

Geometric representations for robot manipulation skills acquisition

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Abstract: Because robots act in a physical world, many fundamental problems in robotics involve geometry, leading to an increased research effort in geometric representations for robotics. For example, to speed up manipulation skills acquisition, prior knowledge about the physical world can be embedded within the representations and associated learning algorithms. Several frameworks can be used to pursue such a goal, including Riemannian geometry and geometric algebra. Riemannian geometry will first be discussed as a way to extend algorithms initially developed for standard Euclidean data, by taking into account the structures and shapes of the manifolds. In robotics, these manifolds can include simple but varied geometries, such as orientations, ellipsoids or subspaces. In complement to Riemannian geometry, geometric algebra allows geometric primitives to be encoded in a uniform manner, by using a representation in a higher dimension space. It can be viewed as a modernization of Clifford algebra, by providing a single algebra for geometric reasoning, alleviating the need of utilizing multiple algebras to express geometric relations. In the context of robotics, it allows translations and rotations to be treated in the same way, without requiring us to switch between different algebras, as is classically done when handling position data in a Cartesian space and orientation data as unit quaternions. This representation provides fast resolution of robot kinematics problems, where the modeling of cost functions in an optimal control problem can be done uniformly across different geometric primitives, leading to resulting expressions that are both intuitive and with a low symbolic complexity.