Bee-Ground: an open-source simulation tool for aggregation of swarm robots controlled by the bio-inspired algorithm BEECLUST

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Abstract

Bee-Ground is an open-source simulation tool based on Unity and Unity Machine Learning Agents which can be applied to the research on aggregation of swarm robots, especially the swarm robots controlled by the bio-inspired algorithm BEECLUST. MONA [1] is the modelled robot in this simulation software, however different robotic platform can be easily developed in Bee-Ground.

Introduction

- Bee-Ground is an open source, cross-platform simulation tool
- Bee-Ground can simulate the operation of swarm robots in various complex and dynamic environments, including obstacles and multiple heat source scenarios.
- Bee-Ground performs multi-layer multi-scenario simulations simultaneously, and the simulation speed can reach 100 times as the real-time without loosing sampling resolution.
- Bee-Ground provides extended possibilities for application of machine learning technics in swarm robotics.

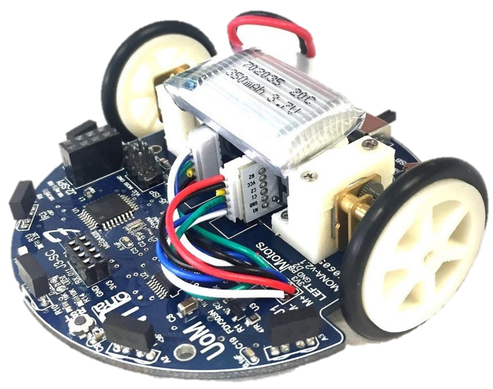


Fig. 1: MONA - Autonomous Mobile Swam Robot

Simulation, algorithm and results

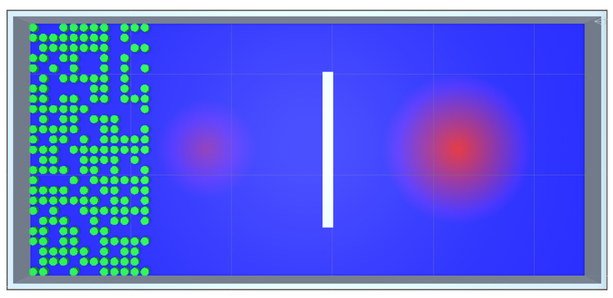
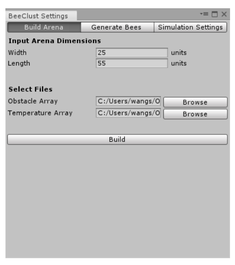


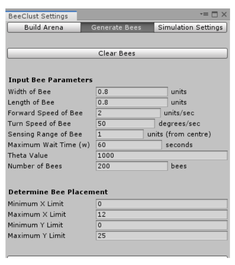
Fig. 2: A simulation example in Bee-Ground

Overview of Bee-Ground



Arena settings

The parameters of arena dimensions can be adjusted in this part and the obstacles and temperature are generated by array files.



Robots settings

The default settings of robots (here using MONA[1] as an example) including size, forward speed, turn speed, sensor range, and wait time are initialized here.

Simulation setting

Simulation duration and number of iterations are defined in this step.

Algorithm

Bio-inspired aggregation scenario[2] was simulated by Bee-Ground. BEECLUST algorithm is shown in Fig. 3.

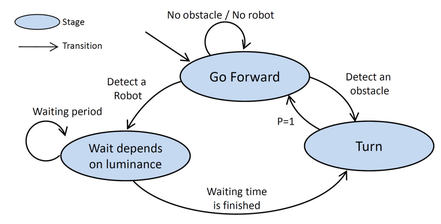


Fig. 3: Finite state automaton that shows the robots' behaviour in BEECLUST.

Experiment

300 MONA [1] robots, two heat sources and obstacle

This experiment evidences that the temperature and size of the heat source is the main factor that affects the robot's aggregation.

In addition, the obstacle (less than 90% of the arena width) in this case just affects the aggregation time, but not the size of the aggregation.

Meanwhile, an over-aggregation phenomenon was exposed in the area of left heat source.

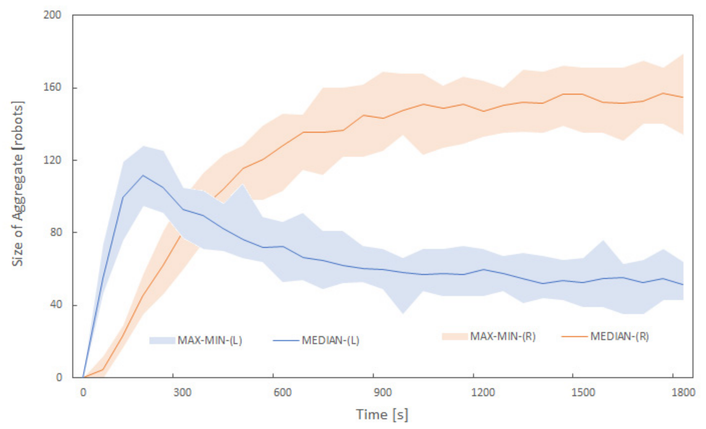


Fig. 4: Size of the aggregation during experiment

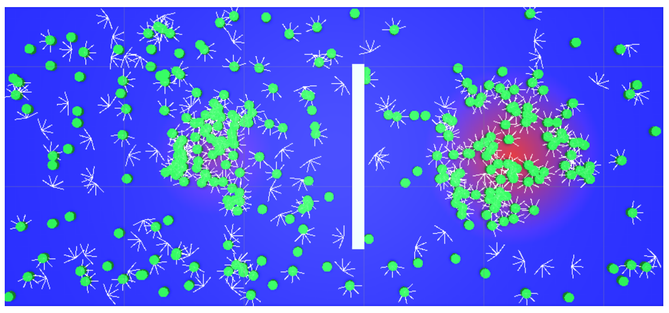


Fig. 5: A screenshot during experiment

Conclusion and expectation

The results from Bee-Ground simulation tool validate the obvious results of many previous studies which have used real robots for experiments [2]. It has greatly improved the efficiency of swarm robotics research and has also obtained many new conclusions. Bee-Ground is an open-source tool for education. All the sources are available on GitHub.

Reference

[1] Arvin, Farshad et al. (2018). Mona: an Affordable Open-Source Mobile Robot for Education and Research. Journal of Intelligent Robotic Systems. DOI: 10.1007/s10846-018-0866-9.

[2] Arvin, Farshad et al. (2016). Investigation of cue-based aggregation in static and dynamic environments with a mobile robot swarm DOI: 10.1177/1059712316632851

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