Particle Swarm Optimization with Aging Leader Algorithm : A Review

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***Abstract*— Aging is an important process in nature, which can't be neglected. Almost each and every organism grows older. This process of being older is inevitable and it corresponds to make the population grow at a normal pace and maintain the balance among species. The Aging mechanism is applied on the Particle Swarm Optimization (PSO) to provide the solutions to some issues related: Premature aging, fast convergence, global search ability. If a leader has a good leading power, it can live longer and better positions of the swarm can be found by it, else, if a leader does not have the capability to improve the swarm and it gets old, some new particles may appear to challenge and claim the leadership and this process can bring diversity in a population. This paper presents the Aging Mechanism applied to the Particle Swarm Optimization and an algorithm is found to prevent the premature aging and fast convergence.**

Keywords*— Particle Swarm Optimization, Aging Leader, Lifespan, Population, Performance, Challenger, Leader, Aging, global search, premature convergence.

I. INTRODUCTION

A. Particle Swarm Optimization

In[1] , Kennedy and Eberhart proposed that particle swarm optimization is a population based stochastic optimization technique. In computer science, particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. The PSO algorithm optimizes a problem by having a population of particles, and moving these particles around in the search-space .The simple mathematical formulae over the particle's position and velocity.[1]

B. Particle

When using PSO, a possible solution to the numeric optimization problem under investigation is represented by the position of a particle. Each particle has a current velocity, which represents the magnitude and the direction toward a new, better, solution/position. A particle also has a measure of the quality of its current position, the particle's best known position, and the quality of the best known position. [6]

C. Aging

Every organism grows older with time. The process of being older is known as aging. With aging, the organisms become weaker and become unable to lead the specific population, with this; other young organisms make themselves available for becoming the new leader and they rise up as the challengers for the older leaders in a population. Aging is essential to maintain the diversity. There may be number of challengers available for taking up the leadership but out of them only one can lead the population. [2] This selection is done using some parameters. There are two main things which are checked to select the new leader. These are: lifespan and performance.

a) Lifespan

Lifespan can be defined as the life time of the leader of a population, that means for how long a leader can live actively; leading that population. The lifespan of the leader can get elongated or can get shortened, according to the situation.

b) Performance

The performance of a leader is defined as its capability to lead a population. If a new particle tries to enter the population, its performance is compared with the performance of the leader. The one with better leading power capability or performance can become the new leader.

II. AGING THEORY AND ITS CONNECTION WITH EVOLUTIONARY COMPUTATION

The biologists have been working on aging theories for about 150 years. Nowadays the aging theories can be divided into two main categories:

1) Non-programmed theories

According to the non-programmed theories, aging is not evolved but is an inescapable biological reality that causes increasing deterioration over time.

2) Programmed theories

According to the programmed theories , aging is a genetically programmed characteristic which is beneficial to animal species. Both the non-programmed and programmed theories have their unsolved problems . According to different theories it has been accepted that aging is able to increase genetic diversity and is helpful for the evolution of a species. An optimal lifespan plays an important role in improving the effectiveness of evolution. Moreover, for intelligent species which are able to learn from experience, aging helps to avoid the adverse effects of excessive experience accumulation of older individuals. Without the aging mechanism, there are no physical and functional differences between younger and

older animals. Because older animals accumulate more knowledge and skills than younger ones, they are always the superior competitors . The outcome of this situation :
1. The older animals always have more chances to survive and breed as they are superior competitors in natural selection.
2. In social animal colonies, it is common that superior individuals are selected as the leaders of the colonies.
3. Without aging, the older animals are always the leaders, being in-charge of the activities, knowledge and skills of the colonies for a very long time.[7]
In genetic algorithm design, each individual is assigned an age. The individual is removed from the population when its age reaches a predefined longevity. The fitness of an individual is evaluated by considering not only the objective function but also the age . In nature, when the leader of a colony gets too old to lead, new individuals emerge to challenge and claim the leadership. In this way, the community is always led by a leader with adequate leading power. [6]

III. PSO WITH AGING ALGORITHM

This algorithm works on the leaders of multiple population / species. An efficient best solution is found by comparing the leaders of different population.

1. Considerations

A database, a new particle $^{\theta}$, a population having a leader with lifespan b and performance p.

2. Working

A particle $^{\theta}$ enters the database containing the leader having lifespan b and performance p. The lifespan of the previous leader is checked, when it expires, a new challenger comes up to challenge former's leading power . The best is found and leads the population.
The algorithm works as follows:

Step 1: Initialization

In an n- dimensional search space, the initial positions of all the particles are initialized randomly with their velocities be set to zero. Among the swarm, one best particle is found and it is selected as the leader with its age and lifespan both initialized to zero .

Step 2: Updating Leader

For every particle, present in the swarm, new positions are found. If the newly generated position is better than the leader, then the new generated particle is made the new leader of that population.

Step 3: Lifespan Control

The leading power of the leader for improving the entire swarm is found, after the positions of all the particles are updated.
The globally best solution (gbest) found and accordingly three cases are defined:

a.) If gbest<0 (good leading power) , lifespan b is increased by 2, b=b+2.
b.) If gbest=0 (fairly leading power), lifespan b is increased by 1, b=b+1.
c.) If gbest>0 (poor leading power), lifespan b is decreased by 1, b=b-1.

Step 4: Generating a Challenger

A newly generated particle challenges the previous leader whose lifespan is expired. If the performance of particle $^{\theta}$ is greater than the leader, or if lifespan of leader expires (b=0), then the challenger is generated and the leader is updated, reporting the best solution.

Step 5: Evaluation of the Challenger

The leading power of the challenger and the previous leader are compared:
a.) If the challenger has more leading power, it will replace the leader.
b.) If challenger has less power, the leader will lead the swarm as it is.

Step 6 :

Best solution for the population is found and report is generated.

Step 7:

Best solution found by other population are compared and more optimal solution in multi-population is generated. [4]

IV. RELATED WORK DONE

[1] J. Kennedy and R. C. Eberhart, "Particle swarm optimization," A concept for the optimization of nonlinear functions using particle swarm methodology was introduced. The evolution of several paradigms was outlined. Benchmark testing of the paradigm was described, and applications, including nonlinear function optimization and neural network training, were proposed. The relationships between the particle swarm optimization and both artificial life and genetic algorithms were described.

[2] Wei-Neng Chen , Jun Zhang, Ni Chen, Zhi-Hui Zhan , Henry Shu-Hung Chung , Yun Li , Yu-Hui Shi "Particle Swarm Optimization with an Aging Leader and Challengers" In nature, almost every organism ages and has a limited lifespan. . In a social animal colony, aging makes the old leader of the colony become weak, and thus it provides opportunities for the other individuals to challenge the leadership position. This paper presents the aging mechanism applied to particle swarm optimization (PSO) and proposes a PSO with an aging leader and challengers (ALC-PSO). ALC-PSO is designed to overcome the problem of premature convergence without significantly impairing the fast-converging feature of PSO.

[3] S.Vijayalakshmi, D.Sudha, S.Mercy Sigamani, K.Kalpana Devi, "Particle Swarm Optimization with Aging Leader and Challenges for Multiswarm Optimization" In reality every organism ages and has a limited life span. Aging is important for maintaining diversity. In nature the aging leader become weak which leaves opportunities to the other individuals to challenge the leadership position. This paper transplants the aging leader and challengers (ALC-PSO) by taking its advantages and proposes Aging leader and challengers (ALC-PSO) in multiswarm. The leader which shows the long leading power attracts the swarm towards the best position, else if the leader of the swarm fails to improve the swarm towards better position, the new challengers claim the leadership. This concept ALC-PSO in multiswarm serves as a mechanism for upgrading a suitable leader to lead the swarm and provides the best optimal solution.

[4] Muhammad Imran , Rathiah Hashima and Noor Elaiza Abd Khalid , " The authors concluded that there is a drawback in the PSO that it stuck in the local minima. To improve the performance of the PSO, the researchers proposed a number of different variants of PSO. Some of the methods include: by improving initialization of the swarm, introduce the new parameters like constriction coefficient and the inertia weight; defining the different method of inertia weight to improve performance of PSO, working on the global and local best particles by introducing mutation operators in the PSO. In this paper, the different variants of PSO with respect to initialization, inertia weight and mutation operators have been presented.

V. ISSUES

Several research papers have been compared with each other to have a distinction between these papers clearly.

Research Paper	Main Features	Remarks
Particle swarm optimization	1. optimization of nonlinear functions using particle swarm methodology 2.The evolution of several paradigms of PSO 3. The relationships between particle swarm optimization and both artificial life and genetic algorithms	The optimization technique for optimizing the candidate solutions has been implemented.
Particle Swarm Optimization with an Aging Leader and Challengers	1. It transplants the aging mechanism to PSO 2. proposes a PSO with an aging leader and challengers	The Aging leader algorithm has been applied to the PSO to enhance its performance.
Particle Swarm Optimization with Aging Leader and Challenges for Multiswarm Optimization	1.Ttransplants aging leader and challengers (ALC-PSO) by taking its advantages and proposes Aging leader and challengers (ALC-PSO) in multiswarm.	the aging leader become weak during the process which leaves opportunities to other individual to challenge for the leadership position.
An Overview of Particle Swarm Optimization Variants	1.PSO is a very good technique for the optimization problems. 2.To improve the performance of PSO, the different variants of PSO have been proposed.	Different invented variants of PSO are capable for improving the performance of PSO Algorithm to a great extent.

VI. OPEN ISSUES AND FUTURE SCOPE

1. Some applications require finding multiple globally optimal solution in the search space.
2. Time for searching the leader in the swarm aimed to be reduced in the future research.
3. Study of the effect of the concept of aging on the complex optimization problems is a promising future work.

VII. CONCLUSION

The proposed algorithm works well on multiswarm and manages to prevent premature convergence but keeps the fast-converging feature of the original PSO. In future research , it would be interesting to test if the aging mechanism is also helpful for leading the swarm to more complex optimization problems and to decrease the search time for selecting the leader in a swarm

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