Trabajo Fin de Máster
Máster en Ingeniería Electrónica, Robótica y Automática

Aerial co-workers: a task planning approach for multi-drone teams supporting inspection operations

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El tribunal nombrado para juzgar el trabajo arriba indicado, compuesto por los siguientes profesores:

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Abstract

This Master's Thesis has addressed problems arising from the recent increase in the applications of cooperative teams, which are the autonomy to operate over a long period of time with robustness to possible failures, and the difficulty of providing the team with cognitive capabilities to be able to operate in dynamic environments with humans.

Many of these applications are currently being executed by humans, making the activities much more expensive, time-consuming, and in some cases even dangerous. This is why there is currently a great deal of interest and effort being put into developing solutions to the problems posed, as they can mean, in addition to significant savings for companies, a drastic improvement in the safety of workers in high-risk jobs. Specifically, the application on which this work has focused is the assistance to human operators in inspection and maintenance tasks on high-voltage power lines.

The aim of the work was to develop cognitive planning techniques for coordinating fleets of quadrotors to assist human operators in inspection and maintenance tasks on high-voltage power lines. These techniques should also extend the autonomy of the system, ensure that safety requirements between drones and human workers are met, and ensure the success of the mission.

A software architecture has been proposed based on a central planner, which is in charge of planning actions over time and monitoring the status of each of the connected equipment; and the behaviour manager, distributed on board each of the UAVs, which is in charge of executing the plan assigned by the central module. The distributed module contains the minimum intelligence that ensures compliance with safety requirements, so that the rest of the intelligence can be concentrated in the centralised module. This reduces the computational load on the aerial equipment as much as possible, thus extending battery life. It has also been assumed that there is some way of recharging the battery during the mission, so that among the actions available to the centralised module for planning, there is also the option of recharging. To carry out the planning, a cost has been defined, which is calculated for each task. Respecting, among other things, the priorities of the tasks and their order of arrival, each task is assigned to the Unmanned Aerial Vehicle (UAV) that costs the least to execute. On the other hand, to control the behaviour of the drones and ensure the safety of the aerial equipment, a behaviour tree has been implemented.

As a result, it has been possible to develop a software architecture capable of dynamically planning missions while ensuring the safety of the equipment involved. Thanks to the planning, a better coordination of the UAVs is achieved and therefore, a better use of the battery, thus extending the autonomy of the equipment. The core module provides a good base that can be easily adapted to other projects involving multi-UAV teams and from which more complex planners can be developed in the future. At the same time, the design of the distributed modules, thanks to the use of behaviour trees, allows for easy reuse and modification. Compared to the typical way of implementing such modules, which involves the creation of complex finite state machines that are difficult for a human

to read, reuse and extend, the use of behaviour trees is a great improvement and will allow the creation of increasingly complex behaviours.

Short Outline

Contents

1 Introduction

Lorem itsum

1.1 Motivation

1.2 Objectives

2 Preliminaries

Lorem itsum

2.1 Current technology

2.1.1 UAVs

2.1.2 Aerial co-workers

2.1.3 Multi-drone teams

2.2 Related work

2.2.1 Inspection applications with UAVs

2.2.2 Task planning in multi-drone teams

2.2.3 Drone behavior management

2.3 Tools

2.3.1 ROS

2.3.2 Gazebo

2.3.3 Rviz

2.3.4 UAL

2.3.5 Behaviour Trees

2.3.6 Groot

3 Problem Formulation

Lorem itsum

3.1 Description of tasks

3.1.1 Inspection tasks

3.1.2 Monitoring tasks

3.1.3 Tool delivery tasks

3.2 Battery recharges

3.3 Connection losses

3.4 Task replanning situations

4 Design of the proposed solution

Lorem itsum

4.1 Node diagram

4.2 Centralized module: task planner

4.3 Distributed module: behavior manager

4.3.1 Main tree

4.3.2 Inspection task tree

4.3.3 Monitoring task tree

4.3.4 Tool delivery task tree

4.4 Lower and upper level modules faker

5 Results

Lorem itsum

5.1 Task planning

5.1.1 Battery

5.1.2 Connection lost

5.1.3 Replanning

5.2 Drone behaviour manager results

5.2.1 Battery management

5.2.2 Connection lost management

5.2.3 Replanning management

5.3 Simulations

5.3.1 One drone simulations

5.3.2 Multi-drone simulations

6 Conclusions and future work

6.1 Conclusions

6.2 Future work

6.2.1 Augmented reality

List of Figures

List of Tables

List of Codes

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Glossary

UAV Unmanned Aerial Vehicle. III