

JHU vision lab

Generalized Principal Component Analysis

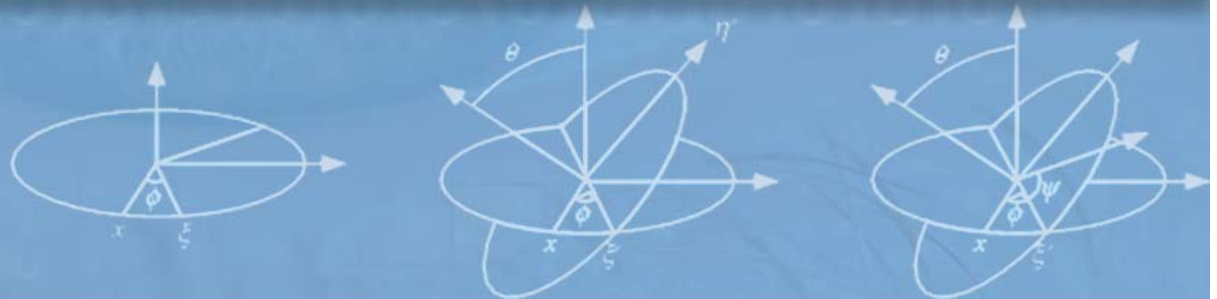
Tutorial @ CVPR 2008

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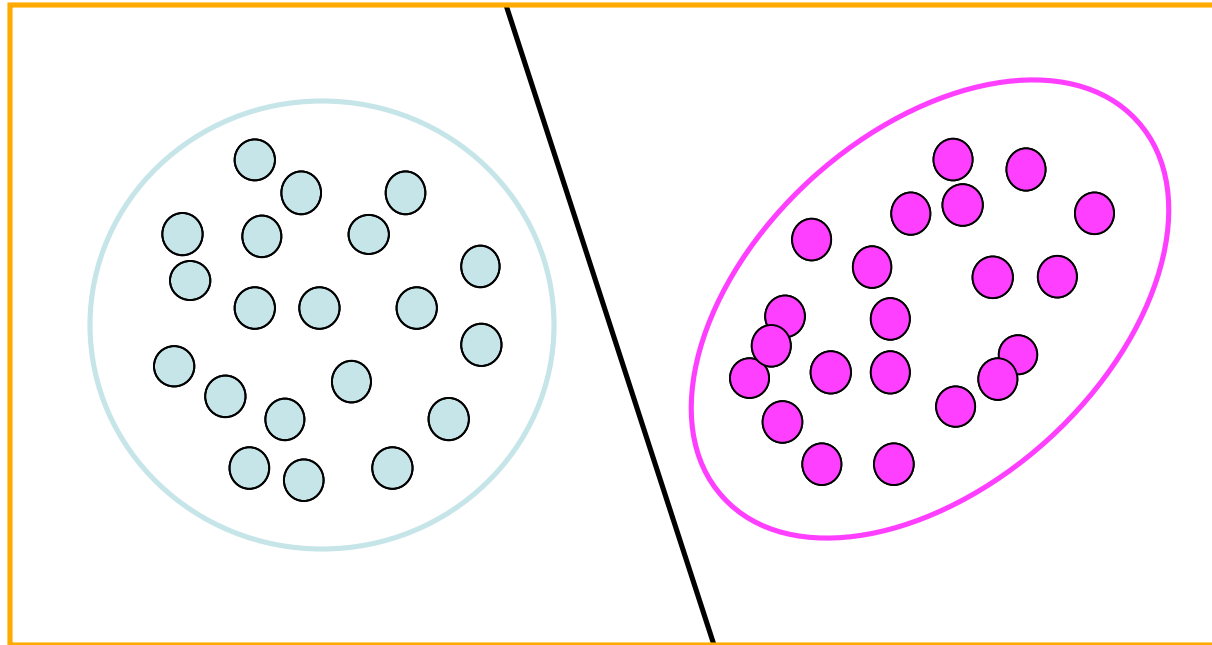
THE DEPARTMENT OF BIOMEDICAL ENGINEERING

The Whitaker Institute at Johns Hopkins



Data segmentation and clustering

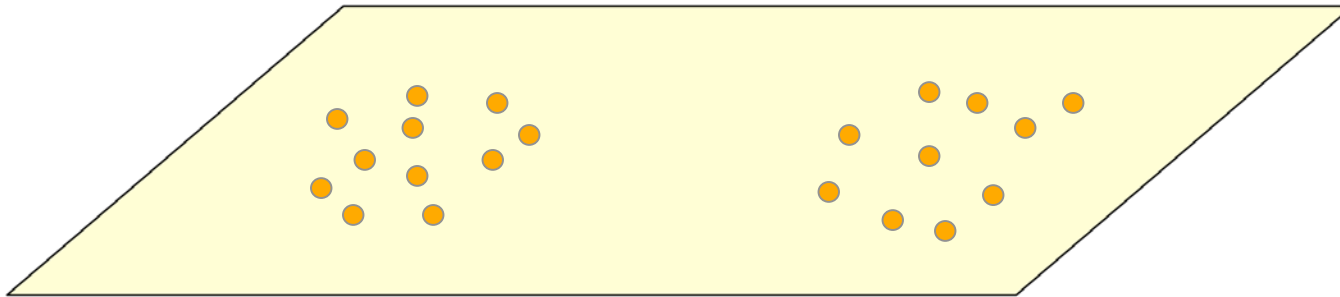
- Given a set of points, separate them into multiple groups



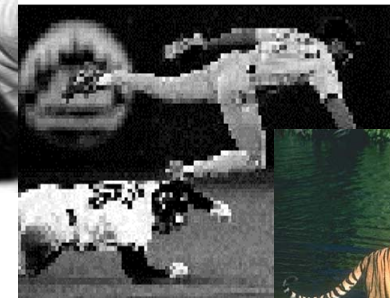
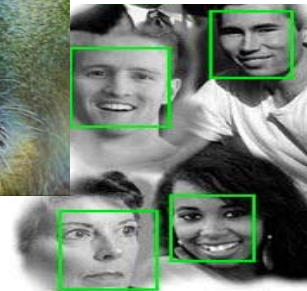
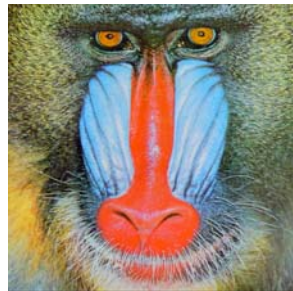
- Discriminative methods: learn boundary
- Generative methods: learn mixture model, using, e.g. Expectation Maximization

Dimensionality reduction and clustering

- In many problems data is high-dimensional: can reduce dimensionality using, e.g. Principal Component Analysis

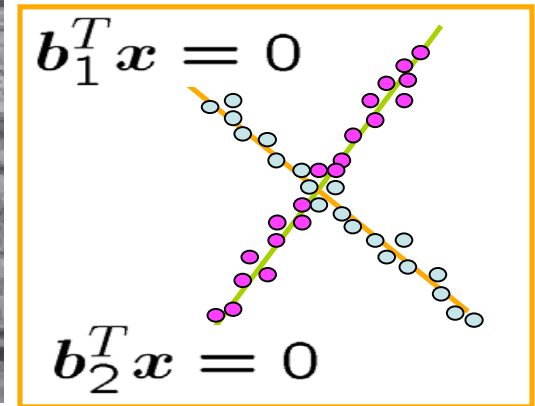


- Image compression
- Recognition
 - Faces (Eigenfaces)
- Image segmentation
 - Intensity (black-white)
 - Texture

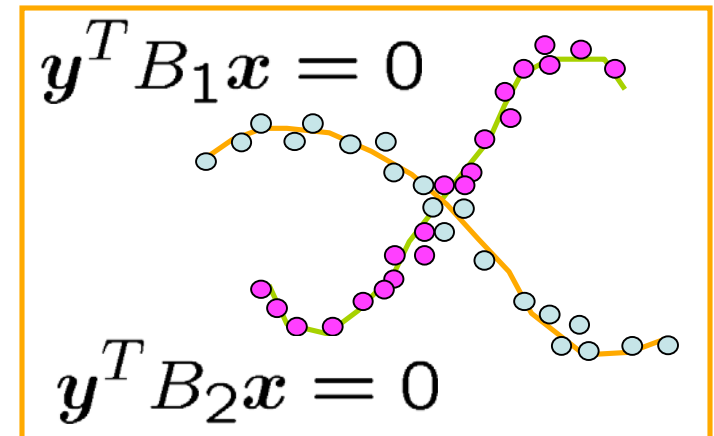
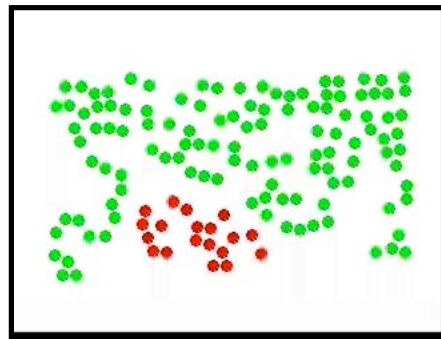


Segmentation problems in dynamic vision

- Segmentation of video and dynamic textures



- Segmentation of rigid-body motions



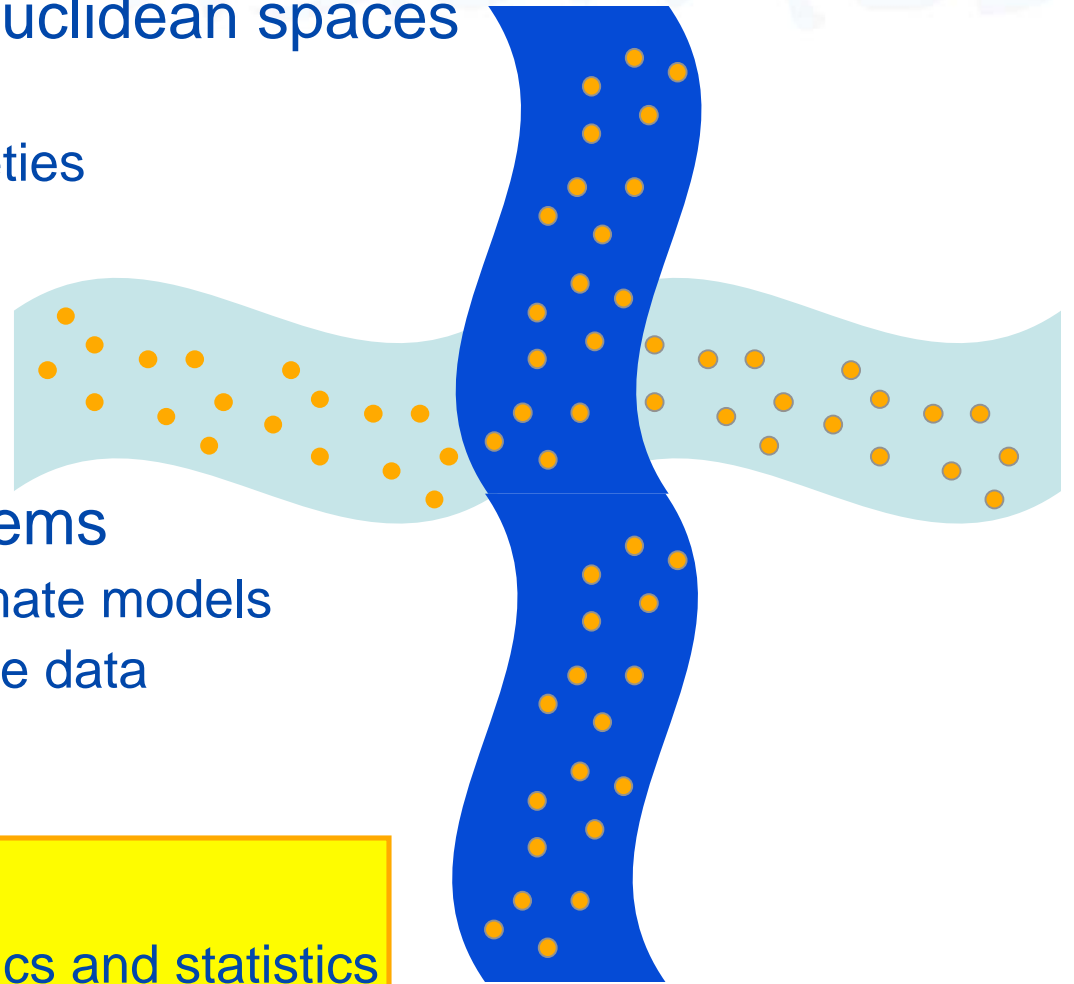
Segmentation problems in dynamic vision

- Segmentation of rigid-body motions from dynamic textures



Clustering data on non Euclidean spaces

- Clustering data on non Euclidean spaces
 - Mixtures of linear spaces
 - Mixtures of algebraic varieties
 - Mixtures of Lie groups
- “Chicken-and-egg” problems
 - Given segmentation, estimate models
 - Given models, segment the data
 - Initialization?
- Need to combine
 - Algebra/geometry, dynamics and statistics



Outline of the tutorial

- Introduction (8.00-8.15)
- Part I: Theory (8.15-9.45)
 - Basic GPCA theory and algorithms (8.15-9.00)
 - Advanced statistical methods for GPCA (9.00-9.45)
- Questions (9.45-10.00)
- Break (10.00-10.30)
- Part II: Applications (10.30-12.00)
 - Applications to motion and video segmentation (10.30-11.15)
 - Applications to image representation & segmentation (11.15-12.00)
- Questions (12.00-12.15)

Part I: Theory

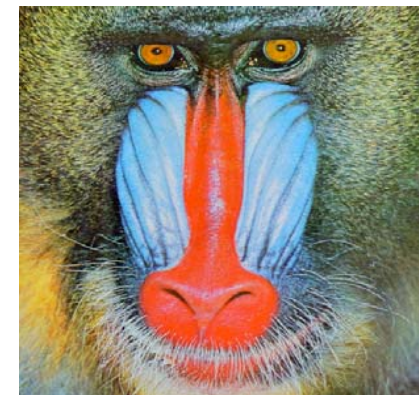
- Introduction to GPCA (8.00-8.15)
- Basic GPCA theory and algorithms (8.15-9.00)
 - Review of PCA and extensions
 - Introductory cases: line, plane and hyperplane segmentation
 - Segmentation of a known number of subspaces
 - Segmentation of an unknown number of subspaces
- Advanced statistical and methods for GPCA (9.00-9.45)
 - Lossy coding of samples from a subspace
 - Minimum coding length principle for data segmentation
 - Agglomerative lossy coding for subspace clustering

Part II: Applications in computer vision

- Applications to motion & video segmentation (10.30-11.15)
 - 2-D and 3-D motion segmentation
 - Temporal video segmentation
 - Dynamic texture segmentation



- Applications to image representation and segmentation (11.15-12.00)
 - Multi-scale hybrid linear models for sparse image representation
 - Hybrid linear models for image segmentation



References: Springer-Verlag 2008

Generalized Principal Component Analysis

Estimation & Segmentation of Geometric Models

René Vidal (BIOMEDICAL ENGINEERING, JOHNS HOPKINS UNIVERSITY)

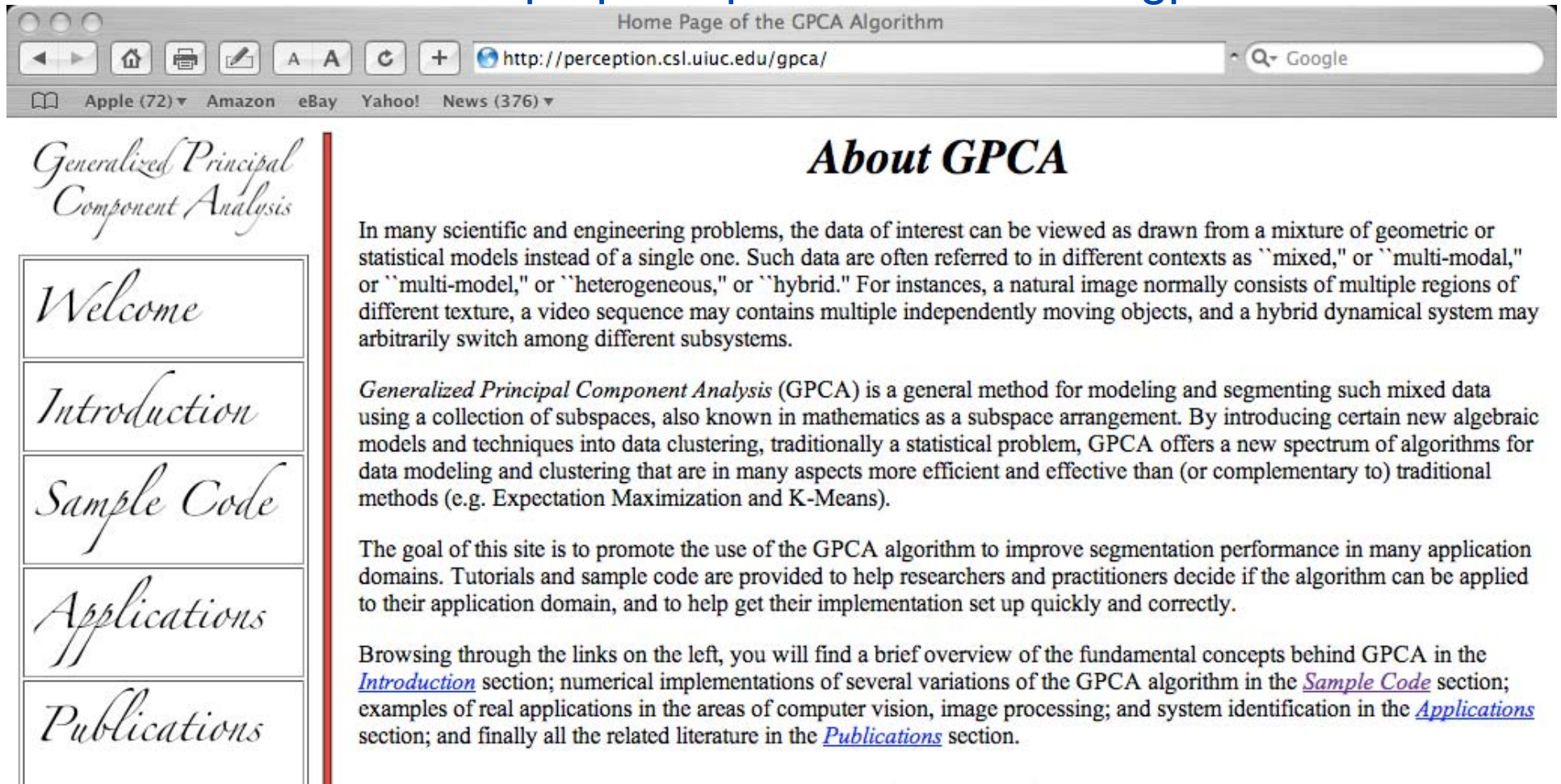
Yi Ma (ECE, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN)

S. Shankar Sastry (EECS, UNIVERSITY OF CALIFORNIA AT BERKELEY)

Slides, MATLAB code, papers

Slides: <http://www.vision.jhu.edu/gpca/cvpr08-tutorial-gpca.htm>

Code: <http://perception.csl.uiuc.edu/gpca>



The screenshot shows a web browser window with the title "Home Page of the GPCA Algorithm". The address bar contains the URL "http://perception.csl.uiuc.edu/gpca/". The browser's search bar shows "Google". The page content includes a navigation menu on the left with links for "Welcome", "Introduction", "Sample Code", "Applications", and "Publications". The main content area is titled "About GPCA" and contains several paragraphs of text describing the GPCA algorithm and its applications.

Generalized Principal Component Analysis

Welcome

Introduction

Sample Code

Applications

Publications

About GPCA

In many scientific and engineering problems, the data of interest can be viewed as drawn from a mixture of geometric or statistical models instead of a single one. Such data are often referred to in different contexts as "mixed," or "multi-modal," or "multi-model," or "heterogeneous," or "hybrid." For instances, a natural image normally consists of multiple regions of different texture, a video sequence may contains multiple independently moving objects, and a hybrid dynamical system may arbitrarily switch among different subsystems.

Generalized Principal Component Analysis (GPCA) is a general method for modeling and segmenting such mixed data using a collection of subspaces, also known in mathematics as a subspace arrangement. By introducing certain new algebraic models and techniques into data clustering, traditionally a statistical problem, GPCA offers a new spectrum of algorithms for data modeling and clustering that are in many aspects more efficient and effective than (or complementary to) traditional methods (e.g. Expectation Maximization and K-Means).

The goal of this site is to promote the use of the GPCA algorithm to improve segmentation performance in many application domains. Tutorials and sample code are provided to help researchers and practitioners decide if the algorithm can be applied to their application domain, and to help get their implementation set up quickly and correctly.

Browsing through the links on the left, you will find a brief overview of the fundamental concepts behind GPCA in the [Introduction](#) section; numerical implementations of several variations of the GPCA algorithm in the [Sample Code](#) section; examples of real applications in the areas of computer vision, image processing; and system identification in the [Applications](#) section; and finally all the related literature in the [Publications](#) section.