Pathfinding Using Swarm Simulation

A decentralized heuristic method for multi-agent navigation

Problem

This project evaluates the effectiveness of a specific swarm intelligence–based distributed pathfinding method.

Methodology

The researcher programmed a computer-based simulation of many “agents,” each with highly limited knowledge, perception, and reasoning capabilities. In the simulation, there exist multiple “sites” between which the agents must navigate, and obstacles obstructing their paths. Each agent keeps track of an approximate distance from each site, which it increases whenever it moves. When an agent finds a site, it updates its counter and sends a message to all agents in the vicinity. When agents receive such messages, they update their counters and relay the messages forward. When said message is about a site it is trying to reach, it will turn in the direction of the sender of the message. Each agent is also able to see obstacles within a proximity in front of them and is able to change direction to avoid colliding with them. This algorithm was tested using large amounts of agents in various environments and observations were recorded about the behaviors exhibited.

Limitations

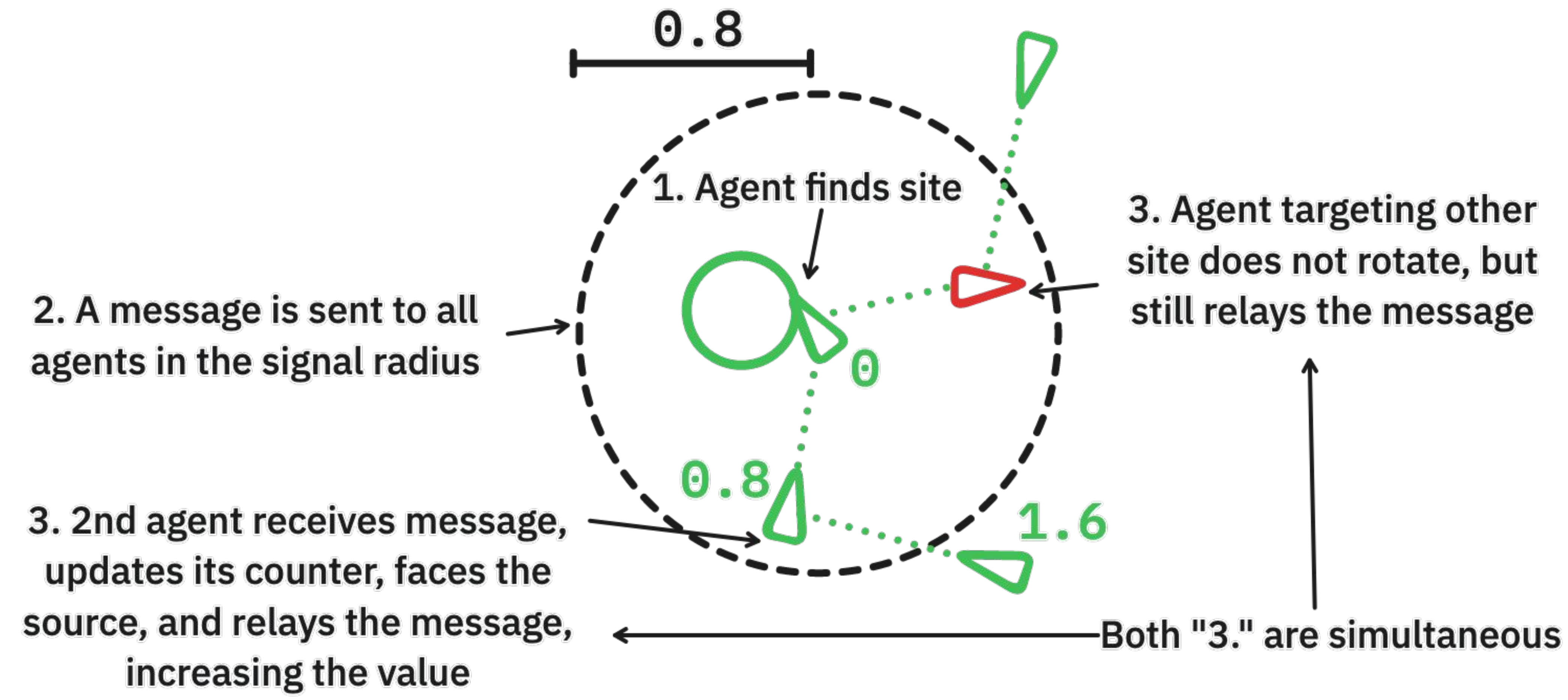
The overall potential of the simulation was limited by the computational power available to the researcher. This resulted in limits upon what capabilities the simulated agents could possess while allowing the simulation to run at an acceptable speed. Additionally, the simulation takes place in only two dimensions, so it may not account for elevation changes in the environment or the complexities of 3D pathfinding in the context of, for example, aerial drones.

Discussion

The simulated swarms of agents demonstrated capability to create efficient routes between target locations. When faced with multiple possible routes, they tended to prefer shorter ones. In traversing a given route, the agents tend towards the shortest way to travel that route, straightening segments of it to optimize path length. However, the agents struggled to identify certain routes that require navigating through very small gaps between obstacles. This is not, however, an inherent fault of the pathfinding system, and may be remedied by additional sensing capabilities for each agent. Also, the algorithm took much longer to identify an effective route when fewer agents were present, on account of the fact that the algorithm relies on agents being within communication distance of each other. This problem may be able to be addressed by agents communicating at multiple ranges, so as to increase potential for discovering routes without sacrificing path granularity. This method was not able to be tested in this project due to computational limitations.

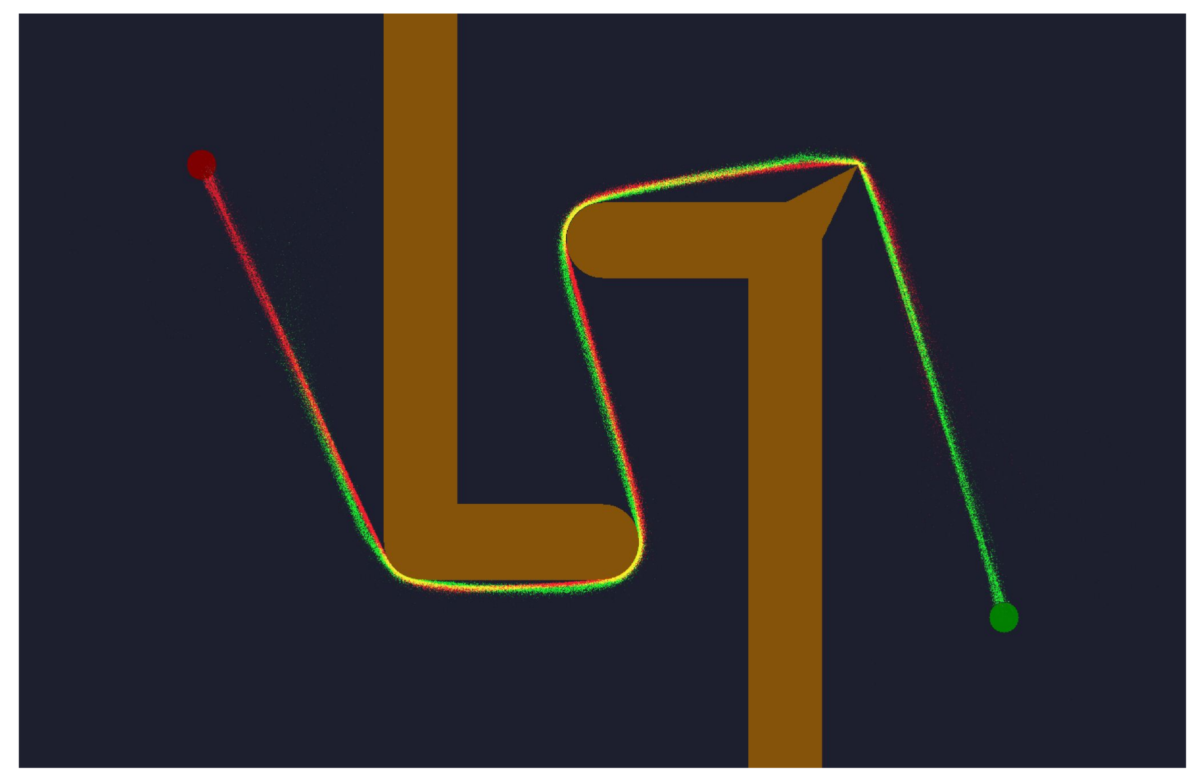
Future Studies

Additional studies of the algorithm may be performed using more powerful computational tools. The simulation could also be modified to run on a graphics processor to further increase performance. This would permit testing larger communication ranges. This extra computation power may also enable the addition of aspects to the simulation to increase applicability, such as allowing agents to see in a range around them and/or ahead of them, to increase efficiency in identifying routes. Other studies on this topic may also address prospects of additional information being communicated between agents, rather than just distances to sites.

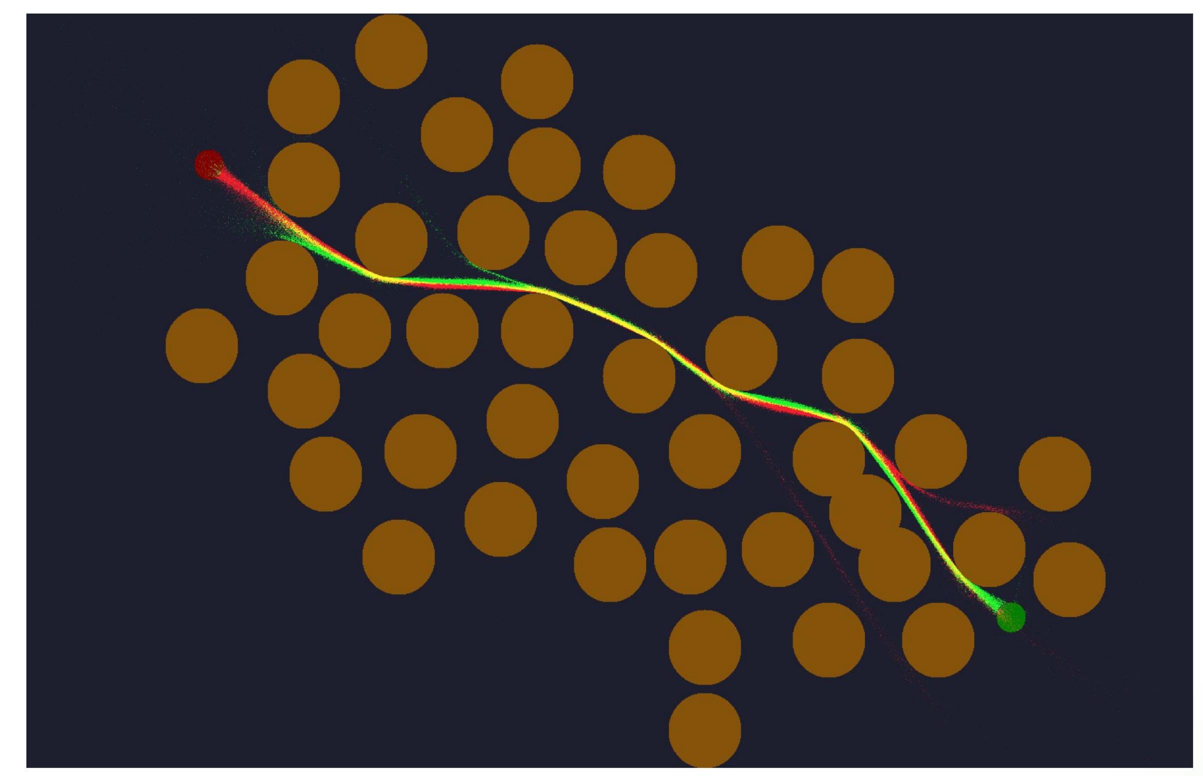


Results

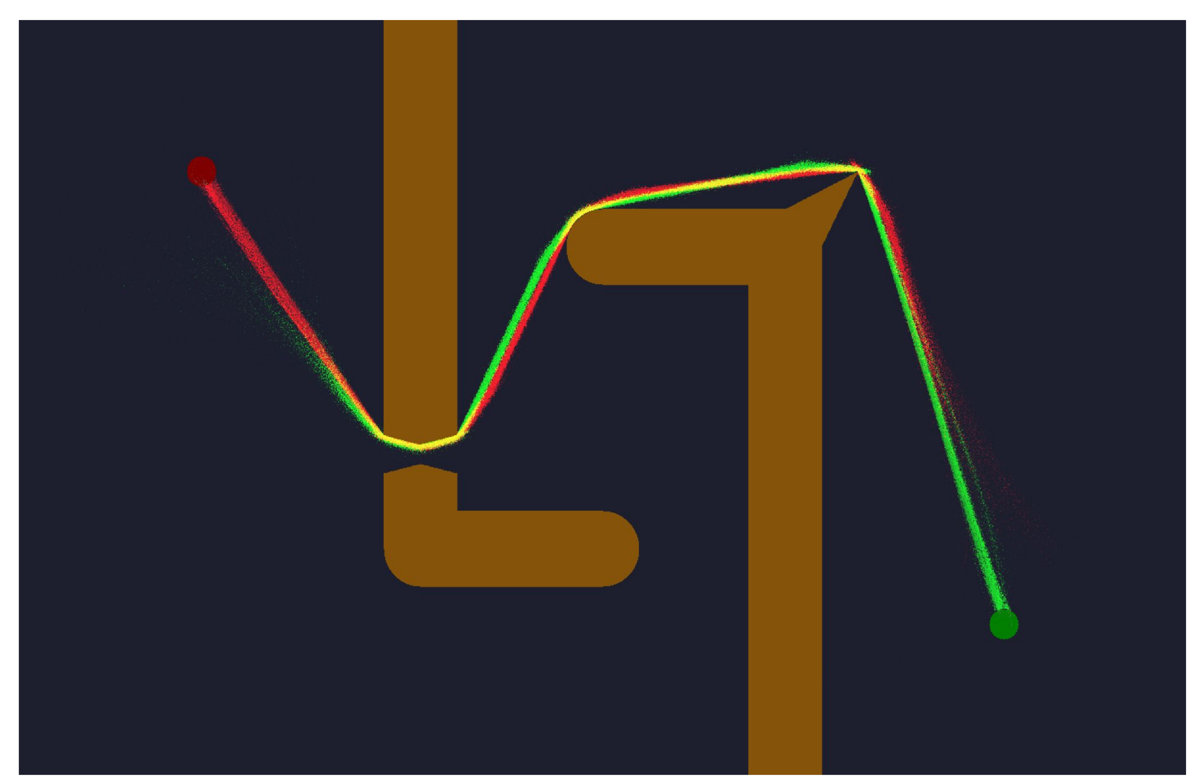
The following images from the simulation display trails showing overall agent paths, rather than displaying individual agents. Trails are colored based on which site agents that leave the trails are seeking.



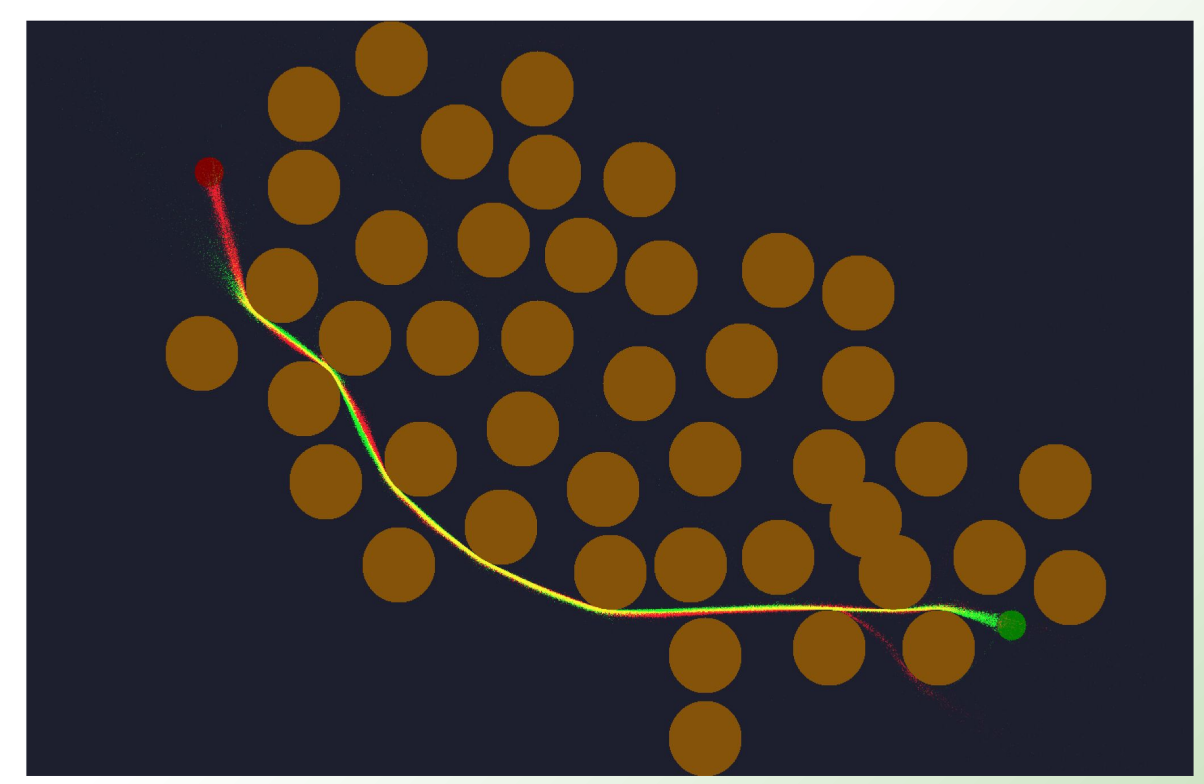
Environment 1: The agents identify the only route between the sites and traverse it in an optimal path.



Environment 2: Having begun in the upper-right corner of the scene, the agents identify an efficient route around the obstacles.



Environment 1, modified: A gap has been introduced in a wall, creating a new, shorter route. The agents identify and travel the new route, again optimizing the length of the path.



Environment 2: Having begun in the lower-center region of the scene, the agents identify a different route than before that is still relatively effective.

All photos taken by researcher. All data tables and graphs created by researcher.