Third Year Project Proposal

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Abstract

In this paper a project is proposed to investigate the efficacy of convoy swarms at protecting a VIP[1] from an attacking agent(s). There will be an analysis of how performant the swarm is at defending the VIP from the antagonistic agent. The algorithm for the individual members of the swarm will be similar to the Boids algorithm [1]. Testing for this project will be conducted using the Stage simulator [2]. Anticipated research findings are that the produced algorithm will show some high degree of efficacy for defense against the attacking agent. Measurement of efficacy will be conducted on how long the swarm can protect the VIP against the attacker, when compared against a swarm that simply surrounds the VIP (with no algorithmic tendencies for defence). This project hopes to produce a model that can be applied to real life swarms that deal with antagonistic agents.

1 Introduction

Emergent behaviour is a phenomenon born when many agents, individually follow relatively simple rules, interact with each other in groups. This behaviour gives the appearance of a higher level of complexity in regards to instructions given to the swarm; the complexity is born through the collective interactions between members. The field of swarm robotics proposes multiple advantages over the typical approach - building an increasingly complex single robot. Considering that the instructions for individual agents can be simpler, the computational cost for the desired behaviour is reduced, such that robotic agents can be made increasingly smaller. An example of this is medical nanobots, a field that does not provide the option for larger computers to be present on the robots carrying out the presented tasks. Additionally, when the workload is split into multiple agents it affords the system a higher degree of fault tolerance; no single point of failure results in robustness increasing. Members of swarms can be dynamic, so faulty agents can be replaced during tasks. The main interest in swarms is how group behaviour emerges, a potential field approach to create attractive and repulsive forces between members of a swarm results in flocking (see [1]).

[1] How this proposal will refer to the agent that is being defended

Flocking makes completely individual agents appear to be a cohesive unit as if controlled by a singular commanding computer.

A large issue to tackle with implementing swarms in real world scenarios is when agents follow different algorithms. In general, swarms can be split into homogeneous and heterogeneous categories, meaning all agents follow the same algorithm, agents can follow different algorithms, respectively (see [3]). For this project the defensive swarm will be homogeneous. Some aspects of heterogeneous swarms can be implemented in this project such as on-line learning (see [4]) to discover how the VIP agent behaves and curate the methods of defense in real-time. As mentioned in the previously cited paper, learnt behaviour is not stored anywhere, therefore each time a simulation is run the swarm must relearn the behaviour, thus it is a more reactive type of learning as opposed to that of a trained model (such as a neural network). This same kind of learning could also be implemented against attacker agent, learning the algorithm for this agents behaviour and adapting the movement of the swarm accordingly could produce greater efficacy for defence.

This project proposes research that builds upon the Boids algorithm [1] and receives inspiration from the similar research displayed in [3], for dealing with a convoy scenario. The primary differences from the latter paper the number of convoy vehicles to protect (one as opposed to many). Unlike the previous citation this project will contain an empirical measurement of efficacy and comparison to how a simple swarm surrounding a moving agent would perform against a more complex one. This should provide insight into how and when it is applicable to use different types of swarms.

2 Background

Fundamentally, one of the largest inspirations for a work like this is the paper by Craig W. Reynolds 1987 [1] on the flocking characteristics of emergent behaviour, the idea of a complex system composed of relatively simple agents has many real world applications and this project aims to contribute towards these. As briefly mentioned at the end of the introduction, there is a paper that covers a similar problem to this [3]. This is an interesting work to draw inspiration from and expand upon. The major improvement that this project can bring over that paper is a real metric of performance between swarm algorithms would be important for anybody that would reference the paper proposed by this proposal. Proof of concept is useful but lacking any means of a just comparison to adjacent options, arguments for a certain approach of solving a problem can be hard to structure. The goal of this project is to produce an algorithm that performs well at the task of defending the VIP from an attacker, proving the advantage over less complex algorithms empirically. By proving that the algorithm is performant it is hoped that the research in this project can be integrated into a real life use case.

3 The Proposed Project

3.1 Aims and Objectives

The aim for this project is to produce an algorithm for the protection of a VIP agent from an attacking agent(s), using a dynamically sized swarm. The swarm should be highly performant when compared with a simple swarm that would only flock about the VIP. Below is a list of the primary objectives for this project.

- Produce a simplistic algorithm based on Boids [1] that flocks around a moving VIP agent, simulated in the Stage Simulator (see [2]). This will be used as the comparison metric for the more complex version.

- Extend upon the previous objective to produce an algorithm for the swarm that allows for more complex defence manoeuvres possibly integrating online learning with respect to the attacking agent.

- Conduct testing on the efficacy of the different algorithms. Testing should be done in multiple environments with proper scientific method, repeatable and measurable. Demonstrate the results of these and draw a conclusion.

3.2 Methodology

The large majority of this project is the production of an algorithm that can produce the desired effect through emergent behaviour, the method of display for this algorithm is integration into a robot model using the Stage simulator [2], which is an industry standard simulator for simulating large numbers of agents in swarm robotics research. The evaluation of the produced algorithm will be conducted through repeated tests of the time that the defensive swarm can protect the VIP agent from the attacking agent for, which is to be compared against the fruits of the first objective (a simplistic algorithm that provokes flocking around the defensive agent and nothing more). Testing is to be conducted in many different environments and be proven reproducible through repeat tests, providing solid results to draw a conclusion from.

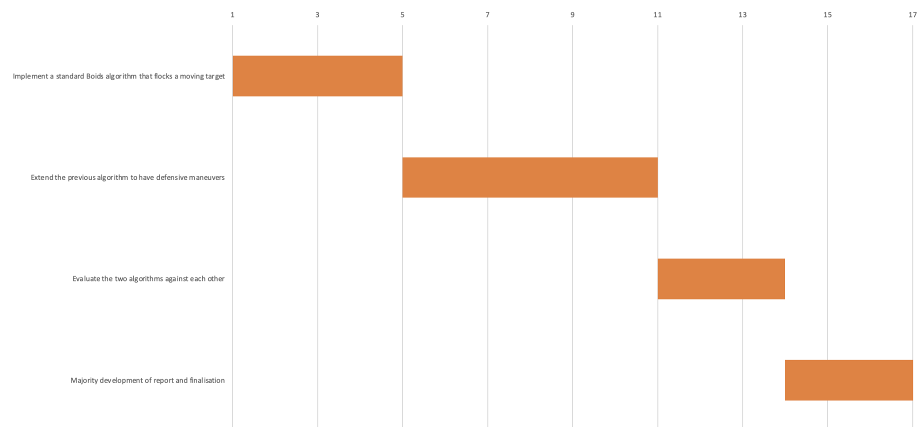
4 Programme of Work

This project will span the period of time from 30/10/2023 to report submission on 22/03/2024, which is a 17 week term time period. Below is a list of the development stages of this project.

- Weeks 1 - 4 completing the first of the primary objectives, implementing a complete Boids algorithm [1] in the Stage simulator [2].

- Weeks 5 - 10 implementing the more complex algorithm for the swarm.

- Weeks 11 - 13 evaluating the efficacy of the two algorithms and drawing a conclusion with empirical results.
- Weeks 14 - 17 this time will be for finishing the report and ensuring presented data is clear and precise.



References

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