VoI for Learning and Inference in Sensor Networks

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Decentralized learning of a mixture of factor analyzers

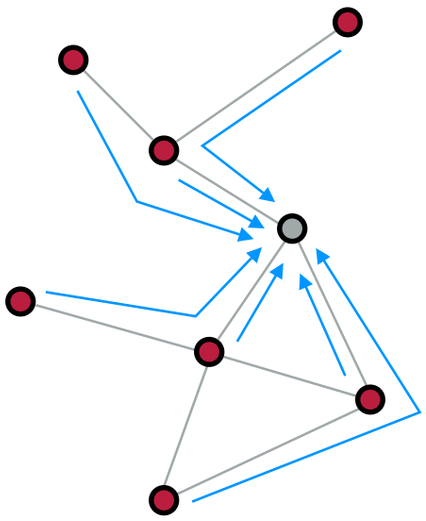
Objectives

- Learn object structure from multiple, distributed partial views for detection and classification applications
- Estimate an underlying low-dimensional data manifold of high-dimensional observations from a spatially distributed network of sensors; disseminate learned structure to all nodes
- Develop decentralized algorithms which are scalable and robust to sensor node or communication link failures

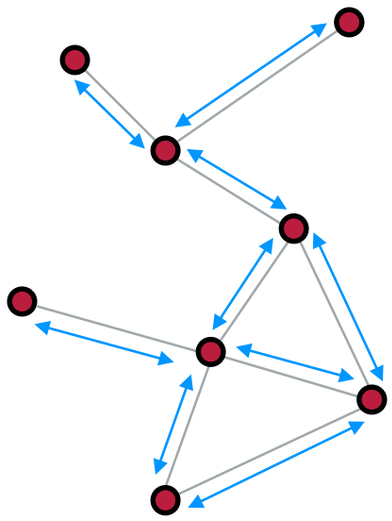
Challenges

- Centralized and distributed learning approaches have poor scalability; not robust to node or link outages
- Disseminating manifold representation out to nodes requires additional communications and delay

Network information flow

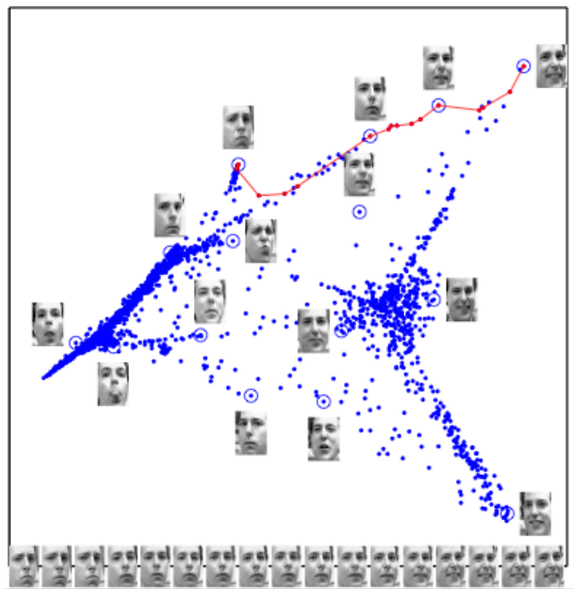


Centralized



Decentralized

Data lives on a lower dimensional subspace



From: Saul, L. and Roweis, S., Think Globally, Fit Locally: Unsupervised Learning of Nonlinear Manifold, Technical Report MS CIS-02-18, University of Pennsylvania,

Approximate statistical model

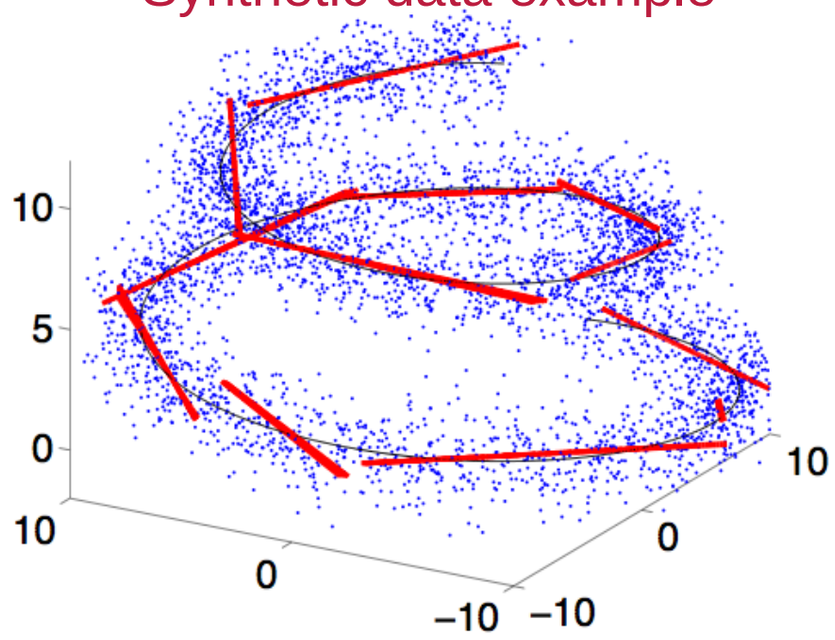
Mixture of factor analyzers

- Locally linear approximation [Roweis, S., *et al.*, 2001, Verbeek 2006]
- Distributed EM of GMM [Nowak 2003]
- Diffusion and consensus averaging [Ram S., *et al*. 2009, Tu, S. & Sayed, A. 2012]
- Initialized by decentralized k-means

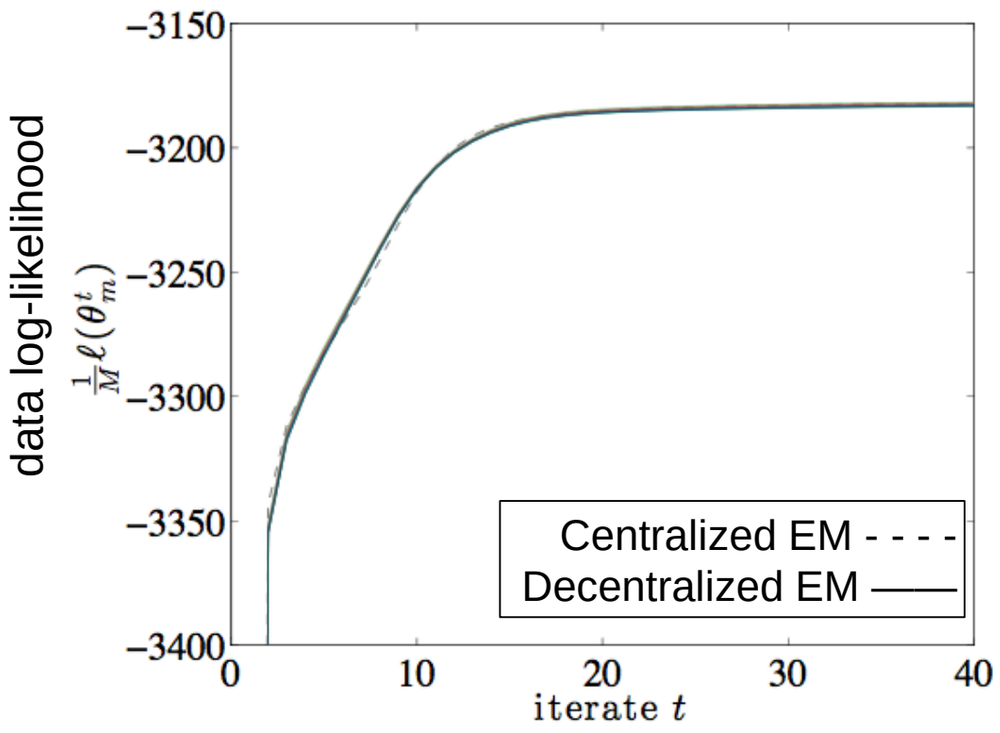
Decentralized EM of MFA

- Local computations scale cubically in intrinsic dimension, instead of data dimension
- Consensus on sample average of MFA local statistics
  - share $Jp(r+2)+J$ instead of Np values
- Consensus iterations disseminates manifold representation
- Metropolis-Hastings-based average consensus
  - Requires only mild constraints on the network
  - Nodes need only neighbor degrees to setup consensus weights

Synthetic data example



Increases data likelihood



Convergence of consensus