

Animal Food Chain Based Particle Swarm Optimization

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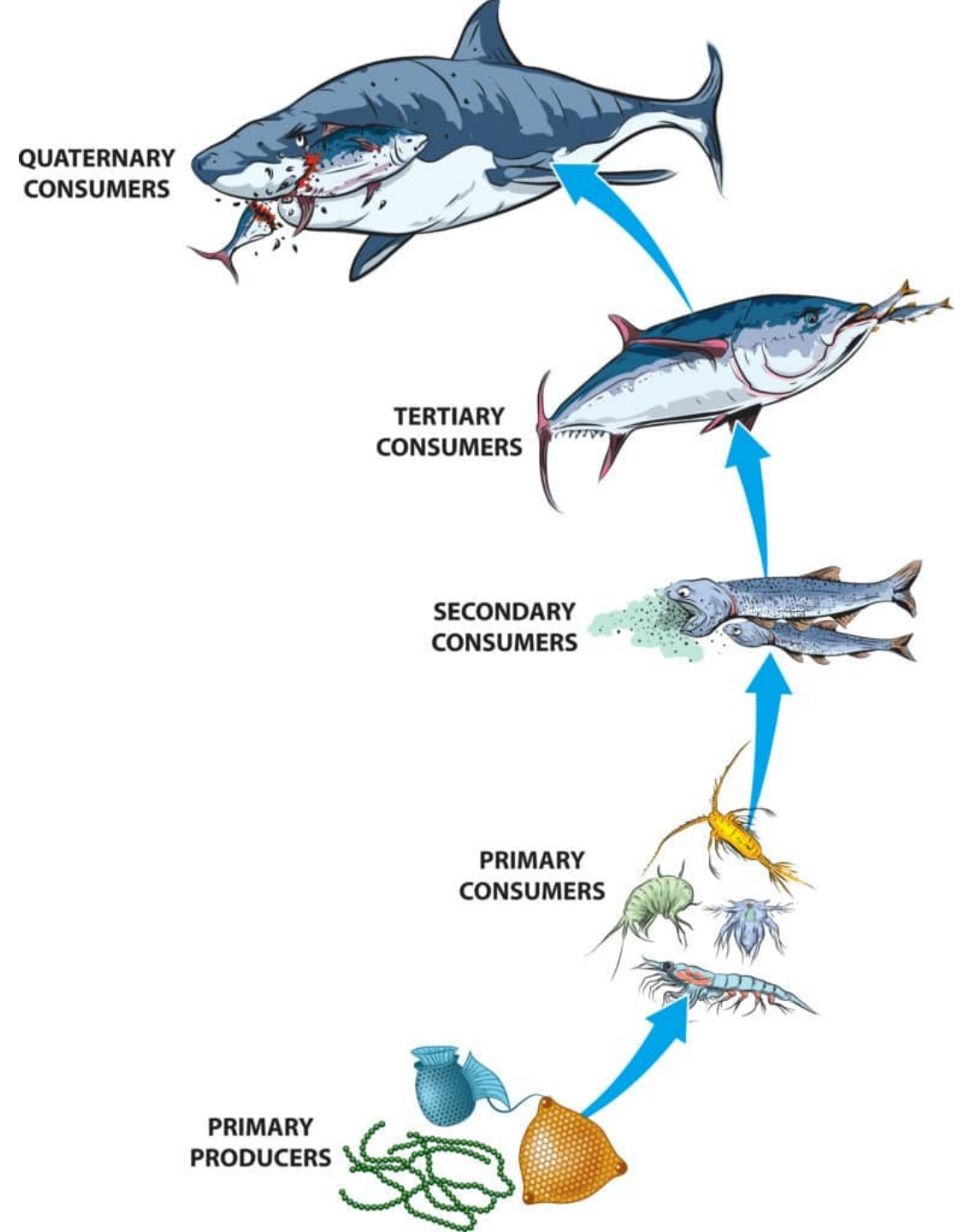
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Predator Pray PSO

The Hunting Search

Animal Food Chain Based PSO

Schedule & Current Process



Animal Food Chain Based Particle Swarm Optimization

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Abstract— Particle Swarm Optimization has been an appealing research area for researchers for over 15 years. During these years, a variety of algorithms have been developed around the particle swarm concept. One of these variations is Predator-Prey Particle Swarm Optimization algorithm which is also based on natural swarms which have a hierarchical relationship. Hunting search has also become a new meta-heuristic originating from hunting structure of species. In this paper, a new Particle Swarm Optimization Algorithm has been developed. Animal Food Chain Based Particle Swarm Optimization Algorithm simulates the animal food chain structure in three swarms: omnivores, carnivores and herbivores, in order to balance exploration and exploitation.

Index Terms— Animal Food Chain Based Particle Swarm, Hunting Search, Particle Swarm Optimization, Predator Prey

Swarm Optimization field has gained interest because of its applicability, simplicity and efficiency. The algorithm is proven to be robust and effective in various types of problems from single objective to combinatorial [6]. However, majority of algorithms developed are focused on exploring. This study aims to develop an algorithm that is required to balance the exploitation and exploration functions. This paper is so organized that, the next part is reserved for summarizing the basic PSO algorithm in detail. In the third section, the most recent approaches for PSO are presented: Predator-Prey and the Hunting Search. In the fifth part, Animal Food Chain Based PSO, our development study will be presented. The final section will include the conclusions.

Predator Prey PSO (0)

Three problems faced with the classical PSO are exploration overwhelming the exploitation, being blocked by the local optima and the early convergence.

In Predator Prey PSO, Particles are divided into two sub-swarms randomly, namely the **predator swarm and the prey swarm.**

If a prey swarm meets a predator swarm, they **diffuse just to regroup again after the predator is gone.** Diffusion provides a better exploration whereas regrouping provides a better exploitation.

- *Fear probability – p_f* : If the fear probability is assigned 0 for all prey particles, then the particles treat as an ordinary swarm given in Part 2., The fear probability is decreased over iterations [6].
- *Prey coefficient – c_3* : If the prey coefficient is assigned much greater than the cognitive coefficient – c_1 and the social coefficient – c_2 , the prey group is expected to diverge and not to regroup which results in random search for the prey particles.
- *Distance coefficients – a and b* : The coefficient a has the same effect as the fear probability and should be decreased over time. On the other hand, b has the counter effect of a and should be increased over time.

Predator Prey PSO (1)

For predator swarm, the velocity update formula is:

$$v_{i,j} \leftarrow \frac{r(x_{i,j}^{sb} - x_{i,j})}{\Delta t}$$

For prey swarm, the velocity update formula is

If $rn \leq p_f$ then

$$\begin{aligned} v_{i,j} \leftarrow & wv_{i,j} + c_1r_1 \left(\frac{x_{i,j}^{pb} - x_{i,j}}{\Delta t} \right) + c_2r_2 \left(\frac{x_{i,j}^{sb} - x_{i,j}}{\Delta t} \right) \\ & + c_3r_3 \frac{D(d)}{\Delta t} \quad i = 1, \dots, N \quad j \\ & = 1, \dots, n \end{aligned}$$

Else

$$v_{i,j} \leftarrow wv_{i,j} + c_1r_1 \left(\frac{x_{i,j}^{pb} - x_{i,j}}{\Delta t} \right) + c_2r_2 \left(\frac{x_{i,j}^{sb} - x_{i,j}}{\Delta t} \right)$$

$$x_{i,j} \leftarrow x_{i,j} + v_{i,j}\Delta t \quad i = 1, \dots, N \quad j = 1, \dots, n$$

The Hunting Search (0)

The steps of the algorithm are as follows.

Step 1. Initializing the hunting group randomly (as in PSO).

$$x_{i,j} = x_{min} + r(x_{max} - x_{min})$$

Step 2. Calculating the objective values of each hunter by $f(x_i)$. Assign the hunter with the best objective value as the hunter leader.

Step 3. Move hunters closer to the hunter leader.

$$x_{i,j} \leftarrow x_{i,j} + r \cdot MML \cdot (x_{i,j}^L - x_{i,j})$$

where r is a random number between $[0,1]$, MML is the maximum movement towards leader and $x_{i,j}^L$ is the position of the leader.

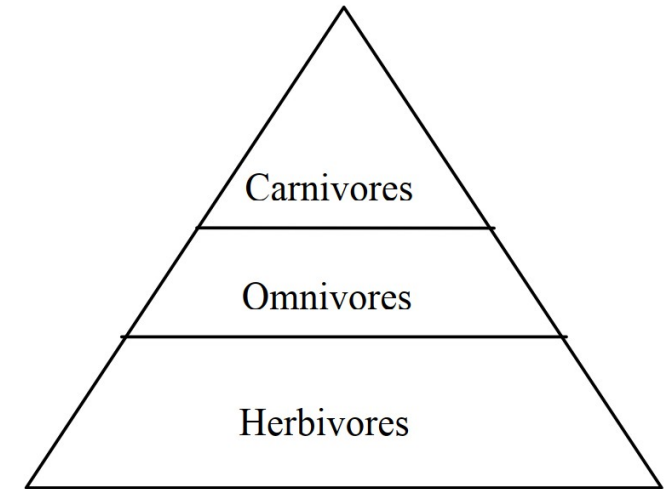
- *Hunting group consideration rate* –It is generally assigned between 0.1 and 0.4 depending on the problem
- *Distance radius – RA*: It is an arbitrary radius for continuous variables and kept constant or reduced during iterations (Oftadeh et. al., 2010).
- *Hunting group size – HGS*: The number of the hunters is defined by HGS . There is no predetermined group size defined for problems. Yet, it can be commented that in PSO, the optimal swarm size is between 10 and 30 and this number can be a reference to HS.

Animal Food Chain Based PSO (0)

In nature, **herbivores** are animals that are below in the food pyramid. **Omnivores** are in the middle in the food pyramid and feed on both plants and specific herbivores. Lastly, **carnivores** are at the top of the food pyramid and feed on specific herbivores and omnivores. This makes herbivores the ultimate preys, the carnivores the ultimate predators and omnivores both predators and preys.

In nature, according to the transformation of energy, the number of herbivores is greater than omnivores and the number of omnivores is greater than the number of carnivores. **In wild environments, the herbivore-omnivore-carnivore ratio can be 10:3:1 whereas in calm environments the ratio can be 40:10:1.**

Omnivores are the slowest of the food chain whereas **carnivores are the fastest.**



Animal Food Chain Based PSO (1)

- Herbivores (Ultimate preys):

$$v_{ij} \leftarrow \omega v_{ij} + c_1 r_{1j}(t)(y_{ij} - x_{ij}) + c_2 r_{2j}(t)(\hat{y}_l - x_{ij}) + p_{fho} c_3 r_{3j} D(d_o) + p_{fhc} c_4 r_{4j} D(d_c)$$

- Carnivores (Ultimate predators):

$$v_{ij} \leftarrow r \cdot (\hat{y}_l - x_{ij})$$

- Omnivores (Both predators and preys):

$$v_{ij} \leftarrow (1 - p_p) \cdot (\omega v_{ij} + c_1 r_{1j}(y_{ij} - x_{ij}) + c_2 r_{2j}(\hat{y}_l - x_{ij}) + p_{foc} c_3 r_{3j} D(d_o)) + p_p \cdot (r \cdot (\hat{y}_l - x_{ij}))$$

Fright factor of herbivores to carnivores – p_{fhc} : This factor is fear factor or probability of herbivores from carnivores. It has the same characteristics with p_{fho} . It is calculated as

$$p_{fhc} = 1 - \frac{d_{fhc}}{d_{fhc}^{min}}$$

Since carnivores move faster than omnivores, $d_{fho}^{min} < d_{fhc}^{min}$.

Fright factor of omnivores to carnivores – p_{foc} : This factor is fear factor or probability of omnivores from carnivores. It has the same characteristics with p_{fho} . It is calculated as

$$p_{foc} = 1 - \frac{d_{foc}}{d_{foc}^{min}}$$

Since omnivores move faster than herbivores, $d_{foc}^{min} < d_{fhc}^{min}$.

All d_{foc}^{min} , d_{fhc}^{min} and d_{fho}^{min} are new parameters to be optimized.

Predator Probability – p_p :

This factor is the probability of omnivores being a predator which is formulated as

$$p_p = \frac{d_o}{d_c + d_o}$$

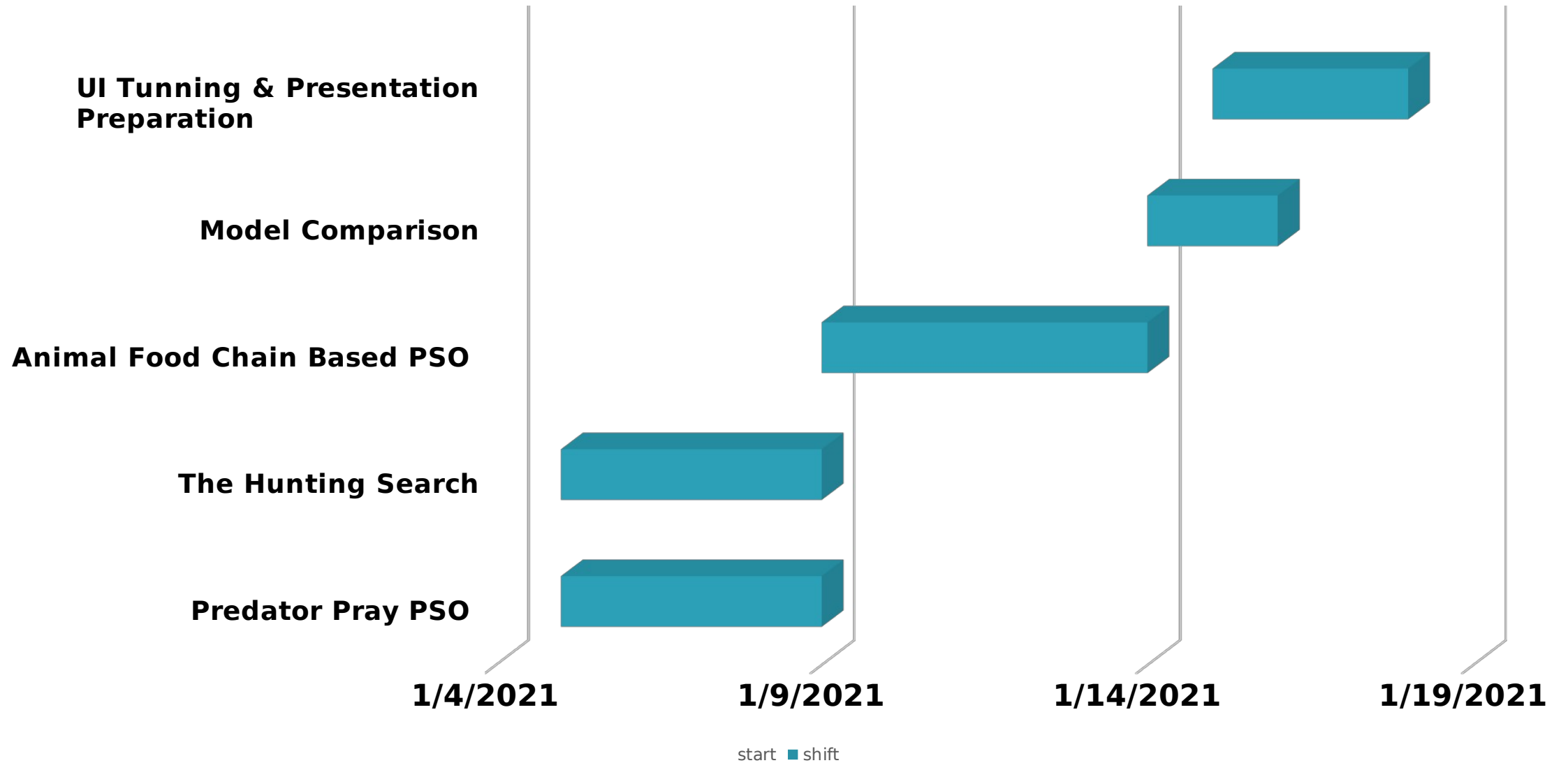
where

d_o : distance to the nearest omnivore

d_c : distance to the nearest carnivore

Environmental Factor: The initial number and rate of swarms are defined according to the environment being wild, average or calm. This is also a parameter to be tuned.

Working Schedule



New Problem

Open

Create PSO Solver

Reset

Run to End

Run One Iteration

Title Ackley(30)

☒ Minimize ☐ Maximize ☐ Goal

Dimension 30 ☐ Same Bounds

ID	Lower Bound	Upper Bound
0	-32.768	32.768
1	-32.768	32.768
2	-32.768	32.768
3	-32.768	32.768
4	-32.768	32.768
5	-32.768	32.768

Number of Known
Optimal Solutions 1

Best Objective Value 0 ☒ Same Coordinates

ID	x[0]	x[1]	x[2]	x[3]	x[4]	x[5]	x[6]	x[7]	x[8]
0	0	0	0	0	0	0	0	0	0

Description (rich text format)

Load File Equation Paste

Set Color

Set Font

Title: Ackley(30)

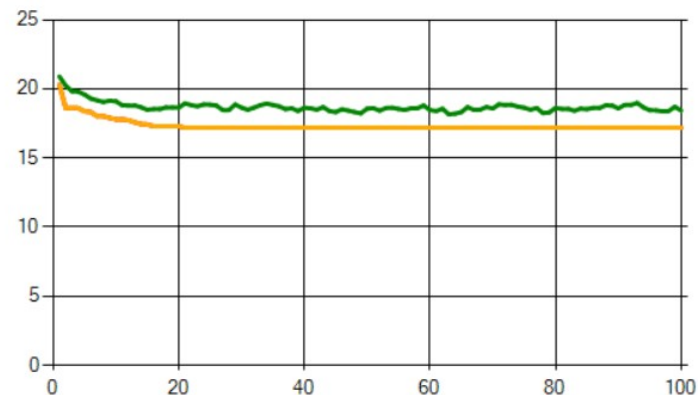
Bound:

$-32.768 \leq x_i \leq 32.768, i = 1, 2, \dots, D$

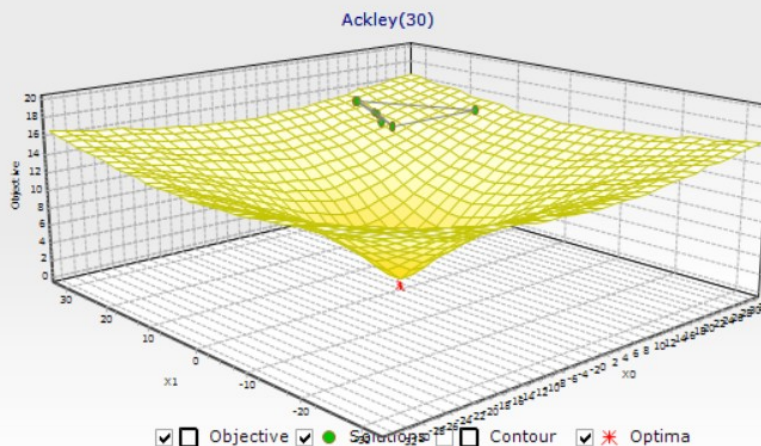
Problem:

$$\min 20 + e - 20e^{\left(-0.2 \sqrt{\frac{1}{D} \sum_{i=1}^D x_i^2}\right)} - e^{\frac{1}{D} \sum_{i=1}^D \cos(2\pi x_i)}$$

Optimal Value: 0



X0 Variable ID 0 Start Color ☒ Points Connected
X1 Variable ID 1 Mid Color End Color Refresh
Points on X0 30



☒ Objective ☒ Solutions ☐ Contour ☒ Optima

Information Grid	
Epoch	100
Best Objective	17.1708673587834
Best Solution	System.Double[]

Misc	
CognitionFactor	0.5
IterationAverage	0
IterationCount	0
IterationLimit	100
NumberOfVariables	30
ObjectivesBestIndividual	
ObjFunction	R08546036SHChaoAss11PSO.Objective
OptimizationMethod	Minimization
ParticleNum	10
SocialFactor	0.5
SoFarTheBestObjective	0
SoFarTheBestObjective	0
SolutionBest	
SolutionLowerBound	Double[] Array
Solutions	
SolutionUpperBound	Double[] Array

CognitionFactor