SWARM INTELLIGENCE: PSO ALGORITHM

Abstract

A natural metaphor is a key to solve any complex optimization problem in scientific community. [1]The classical optimization problem is unable to solve the highly non linear problem because of non-adaptability. A flexible and adaptable algorithm is needed to model the real-time problem easily. More nature inspired algorithms were emerged. One of such algorithm is Swarm Intelligence (SI) that highly focuses on collective behaviour of animals and solve the problem by building a self organising system [1].[2]Most of the SI algorithms uses multiple agents to interact to the population. It uses real-number strings to solve the problem efficiently [2]. [3]Particle Swarm Intelligence(PSO) is an important searching algorithm that finds the optimum solution in an environment. This article show cases the implementation of PSO algorithm in a real time problems[3]

Keywords: Nature Inspired algorithms, Swarm Intelligence(SI), Particle Swarm Optimization (PSO), PySwarms

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I. INTRODUCTION

Many optimization problems evolved from the motivation of nature systems(Pham & Karaboga,2000).Optimization algorithm like Nature Inspired Algorithm(NIA),Meta-heuristic algorithm(MA),Swarm Intelligence plays a vital role in solving the real time optimization problems. The challenges lies between these algorithms are finding the best solution from the search space.

Genetic algorithm (GA) [4,5]was introduced in the year 1970. It is the combination of evolution and natural selection algorithms, which uses the following parameters to find the population of next generation during optimization [4,5]

Crossover- A part of value derived from two chromosomes from parents and produces one offspring which directs to exploitation

Mutation- A random value which is present in chromosomes, used for exploration.

Simulated Annealing (SL) [7] was proposed in 1983. One of the physics based methods to find the global optimum based on the ratio changes in temperature. [7]

Particle Swarm Optimization (PSO) [8] algorithm proposed in1995, SI algorithm inspired by the behaviour of flocks of bird. The actions of particles are affected by the position and speed of previous generation and the other particles around. It has a clear direction with the implementation of static finite predecessor and linear motion. [8]

II. META HUERISTICS

Meta heuristics mimics the evolutionary rules in nature. The SI algorithm mimics the swarm behaviour in animals. These are inspired by the foraging, hunting, navigation and mating approach of animals.

Meta heuristics mimics the physics based methods. Archimedes Optimization Algorithm(AOA) was proposed in 2021 for solving numerical optimization problem inspired by physics rules.

Meta heuristics mimics the human-social behaviour rules in human. One of such algorithm is Harmony search (HS), tells that only human can sing, includes the music sounds.

III. SWARM INTELLIGENCE

Swarm Intelligence [SI] is a collective intelligence from a group of agents.[9] It deals with collective behaviour of decentralized and self-organised swarms i.e no centralized structure to have an interaction with the group. Local interaction will result from global behaviour [9]

Simple interaction between agents can produce complex behavioural pattern in a group. [10]The agents do not have supervisor and each agent has a unique behaviour due to

its perception from and also influence on neighbourhood and the environment. The individual behaviour of agents follows the simple set of rules.[10]

Grouping agents will make random decisions like move or behaviour to perform in uncertain or dangerous environment. The individuals among a group, each cannot determine the information status of other. Such groups are based on a tree structure according to the fitness principle called dominance.

PSO (Particle Swarm Optimization) and ACO (Ant Colony Optimization) adopt a more cooperative strategy according to the population. These can be treated a mutli cellular organism optimizing its performance to an adaptive environment.

IV. GROUP BEHAVIOURS

The collective behaviours in social insects are coordination, cooperation, deliberation and collaboration.[11]

Coordination: manages the spatial temporal density of individuals.

Collaboration: do the allocation of activities

Deliberation: supports for the decision making in an environment

Cooperation: defines the limitations of individuals

Each individual in a group has a unique role, work together to get a maximum benefit. Restrictions exist, for the allocation of resources based on the group size.[11]

Search strategy has two classifications. i.e 1)sit and wait and 2)foraging. It includes its ability to search effectively for the resources i.e food, water. The former has a low energy consumption and lower opportunity to get food

Communication strategy interaction between group is essential and can be done directly or indirectly

V. FORAGING THEORY

Natural selection approach eliminates the animals that have poor foraging, propagates the successful foraging strategies to the next generations. It involves to find a patch of food, determine where to travel, search for food and leaving from patch. Foraging can be modelled using dynamic programming, since animals maximize the energy rate during an uncertain environment.

VI. BASIC PSO ALGORITHMS

One of the widely used swarm algorithm is PSO proposed by Kennedy and Eberhart in 1995.This algorithm searches the objective function to adjust the trajectories of the agents called particles. The movement of a swarming particles has two components 1)A stochastic component 2)Deterministic component

Each particle is attracted towards the position of the current global position g* and the best location x*i in history

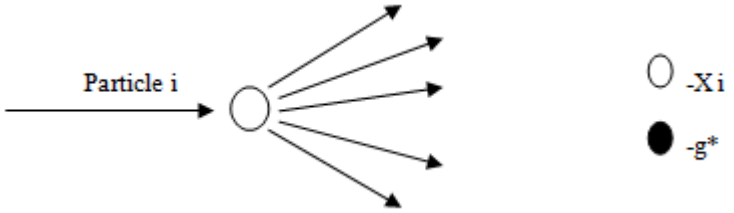
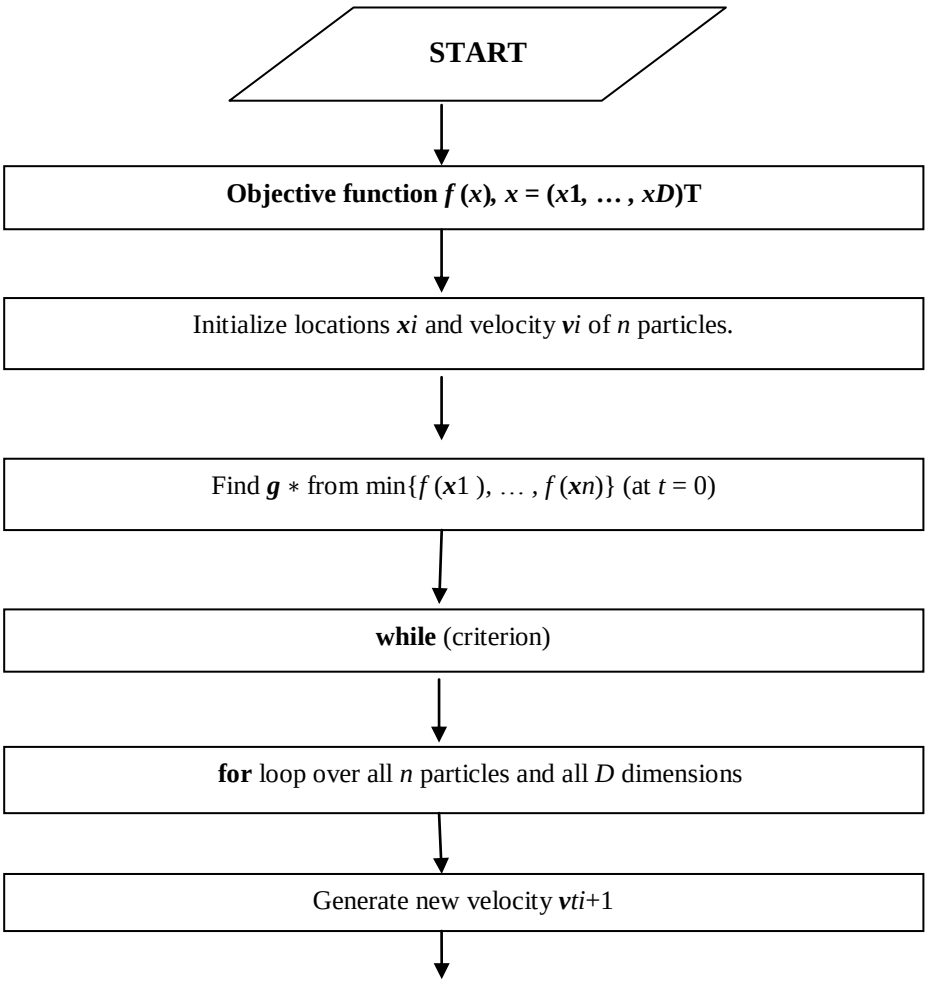


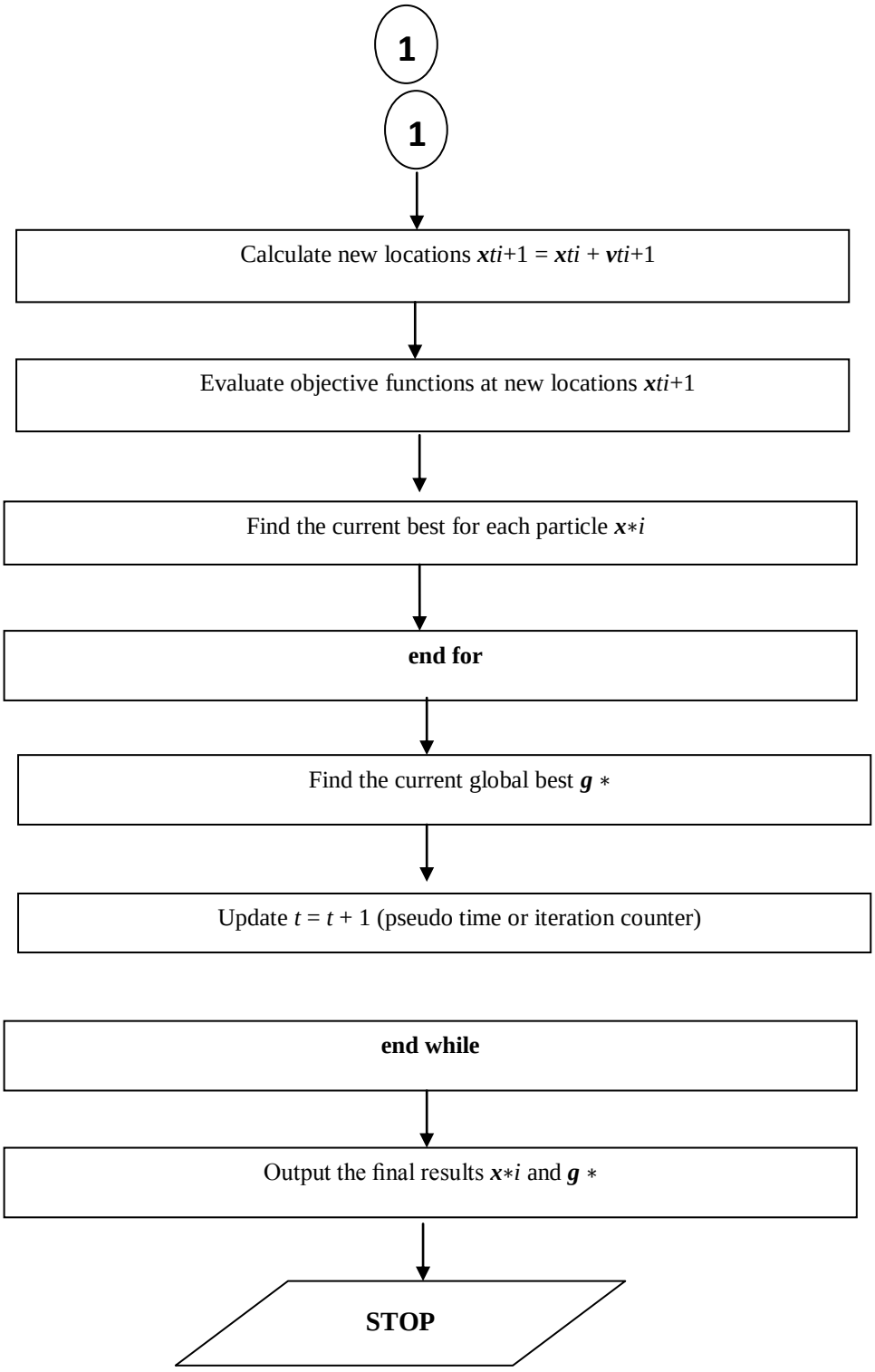
Diagram-1: Reprentation of PSO

When a particle finds the better location than the previous one, it updates the current best for particle i. The current best for all n particles at time T during iterations. The aim is to find the global best location from all the current best.

The particle movement is represented by X*i is the current best particle i. $\boldsymbol{g}* \approx \min\{f(\boldsymbol{x}i)\}$ for $(i = 1, 2, \ldots, n)$ is the current global best at t.

VII. FLOWCHART- PSEUDOCODE OF PARTICLE SWARM OPTIMIZATION





VIII. WORKING OF PSO

As a researcher's theory, PSO algorithm and its parameter should have an adequate balance between the exploration and exploitation. Exploration means seeking the largest region of search space where as exploitation means seeking the smallest region of search

space. Simply focus on local optimum or global optimum. This algorithm avoids early convergence.

Convergence: In PSO, Particles connected each other can be modelled by topological structure.The most common structure is Global star and Local ring. This structure decides the sharing speed and directions of particles.

In Global star structure, all the articles has the shortest average distance in swarm, where as Local ring structure has the highest average distance in swarm because every particles has been connected by two nearby nodes.

Diagram 2: Localring structure representation

Variants of PSO: It has different variants initial value and velocity of the particle, only update Gi and P after the entire swarm has been updated

Gradient PSO: Gradient based local search algorithm calculates the accurate local minimum effectively

Hybrid PSO: To increase the performance new and advanced PSO variants can be added.

IX. CONCLUSIONS

PSO is the successful algorithm for a continuous optimal solution problem. It works according to the population size. All the particles have been distributed in the solution space and it converges to the local minimum using swarm intelligence. Though PSO has many disadvantages like premature, high computational complexity and slow convergence etc, it is widely used. The reason behind that is it does not use crossover operator and does not handle the relationship between exploration and exploitation. It converges to the local minimum quickly. At present nearly hundreds of variants and test functions are exists. It is very difficult and impossible to go through all the results of test functions. Swarm intelligence will continue until for the improvement in behaviour of animals.

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