Swarm intelligence

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Swarm intelligence describes the behavior of decentral- ized cooperative agents, whether natural or artificial, working toward a common global goal Rizk et al. (2018)[120]. Self-organized and distributed behavior of locally aware and locally interacting agents are pillars of swarm intelligence Rizk et al. (2018)[121].Systems mod- eled in this fashion generally consist of many autonomous but homogeneous agents implementing simple rules with agent interactions restricted to local neighborhoods.

Insights

Advantages While such systems exhibit desirable properties like robustness, flexibility, scalability, low complexity, inherent parallelism, and fault tolerance Brambilla et al. (2013), Rizk et al. (2018)[129],

Disadvantages They have important limitations. Most swarm systems consist of identical agents, leading to their limitations according to Rizk et al. (2018)[129]. The agents must be homogeneous or can be divided into a small number of homogeneous clusters following simple rules to make decisions. However, there are many applications, such as search and rescue operations, that require heterogeneous, complex agents working toward a common goal.

Similarity with RL In some ways, swarm intelligence is similar to RL; both are iterative algorithms that use a reinforcement signal to learn a solution Rizk et al. (2018)[121]

Particle swarm optimization

Communication

Trajectory tracking

1 Biology

Cells

Migration See footnote [1]

Bees

Path planning Many algorithms have been inspired by bee colony behavior. Bee colony optimization Rizk et al. (2018)[122] is based on direct communication among agents performing a series of moves for a certain duration based on the strength or fitness of the solution, also known as "waggle dancing." This recruits other agents to the most fit solution. Navigation is based on path integration where agents continuously update a vector indicating the position of the start location.

Ants

Path planning Ant colony optimization (ACO), inspired by ant colony behavior, is a class of algorithms that rely on indirect communication Rizk et al. (2018)[123]. Navigation is based on deposit- ing pheromones along the trail. A more fit solution results in stronger pheromones on the trail that lead to recruiting more agents. Distributed implementations of ACO Rizk et al. (2018)[126], Rizk et al. (2018)[127]

Birds

PSO is inspired by flocks of bird and schools of fish Rizk et al. (2018)[124]. Agents navigate the environment searching for better solutions using principles from birds' movements. Distributed implementations of PSO Rizk et al. (2018)[128] have been developed to speedup convergence.

Pigeon Swarm optimization for path planning A pigeon inspired optimization algorithm relied on the magnetic field, sun and landmarks to achieve path planning Rizk et al. (2018)[125] have been developed to speedup convergence.

Boids See footnote [2]

2 Communication

Reference [3]

[1] https://en.wikipedia.org/wiki/Collective_cell_migration
[2] https://en.wikipedia.org/wiki/Boids
[3] https://ieeexplore.ieee.org/document/4413635

References

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