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 only marginally better at finding tags in clustered environments.**
- **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.

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.

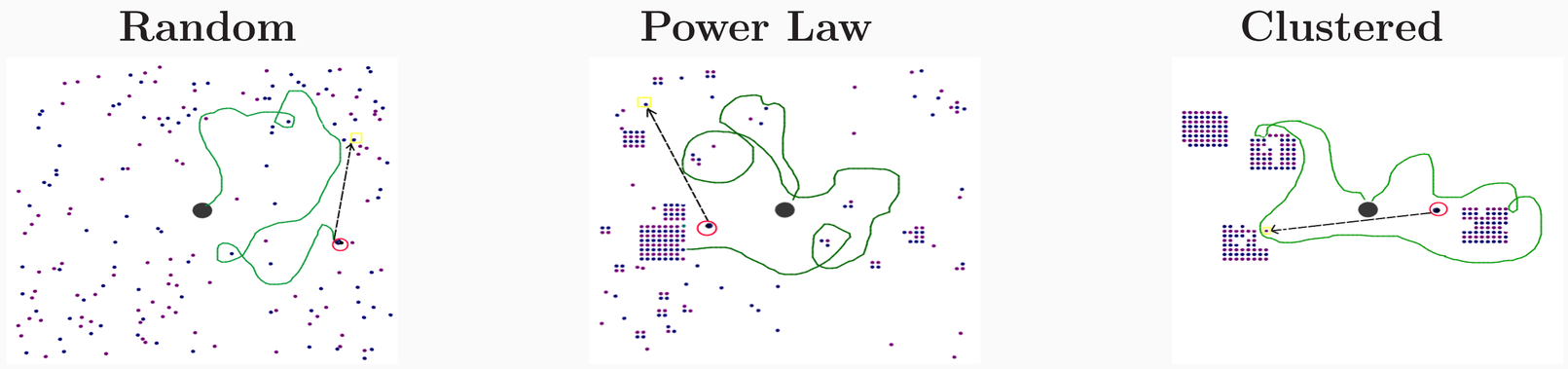


Figure 1: A path of an single robot retrieving a single seed (CPFA).

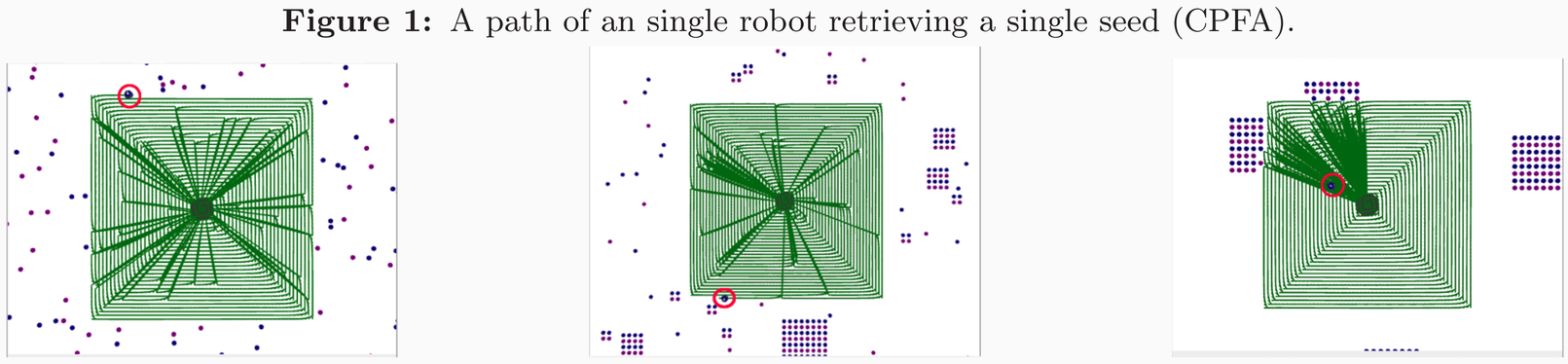
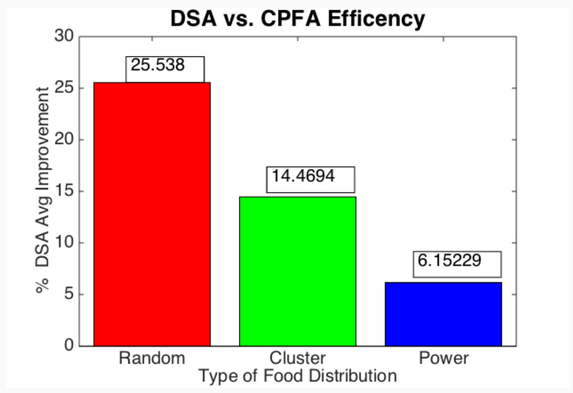


Figure 2: The full path of a single robot collecting for 60 minutes (DSA).

Results



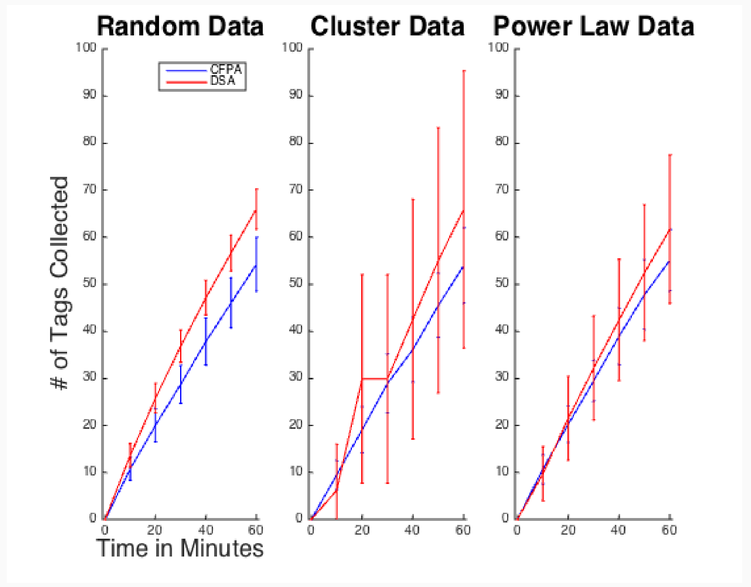


Figure 3: Displays the percentage, standard, and mean improvement of the DSA to the CPFA with a single robot. The left figure shows the overall average improvement percentage.

- A single robot performing the DSA does 25.5% better when collecting randomly distributed resources than the CPFA.
- Given that all data is statistically distinguishable, the improvement in the DSA for the Power law and Clustered environments are relatively small compared to Random.
- 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.

Multiple Robots in the DSA

Figure 4: The paths of 3 robots performing the DSA (Results TBA).