



Investigation and Implementation of Biologically Inspired Flocking Behaviour in Swarm Robotics

Helmi Fraser

H00152077

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Declaration

I, Helmi Fraser, confirm that this work submitted for assessment is my own and is expressed in my own words.

Signature:

Helmi Fraser

Acknowledgements

My acknowledgements

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Chapter 1

Abstract

This is the introduction to the thesis.¹ The conclusion is in Chapter ?? on page ??.

1.1 About the logo

Figure 1.1 shows the logo for the University of Sussex.² This is consistent with Special Relativity [1]

Here is some Latin.

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¹And this is a footnote.

²This is a URL: <http://www.sussex.ac.uk>



Figure 1.1: The logo for the University of Sussex.

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Chapter 2

Introduction

2.1 Aim

Something about aim

2.2 Objectives

Aims and objectives are different, somehow

2.3 Relevance

Swarm shit is cool [2]

Chapter 3

Literature Review

In this chapter, an analysis of previous work completed in the field of swarm robotics is provided, as well as an outline of the theoretical concepts concerning the techniques applied during this project.

3.1 Biologically Inspired Computation and Engineering

Nature has provided examples of outwardly complex biological systems which are often efficient, fluid and resilient to partial breakdowns. Colonies of ants are able to forage for food and build complex structures. Fireflies are able to synchronize their flashing. Flocks of birds and schools of fish exhibit fluid and efficient group movement. In the majority of cases, nature has achieved these despite utilizing very little to no communication between individual creatures and in the absence of a higher level director or supervisor. The animals react only to environmental stimuli, either the strength or type of pheromones detected in the environment in the case of ants (termed *stigmergy*) or the positions of other individuals in the case of fish and birds.

This is defined as *emergent behaviour*, the rise of previously unpredicted and complex behaviour through the interaction of simple rules.

Researchers have attempted to replicate this in an artificial system via various means. For example, Bojinov et. al (2000) demonstrated how simple, local sensory rules can produce complex and useful structures in metamorphic robots. [1] Metamorphic, or modular, robots are a relatively new concept which can be described as "a robot that is composed of modules that are all identical". [3] In their paper, Bojinov et. al explored the use of purely *local* rules and interactions to develop control algorithms which enabled a Proteo robot to accomplish some otherwise difficult and complex tasks. Such tasks include forming three

dimensional structures, locomotion and dynamic adaptation.

From an engineering perspective, mimicking these systems could provide better solutions to a multitude of problems across various industries. One way that is gaining major interest from academics and the industry alike is the application of swarm robotics. Swarm robotics is a relatively new field of multi-robotics, in which the aim is to co-ordinate a large number of robots in a decentralized manner, similar to the natural systems mentioned previously. In order to carry out this project, a thorough understanding of the concepts and mechanisms that underpin swarm robotics systems will need to be achieved, as well as a strong working understanding of various tools used in their implementation such as simulation software and higher level programming.

3.2 Artificial Intelligence

Something about aim

3.3 Collective and Swarm Intelligence

Aims and objectives are different, somehow

Chapter 4

Methodology

4.1 Hardware

4.1.1 E-puck robots

E-pucks

4.1.2 Alternatives

Others

4.2 Software

4.2.1 Webots simulator

Concepts

4.2.2 C++ programming language

Chapter 5

Implementation

5.1 Design

5.1.1 System Diagram

E-pucks

5.1.2 Control Equations

Others

5.1.3 Software Architecture

5.2 Code Implementation

5.2.1 Libraries and dependencies

5.2.2 Low level

5.2.3 High level

5.2.4 Behavioural

Chapter 6

Evaluation

6.1 Testing

6.2 Results

6.3 Analysis

Chapter 7

Conclusion

I was right all along.

7.1 Problems encountered

I was right about the following things.

7.2 Limitations

People thought they understood, but they didn't.

7.3 Future work

Of course.

Bibliography

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- [2] C. Moeslinger, T. Schmickl, and K. Crailsheim. Emergent flocking in low-end swarms. *University of Graz, Artificial Life Lab of the Department of Zoology*, 2010. 4
- [3] M. Yim. *Locomotion with a Unit-Modular Reconfigurable Robot*. PhD thesis, Stanford University, 1995. 5

Appendix A

Code

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10 PRINT "HELLO WORLD"
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