The Robotic Software Developed by WALK-MAN Team for the DRC Finals

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The DARPA Robotics Challenge (DRC) Finals was a great opportunity, for many labs in the world, to test hardware (mostly humanoid robots) and software in a simulated disaster scenario. Due to the difficulty of the competition, hardware and software had to be designed not only to be effective in terms of control and capabilities, but also robust and reliable. From the software point of view, best practice, agile development, unit testing and similar practices are the keys to reach the high standard levels needed to run a humanoid robot that has to perform tasks in a real world scenario.

In this talk we want to introduce the used methodologies and developed tools from the WALK-MAN Team that participated to the DRC Finals. The main aspects of the developed software framework was module reusability. Reusability was a fundamental aspect since the modules and libraries were developed and tested in parallel with the construction of the WALK-MAN robot. Indeed the software components were developed using simulation while validation was performed using the COMAN robot [4]. Once the hardware was completed and assembled, the modules were tuned to run on the WALK-MAN robot. We tried to reduce the amount of work of the developer since not all the members of the team have advanced knowledge of programming. For this reason we designed standard control and perception modules that the developer had to fill with his own code. Our framework is mainly based on YARP and ROS: we used YARP for the control modules while the perception modules, as well as the GUI, were written using ROS components.

The main aspect to guarantee module reusability was the use of a standard description for the kinematics/dynamics and for the structure of the robot. For this reason all the developed libraries needs in input URDF (Universal Robotics Description Format) and SRDF (Semantic Robotic Description Format) files. The URDF description is used mainly for Forward/Inverse Kinematics and Inverse Dynamics, while the SRDF contains information such as the number of kinematic chains, sensors, matrices for the self collision avoidance and so on. Each module has also a configuration file that can be used to set parameters that will be load in the initialization procedure of the module. In our framework, modules are process that runs a loop with the control algorithm.

To design new algorithm we developed a set of plugins for GAZEBO to simulate our robots that are controlled using YARP [1]. This plugins exposes the same control interface as the real robot so, when running, a module does not know if it is interacting with the real robot or the simulated one. The *robotInterface* is the module that connect the low level (DSPs in each joint) to the high level (Control PC). It basically consists in a set of interfaces that have to be implemented using the robot API that permits to read/write from the boards of the robot. Once implemented, the *robotInterface* exposes the same interfaces of the simulator, as written above.

For the control of the robot we developed a library called *OpenSoT* [2] that permits to compute Inverse Kinematics for redundant robots considering constraints and priorities between tasks. *OpenSoT* provides base classes and standard interfaces to specify tasks, constraints and solvers. The architecture of *OpenSoT* encourages collaboration and helps integration and code maintenance. *OpenSoT* has been used to develop all the manipulation tasks performed in the DRC Finals by the WALK-MAN robot.

The GUI used during the competition was developed using RVIZ plugins [3]. It permits to send reference to the robot as well as high level command. It shows the actual internal status of the robot, cameras and Point Cloud and status of the module that are running inside the robot.

Finally, all our software is organized in git repositories that are managed by a build system called *Superbuild* that automatically download and compile modules, libraries and dependencies.

The presented frameworks and modules were mainly used with the COMAN and WALK-MAN robots and recently, some parts of it, were used to control the HYDRA robot [5] in simulation. In particular, just changing configuration files, it was possible to achieve Operational Space Control and Kinematics walking. This corroborates our general approach in robotics software design. Thanks to this framework and tools, the WALK-MAN team was able to develop in one year and half the software infrastructure to participate to the DRC Finals achieving the 17th placement. The presented libraries and tools are Open Source and available at the following repositories: `https://github.com/robotology`, `https://github.com/robotology-playground` and `https://gitlab.robotology.eu/groups/walkman`.

References

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