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CoreRobotics: An object-oriented C++ library with cross-language wrappers for cross-platform robot control

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Summary

Real-time controllers for robot manipulators are typically developed and implemented on a custom basis due to 1) the complexity of control in real application, and 2) requirement of only incremental changes in hardware and software as the design matures. Modular approaches to actuators have made it easier to quickly assemble custom robot designs to address the increasing thrust for physical automation in society. However, development of controllers for such robot platforms is often performed in resource-intensive software suites such as Robot Operating System (ROS). This approach requires unnecessarily high processor performance when the controller does not fully utilize the suite.

The CoreRobotics libraries were developed in an effort to provide generalized implementations of algorithms facilitating rapid development of real-time robot control. CoreRobotics utilizes an object-oriented approach in C++ to implement fast cross-platform thread management and timing, core math solvers (Kreyszig 2011), manipulator control (Craig 2004,R. Murray and Sastry (1993),S. Buss and Kim (2005),Hourtash (2005)), and trajectory shaping (Hogan 1984), and modeling for state estimation (S. Thrun and Fox 2005,Crassidis and Junkins (2012),Arulampalam et al. (2002)).

An example application that makes use of the library runs a single-board computer (e.g.: a raspberry PI or similar computer) to control the motion of a small four-jointed robot arm. A controller that solves for the joint angles to achieve a desired position of the robot tool uses the CoreRobotics InverseKinematics class. To achieve smooth motions between robot tool waypoints, the controller uses the CoreRobotics TrajectoryGenerator class. The Manipulator class presents a convenient way to represent the robot and update the robot kinematics quickly when new sensor data becomes available.

CoreRobotics has been compiled on Windows 8.1, 10, Linux, and MacOS on various hardware architectures. Linear algebra is handled with Eigen. CMake is used to unify the compile process across multi-platform developer environments, and an option is provided to compile Python and MATLAB wrappers using SWIG. The CoreRobotics library is used in several research projects at the University of Washington, Seattle.

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