

**SPRING 2008-STA 6426 Topics in Multivariate Analysis :**

**Nonparametric Statistics on Manifolds and Their Applications -**

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**Days/Time/Room:** MW 09:30 - 10:45 OSB 107

**Office Hours:** MW 11:00 - 11:55 am OSB 208 or by appointment

**Text:** - Nonparametric Statistics on Manifolds and Their Applications, by V. Patrangenaru ( Lecture Notes will be posted online).

**Technology:** Matlab, Minitab, occasionally SAS or S-plus.

**Prerequisite:** One of STA 5707, STA 5746, STA 5167, STA 5207, or STA 5327

**Course description:** This course is concerned with statistical theory for describing and analyzing data on curved spaces, including multivariate data. Students will be provided with the supporting geometry, statistics and computational knowledge necessary for making proper studying such data, selecting appropriate techniques, and understanding their range of applicability.

Inference about mean objects, and extrinsic and intrinsic covariance matrices, principal geodesic components, distance based cluster analysis, digital image data acquisition, landmark based image data reduction, high level digital image analysis techniques. A tentative list of topics covered is :

- Brief review of multivariate techniques including Procrustes analysis and multidimensional scaling. Text: *Applied Multivariate Statistical Analysis*, by Richard A. Johnson, Dean W. Wichern, 6th Edition, 2007, Prentice Hall. ISBN-10: 0131877151, ISBN-13: 978-0131877153
- Examples of nonlinear data: directions, axes, shapes of finite configurations, images, proteins, brains, skeletons, manufactured objects.
- Manifolds. Definitions and examples of manifolds arising in nonlinear data analysis. Differentiable functions between manifolds. Embeddings of manifolds in Euclidean spaces. Lie groups, homogeneous spaces.
- Tangent bundles and vector fields, frame bundles and frame fields.
- Riemannian structures on manifolds. Geodesics, cut-locus.
- Intrinsic and extrinsic geometry of manifolds.
- Random objects, integration and probability measures on manifolds.

- Expected values of functions on manifolds. Fréchet means. Mean directions, mean shapes.
- Sampling distributions on manifolds.
- Edgeworth expansions and nonparametric bootstrap.
- Large sample theory for extrinsic and intrinsic means on manifolds.
- Bootstrap distributions of means on manifolds.
- Confidence regions for Fréchet means on manifolds.
- Estimation and testing for one population mean on a manifold.
- Estimation and testing in directional data analysis and shape data analysis.
- Two sample tests for means on manifolds. Examples from shape analysis.
- Directional data analysis in study of geology, paleomagnetism, meteorology, plate tectonics.
- Applications to morphometrics.
- Applications to medical imaging and bioinformatics.
- Applications to pattern recognition and scene identification .
- Applications to face identification.

**Attendance policy:** Active attendance adds up to 5 bonus points. On the other hand, if you miss at least 3 times in a row, this extracredit is lost.

**Grading:** The course grade will be calculated on the basis of homework (30% ) a midterm exam ( 30% ) and a final project (40%). The date of the test will be announced in class. There will be no make ups. Assigned homework will be discussed in class or at office hours.

**Disclaimer** This syllabus provides a general plan; deviations may be necessary.

**Homework 1, due: Jan 14** : From text by Johnson and Wichern :example 12.14, exercise 12.25 ( metric part only).