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Cutting edge technology algorithms (Ceta)

Evolution of Mimics of Algorithms of Nature (E-man) Part 6: Research Tutorial on bat and Mosquito algorithms

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(Dedicated to Dr L S A Dikshitulu, former professor of chemistry, Andhra University on his 80th birth anniversary)

CONSPECTUS

Background: The processes in nature are comprehended mainly as those in living (animate) creatures and lifeless (non-living) entities (objects). The latter are broadly sub classified into physical-, chemical-, and geological- astronomical-interactions. The broad characteristics of life are foraging for food, digestion, reproduction, shelter seeking, off-spring care, defense against predators etc. Amidst the life threats, harsh surroundings, calamities and eco-imbalance, species adapt to the changing natural/man-made scenarios and survive. However, when it is out-of-proportion, the population of the species diminish slowly and extinct finally.

Nature inspired algorithms: Computations with numerical data is familiar in formal education, but computing with words is of recent thrust area. From the stand point of a deeper level of comprehension, nature does perform computations; need not be in the same fashion we do with numbers. The miracles of human brain and animal behavior inspired invocation of neural networks in 1940s. The mapping of Darwin's postulates of genetics into genetic algorithm is a mile stone in nature inspired computations. PSO (particle swarm optimization, ACO (ant colony optimization), honey bee foraging, group of lions hunting prey are cornerstones of swarm intelligent approaches. SAA (simulated annealing algorithm) speaks of impact of annealing of glass, a chemical process and intelligent water drop/gravity/ big bang big crunch algorithm were invoked from keen research of physical processes. Now there are around fifty nature-inspired mathematical optimization tools. The different types of classifications and a bird's eye view of them are described. The frame consisting of heuristics, meta-heuristics and hyper-heuristics is sought after in this domain.

E-man_ToolBox: It operates in classical and user chosen and research modes. Each of NI (nature inspired) - algorithms in basic/advanced modes can be run using built-in-prefixed sequences of operations. In the research mode, a new approach, an existing one with untried options is available for an exploratory study. An exhaustive search for all possibilities is time consuming, but is easily possible with smaller test data. The structure of the toolbox includes algorithm specific parameters in default, user chosen or those available in reported literature database. The NI_algorithm independent operations like iteration, fitness function, convergence, solution evaluation are kept separate. The initiation, movement in m-D space,

fitness evaluation, and best position selection are programmed as functions using IF-Then-else logic and operators for an instance. The modifications and advances are developed as functions/operators.

Bats in nature: Bats live in groups in their roosting crevices. It is the only mammal with wings. Microbats exhibit echolocation to detect prey for food and also way back to their home. Although a large number of bats move, apparently there is no swarm intelligence in their activities. Evolution made them to transmit ultra sound of 20-250 KHz frequency with an amplitude (loudness) using a definite emission rate and the bursts last for a very small time. It waits for the reflected echo from a prey/obstacle and analyzes the wave. The bat has the ability to distinguish the prey from background even in darkness. The microbats use not only echolocation technique, but also vision and other senses to locate food. It changes the loudness and emission rate when it approaches the prey. Even frequency is a variable and it matches with the size of the food preys. The frequency decreases soon after they find a prey and subsequently approach them slowly.

Artificial bats:The echolocation process is translated into mathematical model. The fixed frequency of bat emission is assumed. Each virtual bat flies randomly with a velocity v_i at position x_i . As it searches and finds its prey, the emitted frequency, loudness and pulse emission rate of ultrasound are changed. Selection of the best continues until certain stopping criteria are met. The translation of biological features into mathematical domain is only partial and some details are ignored. This basic bat algorithm is improved in these five years to a noteworthy state by hybridizing with fuzzy logic, PSO, GA, mutation operators, chaos etc. The data representation ranged from binary to floating point and quaternion formats. The exploration and exploitation of search space is imbedded in this model in right proportion. The bat algorithm is designed for classification, single/multiple optimization criteria and refinement of weights of neural networks as well as the architecture. Bat algorithm is added to E-man tool kit and the operators for velocity, frequency, pulse emission rate, loudness are developed for textual display and numerical computation. The noteworthy hyper heuristic is COBRA (Co-Operation of Biology Related Algorithms) making best use of positive features of algorithms Particle Swarm Optimization (PSO), Wolf Pack Search Algorithm (WPS), Firefly Algorithm (FFA), Cuckoo Search Algorithm (CSA) and Bat Algorithm (BA).

Mosquitoes in nature: The natural evolution enhanced the survival of mosquitoes in widely varying environments and under harsh surroundings. As one of the measures of mosquito control, the sperm of male mosquitoes is deactivated through chemicals in recent advanced man-made intervention. A sterilized male mosquito produces only semen, but not the sperm. Thus, even if it mates with a female mosquito, the latter does not become pregnant.

Mosquito-host-seeking-process in nature: Natural mosquitoes detect a host by heat/ odor and move in radical orbits towards the host for a blood meal.

MosquitoHostSeekAlg:The metaheuristic, 'mosquito-host-seeking-algorithm', is through the inspiration of local interactivity, parallelism and self-organization of movement of natural mosquitoes towards the human target. The terminology of translated biological processes into mathematical paradigm include binary values for sex of mosquito, attraction/ radial distance/ gray values for artificial mosquitoes from host, computing cell to perform parallel computations, traversing path, shortest distance etc. The pseudo code, matlab-modules and heuristics in if-then-else format are critically discussed. MosquitoHostSeekAlg is used to solve travelling sales man task with 110 to 510 cities using one, eight and sixteen parallel nodes. It is also used in quality assurance task. The efficiency of algorithm is compared with ACO, SAA, SOM and EN. The future scope of this coveted algorithm is incorporated.

Egg laying of female mosquitoes in nature:Female mosquito exhibits intelligence to locate a site to lay eggs.

Delay of egg hatching in unfavorable surrounding conditions:

Astonishingly, the in situ eggs are blessed with built in knowledge to detect favorable surroundings, otherwise they delay the hatching process and await for suitable environment.

Mosquito-oviX- optimization algorithm: With inspiration from the highly selective behavior of female mosquitoes in choosing a habitat to lay their eggs and the inhibition of those eggs to hatch into the next stage, Mosquito-oviX- optimization metaheuristic algorithm is proposed. It is used to find global optima of multi-dimensional test functions. MosquitoHostSeekAlg and Mosquito-oviX are also now an integral part of E-man_ToolBox.

Keywords: Multi-object-functions, Nature-inspiring algorithms, E-man, Bat algorithm, Echolocation, Mosquito-oviposition-site/egg-hatching (Mosq-oviX-eggHatch), bio-process-knowledge, swarm intelligence, bio-nspiration.
