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

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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, a 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).

Mathematical foundations of the library are given in (Solà, Deray, & Atchuthan, 2018) and often refers to it in the documentation, especially for providing reference 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).

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