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

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Motivation and Contribution

- Swarm Robotics uses simple, scalable, inexpensive, and flexible approaches that emulate biological systems [1].
- There is no standard to compare the efficiency of foraging search algorithms.
- **This research establishes a benchmark to compare efficiency of multi-robot foraging algorithms.**

This analysis compares the DSA against a stochastic search, Central Place Foraging Algorithm [2]. We use a single robot and assume that the robot has perfect sensors and the environment is free of obstacles.

Main contributions:
A **benchmark algorithm** that allows evaluation of the efficiency of complex search algorithms.

Conclusion

For a single robot,

- **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 statistically better at finding tags in the clustered environment.**
- **The efficiency of the CPFA is less variable than the DSA.**

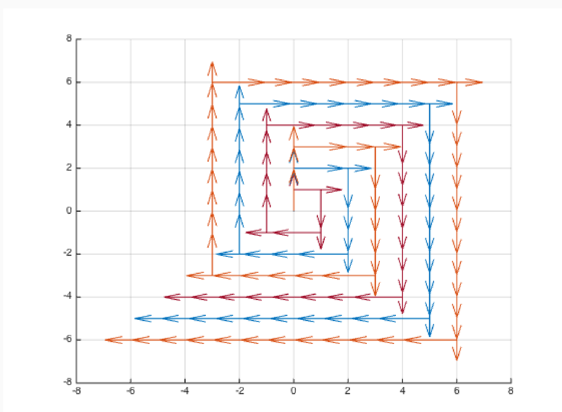

Figure 1: Multiple robots performing the DSA.

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.

References

[1] Visit NasaSwarmathon.com for Swarm Robotics in space exploration.

[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.

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

Source Code

Project source code is available at:
`https://github.com/BCLab-UNM`

Project information, including iAnt build instructions and related work, is available at:
`http://sites.google.com/site/unmantbot/`.

Methods

Both aggregate food items to a fixed central location.

- DSA: Collects food systematically, eliminates revisited tracks, and uses a pre-determined search pattern, but relies on precise planning for robot location.
- CFPA: Recruits robots to large clusters, uses probabilistic communication, and reduces computation and localization planning, but robots may repeatedly search the same location.

We ran each algorithm 50 times for 1 hour real time trials, for multiple resource placements. We observed the number of resources collected per hour in random, power law, and clustered food distributions.

Random | **Power Law** | **Clustered**

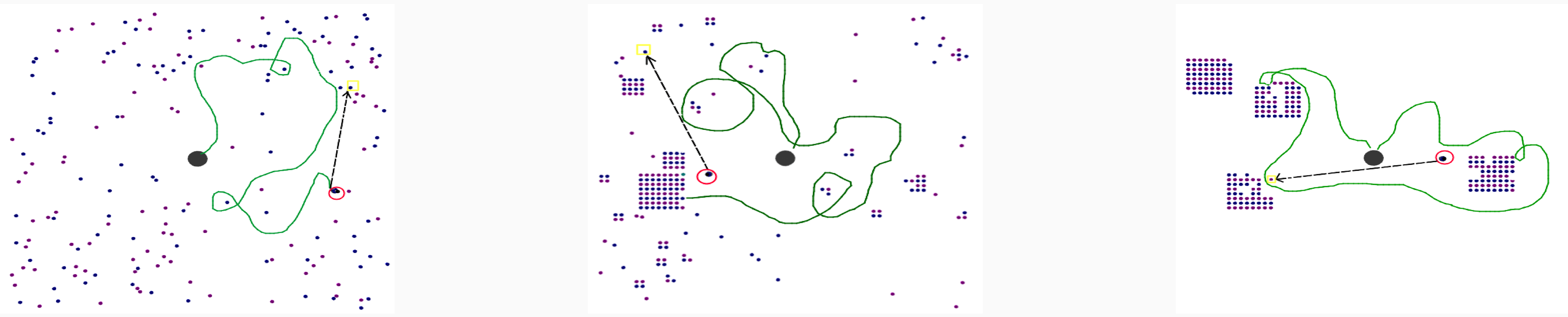

Figure 2: A path of an single robot retrieving a single seed (CPFA).

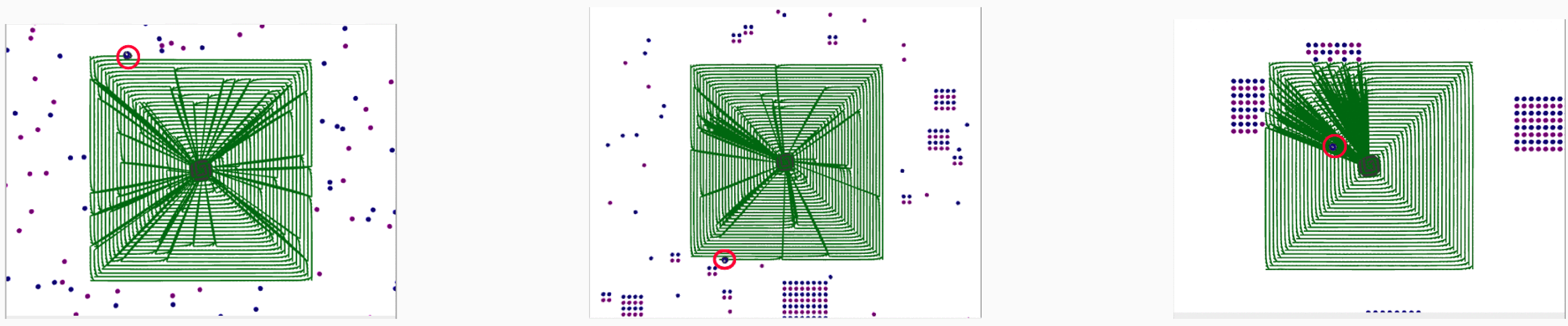

Figure 3: The full path of a single robot collecting for 60 minutes (DSA).

Results

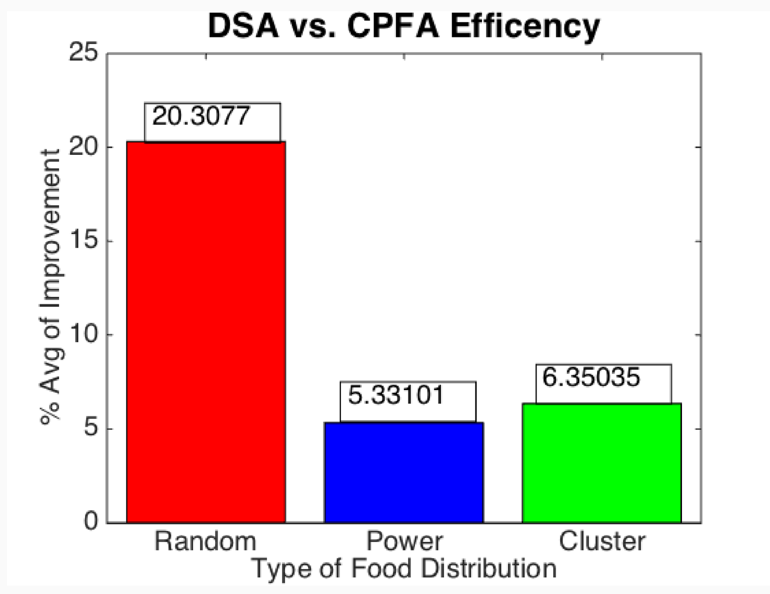

Figure 4: Displays the percentage of improvement of DSA to the CPFA

Our results reveal that:

- A single robot performing the DSA does 20% (Fig. 3) better when collecting randomly distributed resources than the CPFA.
- DSA is statistically indistinguishable in performance for both the Power law and Clustered environments as shown in (Fig. 3).

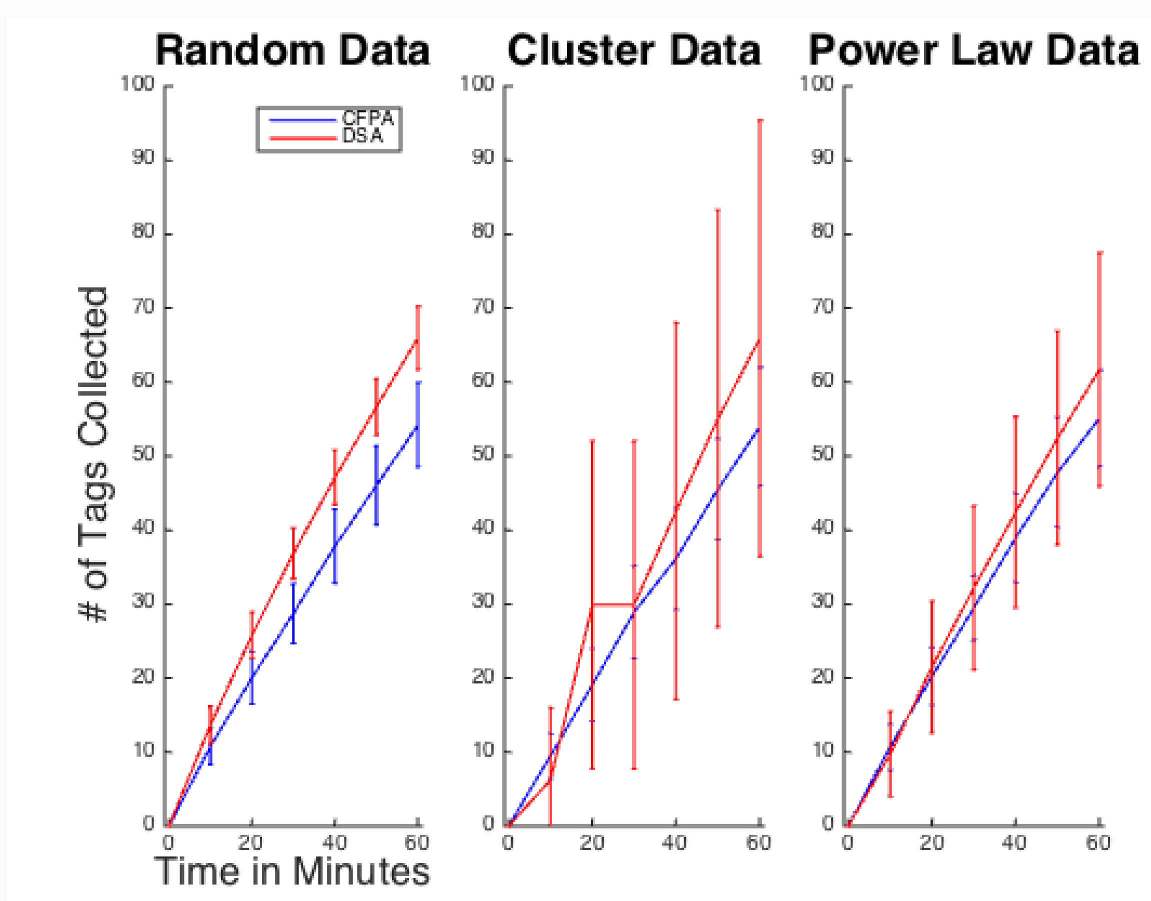

Figure 5: Displays the standard and mean comparison of the CPFA and DSA with a single robot.

The results from (fig. 4) illustrate the DSA produces more variant results due to its dependence on food placement. In comparison, the CPFA produces more predictable results, despite using probabilistic communication.