ADVOCATE II: ADVanced On-board diagnosis and Control of Autonomous sysTEms II

The Advocate Consortium[1]

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Abstract. A way to improve the reliability and to reduce costs in autonomous robots is to add intelligence to on-board diagnosis and control systems to avoid expensive hardware redundancy and inopportune mission abortion. According to this, the main goal of the ADVOCATE II project is to adapt legacy piloting software around a generic SOAP (Simple Object Access Protocol) architecture on which intelligent modules could be plugged. Artificial Intelligent (AI) modules using Belief Bayesian Networks (BBN), Neuro-Symbolic Systems (NSS), and Fuzzy Logic (FL) are coordinated to help the operator or piloting system manage fault detection, risk assessment, and recovery plans.

1 The ADVOCATE II Architecture

ADVOCATE II introduces intelligent techniques for diagnosis, recovery and replanning into UUVs (Unmanned underwater vehicles) and UGVs (Unmanned Ground Vehicles). The global objective of the project is to enhance the level of reliability and efficiency of autonomous robotic systems, as described below:

- To construct an open, modular, and generic software architecture for autonomous robotic systems diagnosis and control.
- To develop or improve a set of intelligent diagnosis modules fully compatible with this architecture and tested in operational applications.
- To carry out practical tests and demonstrations on a set of operational prototypes in order to prove operationality and efficiency of this solution in

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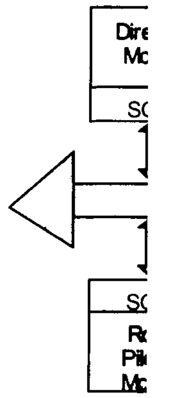

Fig. 1

1.1 Robot Piloting Module

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1.2 Decision Module (DM)

This module has a generic p
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- validation of diagno

several application fields, and particularly for Autonomous Underwater Vehicles (AUVs) and Autonomous Ground Vehicles (AGVs).

ADVOCATE II is based on a distributed architecture, and a generic protocol (SOAP/XML technology implementing HTTP) for communication between the different modules. The ADVOCATE II architecture is distributed around a SOAP bus as depicted in figure 1. (maybe the different colors of the modules should be explained? Also, maybe the intelligent diagnosis modules should be called the intelligent modules in figure 1) The architecture is modular, easy to evolve and to adapt to legacy piloting systems. It comprises five different types of modules.

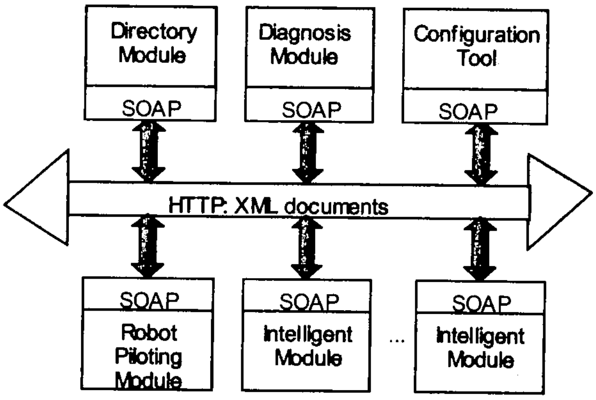

Fig. 1. The ADVOCATE II Architecture.

1.1 Robot Piloting Module (RPM)

This module manages the mission plans and communicates directly with the vehicle sensors and actuators. Several RPMs, each of them working on a specific subsystem, can be plugged onto the ADVOCATE II architecture. Each end-user participating in the project (UAH, STN ATLAS, and IFREMER) is responsible for the corresponding piloting modules.

1.2 Decision Module (DM)

This module has a generic part and a specific part containing knowledge for decision making, according to diagnosis results. The DM manages the overall diagnosis and recovery process, including the following functionalities:

- control of the monitoring/diagnosis/recovery process,
- integration of uncertainty information provided by the intelligent modules,
- validation of diagnosis and recovery actions (if needed),

- interaction with human operators (if any) with regards to diagnosis and recovery.
- conversion of the recovery actions into recovery plans.

1.3 Intelligent Modules

Several Intelligent Modules for each application are currently being developed, using different Artificial Intelligent techniques devoted to solve real problems on operational robots by making use of specific knowledge on them. Intelligent Modules include functionalities providing diagnosis (identification of sub-system state), proposed recovery actions, or both. The present implementation comprises modules based on:

- Bayesian Belief Networks (BBN).
- Fuzzy Logic (FL).
- Neuro-Symbolic Systems (NSS).

The ADVOCATE II architecture supports easy integration of intelligent modules based on different AI techniques.

1.4 Directory Module

The Directory Module is a central point of the architecture. It will be implemented using a Java UDDI tool supplied by IBM. The Directory Module will support progressive integration of the intelligent and piloting modules. This objective implies the adaptation of SOAP implementations so as to integrate the soft real time specifications.

1.5 Configuration Tool

This is an offline, user-friendly application,which eases the production of the XML Configuration File for every modules of the ADVOCATE II system. By generating a graphical view of the system the user will be able to check the concordance of the configuration files, and to foresee the behaviour of the modules in the system.

2 Applications

Three end-users are involved in the ADVOCATE II project:

- UAH (Spain) designing Piloting Modules for either Autonomous or Remotely Operated Groung Vehicles (AGVs or ROGVs, respectively) for surveillance applications.
- IFREMER (France) designing Autonomous Underwater Vehicles (AUVs) for scientific applications.
- STN ATLAS Elektr
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3 Conclusions

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Acknowledgments

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- STN ATLAS Elektronik (Germany) designing Autonomous Underwater Vehicles (AUVs) and semi-AUVs for industrial applications.

Several diagnosis problems are considered for the UAH, STN, and IFREMER applications, involving different kinds of failures:

1 Thruster or motor failure diagnosis and recovery (IFREMER, STN and UAH). As soon as an abnormal behaviour of the vehicle is detected, the system provides a diagnosis on the responsible thruster or motor, and a recovery action is issued based on the redistribution of propulsion power.

2 Sensor Malfunction (UAH and STN). Diagnosis on sensor state is provided so as to account for failure situations, or in case information coming from sensors is corrupted by acoustic noise or interferences.

3 Battery monitoring (UAH and IFREMER). Both an AGV and an AUV are supplied with energy by their own battery. An Intelligent Module is in charge of managing the mission parameters according to the power consumption in order to avoid inopportune mission abortion.

4 Abnormal global behaviour (STN). An Intelligent Module will be developed to provide monitoring and assessment of the motion characteristics and the control inputs of the vehicle.

3 Conclusions

The main objective of the ADVOCATE II project is to develop a software architecture to allow the implementation of intelligent control modules for underwater and ground robotic applications, in order to increase their reliability. The interest of such a concept from the marketing point of view has been demonstrated by a market study. Additional ongoing information concerning the ADVOCATE II project can be found at the project web site: http://www.advocate-2.com .

Acknowledgments

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