Degree Project in Computer Science

Second cycle, 30 credits

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LINUS WALLIN

Master's Programme, Computer Science, 120 credits
Date: August 19, 2025

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Abstract

Write an abstract that is about 250 and 350 words (1/2 A4-page) with the following components:

- What is the topic area? (optional) Introduces the subject area for the project.
- Short problem statement
- Why was this problem worth a Bachelor's/Master's thesis project? (*i.e.*, why is the problem both significant and of a suitable degree of difficulty for a Bachelor's/Master's thesis project? Why has no one else solved it yet?)
- How did you solve the problem? What was your method/insight?
- Results/Conclusions/Consequences/Impact: What are your key results/ conclusions? What will others do based on your results? What can be done now that you have finished - that could not be done before your thesis project was completed?

Keywords

Canvas Learning Management System, Docker containers, Performance tuning

Sammanfattning

Nyckelord

Canvas Lärplattform, Dockerbehållare, Prestandajustering

Acknowledgments

I would like to thank xxxx for having yyyy. Or in the case of two authors: We would like to thank xxxx for having yyyy.

Stockholm, August 2025
Linus Wallin

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List of acronyms and abbreviations

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Chapter 1

Introduction

1.1 Background

Search and rescue (SAR) can be aided by autonomous or teleoperated robots and multi-robot systems, which can help the SAR teams map the area, monitor, or search for victims. There are multiple SAR scenarios in which robots can aid the rescuers, where one such scenario category is urban SAR in which small robots can be used to find their way through collapsed buildings or other urban environments[1].

As earthquakes are very serious disasters which can be fatal due to buildings collapsing and trapping people, it is important that the victims can be found and get help fast. This is an area in which research has been done on multi-agent systems and how they can be used for collapsed building SAR scenarios.[2]

My project will build on the paper by Hengstebeck, et al.[3] which explores the usage of 2D boids in SAR scenarios. Their paper adds ghost boids to the boids algorithm in order to reduce collisions and direct the boids towards a target with a set strength. To reduce the amount of collisions further, Hengstebeck, et al.[3] implemented a control barrier function (CBF).

I will begin my project with implementing the proposed boids algorithm, but in 3D, and also adding the CBF to reduce collisions. The goal is then to expand on it by adding a high level planner (HLP)[4] in the form of an artificial potential field (APF)[5] and explore how it affects the 3D boids SAR algorithm.

The project is of interest to SAR organizations and the general public, as it could lead to advancements in SAR methods which help individuals in difficult scenarios. Collapsed building SAR scenarios are not that common in Sweden, as we do not have high magnitude earthquakes. Although I want to focus on these scenarios in this project, the results might be transferable to other areas that are more relevant in Sweden. Areas that this could be applicable in would be scenarios with fires in buildings or other urban SAR scenarios which might be more of interest to Swedish society.

The high level objective of the degree project is to contribute to the field of SAR by presenting an improvement of the methods that currently used find targets in collapsed building scenarios. The goal is to increase the efficiency of the rescuers by giving them the tools which would allow them to scout a larger area faster than they could without the tools.

1.2 Problem Description

1.3 Research Question

RQ1: How does target-seeking affect the 3D boids algorithm in terms of coverage, safety, and number of boids that are able to find the target location?[3]

RQ2: How does adding a high level planner in the form of a artificial potential field affect the 3D boids algorithm in terms of coverage, safety, and number of boids that are able to find the target.[3][5]

1.3.1 Research Methodology

The

1.3.2 Scientific and engineering issues

1.4 Purpose

1.5 Goals

The goal of the thesis is to provide insight into the potential of APF in combination with the *boids algorithm* to find missing people in SAR scenarios with collapsed buildings.

1.6 Delimitations

Altough the goal is to provide valuable information about how well APF in combination with the boids algorithm could do in real collapsed building SAR scenarios, the focus of the project will not be to create realistic scenarios nor take into account for everything that could affect the agents in real life.

One of the delimitations for the project will be that it will not take into account how the drone would have to adjust in real life to achieve the movement in the simulation. This could lead to the agents movement not being completely realistic.

Another delimiation of the project will be that delays in signal processing will not be considered for both the communication between the different agents in the scene and the potential delays in the hardware of the real life drones. This should not make much of a difference, since the delays in todays drone hardware is quite low.

1.7 Structure of the thesis

Chapter 2

Background

2.1 Summary

Chapter 3

Method or Methods

3.1 Research Process

3.2 Research Paradigm

3.3 Data Collection

3.3.1 Sampling

3.3.2 Sample Size

3.3.3 Target Population

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3.5.3 Data validity

3.5.4 Reliability of data

3.6 Planned Data Analysis

3.6.1 Data Analysis Technique

3.6.2 Software Tools

Chapter 4

What you did

4.1 Hardware/Software design . . . /Model/Simulation model & parameters/. . .

4.2 Implementation . . . /Modeling/Simulation/. . .

Chapter 5

Results and Analysis

5.1 Major results

5.2 Reliability Analysis

5.3 Validity Analysis

Chapter 6

Discussion

6.1 RQ1:

6.2 RQ2:

6.3 General Research Question

6.4 Limitations

6.5 Future work

Chapter 7

Conclusions and Future work

7.1 Conclusions

7.2 Reflections

References

[1] J. P. Queralta *et al.*, "Collaborative multi-robot search and rescue: Planning, coordination, perception, and active vision," *IEEE Access*, vol. 8, pp. 191 617–191 643, 2020. doi: 10.1109/ACCESS.2020.3030190 [Page 1.]

[2] A. V. Nazarova and M. Zhai, "The application of multi-agent robotic systems for earthquake rescue," in *Robotics: Industry 4.0 Issues & New Intelligent Control Paradigms*, ser. Studies in Systems, Decision and Control, A. Kravets, Ed. Springer, Cham, 2020, vol. 272. [Page 1.]

[3] C. Hengstebeck, P. Jamieson, and B. Van Scoy, "Extending boids for safety-critical search and rescue," *Forensic Analysis and Operations Research*, 2024. doi: 10.1016/j.fraope.2024.100160 [Pages 1 and 2.]

[4] J. Schwartz and M. Sharir, "A survey of motion planning and related geometric algorithms," *Artificial Intelligence*, vol. 37, no. 1, pp. 157–169, 1988. doi: https://doi.org/10.1016/0004-3702(88)90053-7. [Online]. Available: https://www.sciencedirect.com/science/article/pii/0004370288900537 [Page 1.]

[5] F. Bounini, D. Gingras, H. Pollart, and D. Gruyer, "Modified artificial potential field method for online path planning applications," in *2017 IEEE Intelligent Vehicles Symposium (IV)*, 2017. doi: 10.1109/IVS.2017.7995717 pp. 180–185. [Pages 1 and 2.]