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EMBEDDED IMPLEMENTATION OF A REAL-TIME SWITCHING CONTROLLER ON A ROBOTIC ARM

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The very high availability of low-cost embedded hardware development kits has enabled the fast prototyping of real-time control architectures and algorithms. The software development environments are usually very specific to the target platform, so that is very challenging to develop code that is portable between architectures (e.g. between an ARM and an ATMEL processor).
The MARTe real-time software [1] is a multi-platform C++ real-time framework which allows the execution of control algorithms, interfaces and services in different operating systems and platforms. A new version of this framework has been developed with a software architecture aiming at enabling the execution of the same code across different bare-metal systems.
This paper presents a project where the new version of the MARTe framework is used for the real-time control of a robotic arm using low-cost embedded technologies. In particular it will be demonstrated that the same algorithms can be used to model the system in the Linux and Microsoft Windows operating systems and then directly deployed in an ARM based processor running. The controllers are achieved by implementing a real time thread with maximum priority that communicates with the motors power amplifier setting the motor voltages and reading the angular position of the joints by mean of optical encoders. Simultaneously low-priority threads will provide the user interface where to visualize in real-time the current position of the robot in terms of angular position of the joints and where it is possible to select a desired robot pose and change the controller's parameters.
The control algorithm to drive the DC motors is based on a new switching PID theory [2]. Thus, given two different PIDs (commonly with different integral gains), the control algorithm can switch from one PID to the other one minimizing overshoots and oscillations and increasing the convergence speed of the angular position to the desired reference. The switching policy is a Lyapunov based equation tailored to minimize a cost functional which considers the L2 norm of the tracking error (to minimize the convergence speed) and the of the tracking error derivate (to minimize oscillations).
This work will present and compare the performance of the control algorithm implementation in the different hardware architectures and will discuss the controller design improvements with respect to the classic PIDs.

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