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Applications of Particle Swarm Optimization

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Abstract

Particle swarm optimization (PSO developed by Dr. Eberhart and Dr. Kennedy in 1995, which is a population based stochastic optimization technique.It is inspired by social behavior of bird flocking or fish schooling.PSO has been successfully applied in many research and application areas, in past several years. It is analyzed that PSO gets better results in a faster, cheaper way then other methods.

Keywords:

Particle swarm optimization; Swarm intelligence and PSO algorithms

1. Introduction

The present work interprets on Particle Swarm Optimization and simple software agents so called particles, move in the explore breathing space of an optimization problem. The position of a particle represents a solution to the optimization problem at hand. Each particle searches for better positions in the search space by changing its velocity according to rules originally inspired by behavioral models of bird flocking. The outlines of the paper explicate the overview, evolution, applications and current trends of the PSO make use of further research.Swam intelligence model were employed in artificial intelligence. The expression was introduced in the year 1989 by Jing wang and Gerardo Beni in cellular robotic systems. Swarm Intelligence (SI) was an innovative pattern for solving optimizing problems. SI systems are typically made up of populations of simple agents interacting locally with one another and with their environment. The agent follows simple rules and the interactions between agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Examples of SI include ant colonies, bird flocking, animal herding, bacterial growth and fish schooling.

The example algorithms of Swarm Intelligence are

i) Ant Colony Optimization
ii) Particle SwarmOptimization
iii) Gravitational Search Algorithm
iv) Stochastic diffusion search.

Particle Swarm Optimization belongs to the class of swarm intelligence techniques that are used to resolve the optimization problems.

2. Algorithm

The pseudo code of the procedure is as follows

For each particle

Initialize particle

END

Do

For each particle

Calculate fitness value

If the fitness value is better than the best fitness value (pBest) in history

set current value as the new pBest

End

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Choose the particle with the best fitness value of all the particles as the gBest

For each particle

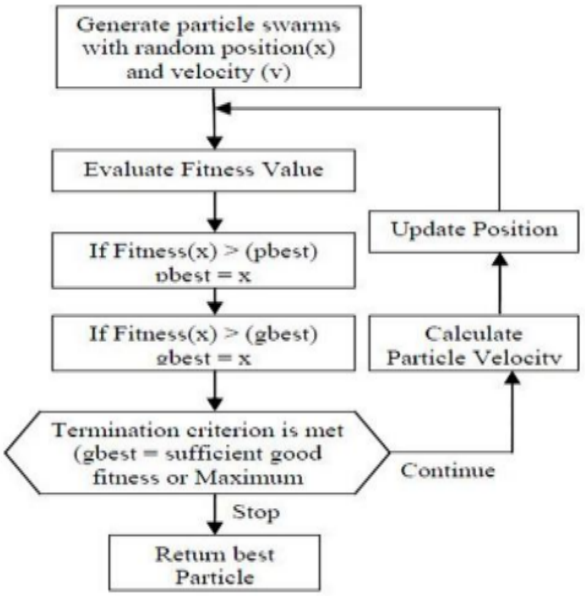
Calculate particle velocity

Update particle position

End

While maximum iterations or minimum error criteria is not attained

Particles' velocities on each dimension are clamped to a maximum velocity Vmax. If the sum of accelerations would cause the velocity on that dimension to exceed Vmax, which is a parameter specified by the user. Then the velocity on that dimension is limited to Vmax.



3. Applications of PSO

The first practical application of PSO was in the field of neural network training and was reported together with the algorithm itself. Swarm intelligence-based techniques can be used in many applications, like telecommunications, control, data mining, design, combinatorial optimization, power systems, signal processing and many others.

The U.S. Military is investigating swarm techniques for controlling unmanned vehicles. The European Space Agency is thinking about an orbital swarm for self-assembly and interferometer. NASA is investigating the use of swarm technology for planetary mapping. A 1992 paper by M.Antony Lear's and George A.Bekey discussed the possibility of using swarm intelligence to control nanobots within the body for the purpose of killing cancer tumors.

3.1 *Artificial Neural Network and PSO*

An Artificial Neural Network, often just called a neural network, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases a neural network is an adaptive system that changes its structure during a learning phase. Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data.

An artificial neural network is an analysis paradigm that is a simple model of the brain and the backpropagation(BP) algorithm is the one of the most popular method to train the artificial neural network. Recently, the significant research efforts were to apply Evolutionary Computation (EC) techniques for the purposes of evolving one or more aspects of artificial neural network.

The PSO–BP is an optimization algorithm combining the PSO with the BP. Similar to the GA, the PSO algorithm is a global algorithm, which has a strong ability to find global optimistic result, this PSO algorithm, The BP algorithm, on the contrary, has a strong ability to find local optimistic result, but its ability to find the global optimistic result is weak. By combining the PSO with the BP, The fundamental idea for this hybrid algorithm is that at the beginning stage of searching for the optimum, the PSO is employed to accelerate the training speed. When the fitness function value has not

changed for some generations, or value changed is smaller than a predefined number, the searching process is switched to gradient descending searching according to this heuristic knowledge. Similar to the APSO algorithm, the PSO–BP algorithm's searching process is also started from initializing a group of random particles. First, all the particles are updated according to the Equations. Until a new generation set of particles are generated, and then those new particles are used to search the global best position in the solution space. Finally the BP algorithm is used to search around the global optimum. In this way, this hybrid algorithm may find an optimum more quickly.

3.2 *PSO for Data Mining*

Data Mining and PSO do not have many properties in universal. However they can be used together to form a method which often leads to formulate the result, even when other methods would be too expensive ordifficultto implement.PSO makes use of particles moving in an n dimensional space to search for solutions for an n-variable function optimization problem. The datasets are the sample space to search and each attribute is a dimension for the PSO-miner.During the search space procedure, each particle is evaluated using the fitness function. The fitness function measures the predictive accuracy of the rule for data mining and it is given by the following equation:

Predictive accuracy = (□ A ^ C|- 1/2))/ |A|

Where, | A ^ C| is the number of examples that satisfy both the rule antecedent and the consequent and |A| is the number of cases that satisfy only the rule antecedent. PSO usually search the minimum for the problem space considered.

Rule pruning is a common technique in data mining. The main goal of rule pruning is to remove irrelevant terms that might have been unduly included in the rules.

The performance of PSO-miner was evaluated using four public-domain data sets. The used parameter settings are as follows:

Swarm size = 30

C1=C2=2

Maximum Position = 5

Maximum velocity = 0:1 ~ 0.5

3.3 *PSO bsedBiclustering of Web usage data*

Swarm intelligent technique is combined with biclustering approach to propose an algorithm called Binary Particle Swarm Optimization (BPSO) based Biclustering for Web Usage Data. The main objective of this algorithm is to retrieve the global optimal bicluster from the web usage data. These biclusters contain relationships between web users and web pages which are useful for the E-Commerce applications like web advertising and marketing. Experiments are conducted on real dataset to prove the efficiency of the proposed algorithms.

Consider the user access data matrix shown in Figure 1. If we consider all pages, users 1, 2, and 4 do not seem to behave similarly since their hit count values are uncorrelated under page 2 ,while users 1 and 2 have an increased hit count value from page 1 to page 2, the hits of user 4 drops from page 1 to page 2.

However, these users behave similarly under pages 1, 3, and 4 since all their hit count values increase from page 1 to page 3 and increase again for page 4. A traditional clustering method will fail to recognize such a cluster since the method requires the three users to behave similarly under all pages which are not the case.

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	Page1	Page 2	Page 3	Page. 4
User 1	**0.0**	5.0	**3.0**	**6.0**
User 2	**1.0**	20.0	**4.0**	**7.0**
User 3	10.0	10.0	20.0	6.0
User 4	**5.0**	0.0	**8.0**	**11.0**

Figure-1. A sample user access data matrix and a hidden bicluster.

3.4 *Homogeneity based approach to edge detection using PSO*

A new edge detector which uses PSO for detection of best available important curves in an image that represent boundaries of objects. Our main idea is to find best fitting curves on edges of an image based on PSO where particles represent these curves. Also, we introduce two new measures, homogeneity and uniformity factor of a curve, that are used to form the objective function of the PSO based edge detection algorithm.

Pseudo code for proposed edge detection algorithm

1: For each pixel P on an image do
2: If P is not marked as an edge then
3: Initialize PSO population randomly for pixel P
4: Repeat
5: For each particle do
6: Decode the particle as curve C
7: Evaluate H_C and U_C according to (6) and (7)
8: Evaluate fcbased on (8)
9: If $fc$is better than the best fitness value then
10: Set current value as the new best particle
11: End if
12: End For
13: For each particle do
14: Find in the particle neighborhood, local best particle
15: Calculate particle velocity according to (4)
16: Apply the velocity constriction
17: Update particle position according to (5)
18: Apply the position constriction
19: End for
20: Until maximum iterations exceeded or minimum error criteria attained
21: Select best particle in the population and decode it as curve C
22: Evaluate as length of curve C
23: If $L_C > Min_L$then
24: Mark all pixels on curve C as an edge
25: End if
26: End if
27: End For

4. The Conclusion

Particle swam optimization is a new heuristic optimization method based on swarm intelligence. Compared with the other algorithms, the method is very simple, easily completed and it needs fewer parameters, which made it fully developed. However, the research on the PSO is still at the beginning, a lot of problems are to be resolved.

Advantages of the basic particle swarm optimization algorithm:

(1)PSO is based on the intelligence. It can be applied into both scientific research and engineering use.

(2)PSO have no overlapping and mutation calculation. The search can be carried out by the speed of the particle. During the development of several generations, only the most optimist particle can transmit information onto the other particles, and the speed of the researching is very fast.

(3)The calculation in PSO is very simple. Compared with the other developing calculations, it occupies the bigger optimization ability and it can be completed easily.

(4) PSO adopts the real number code, and it is decided directly by the solution. The number of the dimension is equal to the constant of the solution.

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