمثل الجزء الأهم في الخوارزميات الجنية من اجل تمكينها للوصول إلى حلول صحيحة.

الكلمات المفتاحية:

الخوارزميات الجينية، تمييز الأنماط، تمييز الأرقام، المعالجة التمهيدية.

Abstract

Preprocessing is an important step in pattern recognition, since the fundamental features of pattern have to be extracted and/or enhanced. This paper proposes a new technique for Arabic digit recognition requires no preprocessing operations. The

proposed technique uses Genetic Algorithms (GA) to extract and enhance features of the unknown pattern and classify it, simultaneously. GA operations enable the pattern recognition system to do refinement process along with classification. The system needs as minimum required as of refinement processes to achieve a successful classification.

The proposed technique consists of two parts. The first part generates prototypes while the second one uses GA to extract features of the unknown patterns and classify it. The generated prototypes are used to evaluate the individuals of GA population, which is the most important component to have GA that can reach a solution.

Keywords:

Genetic Algorithms, Number Recognition, Pattern Recognition and Preprocessing

1. Introduction

One of the important fields in pattern recognition is character recognition that enhances human-machine interfacing, in addition to providing a solution for processing large amount of data automatically. The main objective of character recognition is the conversion of a graphical document into a textual one.

Pattern recognition system is regarded as a system, whose input is the information of the pattern to be recognized, and outputs a class to which the entered pattern belongs.

Mathematically [1], each pattern recognition system consists of a set of pattern classes {w1,w2, … , wm}, where m is the number of possible classes. Each pattern is represented by a vector X=(x1,x2, … , xn). The features that characterize this pattern are represented by the vector components. The element xi represents the ith feature in the pattern. The submitted unknown pattern represented by the vector U is classified by pattern recognition system into wj that belongs to.

Many systems have been proposed to recognize patterns. Some of them have been using genetic algorithms [2, 3, 4, 5]. Most of the character recognition systems require applying preprocessing operations on the unknown patterns. The present system does not need any sort of preprocessing while the genetic algorithm manipulates patterns in a way similar to the preprocessing of traditional systems, with major difference that the proposed technique performs preprocessing along with classification and as minimum as needed.

Next section will outline genetic algorithms and their operations while section 3 will present the proposed technique and its parts. Section 4 states the conclusion and results.

2 - Overview of Genetic Algorithms [6, 7, 8]

A genetic algorithm is an optimization technique that operates on a population of individual solutions. Each individual solution, also called a string, represents a proposed solution to the problem been solved. Subsequent generations of this population are obtained by applying genetic operations on the population individuals. These operations are selection, crossover, and mutation. With these operations, the population is pushed towards a good and optimum solution to the problem.

Each individual in the population is evaluated using a fitness function. This fitness function is used to propagate the good individuals into the next generation. Some set of these fit individuals is chosen for the crossover operation. The crossover operation recombines two parents' individuals into new children solutions, trying to build up fittest individuals in the next population. Usually, one or two common points in a pair of parents are chosen at random. For one point crossover, the portion of the parent strings to the right of the crossover point can be called the crossover area. For a two-point crossover, the area between the points is the crossover area. Taking the crossover area from one parent and the non-crossover area from the other parent forms one child. Reversing the process forms the other child.

The mutation process randomly alters a part of an individual in order to further enhance to the population.

There are several important issues in the design of a genetic algorithm. First, the fitness function must be designed appropriately to select good individuals. Furthermore, the representation of the strings that form the population individuals must be selected carefully. Finally, tuning of the genetic operators for the system is necessary to obtain a good solution in a reasonable time.

3 - The Proposed Technique

The proposed technique consists of two parts. The first part is for generating prototypes of the Arabic digits and the second part uses a simple genetic algorithm to classify unknown patterns.

3.1 Prototype Generation

In pattern recognition systems, each class of patterns has its prototypes. The prototype is a two dimensional matrix that holds integer values represent a weighted image to the corresponding pattern. It is generated through two stages.

In the first stage we use a carefully selected set of patterns of two-dimensional matrix for each number. Then we find the frequency of dots in these patterns cells to build up the intermediate prototype matrix. The cells of the intermediate matrix contain the frequencies of dots in the corresponding cells in the pattern matrices. This stage creates an intermediate matrix contains information about the pattern distribution and concentration areas.

The second stage enhances the intermediate prototype by strengthen some areas in the prototype and/or weaken other areas. This enhancement operation is done by comparing the intermediate prototype with all other intermediate prototypes resulting in the first stage.

The goal of this comparison is to identify the areas that discriminate each prototype from the others. This is achieved by dividing the prototype into three areas; positive area, negative area, and neutral area. The positive area is the area found on the present pattern prototype and not found in the other pattern prototypes. The negative area is the area found in the other pattern prototypes and not found in the present pattern prototype. The neutral area is not important area because it is found in the present pattern prototype and in the others as shown in figure (1). So that, it will be discarded while it cannot be used to discriminate the pattern. The positivity and negativity of an area determines how much this area is required or not.

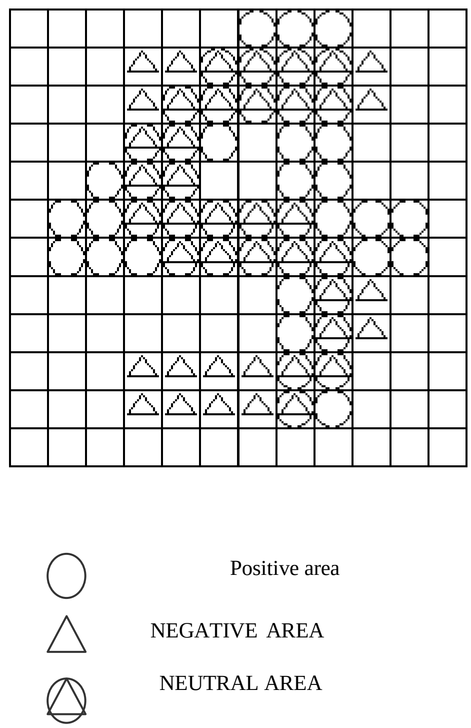

FIGURE (1) PROTOTYPE'S POSITIVE, NEGATIVE. AND NEUTRAL AREAS

This process takes the mentioned intermediate prototype and compares each cell in it with the corresponding cell in the others. If the value of the cell in the intermediate prototype is not zero (or greater than a certain threshold) and the value of the corresponding cell in the others is zero (or less than a certain threshold) the value of this cell is considered as positive and must be strengthen. If the value of the cell in the intermediate prototype is zero (or less than a certain threshold) and the value of the corresponding cell in the others is not zero (or greater than a certain threshold) the value of this cell is considered as negative and must be weaken. Otherwise, the cell is considered as neutral. The value of positivity or negativity depends on the difference between the two compared cells.

3.2 The Pattern Classifier

The objective of this part of the proposed system is to recognize an unknown pattern. It uses a simple genetic algorithm to achieve this task. Each individual in the population is a two-dimensional matrix of zeros and ones represent the dots of the pattern. The value one indicates the existence of the dot, whereas the value zero indicates the absence of the dot.

A population of 10 individuals is entirely generated from the unknown pattern. The system receives the unknown pattern then it derives the 10 individuals from this pattern by shifting it horizontally and/or vertically with a certain number of dots.

Fitness Function

As mentioned earlier, individuals are solutions to a problem. They should be improved from a generation to another. In order to measure their fitness (goodness), fitness function takes an individual as an input and returns usually a number as a fitness value. To compute the fitness value of an individual we find the average of the values of the prototype cells whose corresponding cells in the individual contains one. This process is repeated for all prototypes, and the largest average is the fitness value for this individual.

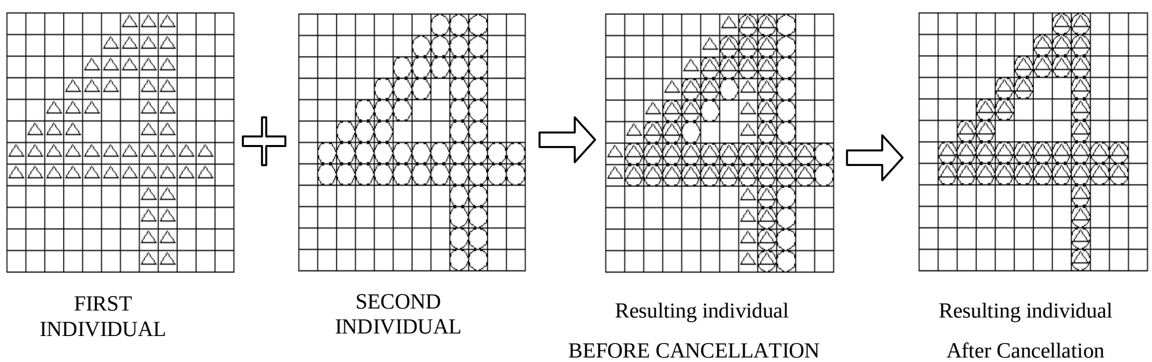

FIGURE (2) CROSSOVER

Genetic Algorithm Operations

In the proposed system, a roulette wheel method is used for individual selection [1]. In this method, individuals with high probability are highly qualified to be selected. In order to obtain a successful genetic algorithm system, the crossover process should be able to produce highly evaluated individuals with high probability. The system uses two individuals to produce one individual in the crossover process. This process is summarized by a cancellation of any uncoincident pixels for both of individual patterns. In other words, the two individuals are positioned over each other then any pixel that found in one individual and not found in the other at the same position will be deleted. Similar method was used for noise elimination in [9]. Figure (2) depicts the crossover process.

This crossover process is applied on the current population to generate a new population. After each crossover process, the resulting individuals are evaluating using the fitness function

and added to the population. Two individuals from the new population with less fitness values are removed to generate the new population. The generation of new populations continues until that the difference between the values of two successive population fitness is less than a certain small value.

The mutation process used in the present work is altering the pixels with probability of 0.01. This process prevents the system from being in a local minimum.

4 - Conclusion and Future Work

It is obvious that the genetic algorithm is always used in the optimization problems not in the classification and recognition problems. This paper presented a genetic algorithm that recognizes Arabic digits. The proposed technique utilizes the GA operations in a way that enables the GA to recognize the Arabic digits. The crossover process manipulates two patterns in a way like that of preprocessing of the unknown pattern, to result in more refined pattern by eliminating the noise and keeping the fundamental pattern features. Whereas the fitness function is used to support the classification process by selecting patterns that are near to any stored prototype.

The system described in this paper has been applied to database of handwritten digits by three writers. It proves a good recognition rate. The recognition rate depends on the resolution of the scanned pattern as shown in the following table. It is obvious that the system gives a good recognition rate when the resolution increases.

Resolution	Recognition
75 dpi	73%
100 dpi	75%
150 dpi	78%
200 dpi	87%
300 dpi	92%

Table (1) Recognition Rates

Further improvements can be reached if we involved two-dimensional transformations in mutation and/or population generation. Scaling, rotation, and transposition sound to bring more enchantments to the crossover operation enabling it to produce more fitted individuals. Two dimensional transformations help in having efficient processing of unknown pattern (during classification) that yield in enhancing the most significant components of pattern and remove any unrelevant components that correct classification, or at least delay it.

List of Figures

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