**The Deterministic Spider: A Benchmark for Evaluating Efficiency of Swarm Search**

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**Key Words:** Robotics, Swarms, Biologically Inspired Robots, Path Planning, Complex Adaptive Systems, and Foraging Algorithm

**Motivation:** Swarm Robotics uses simple, scalable, inexpensive, and flexible approaches that emulate biological systems. Our research focuses on collective foraging to enable multiple robots to collaborate and communicate in a decentralized fashion to collect resources in unmapped environments. Currently, there is no standard against which to analyze the efficiency of these search algorithms. This research establishes a benchmark, the Deterministic Spider Algorithm (DSA) to compare efficiency of collective foraging algorithms.

**Contribution:** Scientists have long recognized the value and advantages of deterministic search algorithms in comparison to stochastic searches. Inspired by the “Balanced Algorithm” from [1], the DSA is a benchmark algorithm that allows evaluation of the efficiency of more complex search algorithms. Our analysis compares the DSA against a stochastic search, the Central Place Foraging Algorithm [2].

**Algorithms:** The DSA allows for a robot to exhaustively explore in predetermined spiral search pattern. The Central Place Foraging Algorithm (CPFA) utilizes a genetic algorithm to optimize robot behavior, [2]. It relies on random movements and probabilistic pheromone communication among robots. The DSA and CPFA both require a robot to aggregate found food items to a fixed central location.

**Methods and Results** We use a single robot and assume that it has perfect sensors and the environment is free of obstacles. We ran each algorithm 50 times for 1-hour real time trials, for multiple resource placements for each search algorithm. We observed the number of resources collected per hour in random and clustered distributions. Our results reveals that a single robot performing the DSA does 20% better collecting randomly distributed resources than the CPFA. The DSA produces more variable results due to its dependence on food placement. In comparison, the CPFA produces more predictable results, despite using probabilistic communication.

**Conclusion:** The DSA is more efficient in finding randomly distributed food because it is a pre-planned exhaustive search that eliminates repeated steps. However, the DSA is not significantly better at finding tags in the clustered environment than the CPFA. The efficiency of the CPFA is less variable than the DSA. Our future work will test our prediction that DSA is a reliable and efficient search algorithm for foraging swarms without error, but the CPFA is superior given large numbers of robots with localization error.

[1] Ricardo A. Baeza-Yates, Joseph C. Culberson, and Gregory J.E. Rawlins. Searching in the plane. *INFORMATION AND COMPUTATION*, 106(2):234–252, 1991.

[2] Joshua P. Hecker and Melanie E. Moses. Beyond pheromones: Evolving robust, adaptable, and scalable ant-inspired robot swarms. *Swarm Intelligence*, 9(1):47–70, Feb 2015.