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TITLE: Bayesian Multilevel Functional Principal Components Analysis with Application to Continuous Glucose Monitoring Data

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ABSTRACT:

Multilevel functional principal components analysis (MFPCA) facilitates estimation of hierarchical covariance structures for functional data produced by wearable sensors, including continuous glucose monitors (CGM). There are several existing methods to efficiently fit these types of models; however smaller datasets necessitate robust statistical inference on all model components, and existing techniques have several drawbacks. Performing bootstrap at the group (person) level can be computationally intensive and produce overly conservative pointwise confidence intervals, and existing Bayesian techniques either neglect uncertainty in the eigenfunctions or have prohibitive computation requirements (Crainiceanu 2010, Goldsmith 2015). We propose an alternative MCMC formulation of fully-Bayesian MFPCA which directly models and samples the orthogonal eigenfunctions. Our model automatically accounts for variability in eigenfunction estimation and its interplay with the greater model structure. This method's flexibility also makes it well-suited to exploring the imposition of additional constraints on the eigenfunctions, such as mutual orthogonality across hierarchy levels. We assess the convergence of our model using Grassmannian distances between the spaces spanned by sampled eigenfunctions at each level. After performing validation using a variety of simulated functional data, we apply our model to 4-hour windows of verified post-meal CGM data for persons with diabetes.

Presenting author bio: Joseph Sartini is a fourth year Ph.D. student in Biostatistics at Johns Hopkins University, with interest in modeling for precision medicine applications. Currently, the focus of his work is extracting meaningful insights from time-series produced by Continuous Glucose Monitoring and other wearable devices.