Connection between Differential Geometry and Estimation Theory for Polynomial Nonlinearity in 2D

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Time: July 6, 2010, 12:00 PM  
Place:  
Georgia Tech Research Institute (GTRI),  
Cobb County Research Facility (CCRF),  
Building 1, Room 107.

Abstract
A relationship between differential geometry and estimation theory was lacking until the work of Bates and Watts in the context of nonlinear parameter estimation. They used differential geometry based curvature measures of nonlinearity (CMoN), namely, the parameter-effects and intrinsic curvatures to quantify the degree of nonlinearity of a general multi-dimensional nonlinear parameter estimation problem. However, they didn’t establish a relationship between CMoN and the curvature in differential geometry. We consider a polynomial curve in two dimensions and for the first time show analytically and through Monte Carlo simulations that affine mappings with positive slopes exist among the logarithm of the curvature in differential geometry, Bates and Watts CMoN, and mean square error.

Keywords: Differential Geometry, Extrinsic Curvature, Parameter-effects Curvature, Degree of Nonlinearity, Polynomial Nonlinearity, Curvature Measures of Nonlinearity, Mean Square Error, Cramér-Rao Lower Bound.

References