GIVING BIRTH TO SAFE ROBOTS
A HUMAN'S BEST FRIENDS

The Business
The CEA List Interactive Robotics Lab (LRI) designs and develops collaborative robots or « *cobots* », which are intended to interact with human operators in a safe and reliable manner.

The Challenge
Robotic systems are a typical example of complex systems. Their design involves a combination of different technologies, requiring a multi-disciplinary approach. This is particularly challenging when a robotic system is required to interact either with humans or other entities within its environment.

The Solution
LRI adopted a design approach based on MDE (Model-Driven Engineering) principles. LRI decided to extend RobotML, a modeling environment based on the Papyrus tool, which was developed specifically for the robotics domain.

The Benefit
The extended RobotML tool was used to model a complete robotic setting, including protagonists, objects, their properties, the interactions between them, the services provided by the robots, and the actions they can perform. The RobotML extension was successfully adopted in an ongoing research project : CPS HII I4.0– Cyber Physical Systems High Impact Initiative for Industry 4.0.

[Papyrus and RobotML]

« We design and validate manipulation, remote handling, and collaborative robots. »

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« Better interactions between humans and robots »

The Business

At the Interactive Robotics Laboratory, research activities are focussed on the fields of remote handling and collaborative robotics dedicated to a very wide scope of applications such as industry, energy (e.g., nuclear, oil & gas), and health.

Robotic research at CEA was initially focused on remote manipulation of nuclear materials in environments that were hazardous to humans.

Nowadays, however, it is being successfully applied to force-feedback telerobotics, which are used in various other hazardous environments, such as tunnel boring, space, or offshore.

In the industrial domain, the focus of research has extended to industrial robotics, where the main upcoming challenge is to evolve from large-scale manufacturing to product customization.

That implies the need for more dextrous and easily programmable robots, capable of supporting versatile, reconfigurable, and intelligent means of production. In that context, cobotics evolved to help mitigate or even eliminate common human musculoskeletal disorders that are the consequence of repetitive and strenuous manual tasks.

These are collaborative robotics systems, designed for permanent or time-shared interaction with human operators using effective gesture assistance.

The laboratory is mandated to provide technological innovations that are integrated in industrial prototypes. The core technologies being developed are new robotic architectures, high-performance actuation, force and supervised control, new development methods, and software tools.

Research activity is organised in three main application themes :

- remote handling based on TAO Control software (a real-time controller that enables force-feedback Cartesian coupling between any master arm or haptic device and any slave robot or manipulator) ;
- collaborative robotics (also called cobotics) focuses on safety and efficiency of human-robot interaction and on new cobot architectures, from force amplification systems to exoskeletons ;
- autonomous dextrous manipulation focuses on robotic hands and context sensitivity (the ability of a robot to « *understand* » its environment and plan its activities).

The Challenge

One of the primary challenges facing the LRI is to simplify the configuration and use of robotic systems. That is, by allowing the design of robotic systems to be accessible not only to programming experts but also to robotics experts and even to actual robotic system users, would greatly help customers to better express their requirements.

Another major challenge is how to deal with platform variability. The term « *platform* » here covers a variety of concerns, such as mechanisms, control strategies, middleware, etc.

This remains an important issue in robotics systems design and implementation.

Yet another key challenge is to simplify the development of robotics applications. Currently, developers spend a lot of time developing and maintaining their applications.

A significant amount of time could be saved using automated code generators, which could produce more reliable and more maintainable code.

The Solution

[" We adopted Papyrus and its specialization for RobotML as a modeling tool, thanks to its ability to be highly adapted to specific domains."]

BAPTISTE GRADOUSSOUFF - RESEARCH ENGINEER, CEA LIST

« An innovative language »

To address the above challenges, the solutions implemented by LRI rely on the domain-specific modeling language, RobotML, which was initially defined for mobile robotics.

An extension of this modeling language was developed for manipulation robotics, which comprises a set of actions and component libraries that guide the system designer during the design process through to code generation.

To deal with platform variability, the tool supporting the RobotML extension for manipulation modeling supports multiple user views.

These are used to design robotic scenes, scenarios, state machines, mechanisms, and, in particular, templates of controller components (defined in the context of the P-RC2 project).

Finally, to simplify robotics applications development, several different code generators are currently being developed at LRI for different target platforms and languages, such as OROCOS (a component-based framework), Hfsm (Hierarchical State Machine Language), OPC-UA (a service-based protocol configuration).

These developments follow an iterative process starting with simple examples and moving to more complex ones.

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The Benefits

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« A groundbreaking innovation for the robotic community »

The above solutions are currently in development in LRI, but some important benefits of the new approach are already apparent.

The experience gained from the use of modeling and dealing with variability has already led to the design of a successful integration solution in the HII-CPS project (founded by H2020 IET-KIC), in which the RobotML extension for manipulation was used as the basis for system configuration.

The Hfsm code generator has been tested and validated in the context of programming a robotic scenario.

The opportunity to have a unified way of describing a robotic system and its use in a given situation is a groundbreaking innovation for the robotic community, including end users, system integrators, and robot manufacturers.

This is why *Sybot* , a cobot manufacturer that is going to be spun off soon from CEA, is fully committed to further development and maturation of these innovations.

Sybot and the Interactive Robotics Lab (CEA List) are fully committed to further the maturation of model-driven engineering for robotics using Papyrus.

About Interactive Robotics Lab at CEA LIST

Nature : Research Laboratory

Domain : Robotics

Employees : 50, including permanents, fixed term contracts, and PhD Students

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About List (www-list.cea.fr) : One of three institutes which comprise CEA Tech (CEA Technological Research Division), the List institute is committed to technological innovation in digital systems. Its R&D activities – driven by major economic, societal and industrial challenges – encompass four main themes : advanced manufacturing ; embedded systems ; ambient intelligence ; and healthcare, including radiotherapy and imaging technologies.

About Papyrus (www.eclipse.org/papyrus) : Papyrus is an Eclipse project led by List (contact : Sébastien Gérard at sebastien.gerard@cea.fr). Papyrus is also labelled as a solution of the Eclipse industrial working group Polarsys (https://www.polarsys.org/solutions/papyrus). Papyrus supports model-driven approaches by providing a standards-based modeling tool that supports, out of the box, both the UML and the SysML international industry standards from the OMG. In addition, Papyrus provides very advanced support for custom UML profiles that specialize UML, which enables users to define and implement their own domain- and project-specific modeling tools and languages (DSMLs). The user interface of Papyrus is highly configurable to support a broad spectrum of user-specific domains and concerns.