ABSTRACT

In the optimization of a process, the plan goal could be essentially to minimize the expense of creation or to maximize the effectiveness of creation. Modified Harris Hawks optimization algorithm is a metaheuristic approach of optimization technique. Modified Harris Hawks optimization algorithm is developed using the exploitation procedure of Harris Hawks optimization and exploration procedure of Particle Swarm Optimization. Modified Harris Hawks Optimization Algortihm is tested on the 20 benchmark function. Harris Hawks Optimization Algorithm is based on the behaviour of harris hawks while the particle swarm optimization algorithm is based on the behaviour of birds.

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Chapter 1

INTRODUCTION

Swarm Intelligence (SI) has attracted many researchers to do research in this fields. Bonabeau described SI as "The emergent collective intelligence of companies of easy agents". Swarm Intelligence is the collective intelligence behaviour of self-prepared and decentralized structures, e.G., artificial corporations of simple agents. Examples of SI consist of the organization foraging of social insects, cooperative transportation, nest-building of social bugs, and collective sorting and clustering. Two essential concepts which might be taken into consideration as essential homes of SI are self-corporation and department of labour. Self-enterprise is described because the functionality of a device to conform its dealers or additives into a suitable form with none external assist. Self-corporation relies on four fundamental residences of fantastic comments, terrible remarks, fluctuations and multiple interactions. Positive and negative feedback are beneficial for amplification and stabilization respectively. Fluctuations meanwhile are useful for randomness. Multiple interactions arise while the swarms share records amongst themselves inside their searching region. The second attribute of Swarm Intelligence is department of labour that is described as the parallel execution of different easy and possible obligations by way of people. This department allows the swarm to address difficult problems that attracts many individuals to work in this field collectively.

Some problem in AI and machine learning have commonly a consistent, discrete, compelled or unconstrained nature. Because of these attributes, it is difficult to handle a few classes of issues utilizing regular numerical programming approaches, for example, conjugate inclination, successive quadratic programming, quick steepest, and semi Newton techniques. A few kinds of exploration have checked that these strategies are not effective enough or consistently productive in managing numerous bigger scope genuine world multimodal, non-persistent, and non-differentiable issues. Appropriately, metaheuristic calculations have been structured and used for handling numerous issues as serious elective solvers, which is a direct result of their

effortlessness and simple execution process. Also, the center activities of these techniques don't depend on slope data of the target scene or its scientific characteristics. Be that as it may, the normal weakness for most of metaheuristic calculations is that they regularly demonstrate a fragile affectability to the tuning of client characterized boundaries. Another downside is that the metaheuristic calculations may not generally unite to the worldwide ideal.

Metaheuristic algorithms are two types. First is single solution based. Example of single solution base is Simulated Annealing (SA). Second type of metaheuristic algorithms is population based. Example of population based is Genetic Algorithm (GA). Name suggest, in the previous sort, just a single arrangement is prepared during the advancement stage, while in the last sort, a lot of arrangements (for example populace) are developed in every emphasis of the improvement procedure. Populace based strategies can regularly locate an ideal or problematic arrangement that might be similiar with the particular ideal or situated in it's locality. Populace based metaheuristic (P-metaheuristics) strategies generally impersonate common marvels. These calculations start the enhancement procedure by creating a set (populace) of people, where every particle in the populace speaks to an up-and-comer answer for the streamlining issue. The streamlining procedure is continued until fulfilling a halting standards (for example most extreme number of emphasess).

There is a typical component: the looking through advances have different two stages: exploration (broadening) and exploitation (increase). During exploration phase, the calculation ought to use and advance its randomized administrators however much as could be expected to profoundly investigate different locales and different angle of the component space. Consequently, the exploratory practices of an all around structured streamlining agent ought to have an enhanced enough irregular nature to proficiently allot more arbitrarily produced answers for various regions of the issue geography during early strides of the looking through procedure. The misuse stage is ordinarily performed after the investigation stage. In this stage, the streamlining agent attempts to concentrate on the area of better quality arrangements situated under the element space. It really heightens the looking through procedure in a neighborhood district rather than comprehensive areas of the scene. An efficient streamlining agent ought to be equipped for making a sensible, fine equalization between the investigation and misuse propensities. Something else, the chance of being caught in nearby optima and youthful union downsides increments.

We have seen a developing interest and mindfulness in the fruitful, economical, proficient utilization of EAs and SI calculations lately. However, alluding to No

Free Lunch (NFL) theorem, all enhancement calculations given technique present an equal exhibition all things considered on the off chance that we apply them to all conceivable improvement assignments. As indicated by NFL hypothesis, we can't hypothetically consider a calculation as a general purpose all around best streamlining agent. Thus, NFL hypothesis energizes scanning for growing increasingly productive streamlining agents. Because of NFL hypothesis, other than the broad examinations on the adequacy, execution perspectives and aftereffects of customary EAs and SI calculations, new enhancers with explicit worldwide and nearby looking through procedures are developing lately to give more assortment of decisions to specialists and specialists in various fields.

HHO, which was proposed in 2019 by Heidari and motivated from the chasing system of Harris birds of prey to chase bunny, utilizes both benchmark test capacities and some essential designing issues to show the presentation of the calculation. Particle Swarm Optimization[PSO] was created in 1995 by the Eberhart and Kennedy, enlivened by observe the social living beings in gatherings, for example, fledgling and fish tutoring or subterranean insect settlements. This calculation copies the cooperation between individuals to share data. Particle Swarm Optimization has been applied to various zones in streamlining and in mix with other existing calculations. This technique plays out the pursuit of the ideal arrangement through operators, alluded to as particles, whose directions are balanced by a stochastic and a deterministic segment. Every molecule is affected by its 'best' accomplished position and the gathering 'best' position, however will in general move arbitrarily.

Chapter 2

LITERATURE REVIEW

In light of the motivation, P-metaheuristics can be ordered in four fundamental gatherings: : Swarm Intelligence (SI) algorithms, Human-based, Physics-based and Evolutionary Algorithms.

Evolutionay Algorithms imitate the biological transformative practices, for example, recombination, change, and choice. One of the Evolutionary is the Genetic Algorithms that copy the Darwin theory of evolution. Some different mainstream instances of Evolutionary Algorithms are Biogeography-Based Optimizer (BBO), Differential Evolution (DE) and Genetic Programming (GP).

Physics-based algorithms are using the physics law. Some examples of physics based algorithms are Central Force Optimization (CFO), Gravitational Search Algorithm (GSA) , and Big-Bang Big-Crunch (BBBC). Salcedo-Sanz has deeply using several physic-based laws.

The third classification of P-metaheuristics incorporates the arrangement of calculations that emulate some human practices. Human based algorithms are Socio Evolution and Tabu Search (TS), Teaching Learning Based Optimization (TLBO) and Learning Optimization (SELO).

As the last class of P-metaheuristics, SI calculations impersonate the social practices of living beings living in swarms, herds, or flocks. For example, the flying creatures running practices is the fundamental motivation of the Particle Swarm Optimization (PSO) proposed by Eberhart and Kennedy. In PSO, every molecule in the multitude speaks to an applicant answer for the optimizatio issue. In the streamlining procedure, every molecule is refreshed with respect to the situation of the worldwide best molecule and its own (neighborhood) best position. Ant Colony Optimization (ACO), Whale optimization algorithm, and Artificial Bee Colony (ABC) are some examples of the Swarm based techniques.

Chapter 3

BACKGROUND

3.1 Particle Swarm Optimization

Particle Swarm Optimization has establishes in two primary part systems. Maybe increasingly clear are its connections to counterfeit life (An actual existence) all in all, and to feathered creature rushing, fish tutoring, and amassing hypothesis specifically. It is likewise related, be that as it may, to transformative calculation, and has connections to both hereditary calculations and developmental programming. It requires just crude scientific administrators, and is computationally modest as far as both memory prerequisites and speed. The particle swarm optimization is most likely best introduced by clarifying its calculated turn of events. As referenced over, the calculation started as a recreation of an improved social milieu. Specialists were thought of as impact evidence feathered creatures, and the first aim was to graphically reproduce the effortless yet unusual movement of a winged animal run. Particle swarm optimization is an incredibly wimple calculation that is by all accounts viable for improving a wide scope of capacities. Notwithstanding its binds with An actual existence, Particle swarm optimization has clear binds with evolutionary calculation. Reasonably, it appears to lie somewhere close to hereditary calculations and developmental programming. It is profoundly subject to stochastic procedures, as developmental programming. The alteration toward pbest and gbest by the particle swarm optimization is thoughtfully like the hybrid activity used by hereditary calculations. It utilizes the idea wellness, as do all developmental calculation ideal models. One of a kind to the idea of molecule swarm streamlining is flying expected arrangements through hyperspace, quickening toward ”better” arrangements. A great part of the accomplishment of particle swarms appears to lie in the specialists’ propensity to rush past their objective.

3.2 Harris Hawks Optimization

The Harris' hawk (Parabuteo unicinctus) is a notable winged creature of swarm that makes due in fairly consistent gatherings found in southern portion of Arizona, USA. Orchestrated scavenging including a few creatures for getting and afterward, sharing the killed creature has been influentially watched for just specific mammalian carnivores. The Harris Hawks bird of prey is recognized due to its extraordinary helpful scavenging exercises along with other relatives living in a similar stable gathering while different raptors as a rule assault to find and catch a prey, alone. This behaviour shows advanced inventive group pursuing abilities in following, encompassing, flushing out, and inevitably assaulting the likely quarry. These savvy winged creatures can sort out evening gatherings comprising of a few people in the non-rearing time. They are called as genuinely agreeable predators in the raptor domain.

The fundamental strategy of Harris' hawks to catch a prey is "surprise pounce", which is also called as "seven kills" tactic. In this wise system, a few birds of prey attempt to helpfully assault from various bearings and at the same time merge on an identified getting away from bunny outside the spread. The attack should exponentially be finished by catching the surprised prey in few time, but some time, regarding the escaping power and behaviors of the target, the seven kills might be in the multiple, short-length, quick dives close the target during several seconds. Harris' birds of prey can show an assortment of pursuing styles subject to the dynamic idea of conditions and getting away from examples of a prey. These exchanging exercises can be seen in various circumstances since they are gainful for befuddling the getting away from bunny.

Chapter 4

PROPOSED METHODOLOGY

4.1 Hybrid Harris Hawks and Particle Swarm Optimization Algorithm

The hybrid optimization algorithm is a combination of harris hawks optimization and particle swarm optimization. Harris Hawks Optimization Algorithm is a population-based, gradient-free improvement rule. In 2019, Future Generation PC Systems (FGCS) has revealed the HHO rule. the most inspiration of HHO is that the cooperative behavior and chasing type of Harris' hawks in nature referred to as "surprise pounce". Harris hawks will reveal a range of chasing patterns supported the dynamic nature of situations and escaping patterns of the rabbit.

Particle swarm optimisation was developed in 1995 by the Kennedy and Eberhart, motivated by the procedure used by the social organisms in groups, like bird, fish group and ant colonies etc. This algorithm copy the interaction between group member's to share the information. Particle swarm optimisation has been used to many field in the optimisation and in combination with other already present algorithms. This method finds the optimum solution using the agents, known as particles, whose path are find out by a stochastic and a deterministic part. Each agent is motivate by its 'best' found position and the group 'best' found position, but agent used random path to move.

In the hybrid harris hawks and particle swarm optimization algorithm, the position of the rabbit is updated according to the particle swarm velocity. Following equation show the updation process:

$$S^d_{i,t+1} = X^d_{i,t} + c_1 * \text{ rand } * \left(p^d_{i,t} - x^d_{i,t}\right) \quad + c_2 * \text{ rand } * \left(p^d_{g,t} - x^d_{i,t}\right) \tag{4.1}$$

4.2 Sudo Code of Hybrid Harris Hawks and Particle Swarm Optimization Algorithm

Inputs: The total population size N and Total iterations T

Outputs: The current location of agent and its fitness function value Initialized the random location $S_l(l = 1,2,\ldots,N)$

while (Till the maximum iteration)

do Calculate the current fitness values of agent

Set S_{agent} as the current location of agent (best possible location)

for (each agent (S_l)) **do**

$$P = 2P_0\left(1 - \frac{t}{T}\right) \tag{4.2}$$

if $(|P| \geq 1)$ **then**

$$S(t+1) = \begin{cases} S_{\text{rand}}(t) - x_1\left|S_{\text{rand}}(t) - 2x_2S(t)\right| & w \geq 0.5 \\ (S_{\text{rabbit}}(t) - S_m(t)) - x_3\left(LowerBound\right. & \\ \left. + x_4(UpperBound - LowerBound)\right. & w < 0.5 \end{cases} \tag{4.3}$$

if $(|P| < 1)$ **then**

if $(x \geq 0.5$ and $|P| \geq 0.5)$ then

$$S^d_{i,t+1} = X^d_{i,t} + c_1 * \text{ rand } * \left(p^d_{i,t} - x^d_{i,t}\right) + c_2 * \text{ rand } * \left(p^d_{g,t} - x^d_{i,t}\right)$$

$$\text{S(t+1)= } \Delta S(t) - P\left[mS_{\text{agent}}(t) - S(t)\right| \tag{4.4}$$

else if $(x \geq 0.5$ and $|P| < 0.5)$ **then**

$$S^d_{i,t+1} = X^d_{i,t} + c_1 * \text{ rand } * \left(p^d_{i,t} - x^d_{i,t}\right) + c_2 * \text{ rand } * \left(p^d_{g,t} - x^d_{i,t}\right)$$

$$\text{S(t+1)=S}_{\text{agent}}(t) - P|\Delta S(t)| \tag{4.5}$$

else if $(x < 0.5$ and $|P| \geq 0.5)$ **then**

$$S(t+1) = \begin{cases} G & \text{if } Function(G) < Function(S(t)) \\ H & \text{if } Function(H) < Function(S(t)) \end{cases} \tag{4.6}$$

else if $(x < 0.5 \text{ and } |P| < 0.5)$ **then**

$$S(t+1) = \begin{cases} G & \text{if } Function(G) > Function(S(t)) \\ H & \text{if } Function(H) > Function(S(t)) \end{cases} \tag{4.7}$$

Return $S_{\textbf{agent}}$

Chapter 5

IMPLEMENTATION & RESULTS

All the experiment had completed on the matlab. Windows 10 machine with 4 GB Ram is used for the experiment with the matlab devlopmetn environment. Proposed algorithm is tested on the mathematical benchmark function. The red line represents the proposed algorithm and Blue line represents the Harris Hawks Optimization algorithm.

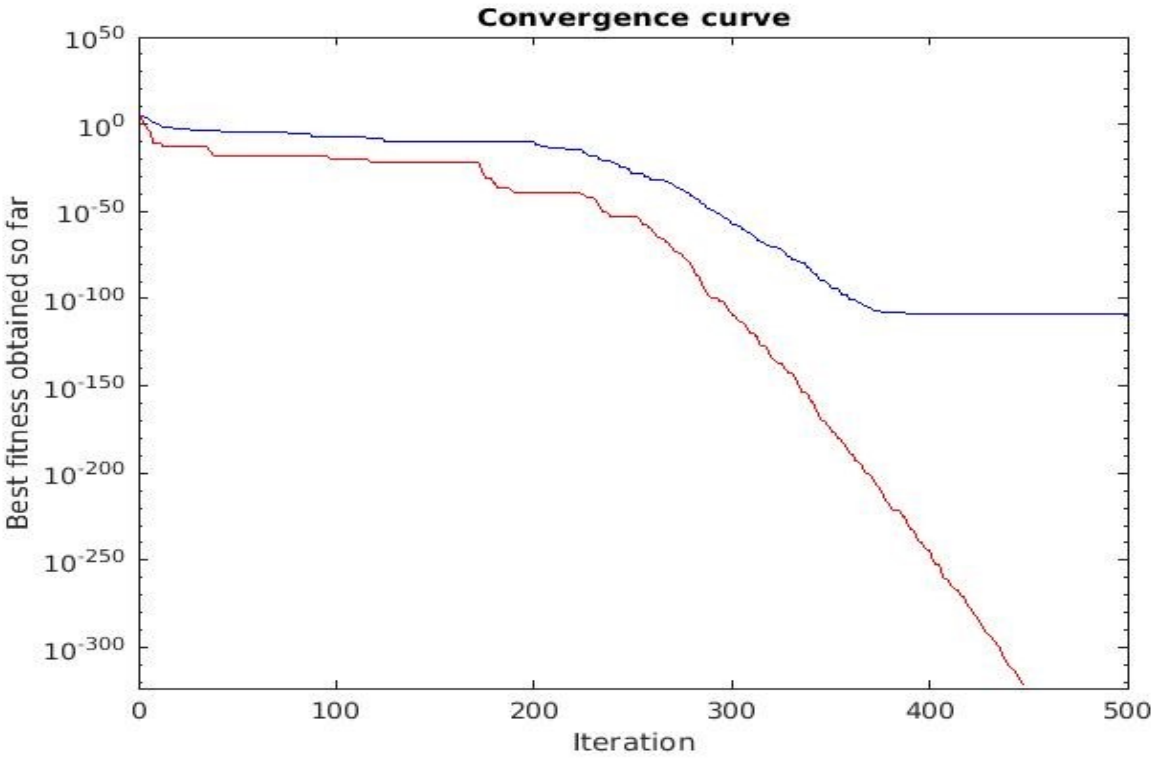

Figure 5.1: 1st Benchmark function result

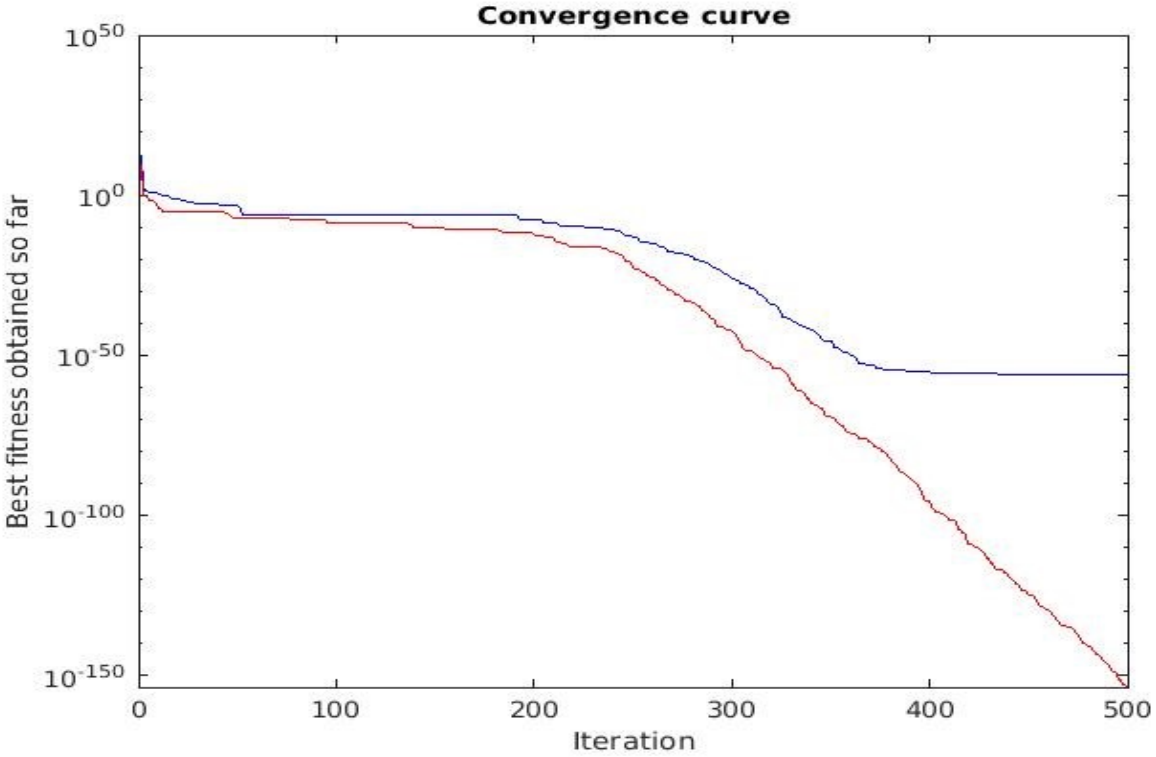

Figure 5.2: 2nd Benchmark function result

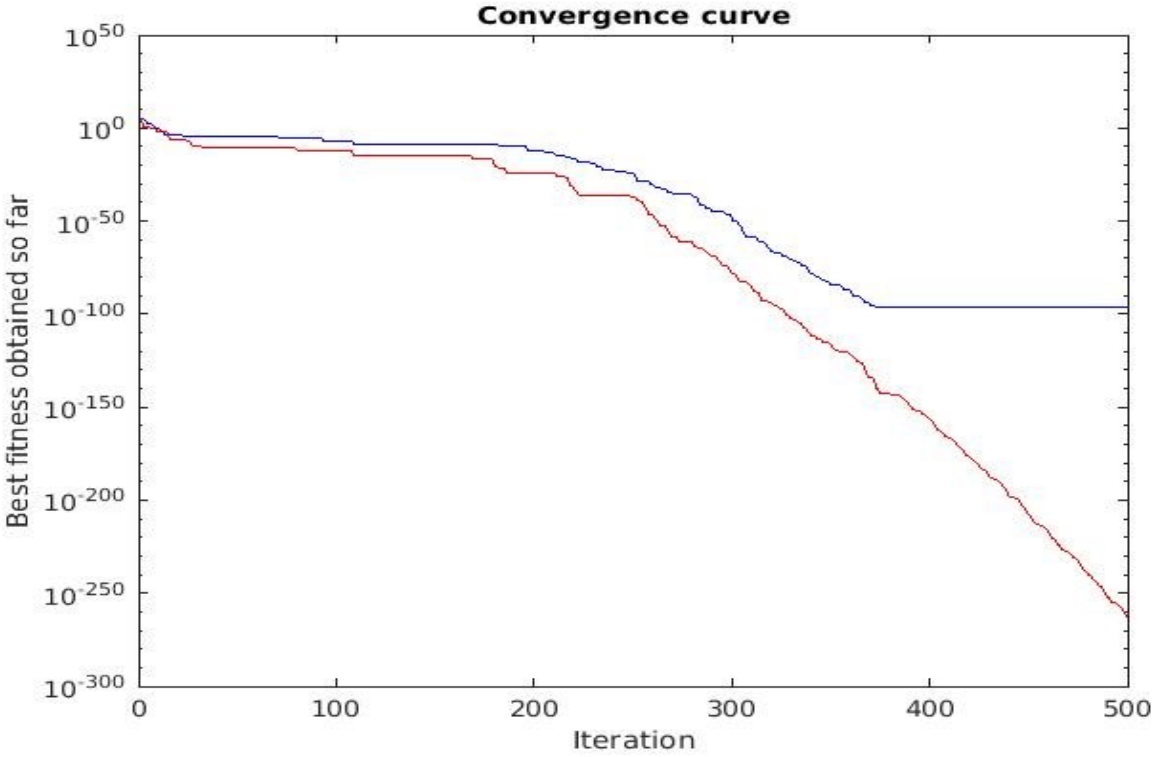

Figure 5.3: 3rd Benchmark function result

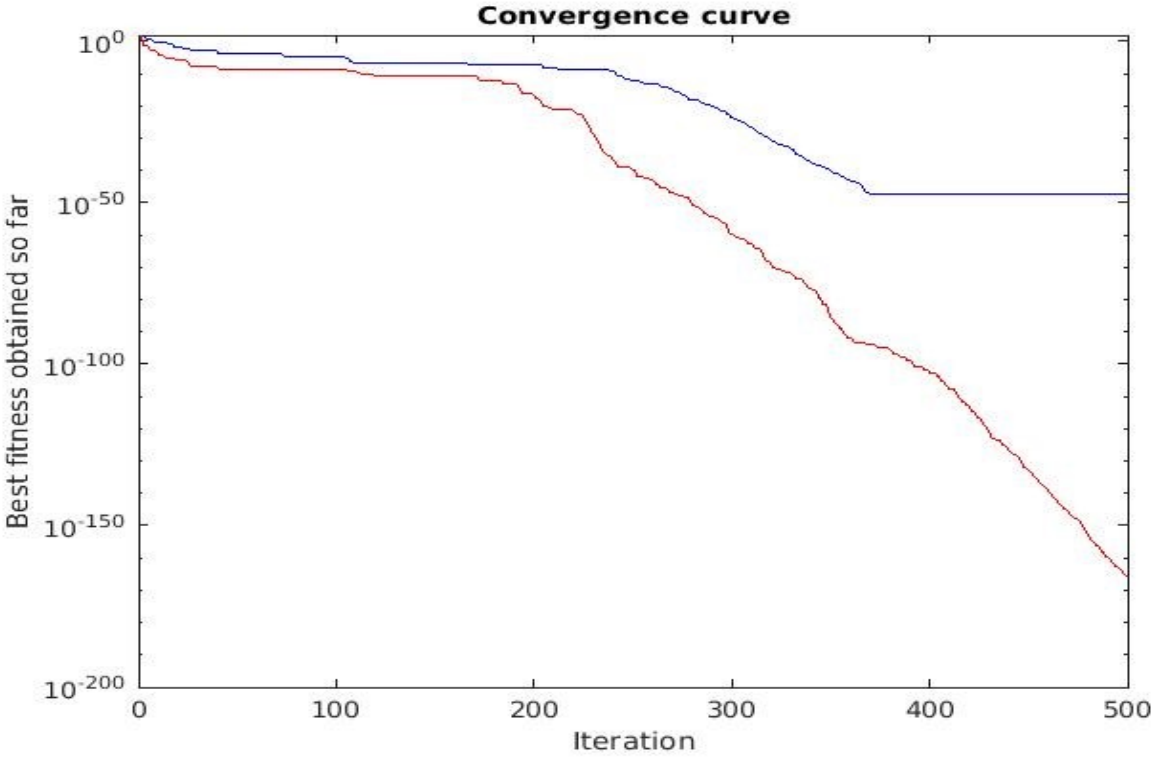

Figure 5.4: 4th Benchmark function result

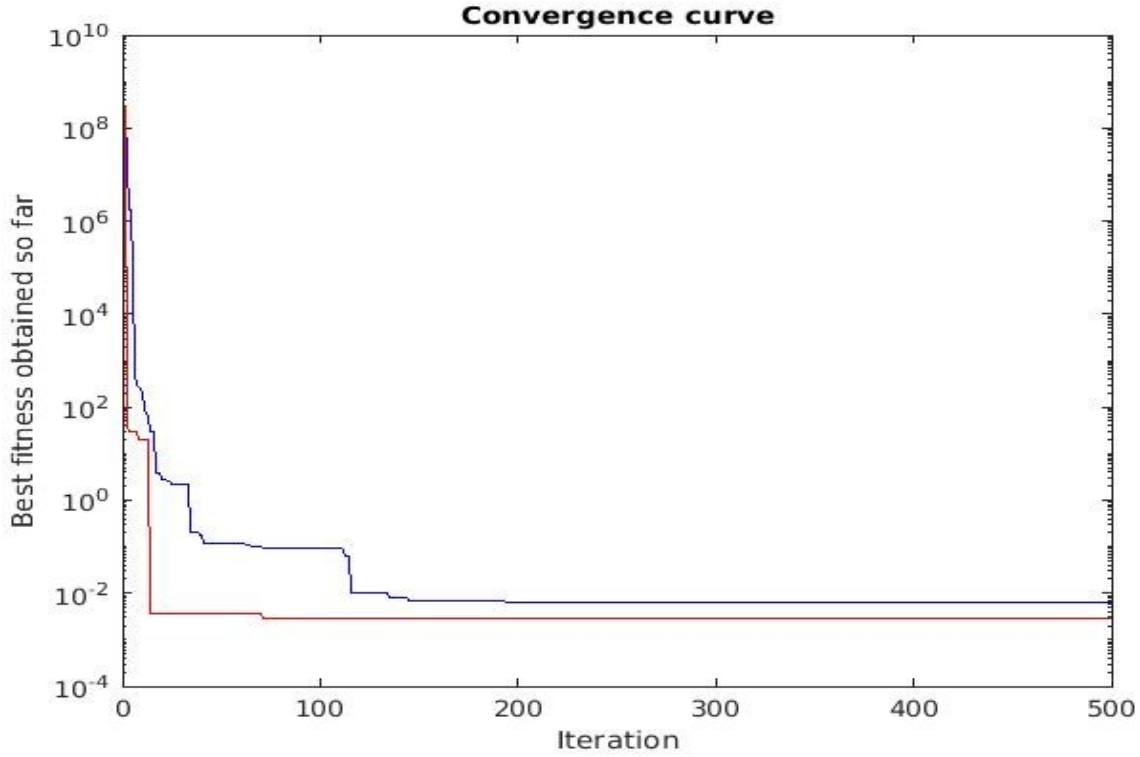

Figure 5.5: 5th Benchmark function result

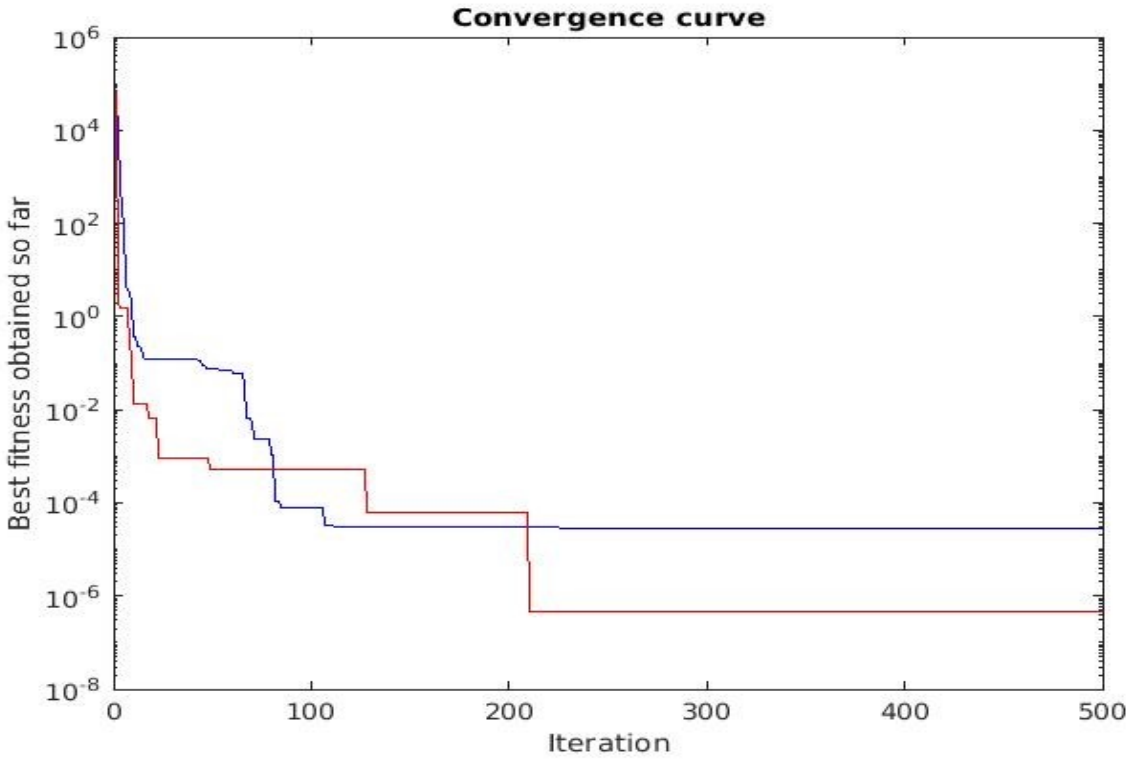

Figure 5.6: 6th Benchmark function result

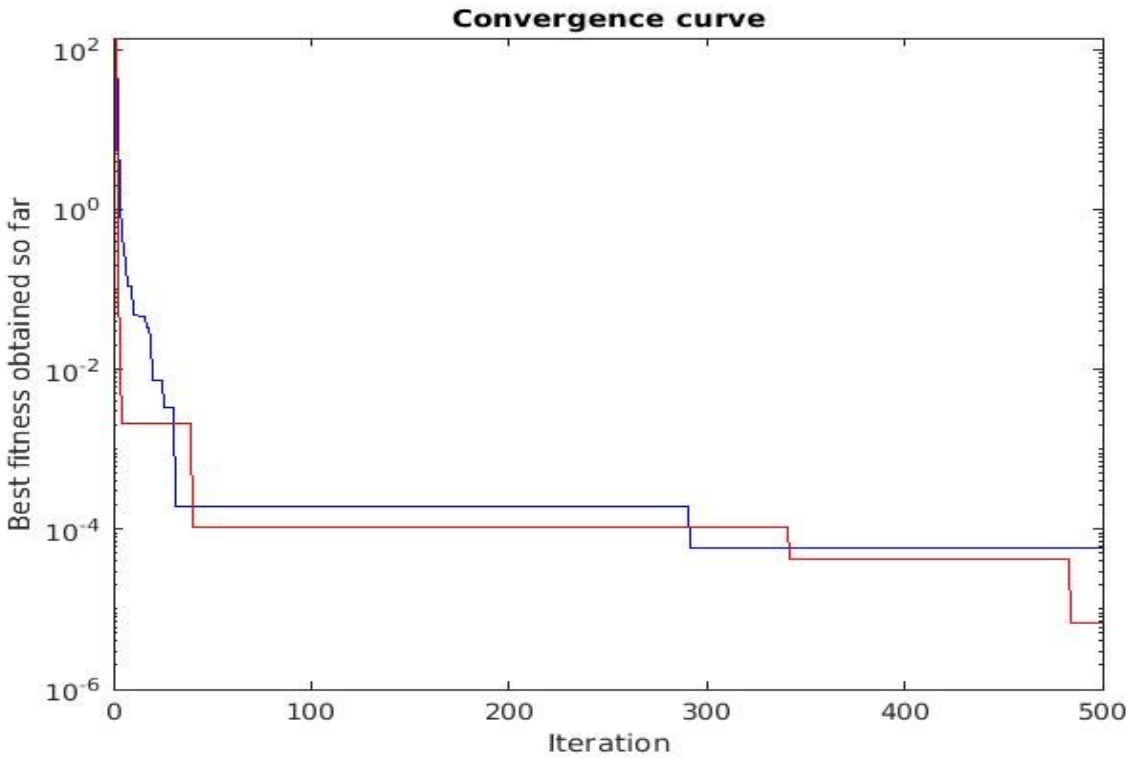

Figure 5.7: 7th Benchmark function result

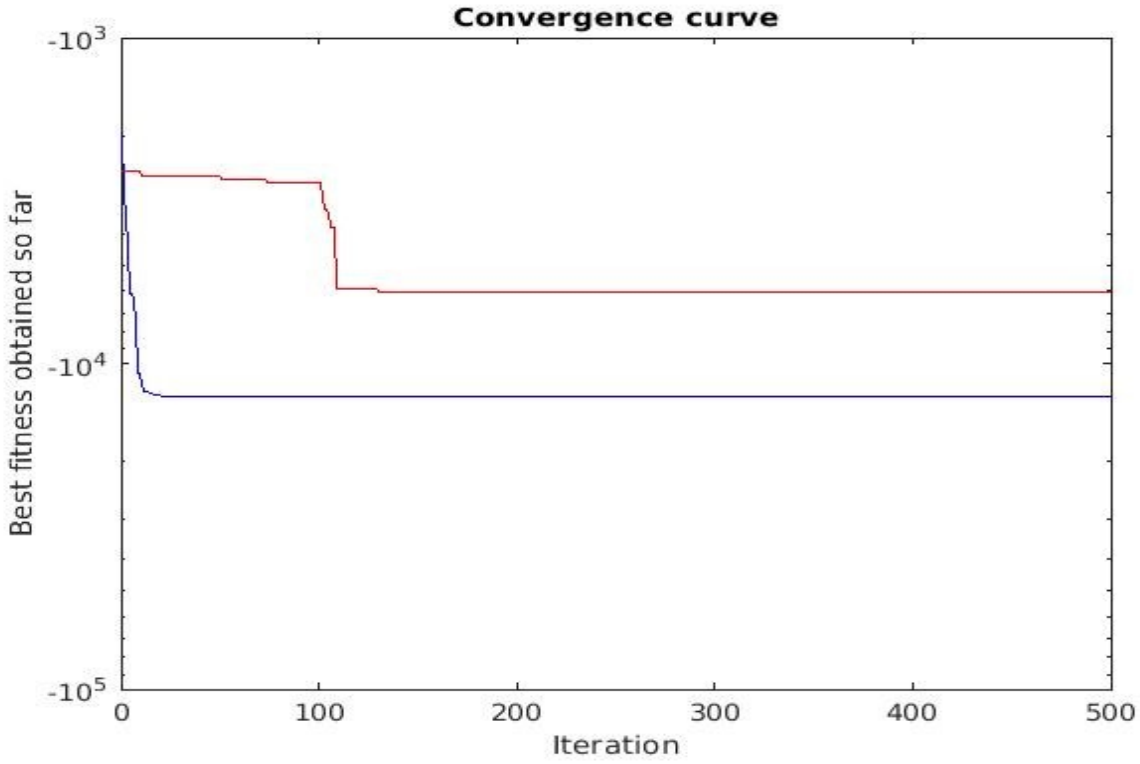

Figure 5.8: 8th Benchmark function result

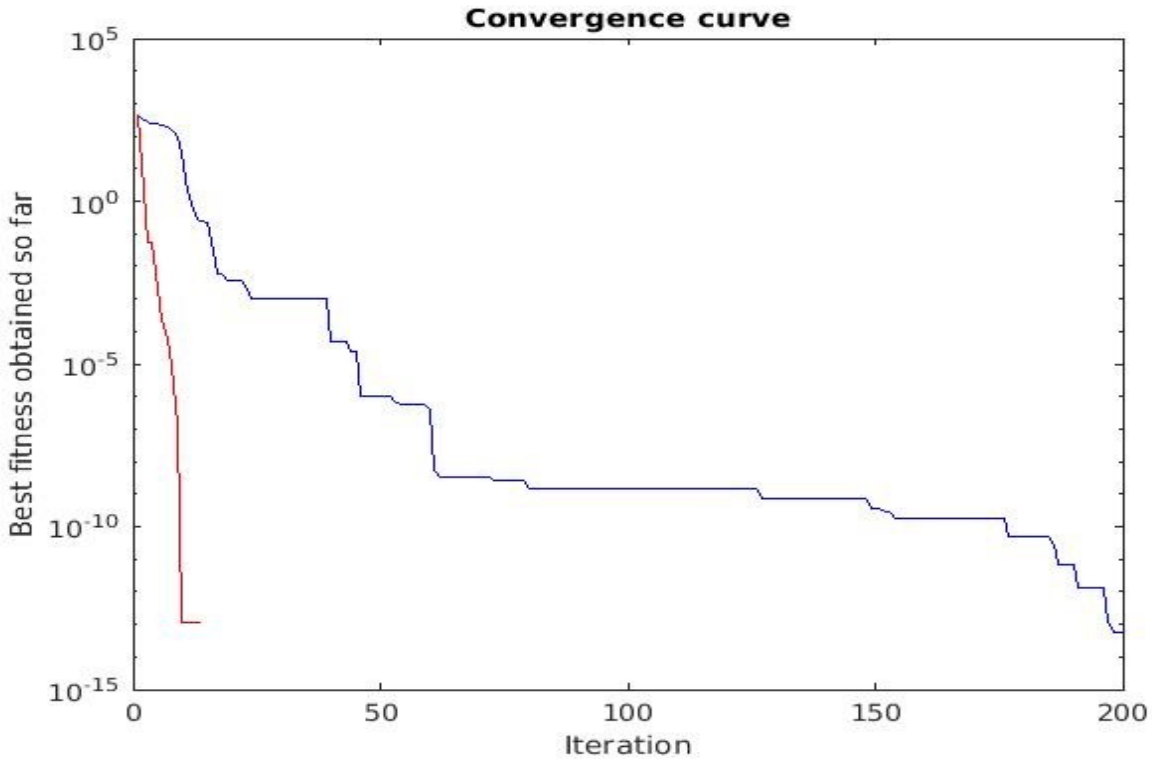

Figure 5.9: 9th Benchmark function result

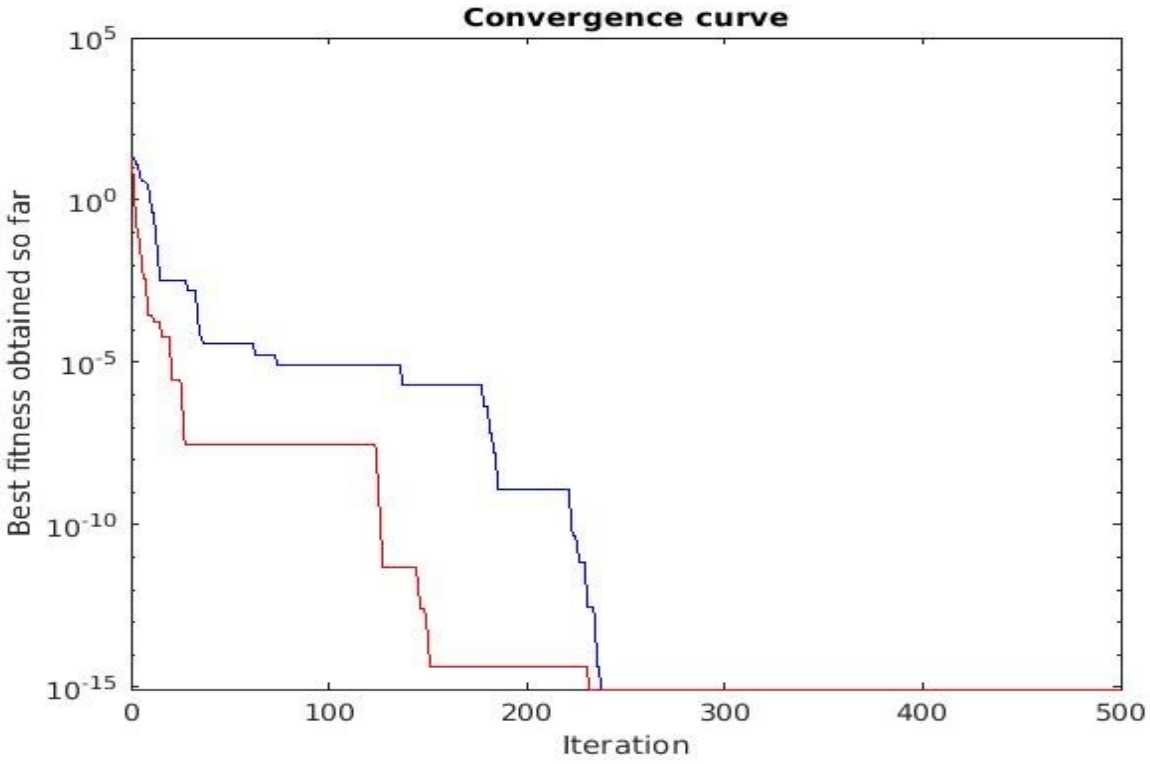

Figure 5.10: 10th Benchmark function result

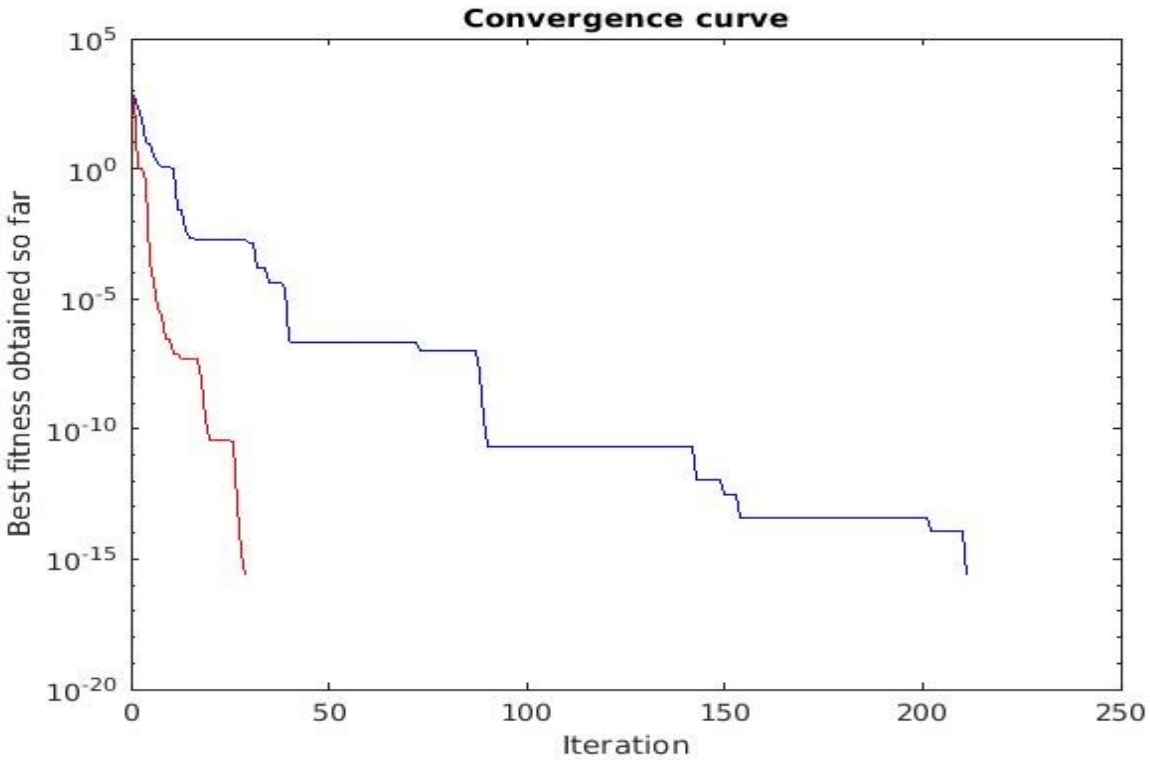

Figure 5.11: 11th Benchmark function result

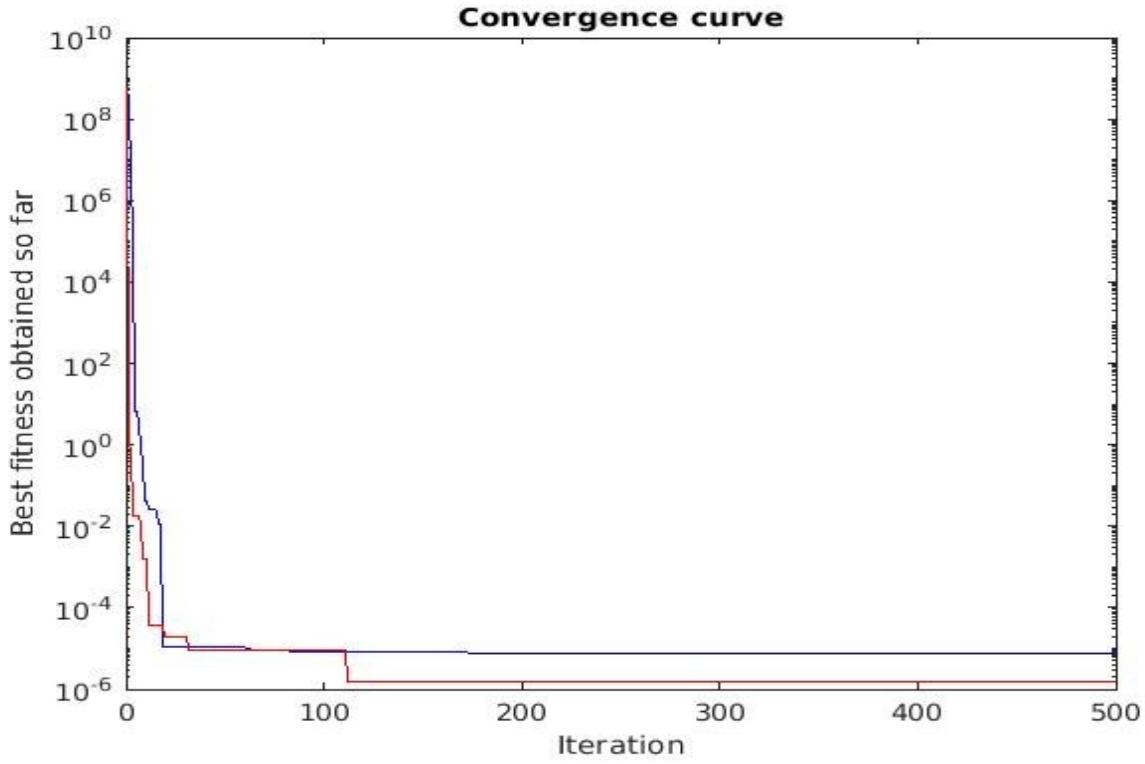

Figure 5.12: 12th Benchmark function result

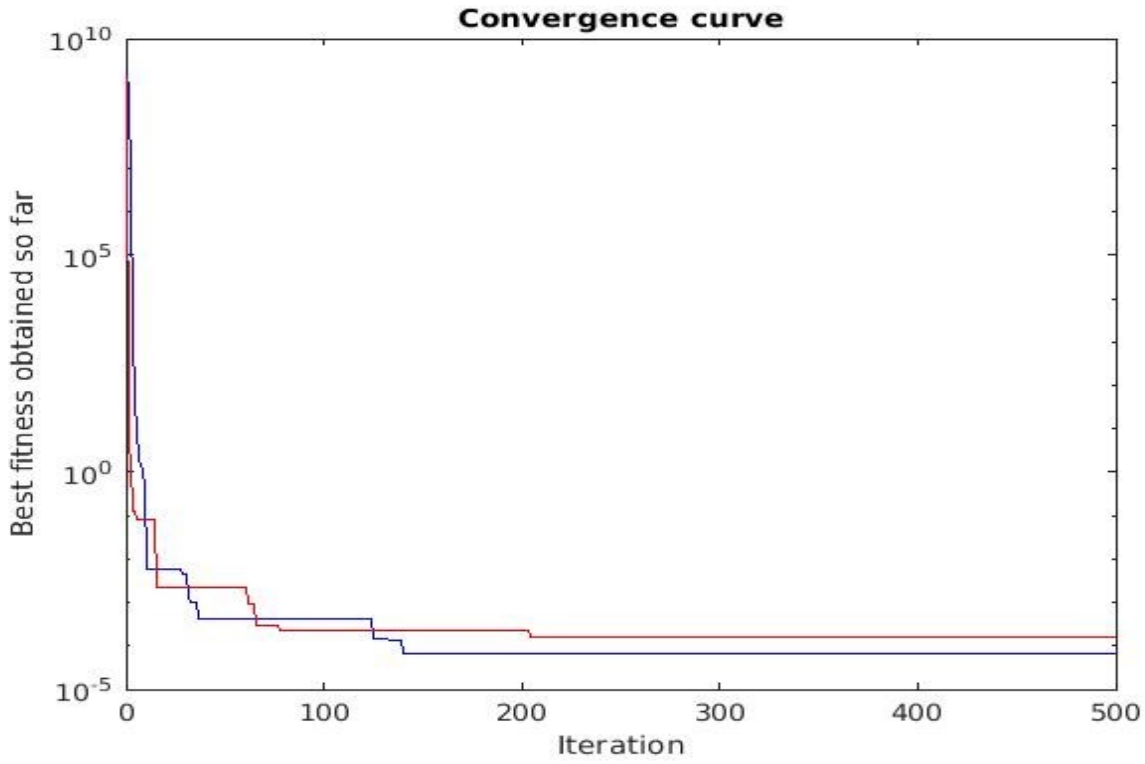

Figure 5.13: 13th Benchmark function result

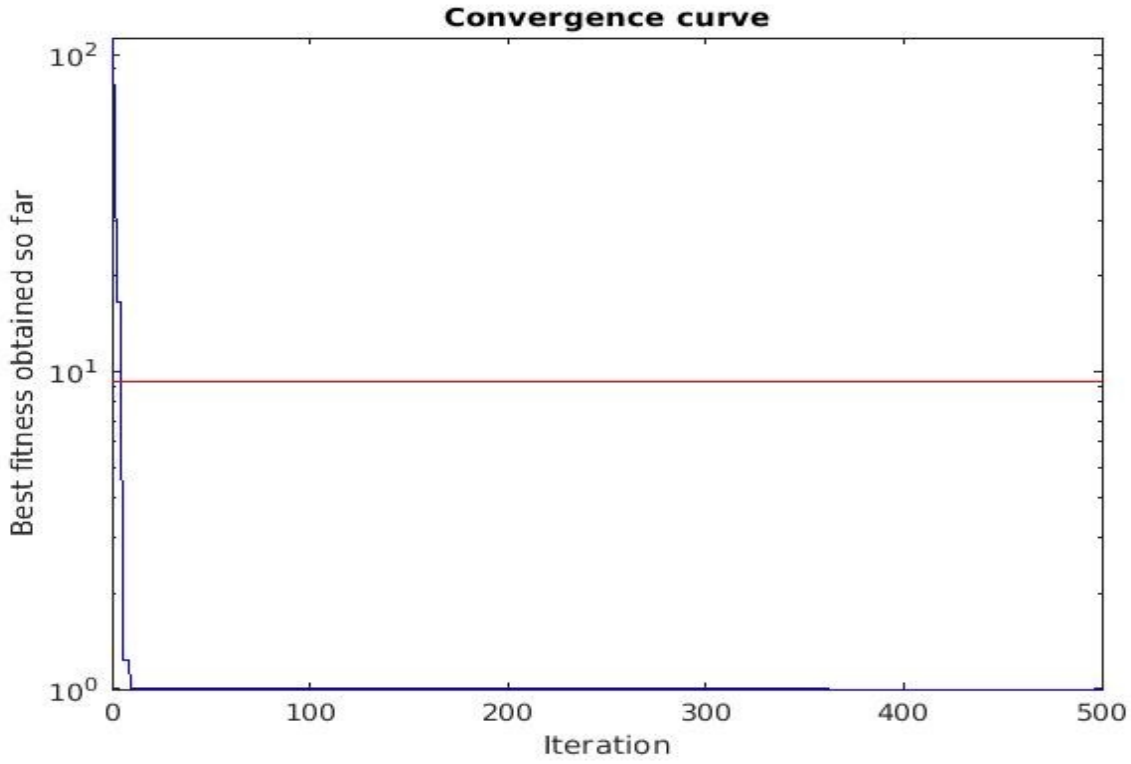

Figure 5.14: 14th Benchmark function result

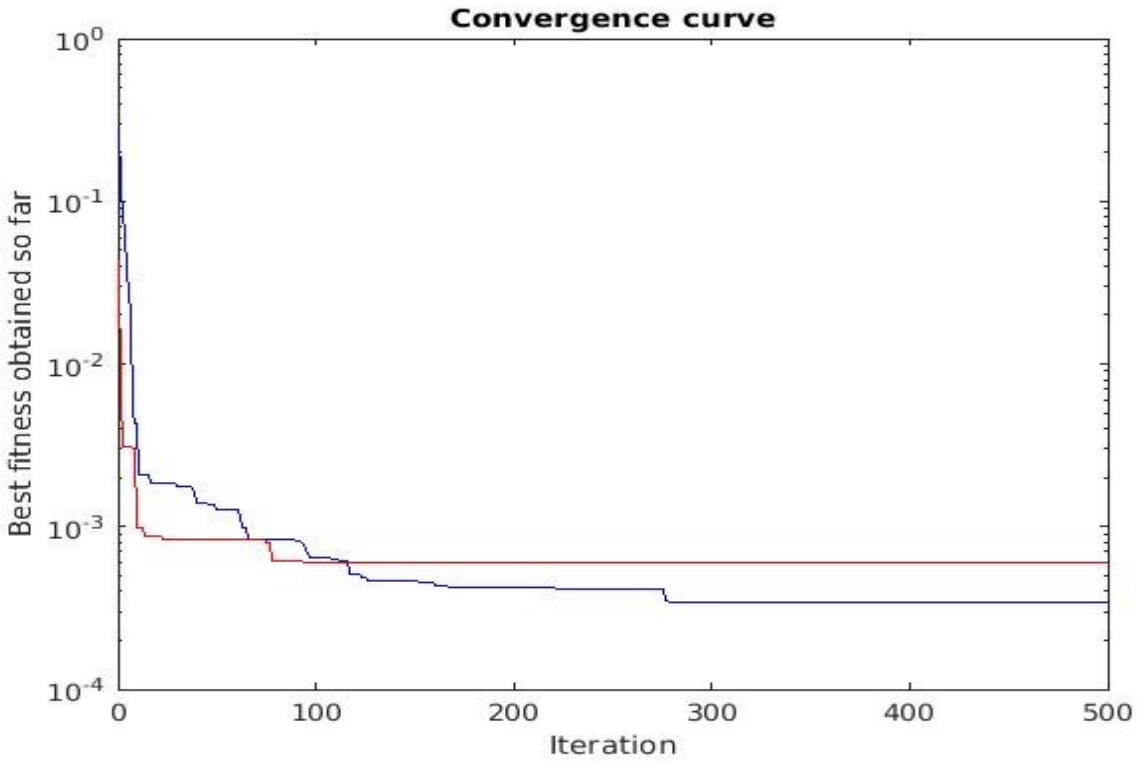

Figure 5.15: 15th Benchmark function result

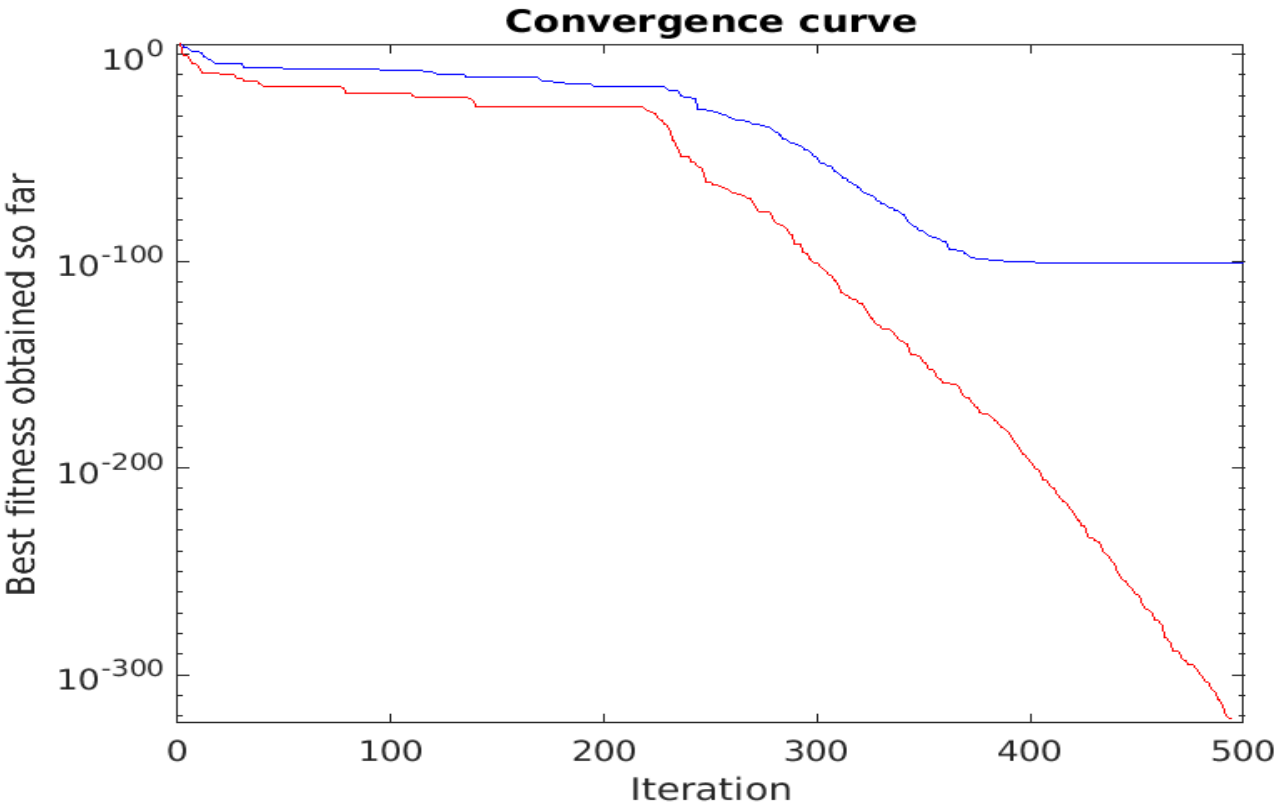

Figure 5.16: 16th Benchmark function result

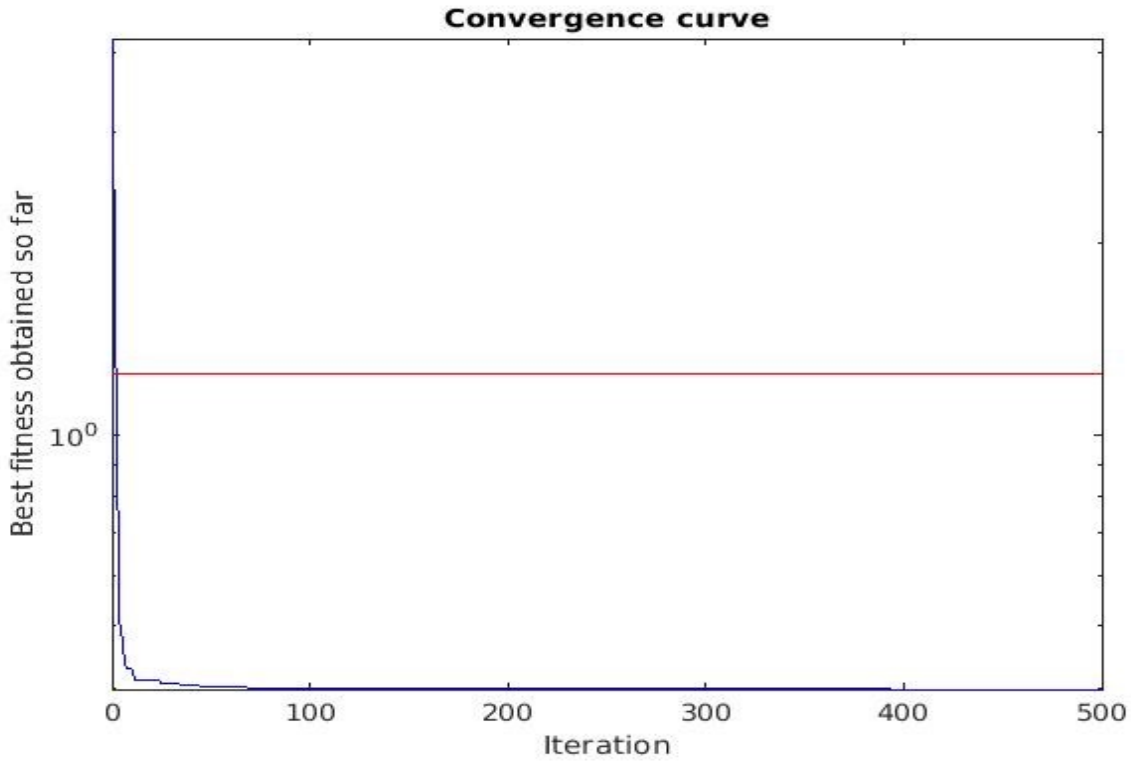

Figure 5.17: 17th Benchmark function result

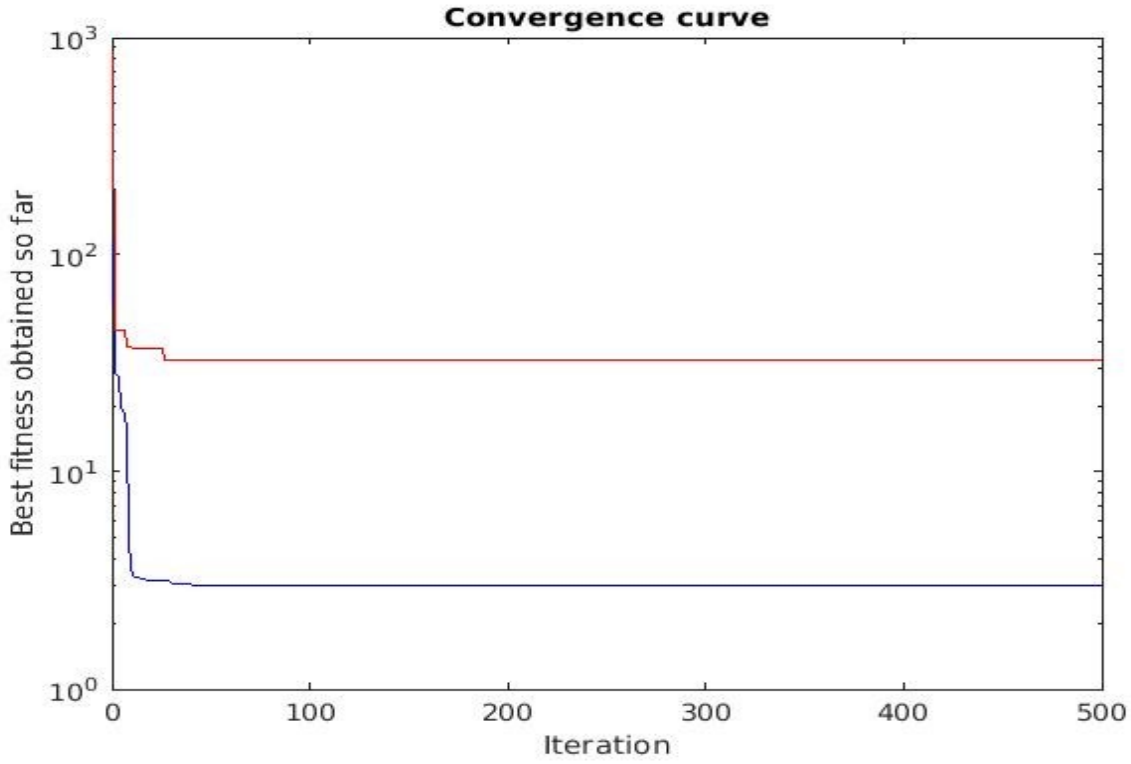

Figure 5.18: 18th Benchmark function result

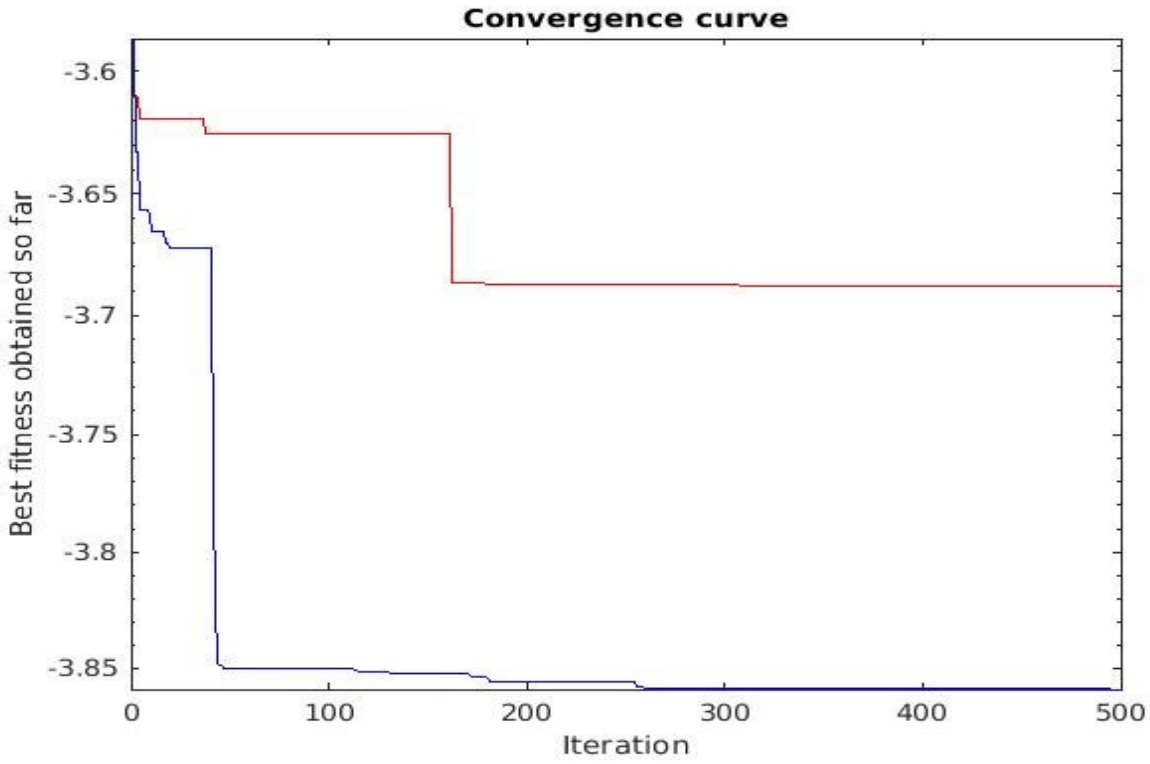

Figure 5.19: 19th Benchmark function result

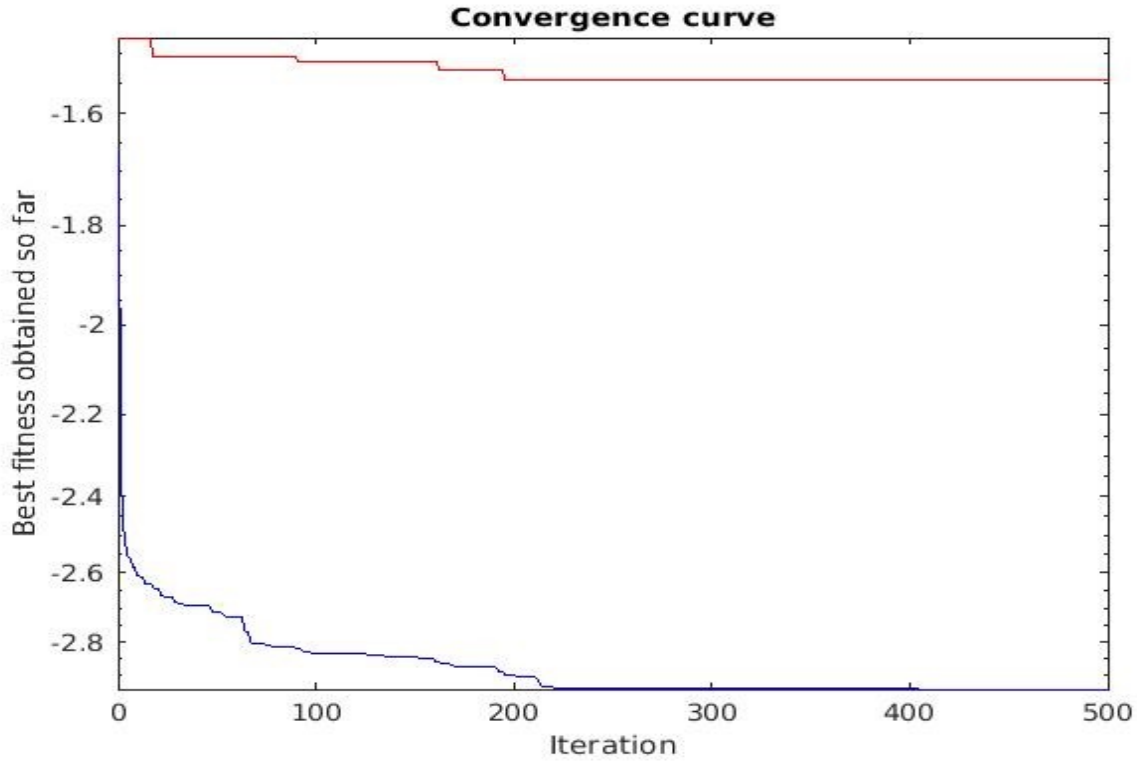

Figure 5.20: 20 Benchmark function result

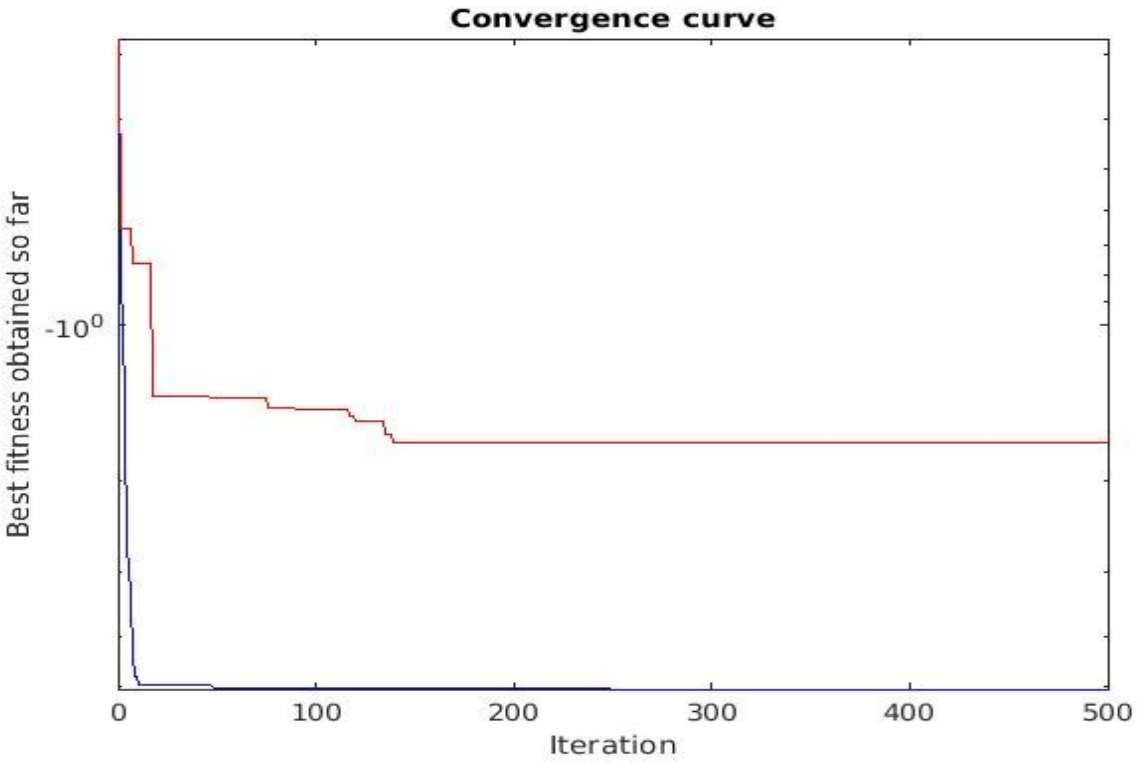

Figure 5.21: 21st Benchmark function result

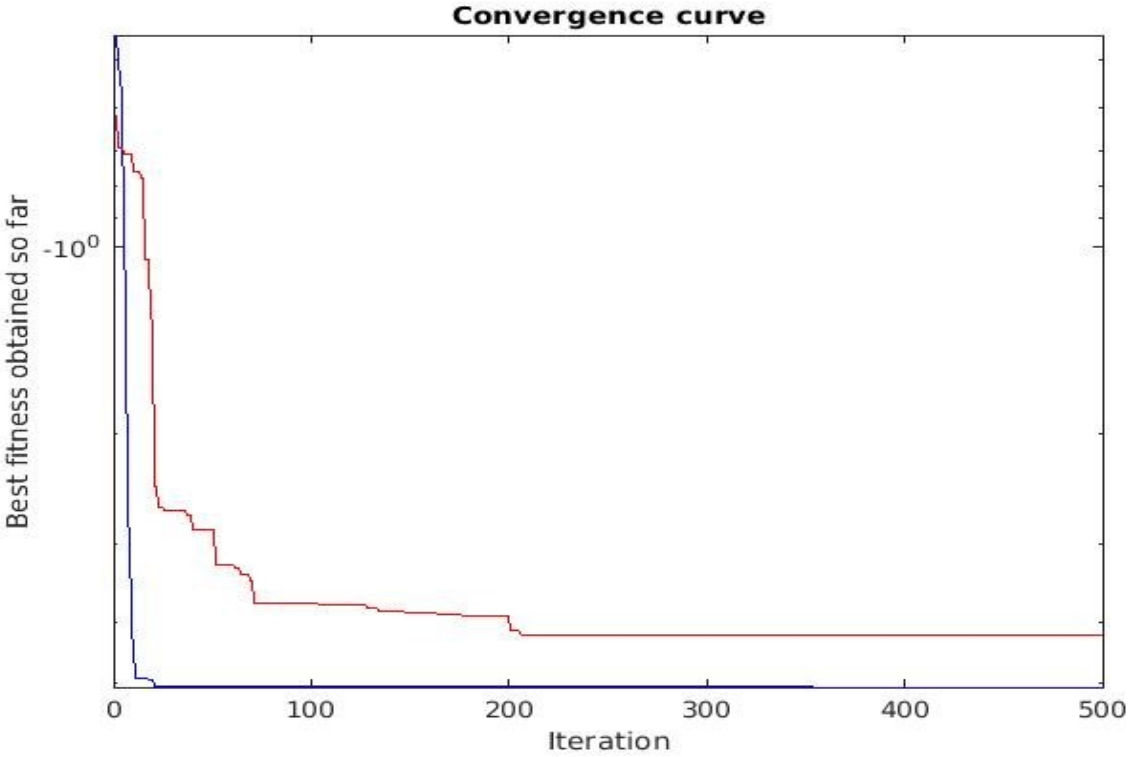

Figure 5.22: 22nd Benchmark function result

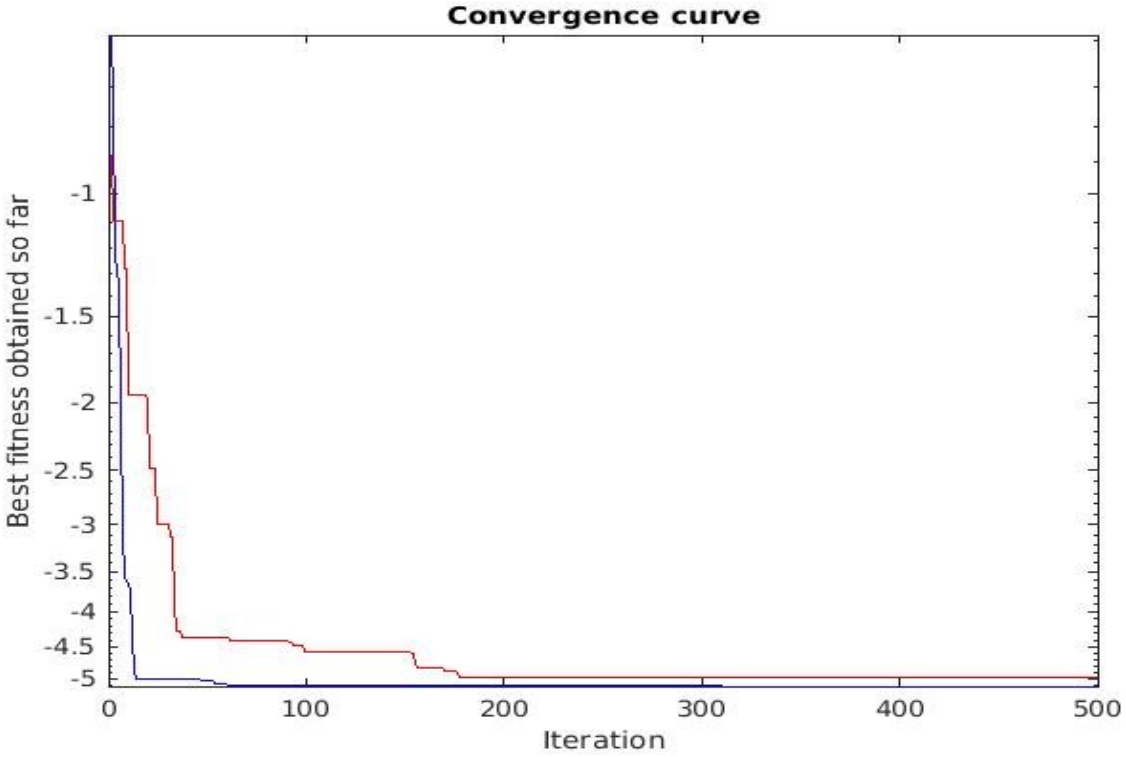

Figure 5.23: 23th Benchmark function result

Chapter 6

CONCLUSION & FUTURE SCOPE

6.1 Conclusion

The proposed algorithm is propelled by the agreeable practices and pursuing styles of ruthless fowls, Harris' hawks and birds of prey, in nature. We structured the proposed algorithm as basic as conceivable with hardly any exploratory and exploitative systems. It is conceivable to use other developmental plans, for example, transformation and hybrid plans, multi-swarm and multi-pioneer structure, developmental refreshing structures, and chaos based algorithm.

6.2 Future scope

For future works, we would like to build the binary and multi-objective versions of proposed algorithm can be developed. Also, it tends to be utilized to handle different issues in designing and different fields. Another intriguing bearing is to analyze distinctive requirement taking care of procedures in managing genuine compelled issues.