Journal of Engineering and Applied Sciences 12 (Special Issue 2): 6219-6222, 2017
ISSN: 1816-949X

A Collective Study on Popular Nature Inspired Optimization

Somya Sneh, Srikar Kompella and S. Chethan
Department of Information and Communication Technology,
Manipal Institute of Technology, Manipal, India

Abstract: The two subsets of nature inspired algorithms are swarm intelligence based and Bio-inspired algorithms. Swarm intelligence based algorithms behave as a sub set for Bio-inspired algorithms. Some other sources of inspiration are Physics-based Chemistry-based algorithms. Though not all of them are particularly efficient however, some of them have become popular tools for modelling and solving real world problems. The purpose of this review is to present a brief description about the four major types of swarm intelligent based algorithms along with their applications so as to provide a comprehensive view on their functioning and performance. The algorithms covered in this study are Particle Swarm Optimisation (PSO), Ant Colony System (ACS), the Artificial Bee Colony (ABC), Cuckoo Search (CS).

Key words: Nature inspired, Bio inspired, Cuckoo search, ant colony, artificial bee colony

INTRODUCTION

Nature is a rich source of inspiration for researchers in various ways. Now a days, most new algorithms are nature-inspired, because of there closeness to real world. This sudden surge in nature inspired algorithms is due to the fact that these algorithms have resulted in a much optimised and quicker solutions to most of the complex real world optimisation problems. The two major subsets of nature Inspired Algorithms are Swarm Intelligence (SI) based and Bio-Inspired (BI) (but not SI based).

Swarm Intelligence (SI) basislies on common behaviour of self-organised components. Some popular swarm intelligence algorithmsare Particle Swarm Optimisation (PSO), Ant Colony System (ACS), the Artificial Bee Colony (ABC), Cuckoo Search (CS) and so on. Swarm Intelligence can be used as a newer and advanced initiative to solve problems that take insight from foraging behaviour of insects and other animals. Self-organisation and division of labour are the two properties of SI. Self-organisation is the ability of the system to form a self-sustainable order without requiring any foreignaid whereas division of labour is parallel completion of many basic and attainable functions. SI requires algorithms to be robust as well as flexible to internal and external changes.

Bio-inspired algorithms are a super set of SI. Biology serves as a perplex source of inspiration for the design of intelligent entities for efficient operation in unknown environment. The main aim towards creating these entities is to allow self prediction, designing, control, optimisation that models real life like situations. Many Bio-inspired algorithms are not completely swarm based. Therefore, they are called them Bio-inspired instead of SI-based.

MATERIALS AND METHODS

Nature inspired algorithms: Based on the above discussion, the four algorithms chosen are Particle Swarm Optimisation (PSO), Ant Colony System (ACS), the Artificial Bee Colony (ABC), Cuckoo Search (CS).

Particle swarm optimisation: Particle swarm optimisation technique is a famous swarm inspired technique. Kennedy and Eberhart (1995) developed it, the inspiration behind this optimisation technique was the swarming behaviour in birds flocking and fish schooling. A particle is an independent item in a swarm and goes by the name of particle. A particle might serve as a probable solution. The main objective of the algorithm was to work on a multidimensional hyper plane on locating a local optima which is done by new particles following the fitter ones (Kennedy and Eberhart, 1995; Eberhart and Kennedy, 1995). Particles are placed in certain positions and certain velocity is also attached. A traditional PSO works in the following ways (Hu *et al*., 2011).

Particle initialisation

Velocity updating: Velocity is updated using an equation that contains variables and constants for obtaining the

Corresponding Author: Somya Sneh, Department of Information and Communication Technology,
Manipal Institute of Technology, Manipal, India

best possible solution. The velocity is kept within a threshold to limit it from reaching a high value. Best solution is G(t).

Position updating: The positions are updated using an equation that contains the initial positions and the velocity. G'(t) will substitute G(t) if G'(t) is a better result.

Repeat steps two to four till local optima is located. In the first iteration every particle is evaluated and all of them circulate to lookfor the best possible result (exploration). Convergence is reached when the particle with best result leads all other particles in the space.

Ant colony system: According to the findings of French entomologist Pierre-Paul Grasse some species of termites react to "significant stimuli" called stigmergy which is a type of information in which the "workers are stimulated by the performance they have achieved". The differentiating features of stigmergy are it is a tortuous form of communication and it is local to the environment.

Pheromone is a substance deposited on the ground by ants while walking to and from a food. In the "double bridge experiment" by Deneubourg in this an ant colony was associated with a food source by two bridge of equal length. Initially, the ants select the bridge at random and keep depositing pheromone as they travel. However, after some time it is observed that one of the either bridge has more concentration of pheromone and is selected by all the ants in that colony. Hence, the entire ant colony converges to one bridge. Positive feedback exploitation is done in this colony level behaviour which helps in finding the shortest path between ant and food source. Double bridge experiment where one bridge is longer than the other causes the initial fluctuations to deteriorate which has an essential impact. But since, the shorter bridge receives pheromone deposition faster than the longer one, hence probability of choosing the shorter bridge increases considerably.

Cuckoo search: The foraging behavior of Cuckoos inspired the development of this algorithm by Suash Deb and Xin-She Yang in 2009. It is based on how some Cuckoo species usually don't lay eggs in their own nets but they prefer nests of other birds. Even though it came out in 2009, it has plenty of variants. Some host birds can put on a direct strife with the encroaching Cuckoos and the characteristics of Levy flights (Pavlyukevich, 2007) such as some birds and fruit flies. Studies have shown that it has outperformed particle swarm optimization. It has three steps of working: in every iteration, each Cuckoo is allowed to lay only one egg and the nest is randomly chosen by them. The eggs and nest with a minimum threshold quality re carried out to the next generation. A fixed number of hosts are available and a prior probability determines the nest in which Cuckoo has laid the egg to be discovered by a host. The local random walk is:

$$xt+1 = xt + \alpha s \otimes h(S-o) \otimes (xt - xt)$$

The equation consists of a heavside function (h(u)), two different results selected randomly (xtj, xtk), step size (s) and a random number (o). This summarizes the basic functioning of Cuckoo search.

Artificial bee colony: Artificial Bee Colony algorithm (ABC) takes its inspiration from the intelligent behavior of bees using population based search mechanism. In this procedure, the main goal of the bee is to locate individuals called food sources with highest amount of nectar which is then updated accordingly (Karaboga and Basturk, 2008; Li and Jianhu, 2010). In such a system, artificial bees fly around multi-dimensional spaces. The employed and onlooker bees select food sources and adjust their positions based on the previous experience. Scout bees do not have any experience and select the food source randomly. Nectar at new location is higher than that at older location then they forget the old one and learn the new location.

It is important to note that the foraging behavior of bees is not simultaneous. Studies have shown that this rate is proportional to the total number of bees and the ones currently foraging. Basic Properties of self-organisation are:

- Positive feedback: the number of onlookers increases with an increase in the amount of nectar
- Negative feedback: poor food source exploitation is cancelled by the bees
- Fluctuations: random search process is carried out by scouts for locating new sources of nectar
- Multiple interactions: dance area is utilized to supply the food source information by bees to their nest mates

RESULTS AND DISCUSSION

Applications: Following are the few applications of the above discussed nature inspired algorithms.

Particle swarm optimisation: PSO has wide range of applications in various fields of engineering and science. Its known for its optimisation and fast convergence. Signal processing, uses many concepts that make use of PSO. A few of them are used in the design of IIR filters, particle filter optimisation, nonlinear adaptive filters. Other applications are in the field of Biomedical, sensor networks, speech coding (Venayagamoorthy and Zha, 2007), power systems, machine learning, image processing.

Ant colony system: One of the major applications of ACS is Max Min Ant System. It serves as a betterment of the original algorithm. Only value bound pheromone trails are updated. There is a variable L best that signifies the length of the best ant's tour. It could be either one Lbi (best route in present step) or Lsb (best result from the sart of the algorithm-best-so-far) or also could be a mix of Lbi and Lsb (Stutzle and Hoos, 2000). The confinement on the pheromone values, the variables omin, omax are obtained and are based on the problem defined (Socha *et al*., 2002). ACS also plays a crucial role in the optimisation of travelling sales person problem (Dorigo and Gambardella, 1997).

Cuckoo search: It has many applications in various fields. Face recognition can be optimized using Cuckoo search. CS is used in the feature selection step of face Recognition. Feature selection is implemented to further reduce the extracted features that lead to reduction in redundancy and irrelevant features. The resulting feature subset is used to recognize the face. Its applied in various other fields too such as of travelling sales person problem, computer games (Speed, 2010), business, neural network, economics, etc.

Artificial bee colony: The artificial bee colony is relatively new algorithm in the field of nature inspired algorithms. The ABC algorithm can be applied to solving General Assignment Problem (GAP) which models the foraging behavior of honey bees. Some of the complex real world problems that are solved using the foraging behavior of honey bees are: continuous optimization problem, TSP, ride matching problem. It has widespread applications in various fields, some of which are in nuclear power plant to check accident diagnosis, computers (Li and Jianhu, 2010; Jun and Xian, 2009) and also in neural networks (Karaboga and Basturk, 2008).

Improvements: In this study, we see few ways in which we can improve the above discussed algorithms.

Particle awarm optimization: The PSO algorithm has many benefits. Its implementation is easy and simple, only a some parameters have be initialised, its efficiency in global search is high. It has no major effect in scaling of design variables and can be efficiently paralleled. It has its advantages and disadvantages. Early convergence is the main disadvantage of PSO. There are several ways and techniques to improve PSO. Faster and precise convergence can be ensured with high population size. Commonly used technique for PSO is to use a sub-swarm method. Its very popular and has proved to increase its performance. Each sub-swarm could be allocated a different task or a duty which in turn increases the efficiency of PSO in multi-objective problems. Setting the contributing factors of velocity equation can result in faster convergence because it causes the particles to be fired in different directions.

Ant colony system: Ant colony systems have tried to improve the basic ant algorithm. An ant can make use of information and the search for improving the system robustness without having to be limited to pheromone trail. During experiments it was found that the algorithm luckily falls into a local minimum. This leads to premature convergence of the whole system because the route is not allowed to evolve towards an optimized solution.

Cuckoo search: CS boasts a lot of advantages, efficient random walks, balance mixing, efficiency in global search and resemblance between eggs can produce improved solutions. Since, p(a) is used, good solutions are inherited to future generations whereas the not so good ones are not passed and replaced. Cuckoo search can be extended to perform multi-objective optimisation. Some of its variants are multi-objective CS, multi-objective scheduling problem etc. There are many improvements made to the general CS such as Tsallis entropy (Agrawal *et al*., 2013), improved scatter search using cuckoo search, etc.

Artificial bee colony: FMBAC an improvised version of ABC was proposed. Sensitivity model in the free search algorithm was used to displace the selection wheel model this was done so as to reduce the possibility of a local optimum. A opposition-based learning based on mutation strategy was proposed instead of the behaviour of scouts because the behaviour of scouts was tedious to set which had a huge impact on the algorithm's performance.

CONCLUSION

In this study, four Swarm-Intelligent based (SI) algorithms were studied. The algorithm working was observed thoroughly, along with a real life application of the four mentioned algorithm. We saw how SI based algorithm works on the foraging behavior of insects and other animals. We also studied the optimization techniques used by some of the insects and animals to solve the real life complex problems. Further a few improvements were also mentioned for these existing algorithms.

REFERENCES

Agrawal, S., R. Panda, S. Bhuyan and B.K. Panigrahi, 2013. Tsallis entropy based optimal multilevel thresholding using cuckoo search algorithm. Swarm Evol. Comput., 11: 16-30.

Dorigo, M. and L.M. Gambardella, 1997. Ant colony system: A cooperative learning approach to the traveling salesman problem. IEEE Trans. Evol. Comput., 1: 53-66.

Eberhart, R.C. and J. Kennedy, 1995. A new optimizer using particle swarm theory. Proceedings of the 6th International Symposium on Micro Machine and Human Science, October 4-6, 1995, Nagoya, Japan, pp: 39-43.

Hu, J., Z. Wang, S. Qiao and J. Gan, 2011. The fitness evaluation strategy in particle swarm optimization. Appl. Math. Comput., 217: 8655-8670.

Jun, D.H. and F.Q. Xian, 2009. Artificial bee colony algorithm based on Boltzmann selection policy. Comput. Eng. Appl. China, 45: 53-55.

Karaboga, D. and B. Basturk, 2008. On the performance of Artificial Bee Colony (ABC) algorithm. Applied Soft Comput., 8: 687-697.

Kennedy, J. and R. Eberhart, 1995. Particle swarm optimization. Proceedings of the International Conference on Neural Networks, Volume 4, November 27-December 1, 1995, Perth, WA., USA., pp: 1942-1948.

Li, B. and Z. Jianhu, 2010. Self-adapting search space chaos-artificial bee colony algorithm. Appl. Res. Comput. China, 27: 1331-1335.

Pavlyukevich, I., 2007. Levy ?ights, non-local search and simulated annealing. J. Comput. Phys., 226: 1830-1844.

Socha, K., J. Knowles and M. Sampels, 2002. A MAX–MIN ant system for the university timetabling problem. Ant Algorithms, 2463: 1-13.

Speed, E.R., 2010. Evolving a mario agent using cuckoo search and soft max heuristics. Proceedings of the International IEEE Conference on Consumer Electronics Society's Games Innovations (ICE-GIC), December 21-23, 2010, IEEE, Hong Kong, China, ISBN:978-1-4244-7178-2, pp: 1-7.

Stutzle, T. and H.H. Hoos, 2000. MAX-MIN ant system. Future Gener. Comput. Syst., 16: 889-914.

Venayagamoorthy, G.K. and W. Zha, 2007. Comparison of non uniform optimal quantizer designs for speech coding with adaptive critics and particle swarm. IEEE. Trans. Ind. Appl., 43: 238-244.