Face Clustering summary

Prof. Ioannis Pitas
Aristotle University of Thessaloniki
pitas@csd.auth.gr
www.aiia.csd.auth.gr
Version 2.3

Artificial Intelligence & Information Analysis Lab

Face Clustering

- Facial image similarities
- N-cut clustering
- Applications

Face clustering

Problem statement:

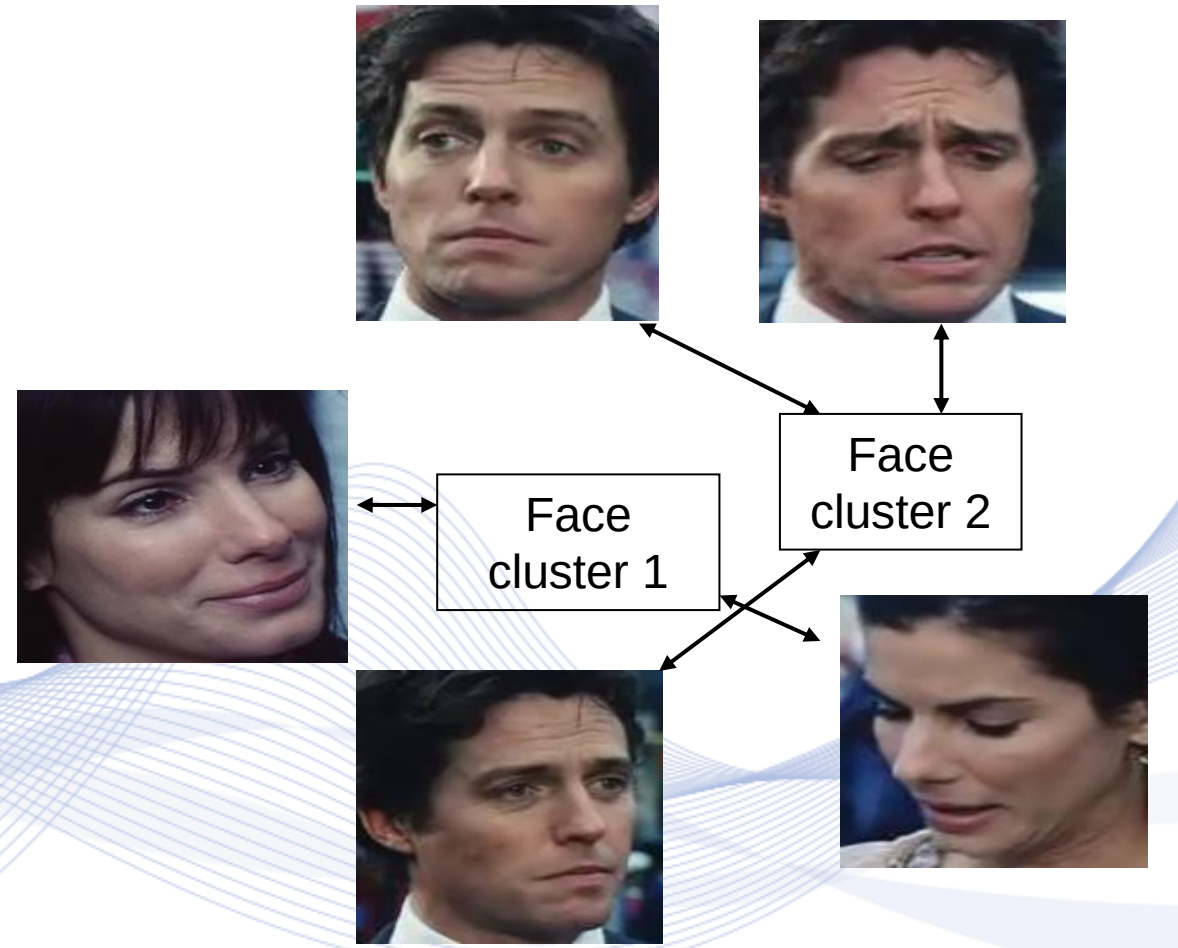
- To cluster facial images
- Input: many facial ROIs
- Output: facial image clusters

- Unsupervised learning
- Applications:

  Biometrics

  Surveillance applications

  Video analytics



Face Clustering

Problem statement:

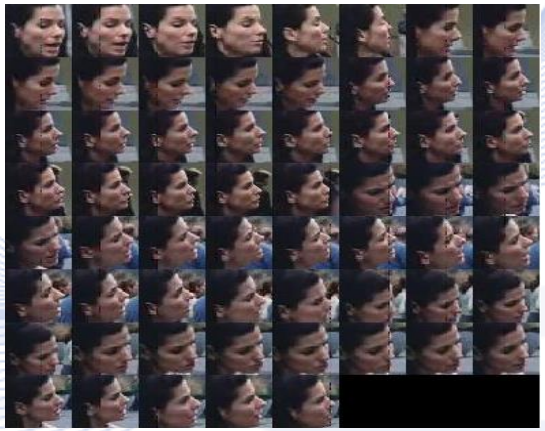
- To cluster a set of facial ROIs
- Input: a set of face image ROIs
- Output: several face clusters, each containing faces of only one person.
- Applications

Cluster actor images, even if they belong to different shots.

Cluster various views of the same actor.

Generate the cast of a movie.

Semi automatic face recognition



Facial image clustering in videos

- In videos facial images can result from the application of face detection and tracking algorithms
- This leads to "**facial trajectories**": series of facial images of (usually) the same person over time

- Each such facial trajectory can be represented by any of the images included in it.
- Facial image clustering in videos: cluster facial trajectories by using their representative images

Facial image trajectory representatives

- Two approaches to choose trajectory representative:

  A **single** detected facial image

  Multiple images from the trajectory

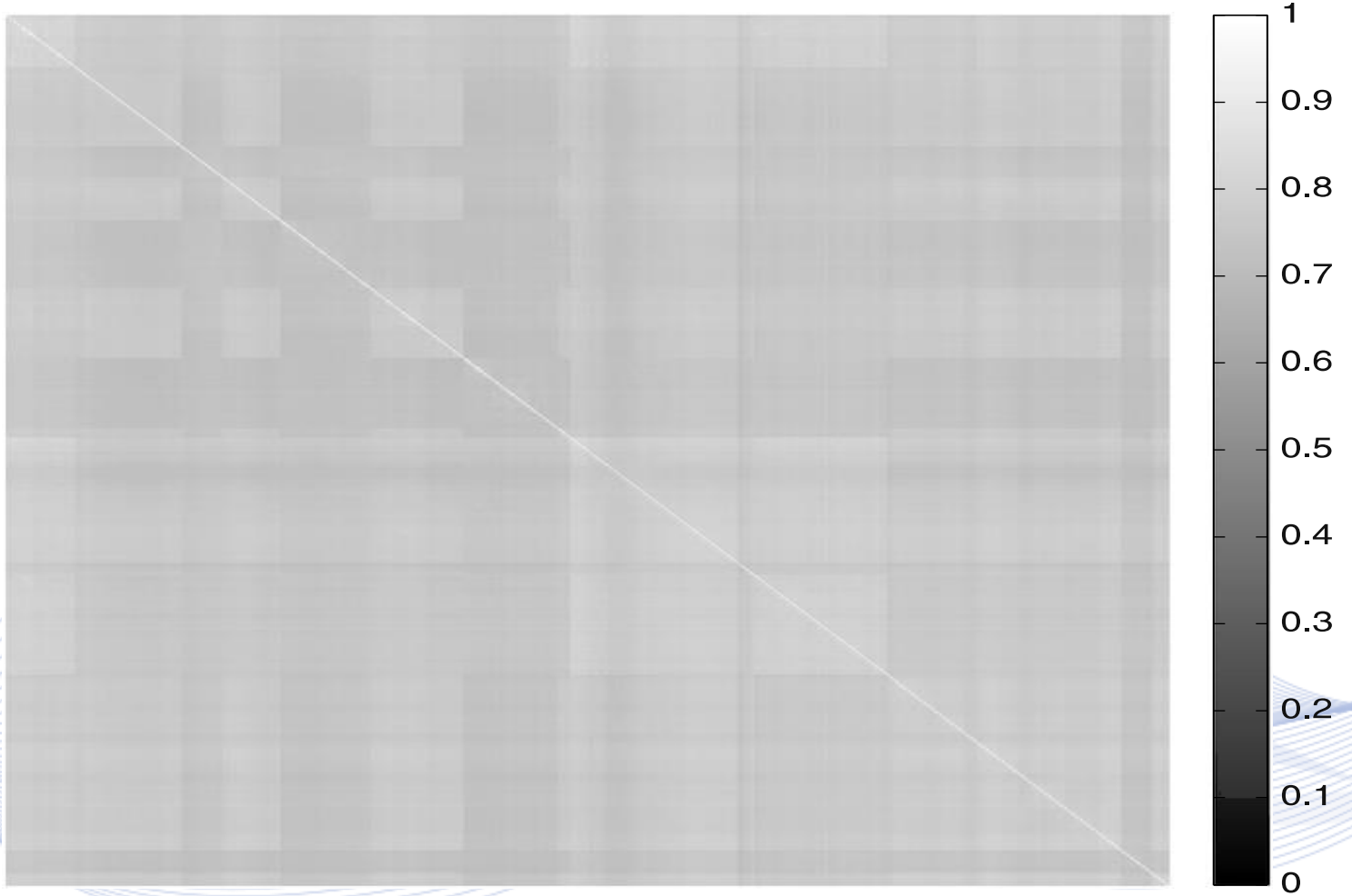
Similarity Criterion: Normalized Mutual Information

- The Normalized Mutual Information (NMI) between two facial ROIs is used as a facial ROI similarity criterion:

$$NMI(X,Y) = \frac{H(X)+H(Y)}{H(X,Y)}.$$

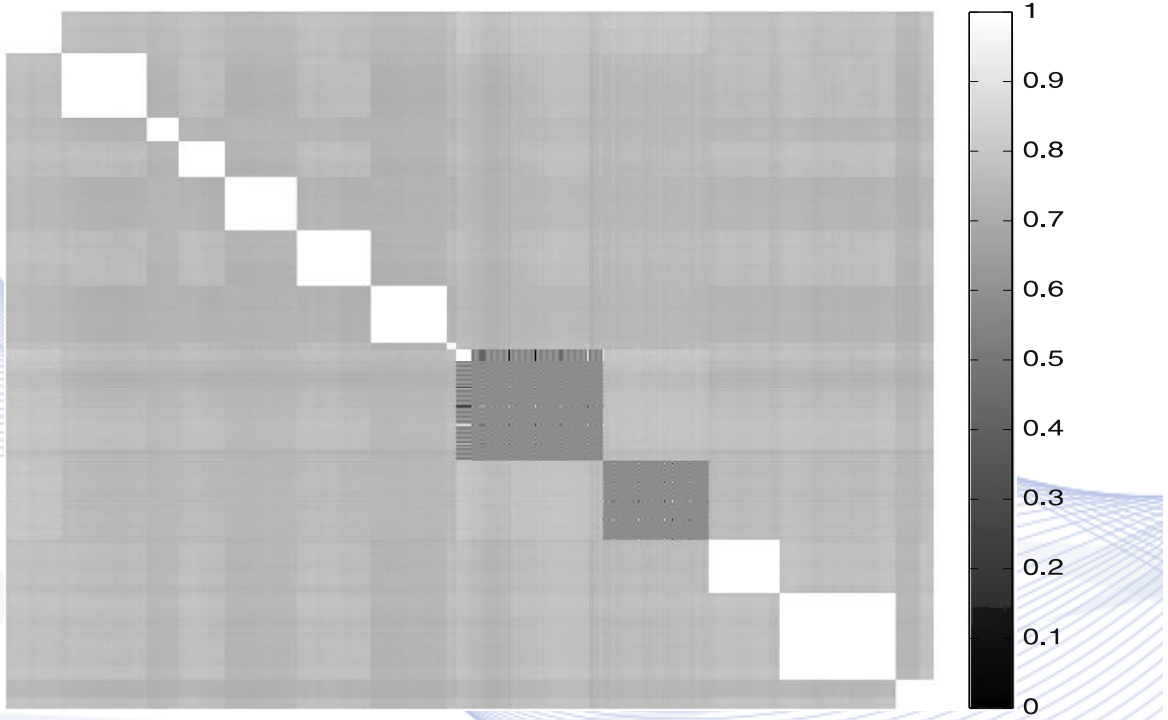
- $H(X)$ and $H(Y)$: marginal entropies.
- $H(X,Y)$: joint entropy.

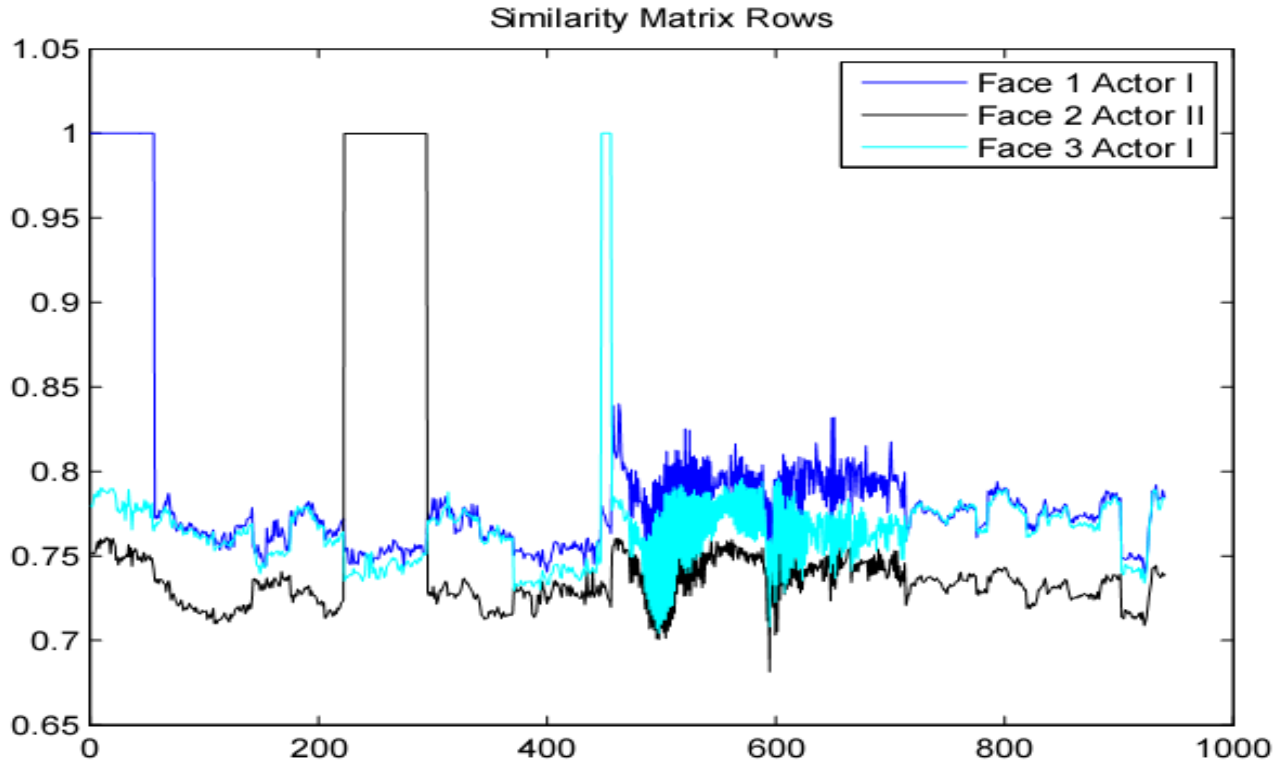
Similarity Matrix



Similarity Matrix with Heuristics

Similarity matrix and similarity matrix rows for 3 different facial ROIs for 2 actors with heuristics.





N-Cut Graph Clustering

- The similarity graph is constructed from the similarity matrix. The similarity matrix (with diagonal elements equal to zero) forms the adjacency matrix of such a graph.
- Clustering is based on the graph Laplacian matrix $\mathbf{L}$:

$$\mathbf{L} = \mathbf{D} - \mathbf{A}.$$

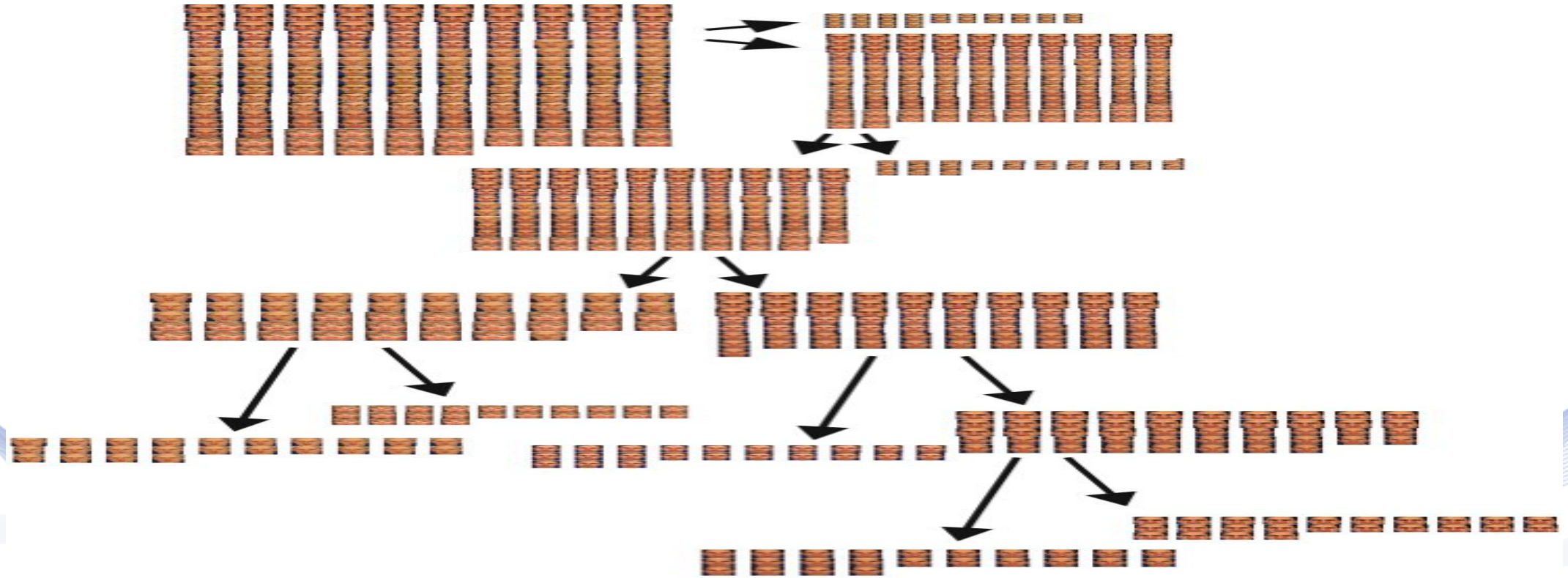
  - $\mathbf{D}$: degree matrix
  - $\mathbf{A}$: adjacency matrix of the graph.
- After solving the eigenproblem $\mathbf{Lf} = \lambda\mathbf{Df}$, we get the eignvector corresponding to the second smallest eigenvalue.

N-Cut Graph Clustering

2-way partitioning:

- Since the number of clusters is not a priori known we use a recursive 2-way partitioning algorithm to cluster the similarity graph.
- The recursion stops when the homogeneity of the cluster exceeds a threshold.
- The homogeneity is defined as the median of the similarity matrix corresponding to the cluster.

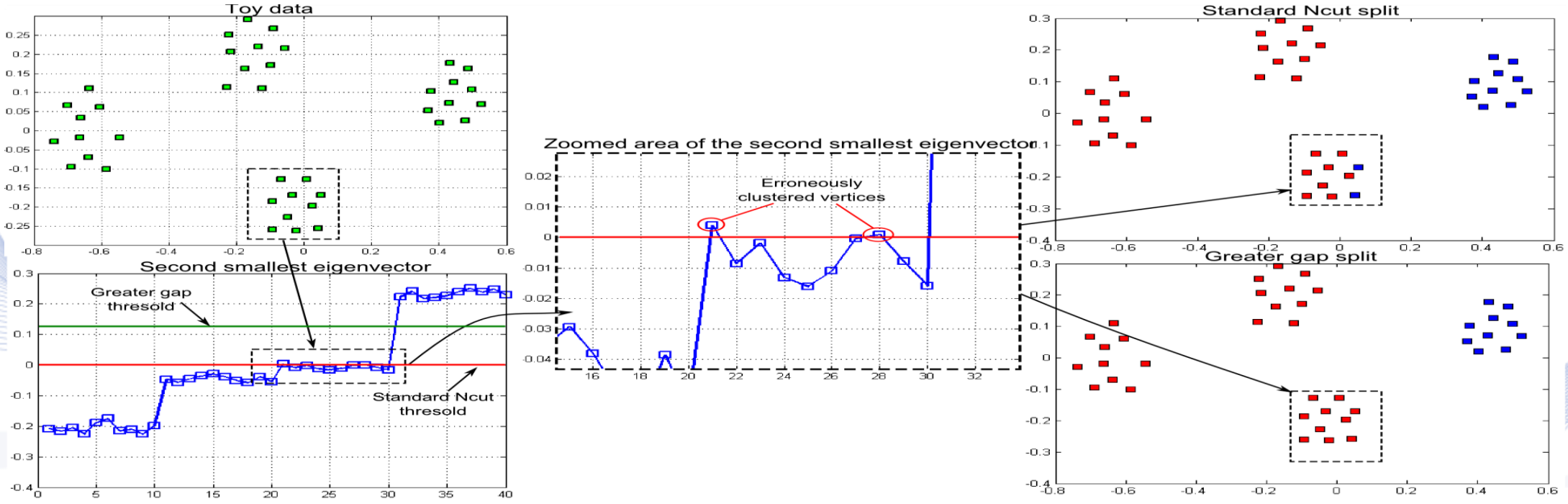
N-Cut Graph Clustering



2-way partitioning.

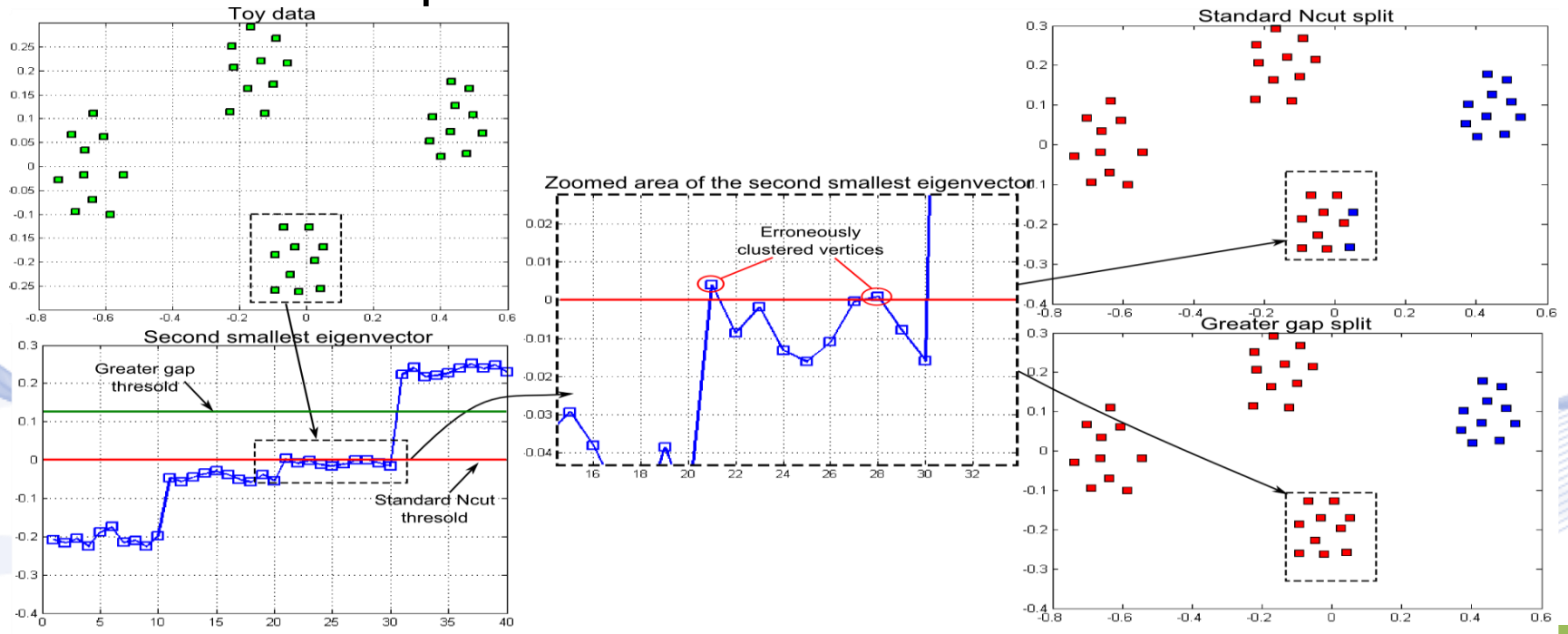
Spectral Clustering variant #1

- Occasionally the standard zero threshold of N-cut gives poor clustering results.



Spectral Clustering variant #2

- Novel variant #2: modify N-cut within proposed variant #1.
- Find the greatest gap between successive elements of the second eigenvector of $\mathbf{L}'$.
- Split the data at this point.



Cluster Examples

Images of different scales

Images of different illumination and poses

Bibliography

[PIT2021] I. Pitas, “Computer vision”, Createspace/Amazon, in press.
[PIT2017] I. Pitas, “Digital video processing and analysis” , China Machine Press, 2017 (in Chinese).
[PIT2013] I. Pitas, “Digital Video and Television” , Createspace/Amazon, 2013.
[NIK2000] N. Nikolaidis and I. Pitas, “3D Image Processing Algorithms”, J. Wiley, 2000.
[PIT2000] I. Pitas, “Digital Image Processing Algorithms and Applications”, J. Wiley, 2000.

Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

Contact: Prof. I. Pitas
pitas@csd.auth.gr