Texas Tech University. Applied Mathematics Seminar.

STATISTICAL ANALYSIS OF TRAJECTORIES ON RIEMANNIAN MANIFOLDS: BIRD MIGRATION, HURRICANE TRACKING, AND VIDEO SURVEILLANCE

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ABSTRACT. We investigate statistical analysis of trajectories on Riemannian manifolds that are observed under arbitrary temporal evolutions. The past methods rely on cross-sectional analysis, with the given temporal registration, and consequently lose the mean structure and artificially inflate the observed variance. We introduce a quantity that provides both a cost function for temporal registration and a proper distance for comparison of trajectories. This distance, in turn, is used to define statistical summaries, such as the sample means and covariances, of synchronized trajectories, and Gaussian-type models to capture their variability at discrete times. This distance is invariant to identical time-warpings (or temporal re-parameterizations) of trajectories. This is based on a novel mathematical representation of trajectories, termed transported square-root vector field (TSRVF), and the L2 norm on the space of TSRVFs. We will illustrate this framework using three representative manifolds S2, SE(2) and shape space of planar contours involving both simulated and real data. In particular, we will demonstrate: (1) improvements in mean structures and significant reductions in cross-sectional variances using real datasets, (2) statistical modeling for capturing variability in aligned trajectories, and (3) evaluating random trajectories under these models. Experimental results are used to demonstrate this framework in bird migration, hurricane tracking, and video surveillance.