Coordinated Navigation of Multiple Underwater Vehicles

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ABSTRACT

For a group of underwater vehicles, the relative positioning problem is considered. That is, the mutual relative positions of the individual vehicles and hence the group formation is determined. The observations to be used are the relative ranges between the vehicles and the dead reckoning estimates of the individual navigation systems of the single vehicles. These data are to be distributed via an acoustic underwater communication system. The solution to the relative positioning problem is a prerequisite for implementing algorithms for coordinated behaviours of multiple underwater vehicles. A crucial condition is the limited communication capability in the underwater communication network. This is due to the comparably small bandwidth of the underwater acoustic channel and the lack of reliability of those connections, caused by multipath, diffraction and other acoustic wave propagation related effects.

This paper introduces a simple concept for the solution to this problem, which avoids the usage of an acoustic positioning system such as LBL or USBL. This is achieved by implementing a variant of a trilateration technique in an extended Kalman filter.

KEY WORDS: Multiple AUVs, Coordinated Navigation, Trilateration

INTRODUCTION

The technology of Autonomous Underwater Vehicles has achieved an impressive degree of maturity during the last decade. However, due to the limitations of state-of-the-art embedded systems, underwater research vehicles are still limited in both their autonomy and capabilities. It would be a leap ahead, if researchers could use a multiple vehicle approach, whereby each vehicle plays the role of a sophisticated node (with sensor, processing, and communication capabilities) in a possibly large network – this means combining the properties of different systems in a team. Therefore, the request for application of multiple autonomous marine vehicles, operating in a coordinated way, has largely been growing. A multitude of tasks can be defined which are now becoming feasible by means of a coordinated network of agents which were out of reach for one single underwater vehicle.

The following section briefly describes the multiple AUV GREX project, funded by the European Union (www.grex-project.eu).

The GREX Project

"GreX" - the latin word for a herd or flock – indicates the focus of the project: to create a conceptual framework and middleware to coordinate a flock of heterogeneous robotic vehicles in order to achieve a well defined practical goal in an optimized manner.

Objectives. The main goal of the project is to achieve a first level of distributed "intelligence" through dependable embedded systems that are interconnected and cooperate towards the coordinated execution of tasks. Thus the project will witness the development of theoretical methods and practical tools for multiple vehicle cooperation, bridging the gap between concept and practice. The technology developed must be on one hand sufficiently generic in order to interface pre-existing heterogeneous systems. On the other hand, it must be sufficiently robust to cover problems caused by faulty communications.

Practically, developments will cover methods for effective programming of multiple systems, coordinated mission control and navigation, formal methods for validation and testing of the programming language, and the use of perception and communication techniques to enable ad hoc formation of information- and sensor-networks. A series of field trials will be carried out to assess the efficacy of the methods developed. They conclude and demonstrate the success of the GREX project.

Expected Results. The main innovation key points will be composed