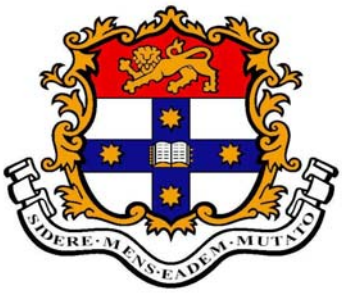
A Comprehensive Architecture for the Cooperative Guidance and Control of Autonomous Ground and Air Vehicles

Hai Ngoc Pham

A thesis submitted in fulfillment
of the requirements for the degree of
Master of Engineering (Research)



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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the University or other institute of higher learning, except where due acknowledgement has been made in the text.

Hai Ngoc Pham

March, 08^{th}, 2007

Abstract

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This thesis deals with the problem of cooperative explorations of a group of autonomous vehicles in unknown environments in the context of decentralized behaviour.

The main contribution of this thesis is the development of a comprehensive decentralized cooperative exploration frame work in which each individual vehicle has the ability to explore an unknown environment by itself and also by cooperative behaviour in a team of several vehicles.

To simulate the whole system, each individual vehicle will have the ability to explore an unknown environment by dynamically path-planning (with obstacle and collision avoidance), high-level controlling, updating the environment map, proposing potential destinations (frontiers), and solving online task assignment. In this thesis, the framework simulates an unknown environment as an occupancy grid map and uses a frontier-base exploration strategy, in which a cell will be marked as a frontier if it is adjacent at least one open cell, as the core architecture. In dealing with the uncertainties in process transition and observation models of autonomous vehicles, the well-known discrete extended Kalman filter (EKF) algorithm is investigated and implemented.

When exploring the environment, a vehicle will update its surrounding information, then propose its potential destinations and evaluate the utility (benefit) to travel to each of those destinations. The benefit to go to each destination is derived from the subtraction of the utility (value) of that cell to the sum of the cost to travel to that cell and the steering cost. The key to cooperative exploration in the team of vehicles lies in each vehicle's ability to communicate the updates of the world to the whole team and to contribute to the global list of potential destinations. And each vehicle has the capability of solving the task assignment problem for the team by calling its own online-task-assignment solving engine. This algorithm results each vehicle in having a destination to visit, which benefits the whole team the most and reduces the total exploration time of the team.

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To my Parents

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