# Topics in Multi-manifold Modeling

## Math 8600, Spring 2009

**Instructor:** Gilad Lerman
lerman@umn.edu
612-624-5541
534 Vincent Hall

**Time**: MW, 2:30-3:45 PM

**Location:** Vincent Hall 6

### Course description and objectives

We will cover some emerging techniques (most of them are fairly recent) for modeling data as a mixture of ``manifolds'' and for extracting low-dimensional structures from high-dimensional data. We will also discuss related algorithms, theory and applications.
The course has the following objectives:
1. Acquainting students with recent advances in machine learning
2. Formulating specific mathematical problems and applications to focus on
3. Creating a clear mathematical framework to organize and compare the recent advances (ideally documented by class notes)

### Prerequisites

Basic probability and analysis, numerical linear algebra

### Workload and grades

You have the option to choose either an A-F grade (with 3 credit points) or an S/N grade (with your choice of 1 to 3 credit points). 70% of the grade will be based on a final project (chosen by the student and the instructor) which will also include a presentation in class. 30% of the grade will be based on class participation. Each week I will give some reading assignments and also few exercises (if needed) in order to clarify and encourage further discussion about the class material, you are expected to try them.

## Preliminary Syllabus

Below is a list of topics. I plan to cover only some of them considering your interests.

- Introductory concepts of learning and making inferences from data
- Introduction to linear data modeling (linear regression and PCA via SVD)
- Kernel methods for learning (in particular kernel PCA)
- Algorithms for clustering (without intersections) and their analyses
- Algorithms for manifold learning and nonlinear dimensionality reduction
- Algorithms for hybrid linear modeling
- Recent methods for multi-manifold modeling
- Semi-supervised (and supervised) multi-manifold modeling
- Detection of geometric shapes in noisy environment
- Randomized strategies and their use in speeding up the above methods
- Sparse versions of some of the above methods
- Statistical robustness of some of the above algorithms
- Applications exploiting the above methods (in particular, motion detection and segmentation, and multiscale hybrid models for lossy image representation)

## References

We will read recent journal papers (I will provide you with corresponding URLs or files before discussing them in class). There are no textbooks that address the scope of the class. Some books will be suggested to supplement different parts of the course (references will be provided when needed).