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Communications within Thetis, a Real Time Multi-vehicles Hybrid Simulator

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ABSTRACT

The purpose of this paper is to present the communications aspect in *Thetis*, a real time multi-vehicles hybrid simulator for heterogeneous vehicles.
This simulator allows *hardware in loop* (HIL) simulations including virtual sensors which allow to provide a representation of a virtual world, and with the support of communication devices, which allow overall communications between vehicles.
Our contribution concerns the proposed simulator architecture. This architecture gathers all the important features required to simulate a flotilla (including communications skills).
After a short state of the art, we introduce the main mechanisms of our simulator. Then we present the modeling of the phenomena which are encountered when AUVs (Autonomous Underwater Vehicle) communicate with aquatic modems, and the messages distribution system considering the assumptions we have made. Finally, we present the results of our HIL Simulation in which *Taipan 2* and *Taipan 300* (our 2 AUVs) exchange messages in different spatial configurations.

KEY WORDS:
Simulation; Modeling; Multi-vehicles simulator; Real-time systems.

INTRODUCTION

The development and control of an autonomous vehicle are far from being an easy task; this is especially true for underwater robots because of the difficulty to supervise it during the experiments. In order to avoid long time and expensive design and implementation during which there is a possibility to lose or damage the material, it is necessary to test all the sub-systems of the robots before launching the robot in the harsh underwater environment. Moreover scenarii, in which many autonomous vehicles are simultaneously used, are nowadays seriously considered. Indeed this kind of mission allows to deploy heterogeneous vehicles with different sensors in order to grasp the environment more efficiently and faster than with a single vehicle. Currently there are few experimentations in which many AUVs are simultaneously deployed. Possible reasons are the cost of such experimentations, the unavoidable logistic burden, and the theoretical aspect of most control laws, which rarely consider the computation time or the underwater communications restrictions.
Hence, simulation tools play an important role: they help us to test and validate control laws and software architecture, and to detect preliminary inconsistencies within the scenarii. Moreover, these technologies limit the required human resources, decrease the number and difficulty of necessary real experiments, the cost and the time spent. There are different types of simulators. A useful classification is proposed in (Ridao, Batlle, Ribas, Carreras, 2004). Simulators are classified in 4 categories: the offline simulators, the online simulators, the hardware in loop simulators and the hybrid simulators.
Offline Simulators allow to design the control of robots in a first approximation. Matlab/Simulink is often used for this kind of simulation because of the availability of toolboxes (such as the one proposed by Fossen described in (Fossen, 2002) and because of the easy implementation of mathematical models. But we have to keep in mind that the temporal aspect of the simulation is not taken into account and it potentially makes the control algorithm inoperative when it is transferred on a real robot. Thus it is not possible to validate control architecture or a sensor referenced command with such a simulator.
Online Simulators belong to another type; they allow to take into account the temporal consistency of the simulation. Indeed, in this type of simulation, 1 second of simulated time actually corresponds to 1 second in real time. This is the case in the *SubSim* simulator (Tobias Bielohlawek, 2006). However the algorithms are still not executed on the robot itself, and the temporal behavior of the computer used for the simulation can be different from the one onboard the robot.
In *Hardware In Loop* simulations, the control algorithm is executed on the robot itself, but the commands sent to the actuators are routed towards the simulator instead of the real robot (Suriano, Moriconi, 2007). The simulator then considers the actuation commands in order to compute the evolution. However, in this sort of simulation the external world is not taken into account, except for the dynamic properties of the environment. Only the proprioceptive sensors are simulated and the overall algorithms suite cannot be fully tested.
Hybrid simulators are HIL simulators where real and virtual systems interact together in an virtual environment. It is therefore necessary to simulate an environment (static or dynamic) in which the robot will be fully functionally operative. Therefore, it is possible to test all the algorithms of the machine, from low level control of sensors or actuators to the whole architecture. This approach has been used by several authors such as in (Ridao, Batlle, Ribas, Carreras, 2004), in which authors present Neptune, their real time graphic multi-vehicles simulator, allowing to performe online, HIL and hybrid simulation.