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FORWARD KINEMATIC MODELING OF CONSTANT CURVATURE CONTINUUM ROBOTS USING DUAL QUATERNIONS

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Summary: A continuum robot can modify the shape of its elastic structure to wrap around an object and to grasp it, to move with dexterity in un-structured environments (e.g. nuclear decontamination, search and rescue), availing of its compliance to interact safely with its environment (e.g. medical applications) and for locomotion. Piecewise constant curvature approach has allowed researchers to apply on continuum robots the mathematical tools widely used to model rigid-links robot, such as Denavit-Hartenberg parameters and Euler-Lagrange equations. Despite the use of these well-established methods leads continuum robots to inherit experience from a vast literature of applications, the high complexity of the resulting models due to the continuum nature of these robots represents a significant issue to their actual numerical implementation.

The application of the dual quaternions to the kinematic modelling of the constant curvature backbone has led to positive results with respect the compactness and efficiency of the representation of the transformations. With its five variables among the eight constitutive elements, the dual quaternion is a much more compact representation of the homogeneous transformation with respect to the matrix of twelve variables. Benefits due this representation are inherited by the differential kinematic problem, where the derivative of the homogeneous transformation are defined by three dual quaternions instead of a much more complex matrix with dimensions 4x4x3. Thus, real time applications are achievable and intrinsic instabilities can easily be handled.