Multiple-Place Foraging Algorithm: A Distributed Foraging Model for Evolutionary Swarm Robotics

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Introduction

Central-place foraging is a canonical task for swarm robotics. The central place foraging algorithm (CPFA) [1] features a centrally placed nest, where robots search for resources in an arena. Due to crowding, the time utilized in avoiding collisions increases along with the number of robots, therefore, one central nest cannot serve a large number of robots efficiently if the network scales up. Additionally, resources that are clustered far away from a central nest impose long travel times.

Objectives

- We implemented the MPFA for the swarm robotics, and we optimize the performance of the CPFA and MPFA by GA (Genetic Algorithm).
- We compare the foraging rate and the collision rate of the CPFA and 4 nests MPFA. We show the improvement of the performance and the reduce of the collision rate.

MPFA

We propose a multiple-place foraging algorithm (MPFA)for swarm robotics. The MPFA is inspired by Argentine ants, which live in multiple nests [2]. In MPFA, the robots start from a home nest, but return to the closest nest to their positions.

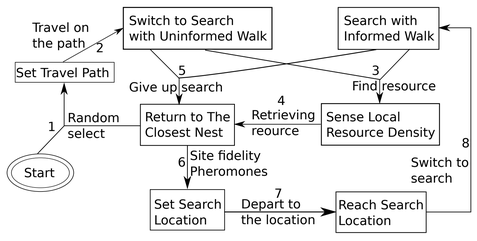

Figure 5: The flow chart of behaviour for individual robot during an experiment

Implementation

We implemented the CPFA and MPFA in the multi-physics robot simulator platform Autonomous Robots Go Swarming (ARGoS) [3].

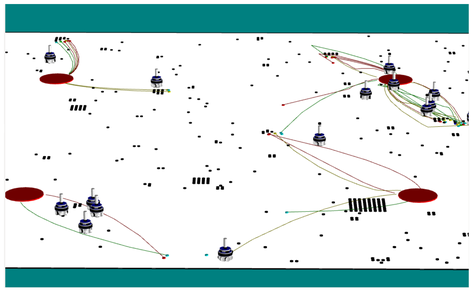

Figure 6: The simulation of the swarm robotics with the MPFA in ARGoS

Experiments

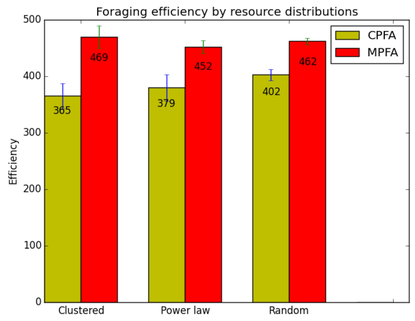

Figure 1: The number of resource collected by CPFA and 4 nests MPFA in 20 minutes. The simulated environments have 48 robots and 512 resource in clustered, power law and random distributions.

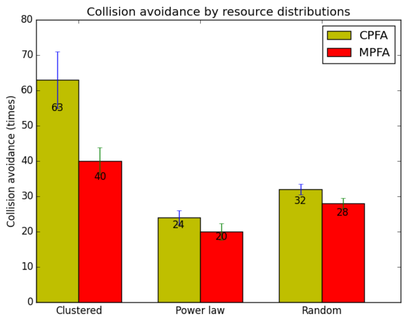

Figure 2: The number of detected collision by CPFA and 4 nests MPFA in the three resource distributions.

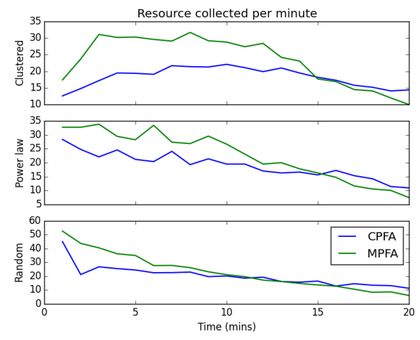

Figure 3: The resources collected per minute of CPFA and 4 nests MPFA in three resource distributions

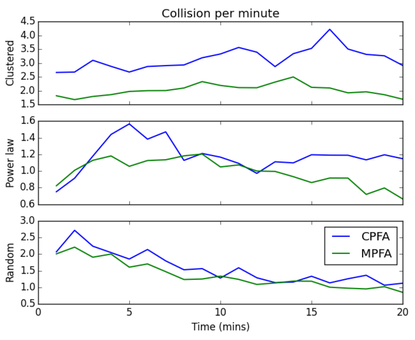

Figure 4: The collision per minute of CPFA and 4 nests MPFA in three resource distributions

Future Research

- Exploring an optimized (transport efficient, low cost and robust) network for different numbers of nests.
- Exploring a productive and optimized network (minimum number of nests) in different environments (resource distributions).

References

1. Joshua P. Hecker et. al. Beyond pheromones: evolving error-tolerant, flexible, and scalable ant-inspired robot swarms. 2015
2. Tatiana P. Flanagan et. al. Fast and flexible: Argentine ants recruit from nearby trails. 2013
3. Carlo Pinciroli. Argos: Large-scale robot simulations. 2015

Conclusion

Our results show that the MPFA overs the CPFA. The foraging rates of the CPFA and 4 nests MPFA are 92% and 71% in clutered, 88% and 74% in power law, 90% and 80% in random distributions. The CPFA has a 58%, 20%,and 14% higher collision avoidance rate than the MPFA in the three resource distributions.
These results indicate that the evolved 4-nest-MPFA has the potential to greatly improve foraging efficiency and have a much lower collision rate than the CPFA. It is worth to check the performance of a larger number of nests MPFA.