Manif: A micro Lie theory library for state estimation in robotics applications

Jérémie Deray¹ and Joan Solà¹

¹ Institut de Robòtica i Informàtica Industrial, CSIC-UPC, Llorens Artigas 4-6, 08028, Barcelona, Spain.

Summary

There has been a remarkable effort in the last years in the robotics community to formulate estimation problems properly (Eade, 2013)(Barfoot, 2017). This is motivated by an increasing demand for precision, consistency, and stability of the solutions. Indeed, proper modeling of the states and measurements, the functions relating them, and their uncertainties, is crucial to achieve these goals. This has led to problem formulations involving what has been known as ‘manifolds’, which in this context are no less than the smooth topologic surfaces of the Lie groups where the state representations evolve (Chirikjian, 2011).

manif (Deray & Solà, 2019) is a micro Lie theory library targeted at state estimation in robotics applications. With a single dependency on Eigen (Guennebaud, Jacob, & others, 2010) and a requirement on C++11 only, it is developed as a header-only library, making it easy to integrate to existing projects.

The manif library provides simple interfaces to the most common operations on Lie groups in state estimation. Its design is similar to Eigen, in that all Lie group classes inherit from a templated base class using static polymorphism. This allows for writing generic code without paying the price of pointer arithmetic. Thanks to this polymorphism, the library is open to extensions to Lie groups beyond the currently implemented: the Special Orthogonal groups SO(2) and SO(3) and the Special Euclidean groups SE(2) and SE(3).

The mathematical foundations of the library are given in (Solà, Deray, & Atchuthan, 2018), which is often referred to in the documentation, especially for providing references for the mathematical formulae.

Related work

Sophus (Strasdat, 2018) is a C++ implementation of Lie Groups using Eigen. Our work differs from Sophus in that all our classes inherit from a common templated base class, which enforces a common minimal API. This allows for writing generic algorithms on Lie groups. Moreover, the analytical Jacobian matrices are available to the user for most of the operation on groups, allowing complex chain of operations to be differentiated through the chain rule. Jacobian matrices in manif are defined with respect to local perturbations on the Lie group’s tangent spaces, whereas Sophus defines them with respect to the representation vector that underlies the implementation.

wave_geometry (Koppel & Waslander, 2018) is a library for manifold geometry with fast automatic derivatives and coordinate frame semantics checking. Our work differs from wave_geometry in that it relies on C++11, which is still the standard in many laboratories and
companies, while `wave_geometry`, as of the time this paper is written, requires a C++17-compatible compiler. While both libraries rely on the external dependency `Eigen`, `wave_geometry` also relies on Boost (Koranne, 2011). Finally, as of the time this paper is written, `wave_geometry` only implements the groups SO(3) and SE(3) while `manif` also provides SO(2) and SE(2).

References


manif is a header-only C++11 Lie theory library for state-estimation targeted at robotics applications. Maintainer status: maintained. Maintainer: Jeremie Deray deray.jeremie@gmail.com. While the manif package differentiates Jacobians with respect to a local perturbation on the tangent space, many non-linear solvers (e.g. Ceres) expect them to be differentiated wrt the underlying representation vector of the group element (e.g. wrt to quaternion vector for ). For this reason manif is compliant with Ceres auto-differentiation and the ceres::Jet type. Documentation. Some general documentation on the use of the library is available on the wiki-page. Type in the terminal. cd [manif] doxygen .doxygen.txt. manif is a header-only C++11 Lie theory library for state-estimation targeted at robotics applications. At the moment, it provides the groups: $\mathbb{R}(n)$: Euclidean space with addition. manif is based on the mathematical presentation of the Lie theory available in this paper. We recommend every user of manif to read the paper (17 pages) before starting to use the library. The paper provides a thorough introduction to Lie theory, in a simplified way so as to make the entrance to Lie theory easy for the average robotician who is interested in designing rigorous and elegant state estimation algorithms. In a rush? Check out our Lie group cheat sheet. manif has been designed for an easy integration to larger projects: A single dependency on Eigen, header-only for easy integration Manif: A micro Lie theory library for state estimation in robotics applications. Journal of Open Source Software, 5(46): 1371, 2020. Abstract Info PDF. The Mobile Robotics Laboratory is an experimental area primarily devoted to hands-on research with mobile robot devices. The lab includes 3 Pioneer platforms, 2 service robots for urban robotics research based on Segway platforms, and a 4-wheel rough outdoor mobile robot, a six-legged LAURON-III walking robot, and a vast number of sensors and cameras. Barcelona Robot Laboratory. The Barcelona Robot Lab encompasses an outdoor pedestrian area of 10,000 sq m., and is provided with 21 fixed cameras, a set of heterogeneous robots, full coverage of wifi and mica devices, and partial gps coverage.