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Role of Hybrid Evolutionary Algorithms in Pattern Recognition

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Abstract - The Pattern Recognition has attracted the attention of researchers in last few decades as a machine learning approach due to its wide spread application areas. The application area includes medicine, communications, automations, military intelligence, data mining, bioinformatics, document classification, speech recognition, business and many others. Evolutionary computation has become an important problem solving methodology among many researchers. The population-based collective learning process, self-adaptation, and robustness are some of the key features of evolutionary algorithms when compared to other global optimization techniques. Even though evolutionary computation has been widely accepted for solving several important practical applications in engineering, business, commerce, etc., but in this review paper, we illustrate the various possibilities for hybridization of an evolutionary algorithm and their application in the field of Pattern Recognition.

***Keywords* - Evolutionary Algorithms, Fuzzy Logic, Hybrid Algorithms, Genetic Algorithms, Neural Networks.**

1. Introduction

Evolutionary computation, offers practical advantages to the researcher facing difficult optimization problems. These advantages are multifold, including the simplicity of the approach, its robust response to changing circumstance, its flexibility, and many other facets. The evolutionary algorithm can be applied to problems where heuristic solutions are not available or generally lead to unsatisfactory results. As a result, evolutionary algorithms have recently received increased interest, particularly with regard to the manner in which they may be applied for practical problem solving. Usually grouped under the term evolutionary computation or evolutionary algorithms, we find the domains of genetic algorithms [1], evolution strategies [2], [3], evolutionary programming [4], and genetic programming [5]. A hybrid system is a dynamic system that exhibits both continuous and discrete dynamic behavior a system that can both flow and jump. The term "hybrid dynamic system" is used, to distinguish over hybrid systems such as those that combine neural network sand fuzzy logic, or electrical and mechanical drivelines. A hybrid system has the benefit of encompassing a larger class of systems within its structure, allowing for more flexibility in modelling dynamic phenomena. Hybrid system employs more than one technology to solve a problem. Hybrid systems could be considered those systems that have the properties of self-maintenance, adaptivity, information preservation, and increase in complexity. In this paper this paper we will study the role played by hybrid evolutionary algorithms in Pattern recognition. Interest in the area of pattern recognition has been renewed recently due to emerging applications which challenging but also computationally more rapidly growing and available computing power, while enabling faster processing of huge data sets, has also facilitated the use of elaborate and diverse methods for data analysis and classification. At the same time, demands recognition systems are rising enormously due to the availability of large databases and stringent performance requirements (speed, accuracy, mid cost). In applications, it is clear that no single approach for classification is "optimal" and that multiple methods and approaches have to be used. Consequently, combining several sensing modalities and classifiers is now used practice in pattern recognition.

2. Pattern Recognition

Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of in their background, and make sound and reasonable about the categories of the patterns. In spite of almost 50 years of research, design of a general purpose machine pattern recognizer remains an elusive goal. The best pattern recognizers in most instances are humans, yet we do not understand how recognize patterns. The pattern recognition process has three primary stages, Preprocessing, Learning and Classification.

Preprocessing is used to remove noise and eliminate irrelevant, visually unnecessary information. Learning stage involves either supervised or unsupervised learning and Classification stage classifies the pattern, which is pre-processed in the first stage, by computing the output and considering the maximum output is the more similar image in database library to the unknown input pattern image.. The traditional best known approaches for pattern recognition are following:-

2.1 The Deterministic Approach to Pattern Classification

Most of the procedures minimize or maximize a deterministic quantity that reflects separability of pattern classes. Many deterministic procedures have statistical interpretations when the sample size is large.

2.2 The Statistical Approach to Pattern Classification

In the statistical approach, each terms of ‘d’ features or measurements is viewed in a d-dimensional space. The goal is that allow pattern vectors belonging to different categories to occupy compact and disjoint regions in a ‘d’ feature space. The effectiveness of the representation space (feature set) is determined by how well patterns from different classes can be separated. Given patterns from each class, the objective is boundaries in the feature space which separate patterns belonging to different classes. Theoretic approach, the decision boundaries are determined by the probability distributions of the patterns class, which must either be specified or learned.

2.3 Syntactic Approach

In many recognition problems involving complex patterns, it is more appropriate to adopt a hierarchical perspective where a pattern is viewed as being composed patterns which are themselves built from yet simpler sub patterns. The simplest/elementary sub patterns to be recognized are called primitives and the given complex pattern is represented in terms of the interrelationships between these primitives. In syntactic pattern recognition, a formal analogy is drawn between the structure of patterns and the syntax language. Thus, a large collection describe by a small number of primitives and grammatical rules. Structural pattern recognition is in addition to classification, this description of how the given pattern primitives. The implementation of a syntactic approach, however, leads to many difficulties which primarily have with the segmentation of noisy patterns (to detect the primitives) and the inference of the grammar from training data.

2.4 Template Matching

One of the simplest and earliest approaches to pattern recognition is based on template matching. Matching is an operation in pattern recognition which is used to determine similarity between two entities (points, curves, or shapes) of the same type.

2.5 Fuzzy Logic in Pattern Recognition

Dealing with uncertainties is a common problem in pattern recognition and the use of fuzzy set theory to a lot of new methods of pattern recognition. Fuzzy set theory plays a key in formalizing uncertainties Zadeh (1965), Bezdek (1981), Adlassing (1986), Sterimann (1997), K Steimann (2001). According to Nagalakshmi [6] the fuzzy set theory in the realm of pattern recognition is adequately justified in

1. Representing linguistically phrased input features for processing.
2. Providing an estimate of missing information in terms of membership values.
3. Representing multiclass membership of ambiguous patterns and in generating rules and inferences in linguistic form.
4. Extracting ill-defined images regions, primitives and properties and describing relations among them as A fuzzy set A represented as A = {µA (xi)/xi, i =1, 2… n} µA (xi) gives the degree of belonging of the element xA.

The relevance of fuzzy sets theory in pattern recognition problems has adequately been addressed that the concept of fuzzy sets can be used at the feature level in representing an input pattern as an array of membership values denoting the degree of possession of certain properties and in representing linguistically phrased input features; at the classification level in representing multi-class membership of an ambiguous pattern, and in providing an estimate of missing information in terms of membership values. In other words, fuzzy set theory may be incorporated in handling uncertainties in various stages of pattern recognition system.

S.B.Cho [7] defined the fuzzy integral as a nonlinear function that is defined with respect to a fuzzy measure, especially *g*- fuzzy measure introduced by Sugeno. The ability of the fuzzy integral to combine the results of multiple sources of information has been established in several previous works O.Mema Devi [8] stated the main reasons for the application of fuzzy set theory in pattern recognition: (i) its way of representation in linguistic approach with excellent formulation of input feature, (ii) representation of missing or incomplete knowledge as a degree of membership and (iii) its capability of drawing approximate inferences.

The use of pattern recognition methods for abstraction, indexing and retrieval of images is presented by Anatani (2002). Uncertainties also affect image analysis and the most challenging problem in image analysis and pattern recognition segmentation [Souza (2008), Hasanzadeh (2008), Yang (2009)] In the fuzzy classification rule described by Ishibuchib [9], the partitioning is uniform, i.e., the regions continue to be split until a sufficiently high certainty of the rule, generated by each region, is achieved. Ishibuchi extended this work later [9] by using an idea of sequential partitioning of the feature space into fuzzy subspaces until a predetermined stopping criterion is satisfied and studied its application for solving various pattern classification problems.

2.6 Neural Network Based Approach

Artificial neural networks (ANN's) attempt to replicate the computational power (low-level arithmetic processing ability) of biological neural networks and, thereby, hopefully endow machines with some of the higherbiological organisms possess (due in part, perhaps, to their low level computational prowess). However, an impediment to a more widespread acceptance of ANN's is the absence of a capability to explain to the user, in a human form, how the network arrives at a particular decision. Fuzzy logic is capable of modeling vagueness, handling uncertainty, and supporting human-type reasoning.

A neural network is widely regarded as black box that reveals little about its predictions Jayanta Kumar Basu [10] in their work stated that the main characteristics of neural networks are that they have the ability to learn complex nonlinear input sequential training procedures, and adapt themselves to the data. The most commonly used family of neural networks for pattern classification tasks is the feed-forward network.

2.7 Genetic Algorithm Based Approach

Basic Genetic Algorithm Mukhopadhyay [11] in their review stated the basic structure of a genetic algorithm as given here under:

Algorithm
t: = 0;
Compute initial population B0;
WHILE stopping condition not fulfilled DO
BEGIN
Select individuals for reproduction;
Create offspring's by crossing individuals;
Eventually mutate some individuals;
Compute new generation
END

As obvious from the above algorithm, the transition from generation to the next consists of four basic components:

1. Selection: Mechanism for selecting individuals (strings) for reproduction according to their function value).

2. Crossover: Method of merging the genetic information of two individuals; if the coding is good parents produce good children.

3. Mutation: In real evolution, the genetic material can be changed randomly by erroneous deformations of genes, e.g. by genetic algorithms, mutation can be realized as a random deformation of the strings with a positive effect is preservation of genetic diversity and, as an effect, that local maxima can be avoided.

4. Sampling: Procedure which computes a new generation from the previous one and it is Mukhopadhyay [11] compared GA with traditional continuous optimization methods, such as Newton or gradient descent methods, they have stated the following differences:

    1. GAs manipulate coded versions of the problem parameters instead of the parameters themse search space is S instead of X itself.

    2. While almost all conventional methods search from a single point, GAs always population of points (strings).

the robustness of genetic algorithms. It chance of reaching the global optimum and, vice versa, reduces the risk of becoming trapped in a local stationary point.

3. Normal genetic algorithms do not use any auxiliary information about the objective function value such as derivatives. Therefore, they can be applied to any kind of continuous or discrete optimization problem. The only thing to be done is to specify a meaningful decoding function.

4. GAs use probabilistic transition operators while conventional methods for continuous optimization deterministic transition operators.

3. Hybrid Evolutionary Architectures

The integration of different learning and adaptation techniques, to overcome individual limitations and achieve synergetic effects through hybridization or fusion of these techniques, has in recent years contributed to a large number of new hybrid evolutionary systems. Most of these approaches, however, follow an ad hoc design methodology, further justified by success in certain application domains. Due to the lack of a common framework it remains often difficult to compare the various hybrid systems conceptually and evaluate their performance comparatively.

3.1 Evolutionary Algorithms Assisted by Evolutionary Algorithms

Tan et al. [12] proposed a two-phase hybrid evolutionary classification technique to extract classification rules that can be used in clinical practice for better understanding and prevention of unwanted medical events. In the first phase, a hybrid evolutionary algorithm is used to confine the search space by evolving a pool of good candidate rules. Genetic programming [13] is applied to evolve nominal attributes for free structured rules and genetic algorithm is used to optimize the numeric attributes for concise classification rules without the need of discretization. These candidate rules are then used in the second phase to optimize the order and number of rules in the evolution for forming accurate and comprehensible rule sets. Zmuda et al. [14] proposed an hybrid evolutionary learning scheme for synthesizing multiclass pattern recognition systems. A considerable effort is spent for developing complex features that serve as inputs to a simple classifier back end. The nonlinear features are created using a combination of genetic programming to synthesize arithmetic expressions, genetic algorithms [15] to select a viable set of expressions, and evolutionary programming [16, 17] to optimize parameters within the expressions. The goal is create a compact set of nonlinear features that cooperate to solve a multiclass pattern recognition problem

3.2 Evolutionary Algorithms Assisted by Neural Networks

Wang [18] proposed a hybrid approach to improve the performance of evolutionary algorithms for a simulation optimization problem. Simulation optimization aims at determining the best values of input parameters, while the analytical objective function and constraints are not explicitly known in terms of design variables and their values only can be estimated by complicated analysis or time-consuming simulation.

3.3 Fuzzy Logic Assisted Evolutionary Algorithms

Fuzzy logic controller (FLC) is composed by a knowledge base, that includes the information given by the expert in the form of linguistic control rules, a fuzzification interface, which has the effect of transforming crisp data into fuzzy sets, an inference system, that uses them together with the knowledge base to make inference by means of a reasoning method, and a defuzzification interface, that translates the fuzzy control action thus obtained to a real control action using a defuzzification method. FLCs have been used to design adaptive evolutionary algorithms. The main idea is to use an FLC whose inputs are any combination of EA performance measures and current control parameter values and whose outputs are EA control parameter values.

3.4 Evolutionary Algorithms Assisted by Particle Swarm Optimization

A hybrid evolutionary algorithm – PSO method is proposed by Shi et al. [19]. The hybrid approach executes the two systems simultaneously and selects P individuals from each system for exchanging after the designated N iterations. The individual with larger fitness has more opportunities of being selected. The main steps of the hybrid approach are depicted below [19]: 1. Initialize EA and PSO subsystems. 2. Execute EA and PSO simultaneously. 3. Memorize the best solution as the final solution and stop if the best individual in one of the two subsystems satisfies the termination criterion. 4. Perform the hybrid process if generations could be divided exactly by the designated number of iterations N. Select P individuals from both sub-systems randomly according to their fitness and exchange. Go to step 3. A hybrid technique combining GA and PSO called genetic swarm optimization (GSO) is proposed by Grimaldi et al. [20] for solving an electromagnetic optimization problem. The method consists of a strong co-operation of GA and PSO, since it maintains the integration of the two techniques for the entire run. In each iteration, the population is divided into two parts and they are evolved with the two techniques, respectively. They are then recombined in the updated population, that is again divided randomly into two parts in the next iteration for another run of genetic or particle swarm operators. The population update concept can be easily understood thinking that a part of the individuals is substituted by new generated ones by means of GA, while the remaining are the same of the previous generation but moved on the solution space by PSO.

3.5 Evolutionary Algorithms Assisted by Ant Colony Optimization (ACO)

ACO deals with artificial systems that are inspired from the foraging behavior of real ants, which are used to solve discrete optimization problems [8]. Tseng and Liang [21] proposed a hybrid approach that combines (ACO), the genetic algorithm (GA) and a Local Search (LS) method. The algorithm is applied for solving the Quadratic Assignment Problem (QAP). Instead of starting from a population that consists of randomly generated chromosomes, GA has an initial population constructed by ACO in order to provide a good start. Pheromone acts as a feedback mechanism from GA phase to ACO phase. When GA phase reaches the termination criterion, control is transferred back to ACO phase. Then ACO utilizes pheromone updated by GA phase to explore solution space and produces a promising population for the next run of GA phase.

3.6 Hybrid Approaches Incorporating Local Search and Others

Hybridization between evolutionary algorithms and local search is known as memetic algorithms. Memetic Algorithms have been proved to be orders of magnitude faster and more accurate than evolutionary algorithms for different classes of problems. As reported in the literature, hybrid methods combining probabilistic methods and deterministic methods have found success in solving complex optimization problems [22–24].

4. Conclusion

An exhaustive survey of different hybrid computing algorithms for pattern recognition is presented. This paper has presented various combining methods of neural-fuzzy-genetic networks for producing an improved performance on real-world classification problem, in particular pattern recognition. In case of noisy patterns, choice of statistical model is a good solution. Practical importance of structural model depends upon recognition of simple pattern primitives and their relationships representation description language. As evident from the scientific literature/databases, the use of hybrid evolutionary algorithms are getting very popular.

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