PhD subject

Autonomy and reliability enhancement of robot for the observation of submarine ecosystems.

This PhD will be co-supervised by researchers from LIRMM (K. Godary-Dejean and D. Crestani, Robotics) and LAAS (J. Guiochet, Computer Science / Dependability), in close collaboration with marine biologists from MARBEC (S. Villéger and T. Claverie, Marine Biology).

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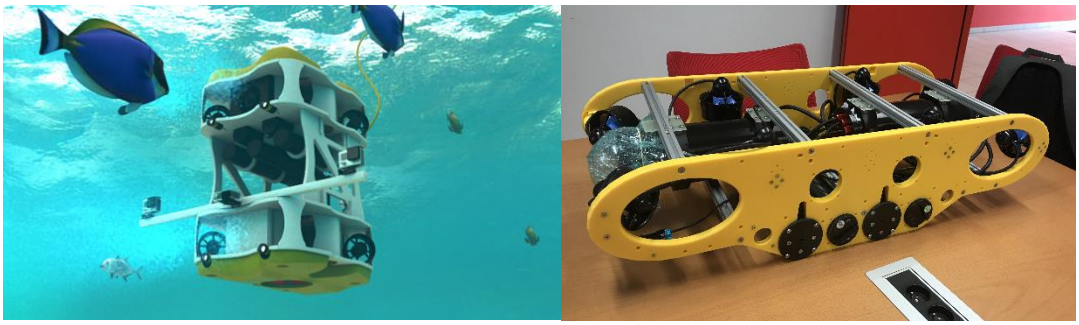
Abstract

This work aims to develop a reliable and Autonomous Underwater Vehicule (AUV) (a robot) for the observation of the biodiversity of coastal marine ecosystems. Protocols for observing and monitoring the marine environment have multiple constraints: physiological limitations of divers, significant logistics and operational costs, technological limitations. The submarine robots are of an interesting contribution for the biology but current robots often require heavy and constraining operational means, or can only perform simple autonomous missions. The realization of longer and / or complex missions in autonomy requires the use of *specific techniques to ensure the reliability of the system and the integrity of its environment*. Yet current dependability techniques are only partially applicable to submarine robots, because of the specific environmental constraints of this environment, and their increasing autonomy. The way of improvement proposed here is based on *an interdisciplinary collaboration between roboticists expert in fault tolerance (LIRMM), computer scientists expert in the dependability domain (LAAS) and marine biologists (MARBEC)* that will lead to a mutual enrichment of robotic and computer science methods and the improvement of their efficiency through the integration of the knowledge of field experts. The contribution of the biologists will allow the definition of the operational constraints, but also and especially to the refinement of the techniques and the parameters useful to the detection of the failures, and to the development of techniques of recovery more relevant and more effective in the intended context.



The submarine robots of the Explore team of LIRMM

Context

In a submarine environment, by nature complex and dynamic, the probability of losing or damaging the robot or the environment by performing a robotic mission in autonomy is high. The question of the trust that can be placed in these systems is today the main obstacle to their deployment. In

underwater robotics, the coupled consideration of safety and autonomy issues is very recent and unusual. To our knowledge, few recent projects (H2020: SWARMs, TIC-AUV) address this topic. One solution may be the use of dependability techniques [1,2]. Outside the underwater domain, current works in autonomous robotics assume that the techniques for dependability, mainly based on the development of secure modes for robot, make it possible to satisfy safety constraints. But the specificities of the underwater environment exacerbate the limitations of these techniques: the definition of a safe, stable and passive state is complex, and human intervention difficult.

Objectives

This thesis aims to design and validate an underwater robot that can perform autonomous and safe complex marine observation missions. For this, it is necessary to enrich the decision-making autonomy of the robot while assuring an acceptable level of safety. This thesis will therefore propose a strategy for dependability applied to AUVs using autonomous monitoring mechanisms that allow the robot to cope with its internal failures, adverse environmental situations or uncertainties of perception, and to ensure that it could switch in a safe state. Inspired by the previous work of the partners involved [3-7], this strategy of dependability will be based on the development of two complementary mechanisms:

- Tolerance to internal faults: a robot must implement fault tolerance mechanisms to be resistant to internal failures. The usual detection-diagnosis-recovery mechanisms will be adapted to the context of underwater robotics.
- Active security monitoring: The system may fail due to system crash or to the occurrence of unexpected situations that could not be detected or recovered by the previous approach. For this, an ultimate safety protection mechanism, the safety monitor, will be developed.

It will also be necessary to use and adapt standard risk analysis techniques (HAZOP, FMECA or FTA), coupled with a methodology to define the faults to be detected and the recovery actions to be implemented.

Method

The progress of this thesis will be a classical one integrating an experimental approach: 1) bibliography review, 2) development of theoretical solutions 3) implementation of these solutions on the robotic prototype 4) simulation and experimental validation. Validation in the field (pool, canal, sea) is essential in the intended context and will be carried out with biologists.

Bibliography

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