Implementation of A\* and BFS On Swarm Robotics Using Unity Game Engine

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*Abstract*— This paper presents an implementation of swarm robotics using A\* and Breadth-First Search (BFS) algorithms to solve uncharted mazes in the Unity game engine. Swarm robotics, inspired by the collective behavior of social insects, offers robust and scalable solutions for complex tasks. We explore the application of two distinct pathfinding algorithms, A\* and BFS, within a simulated environment, emphasizing collision avoidance and dynamic path recalculation. The Unity game engine serves as the development platform due to its powerful simulation capabilities and ease of use. Our approach demonstrates how these algorithms can be effectively utilized in swarm robotics to navigate and solve maze-like environments, ensuring efficient pathfinding and collision-free navigation.

Keywords—Algorithm, A\*, BFS, Unity, Swarm Robotics

# Introduction

Swarm robotics is a field of multi-robot systems inspired by the behavior of natural swarms, such as ants and bees. These systems leverage simple individual behaviors to achieve complex group tasks, offering advantages in terms of robustness, scalability, and flexibility. In pathfinding and navigation, swarm robotics can significantly enhance the efficiency and effectiveness of solving problems in dynamic and unknown environments.

Pathfinding is a fundamental aspect of robotics and artificial intelligence, crucial for navigation and exploration tasks. A\* and BFS are two widely used algorithms in this domain. A\* is known for its efficiency and optimality, utilizing heuristics to guide the search process. BFS, on the other hand, guarantees the shortest path in an unweighted grid but can be computationally intensive.

This paper investigates the implementation of A\* and BFS algorithms for swarm robotics in Unity, focusing on maze-solving scenarios. Unity provides a versatile and interactive platform for developing and testing complex simulations, making it an ideal choice for this study. By integrating these algorithms into a swarm robotic system, we aim to demonstrate how collaborative robots can effectively navigate and solve mazes, avoiding collisions and dynamically adapting to changes in the environment.

# Theoretical Framework

## Swarm Robotic

Swarm robotics based from the collective behaviours observed in nature. It represents numerous simple agents collaborate autonomously to accomplish intricate tasks without centralized control. This approach leverage several key principles that underlie its effectiveness in various application. First the decentralitation allowed no single agents control the entire swarm. This promotes greater flexibility and robustness as each agent can respond independently to environtmental stimuli and collaborate with neighboring agents to achieve common goals just like in natural herds [2].

## A\* Algorithm

The A\* algorithm, a heuristic-based search method, presents a compelling approach for solving pathfinding problems efficiently. By integrating heuristic approach and exact cost, A\* achieves a balanced exploration of potential paths while maintaining optimality. In order to calculate the cost function

|  |  |
| --- | --- |
|  | (1) |

where g(n) denotes the cost from the start node to the current node, and h(n) represents an estimated cost from the current node to the goal. Through a systematic exploration of nodes guided by this cost function, A\* efficiently navigates through a graph, identifying the shortest path from a starting node to a goal node.

Furthermore the advantage of using this algorithm is its efficiency in finding the shortest path, particularly in weighted grids, and flexibility in adjusting the heuristic for different scenarios.

## BFS Algorithm

The Breadth-First Search (BFS) algorithm is a methodical approach used to explore graphs or trees. Unlike other search algorithms, such as Depth-First Search (DFS), BFS prioritizes exploring nodes at the present depth level before moving on to nodes at deeper levels. This is achieved by utilizing a queue data structure, where nodes are systematically added and explored based on their proximity to the starting point. In essence, BFS systematically expands outward from the starting node, exploring all neighboring nodes at each level before proceeding to deeper levels of the graph or tree.

One of the primary advantages of BFS is its ability to guarantee finding the shortest path in unweighted grids or graphs. This characteristic makes BFS particularly suitable for scenarios where the goal is to find the shortest path from a starting point to a target node. Additionally, BFS is relatively simple to implement and understand, making it a reliable choice for solving certain types of problems efficiently and accurately.

# Proposed Scheme

These are the configurations that need to be implemented.

## Environtment

In order to create the simulation, the writer utilize Unity as a mean to create the simulation. There are

1. Grid Base Maze. The grid base maze are represented in 10x10 matrix of integer. Where the value 0 represents an empty
2. Robots

## Units

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* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o.”
* In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset,” not an “insert.” The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
* Do not use the word “essentially” to mean “approximately” or “effectively.”
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* Do not confuse “imply” and “infer.”
* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”
* The abbreviation “i.e.” means “that is,” and the abbreviation “e.g.” means “for example.”

An excellent style manual for science writers is [7].

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##### Acknowledgment

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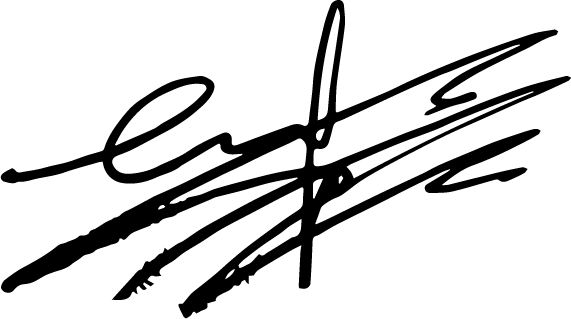
##### References

1. E. Bonabeau, M. Dorigo, and G. Theraulaz. Swarm Intelligence: From Natuarl to Artificial Systems. Oxford University Press, 1999.
2. Sahin, E., Labella, T. H., and Trianni, V. (2005). SWARM-BOTS: Swarm of autonomous mobile robots with self-assembling capabilities. Springer Tracts in Advanced Robotics, 11, 142-151.
3. I.S. Jacobs and C.P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.
4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
6. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

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