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BIO-INSPIRED OPTIMIZATION ALGORITHMS IN WIRELESS SENSOR NETWORKS

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ABSTRACT
A contemporary rise in the number of bio inspired optimization algorithms could be attributed to the increasing relevance of sensor networks in our daily lives. All these algorithms are used for optimising various aspects of sensor networks.. This has undoubtedly created a sundry of new possibilities for optimizing these networks. With such a variety at hand, choosing the best ones for our purposes could become quite a task. This paper exclusively concentrates on algorithms that improve wireless sensor networks from a routing perspective. We have focussed on routing because each and every sensor produces a large amount of data. These data has to be routed intelligently in a network. To keep the network alive for a long time. Thus this paper proposes various algorithms that can be efficiently used for routing optimisation in sensor networks.
KEYWORDS Bio-inspired Optimization, Swarm intelligence, Routing, Energy Efficiency

INTRODUCTION

Wireless sensor network's reach spans from agriculture to surveillance making every aspect of our life "smart" with its touch. Its size and advanced sensing technology has added to its popularity and outreach .In face of all its useful features, there exists a downside to it. Its main drawback is that it is battery operated. If a sensor runs out of its battery the sensor dies and has to be replaced. A sensor failure has the potential to knock down an entire network. Thus increasing the battery life at the same time efficient use of that energy becomes of paramount importance. Thus to tackle this problem there are many algorithms developed in many different fields like fuzzy algorithms, artificial neural networks and genetic algorithms. When it comes to swarm intelligence the study of the behaviour of many animals, flocks of birds and micro organisms in the nature has been used to solve the existing real time problems. All the above can be collectively referred as bio inspired computing or bio inspired algorithms. The inherent intelligence of these algorithms and its remarkable capability t adapt to its surrounding just like life-forms has done much to increase its prominence in the arena of meta heurestics. These algorithms. The speciality of these algorithms are that it is capable of solving problems with dynamic constraints with a wide range of viable solutions and its ability to make decisions based on probabilistic or at times incomplete input data. Thus considering the salient features of bio inspired algorithms and the dynamic nature of routing problem we propose to analyse different algorithms that may be used for route optimisation in wireless sensor networks.

SWARM INTELLIGENCE

Swarm optimization techniques are those inspired from the flocking activity of birds, fishes, ants ,bees etc. All these organisms , despite navigating in huge numbers shows remarkable pattern in its' movement. This behaviour helps them in foraging, surviving their predators, using their valuable energy efficiently. The essence of swarm intelligence is the transmission of knowledge rather than data i.e each and every sensor does transmit all the data it has procured from its surrounding. It transmits the knowledge or the observation or the conclusion the sensor deduces from its procured data. This concept is a revolutionary one when considering the amount of energy it is capable of reducing in huge networks which simply can't afford to fail frequently.

ANT COLONY OPTIMIZATION

Ant colony optimization is a search algorithm, for solving combinatorial optimization problems. This algorithm finds its inspiration in the behaviour of ants. When an ant starts to roam around searching for food, initially its movement is random .While it is roaming around it leaves a mild trace of a hormone called pheromone. This pheromone trail is similar to a bread crumb trail ,left by the ant intentionally so that other ants could pick-up the trail and follow. Once the ant finds its prey it returns back to its colony following the same trail it left behind. If

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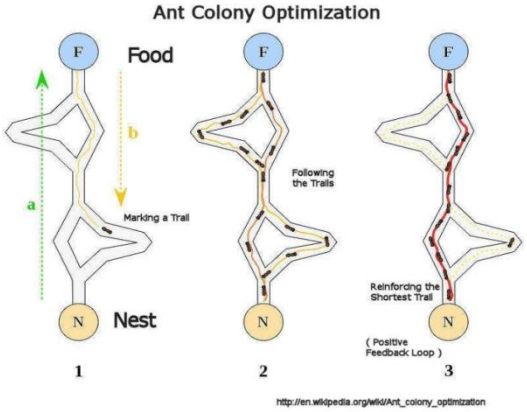
the path is short the ant could make many round trips there by leaving a strong



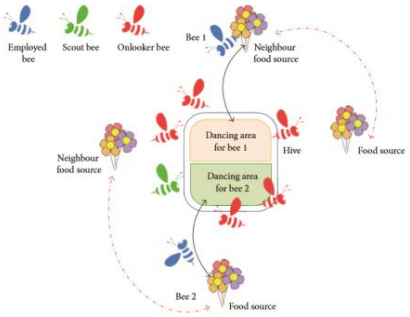
Trail ,thus encouraging other ants to follow the same route. If the path found is long then it could possibly leave a weak pheromone trail and thus discourages the ants from following the trail when there exists en even more stronger pheromone trail. The same concept is followed in the algorithm. Entities called ant agents are deployed in field of search , each agent goes about exploring the candidate solution leaving a trail specific to it. These random candidate solutions formed in the initial phase are considered and the best path is deduced from it. In general, the k-th ant moves from x to y with a probability.

$$.P_K(r,s) = \{\frac{[T(r,s)]^{\alpha}[E(s)]^{\beta}}{\sum_{\mu \epsilon M_k}[T(r,s)]^{\alpha}[E(s)]^{\beta}}, if\ s\ \epsilon M_k$$

$$0, \quad otherwise$$

ARTIFICIAL BEE COLONY ALGORITHM

The artificial bee colony algorithm is the bio-inspired optimization algorithm it searches the best analytical solution in the large number of surrogate. This algorithm depends on the aggregate foraging character of honey bees. The honey bees character is depend on the task allocation, communication, nest site choosing, breeding , crossbreed, floral foraging, pheromone laying and navigation characters . These divided into three troops: employed bees, onlooker bees and scout bees. The employed bees visits' the food origin and sharing the information that is direction and richness of the food origin with the onlooker bees, through the waggle dance. The onlooker bees are making a decision to choose the origin with an probability value related to the fitness of the food source. Scout bees carried out the random pursue near the hive. On the other hand, when a food has been fully finished means , all the employed bees will move from the site, and they scout again[9]. Fuzzy logic approach is used to improving the ABC(Artificial bee colony) optimization methods.



PARTICLE SWARM OPTIMIZATION

A swarm of software defined entities called particles are involved in finding the best solution in the pso technique. These particles wander about & explore the search-space this process is called as exploration. Though initially they move about randomly , in further iterations particles move based on its inertia or simply its own previous. Cognitive Force [5].

Social Force or an individual particle's direction is swayed by the swarm direction.

A swift convergence takes place when the particles communicate each other.[5] Exploring the entire search space will result in prolonged processing time which will greatly decrease the efficiency. At the end of every trip or iteration the particles updates its local best position and global best position. If the particles local best solution is efficient and finer than the global best the the global best position is updated to local best if not it is left unaltered. Thus at any given point the overall direction of the swarm itself gets altered[5]. Thus the swarm's ultimate goal is to deduce the global minimum of a function. Thus the activity of the swarm injects disorder and

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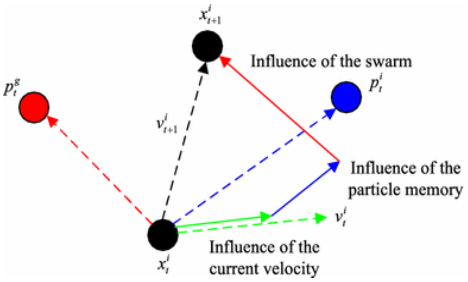
eventually brings us close to the global minima of the cost function. We can illustrate the phenomenon by assuming a d dimensional space and n number of particles with it's own position and velocity, such as

$$Xi=\{X1,X3,\ldots\ldots,Xn\}$$
$$Vi=\{V1,V2,\ldots\ldots,Vn\}$$

respectively. With time the changes are made to reflect in the characteristic equations of PSO as given in Eqs. (1) and (2).

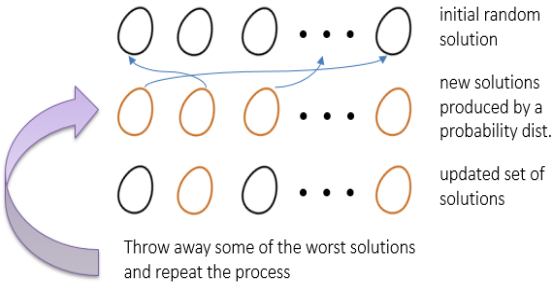
$$Vi,t+1=Vi,t+c1*r1*(pbest-Xi,t)+c2*r2(gbest-Xi,t) \quad E1$$
$$Xi,t+1=Xi,t+Vi,t+i \quad E2$$



CUKCOO SEARCH ALGORITHM

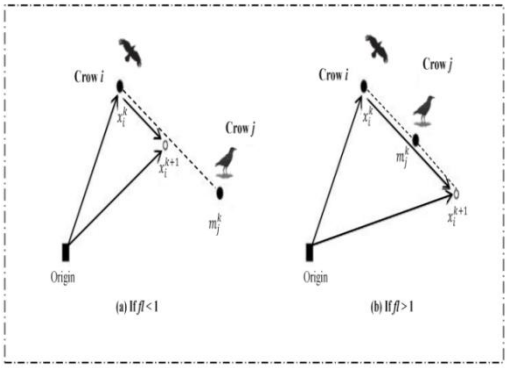
Cuckoo search algorithm as the name implies is inspired from cuckoo. It is a metaheuristic algorithm which is simple to implement and has very few parameters. It works best at solving optimization problems. The essence of the algorithm lies in obligate brood parasitic approach [1] of the cuckoo. When cuckoo lays its egg in a foreign birds nest there is a chance of the foreign bird recognising it. At such instances the host bird either pushes the odd egg out of its nest or moves out of its nest and builds another. Thus it becomes very important for the cuckoo to find the best nest

for its egg. This natural urge to find a best place for its own egg becomes the core of cuckoo search algorithm. In this algorithm every egg is considered as a solution and the cuckoo eggs are considered as new solution. Thus the objective of this approach is to find and use better solution rather than the ones that are lacking[2].



CROW SEARCH ALGORITHM

The crow is an intelligent bird living in the group. It has extraordinary memory power. It uses the memory power to keep or hide the food in some location and after that it remembers the place where they keep the food. Some crows follow other crows to steal the food but the crow has to keep its eye on another crow and change their food location timely.[12] In CSA, the fast fuzzy c means (FFCM)algorithm is used. We have to initialize some parameters for optimization. This FFCM algorithm provides some better flexibility and smartness in the CSA (cuckoo search algorithm). Few steps are followed to derive the foraging process,



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BAT ALGORITHM

Bat algorithm is an efficient algorithm to solve the optimization problems. Echo-location of bats have been influenced in bat algorithm, which is useful for hunting mechanism. Bats uses the echolocation is known as bio-sonar. Bats hear the echo sound which is emitted from the object and also used to avoid obstacle[7]. The bio-sonar method has been used to detect the prey(food) for bat. The length of the micro-bat of about 2.2 to 11 cm. The bat have some pulses they changes depend on their features. There are two types of frequency signals. They are short frequency signal and constant frequency signal. For echolocation, constant frequency signal is used. The frequencies of these signals are high and also by more number of harmonics usage, the bandwidth can be increased. The pulse rate is increased, when they find their prey and they are very close to their prey, this also increases the frequency signal[7]. Range of loudness is given from A0 to Amin where A0 is the maximum and Amin is the minimum value[9]. The number of bats is taken as 'xi' with their respective velocity 'vi'. The frequency is given by 'f'. 'x*' represents the best solution, 't' gives the number of iteration. Here, the mathematical equation is given by

$$f_i = f_{min} + (f_{max} - f_{min})\beta$$

$$v_i = v_i^{t-1} + (x_i^t - x_i)f_i$$

$$x_i^t = x_i^{t-1} + v_i^t$$

COMPARATIVE ANALYSIS:

This section presents a comparative analysis of the algorithms seen so far in terms of the representation, operators, areas of application and control parameters Out of many algorithms only a select few are taken for considerations. All the algorithms that have been considered are in one or other way capable of solving route optimization in wireless sensor networks .

ANALYSIS

S.No	Source Of Inspiration	Name of Algorithm	Algorithm Parameters	Algorithm Application	Year Published
1.	Inspired from the foraging behaviour of ant.	Ant Colony Optimization	Pheromone evaporation, no. of. Ants.	Routing protocols, Enhance network lifetime.	2011
2.	Inspired from the flocking behaviour of birds.	Particle Swarm Optimization	No. of. Particles, acceleration coefficients, inertia weight, neighbourhood size.	Fault tolerance, node localisation.	2017
3.	Inspired from the foraging behaviour of bee.	Artificial Bee Colony Optimization	No. of. bees, No. of. food sources, no. of. Trial limit, stopping condition.	Routing protocols, fault tolerance, congestion control, load balancing.	2016
4.	Inspired from the feature in terms of egg laying and breeding	Cuckoo Search Algorithm	Transition probability coefficient, transition separation coefficient, levy distribution.	Enhance network lifetime.	2018
5.	Inspired from echolocation features for hunting process.	Bat Algorithm	Loudness, Pulse rate.	Node localisation.	2017
6.	Inspired from the crows behaviour of storing and	Crow Search Algorithm	Awareness probability, flight length.	Document classification, feature extraction and prediction, optimization problems.	2018

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	retrieving food				

CONCLUSION

Bio inspired algorithms are poised to revolutionize the world of computer science . Swarm intelligence in particular is garnering increased attention from the scientific community. Nature exhibits swarm intelligence in various organisms and each of which handles swarm intelligence in different style . This paper provides a sundry of algorithms that draws inspiration from ants, bees, fishes (PSO, ACO, ABC).Bio inspired algorithms are metaheuristic ones and are heavily based on the population of the swarm(BA,CSA). Thus this study requires an influx of insight and knowledge from various science disciplines such as biology, physics, computer science ,sensor networks etc.

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