Enabling Multirotors to Perform Construction Tasks Using Swarm Algorithms

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Summary (English)

The goal of the thesis is to ...

Summary (Danish)

Målet for denne afhandling er at ...

Preface

This thesis was prepared at DTU Compute in fulfilment of the requirements for acquiring an M.Sc. in Engineering.

The thesis deals with ...

The thesis consists of ...

Lyngby, 01-August-2016

Jens-Christian Finnerup

Acknowledgements

I would like to thank my....

Contents

Chapter 1

Introduction

In today's world, we increasingly rely on robotics to perform a wide range of tasks, with use cases ranging from complimenting, or even substituting, human labour in factories to more complex tasks such as automated aerial photography. Though technology continues to improve, the use of robotics is often confined to within predictable environments, where machines are told what to do and when to do it. More recently though, as control algorithms improve, autonomous robots are starting to become a practical reality, with increasing ability self-plan and work unsupervised. As such we experience a paradigm shift, where robots are no longer limited to predictable and confined environments, but can act freely and adapt to changing circumstances.

As a consequence of this, new use cases and areas within robotics are starting to gain interest. Specifically the area of autonomous flying vehicles is gaining interest with companies such as amazon, preparing to use flying drones to deliver packages. This requires the drone to be able to plan according to changes in the environment as well as being able to coordinate its movements in relation to other drones around it. At a currently more theoretical scale, using flying drones to perform construction tasks has been subject for testing by universities such as *ETH Zurich*, where micro drones were used to construct a 6 meter tall tower [ALH+14].

The task of using flying vehicles to perform construction is especially interesting

because it combines many of the challenges that face robotics today, as they become more autonomous. A construction task work as a great test bed, for testing flying drones as it involves multiple agents working on the same problem as once and as such they must have the ability to plan according to changes in their individual environment.

One solution to the challenges of enabling drones to collaborate, is to create individual sectors of space in which only a single agent is allowed to move at a certain time. This however is a suboptimal solution and for drones to trulu

- from supervised to unsupervised - from instructed to self planning - from ground-based to arial

1.1 Problem Description

1.2 Project plan

We note that the contents of the project plan is also something we would like to see in the introductory chapter of your thesis. In fact, you can reuse your final project plan (possibly extended) as the introduction. If you prefer to write an introduction from scratch, it is, of course, important that it is consistent with the final project plan.

Chapter 2

Methodology

2.1 Simulation construction

2.2 Experimentation

2.3 Validation

2.4 Optimisation

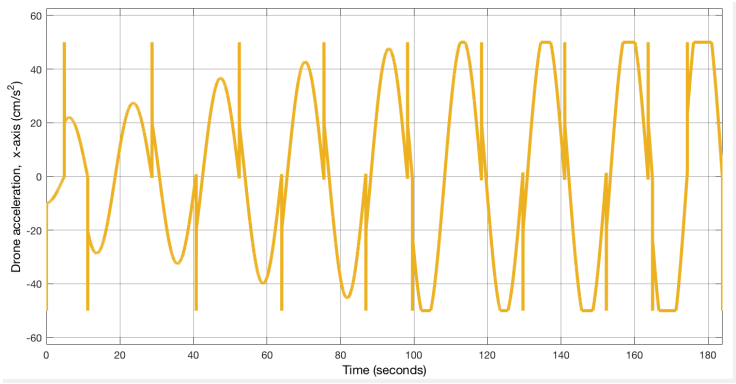

Figure 2.1: Acceleration of agent - without velocity limit

Chapter 3

Simulation

This was otherwise known as an impressive illusion, drone swarms have become of increasing importance as robotics enter our daily lives (as with the example of google car) but are not yet adapted with the intuition we have come to expect from the elements around us. Path planning and multi agent navigation are some of the aspects we expect from objects and people around us, who all for the purpose of path planning theory, act as individual agents

3.1 Simulation vs. Animation

3.2 Reality criterias

3.3 Assumptions on Physics

Chapter 4

Design

Bibliography

[ALH+14] F. Augugliaro, S. Lupashin, M. Hamer, C. Male, M. Hehn, M. W. Mueller, J. S. Willmann, F. Gramazio, M. Kohler, and R. D'Andrea. The Flight Assembled Architecture installation: Cooperative construction with flying machines. *IEEE Control Systems*, 34(4):46–64, August 2014.

[CPD+14] Ruaridh Clark, Giuliano Punzo, Gordon Dobie, Rahul Summan, Charles Norman MacLeod, Gareth Pierce, and Malcolm Macdonald. Autonomous swarm testbed with multiple quadcopters. In *1st World Congress on Unmanned Systems Enginenering, 2014-WCUSEng*, 2014.

[DHB15] Shreyansh Daftry, Christof Hoppe, and Horst Bischof. Building with drones: Accurate 3d facade reconstruction using mavs. In *Robotics and Automation (ICRA), 2015 IEEE International Conference on*, pages 3487–3494. IEEE, 2015.

[HM99] Owen Holland and Chris Melhuish. Stigmergy, self-organization, and sorting in collective robotics. *Artificial life*, 5(2):173–202, 1999.

[LGB+] Pierre LATTEUR, Sébastien GOESSENS, Jean-Sébastien BRETON, Justin LEPLAT, Zhao MAb, and Caitlin MUELLER. Drone-Based Additive Manufacturing of Architectural Structures.

[PKG+02] Giovanni Cosimo Pettinaro, I. Kwee, Luca Maria Gambardella, Francesco Mondada, Dario Floreano, Stefano Nolfi, J.-L.

Deneubourg, and Marco Dorigo. Swarm robotics: A different approach to service robotics. In *33rd International Symposium on Robotics*, pages 71–76, 2002.

[SMVDPB05] John A. Sauter, Robert Matthews, H. Van Dyke Parunak, and Sven A. Brueckner. Performance of digital pheromones for swarming vehicle control. In *Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems*, pages 903–910. ACM, 2005.