Honey Bee Foraging Algorithm for Multimodal & Dynamic Optimization Problems

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ABSTRACT
We present a new swarm based algorithm called Honey Bee Foraging (HBF). This algorithm is modeled after the food foraging behavior of the honey bees and performs a swarm based collective foraging for fitness in promising neighborhoods in combination with individual scouting searches in other areas. The strength of the algorithm lies in its continuous monitoring of the whole scouting and foraging process with dynamic relocation of the bees if more promising regions are found. The algorithm has the potential to be useful for optimization problems of multi-modal and dynamic nature.

Categories and Subject Descriptors
I.2.8 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search – *Heuristic Methods*

General Terms
Algorithms, Experimentation.

Keywords
Swarm intelligence, honey bees, PSO, multi-modal functions, dynamic functions, optimization.

1. HBF OPTIMIZATION ALGORITHM
HBF is an optimization algorithm inspired by the swarm behavior of honey bees. We assume several swarms of bees foraging for better fitness values in a collective and coordinated manner. We also have scouting bees searching randomly for regions of better fitness. Corresponding to the waggle dance of the bees at the hive, a blackboard is maintained which may be updated asynchronously whenever some useful information is available. Bees returning after foraging or scouting update the blackboard and reallocate themselves after analyzing the information on the blackboard. Due to the formation of multiple swarms for foraging in multiple regions combined with continuous scouting of the landscape, HBF algorithm is potentially suitable for multi-modal problems where all the peaks above a certain height are to be discovered and also for dynamically changing environments where the position and height of peaks may shift. Many researchers have attempted these two problems by swarm intelligence e.g. [2].

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One bee is one complete solution of the problem. A fixed number of bees (h) are created and placed randomly in the fitness landscape. The fitness at each of these points is calculated. The points are sorted on the basis of their fitness and bee swarms (of n bees each) are created around each of the m best points. If any two or more of the best points are near one another then they are considered as belonging to the same region and only one swarm is created for them (overlapping of swarms is not allowed). The remaining bees ($h - m*n$) are used as scouts and placed randomly. The foraging and scouting bees search for a small fixed number of iterations in the following manner. The n foraging bees search for a peak as a swarm in a coordinated and collective manner (e.g. according to GA, PSO or ACO algorithm). Meanwhile each of the f scout bees searches around its lieu of placement alone (e.g. according to PSO algorithm without social component or mutation only GA).

After a few iterations of simultaneous foraging and scouting a global analysis takes place. The best fitness reported from each of the swarms and the best fitness of each of the scout bees are all sorted and the swarms for the next iteration are determined on the basis of this information. An old swarm is allowed to survive only if its best fitness comes within the first m best points. If one of these best points has been newly discovered by a scout bee, then a new swarm is created around it. No overlapping is allowed during creation of swarms. Also a swarm which has converged is disbanded and the region around its best fitness is considered as completely foraged. This scouting/foraging followed by analysis continues until a stopping condition (e.g. specific number of iterations) is fulfilled.

The algorithm has been tested on several multi-modal functions as well as on moving peaks benchmark. It is able to find all the peaks in multi-modal environments in a reasonable number of fitness evaluations. Similarly it works well in dynamic environments. For details of the experiments and the performance metrics used the reader can refer to [1] (can be procured by e-mailing the authors of this paper).

2. REFERENCES
[1] Baig, A.R., and Rashid, M., "Foraging for Fitness: A Honey Bee Behavior based Algorithm for Function Optimization", *Technical report, NUCES, Pakistan,* Nov 2006.

[2] Blackwell, T., and Branke, J., "Multiswarms, Exclusion, and Anti-Convergence in Dynamic Environments", *IEEE Trans. on Evolutionary Computation*, Vol. 10, No. 4, Aug 2006.