Introduction and Sharing: My Research in CSE

Hu Ding

Department of Computer Science & Engineering
State University of New York at Buffalo

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cse@buffalo

Self Intruduction

- In 2009, I got my BS in *mathematics* from *Zhongshan University* in China, and start my PhD life in the same year.
- My advisor is Prof. Jinhui Xu.
- My research area: algorithms for machine learning and pattern recognition.

Research in Our Group

Quite broad, and hard to summarize

- Currently 6 PhD students in our group, and more than 10 graduated. Each one works on one or more individual topics.
- Generally, algorithmic aspect for any real world problem.

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  1. **Data analytics**: clustering, regression, classification *et al.*
  2. **Computer vision**: image matching, pattern recognition, reconstruction *et al.*
  3. **Medical imaging**: Computed Tomagraphy (CT) reconstruction, segmentation *et al.*
  4. **Computational biology**: normal/cancer cells discrimination, pattern discovery for chromosome territories *et al.*
  5. **Fundamental topics in algorithms** (from 531): matching, max flow, shortest path, minimum cut *et al.*

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  5. **Fundamental topics in algorithms** (from 531): matching, max flow, shortest path, minimum cut *et al.*
- We care both theory and practice:
  1. Time and space complexities, quality guarantee *et al.*
  2. Performance on real data.

Overview of My Research

Geometric Algorithms for Machine Learning and Pattern Recognition:

1. Constrained clustering in high dimensional space
2. Robust algorithms for classification and regression
3. Pattern matching, recognition, and retrieval

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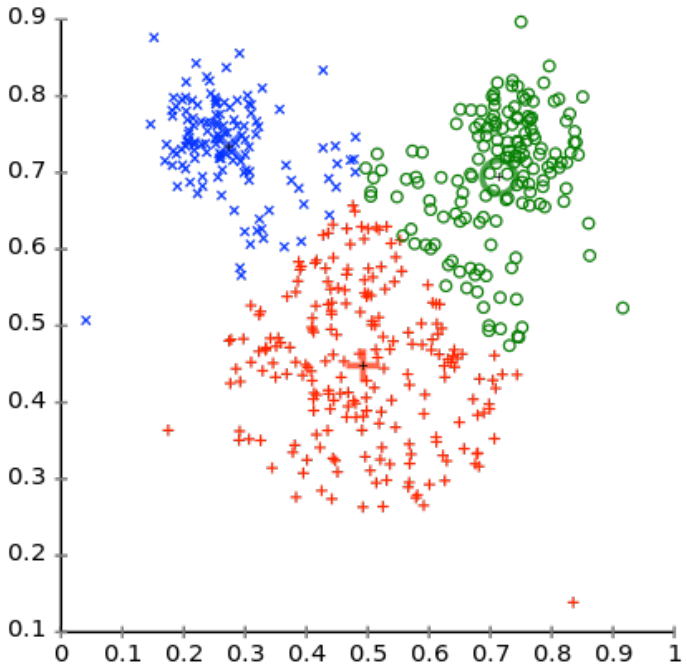
Constrained Clustering in High Dimensional Space

- Ordinary clustering assumes that all data items are independent from each other, and clustering is based only on distance or cost, *e.g.*, *k-means*, *k-medians*



Constrained Clustering in High Dimensional Space (cont.)

- Data items in real world applications are often correlated. Thus, clustering needs to consider both distance and some additional constraints, such as coloring, cluster size, etc.
  - l-Diversity clustering.
  - Chromatic clustering.
  - r-Gather clustering.
  - Capacitated clustering.
  - Semi-supervised clustering.
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- The additional constraints could complicate the problems considerably. No problem above has been solved satisfactorily.
- **Our result:** A unified framework (based on new geometric techniques) yielding good quality guarantees for all above constrained clustering problems in any dimensional space (accepted to **SODA'15**, one of the best conferences in algorithms).

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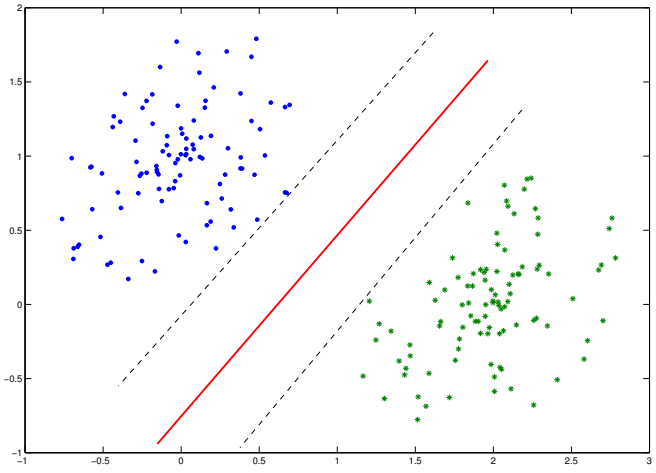
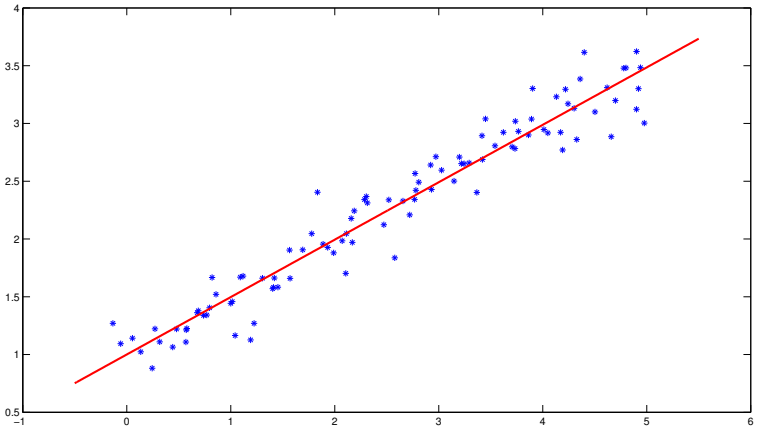
Robust Algorithms for Classification and Regression

- **Support Vector Machine (SVM)** and **Linear Regression**:





Robust Algorithms for Classification and Regression

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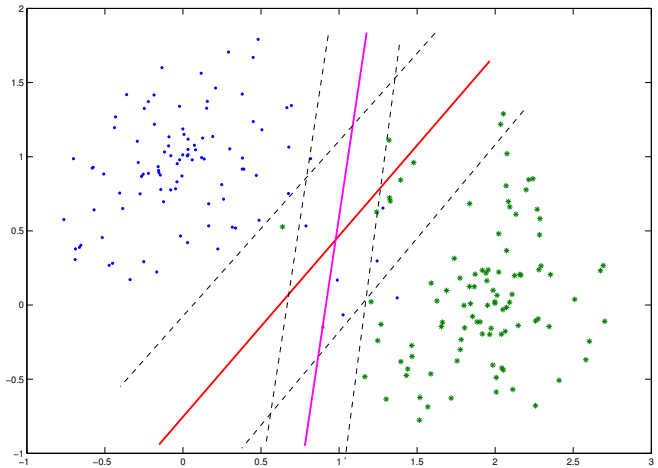
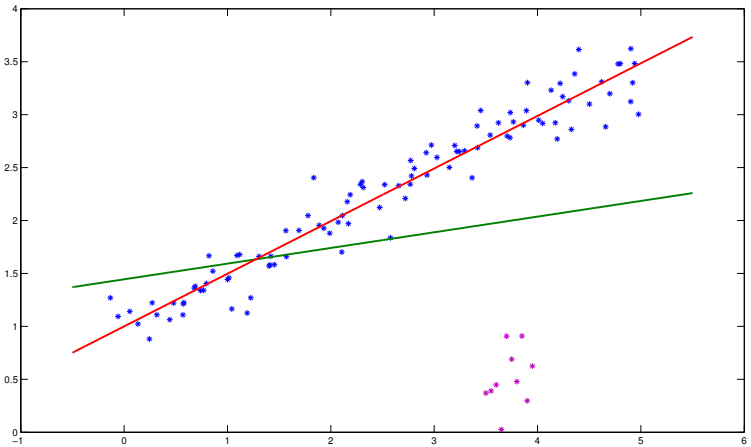
- Outliers could significantly deteriorate the solution:





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- Outliers could significantly deteriorate the solution:
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- **Our results:** new combinatorial approaches for explicit outliers detection.
  - Theoretical guarantee on quality of solution.
  - Better performance in practice.

Overview of My Research

Geometric Algorithms for Machine Learning and Pattern Recognition:

1. Constrained clustering in high dimension
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3. ▷**Pattern matching, recognition, and retrieval**

- **Point-sets matching** under *Earth Mover's Distance (EMD)*, which can be viewed as a min-cost max flow problem in the Euclidean space.

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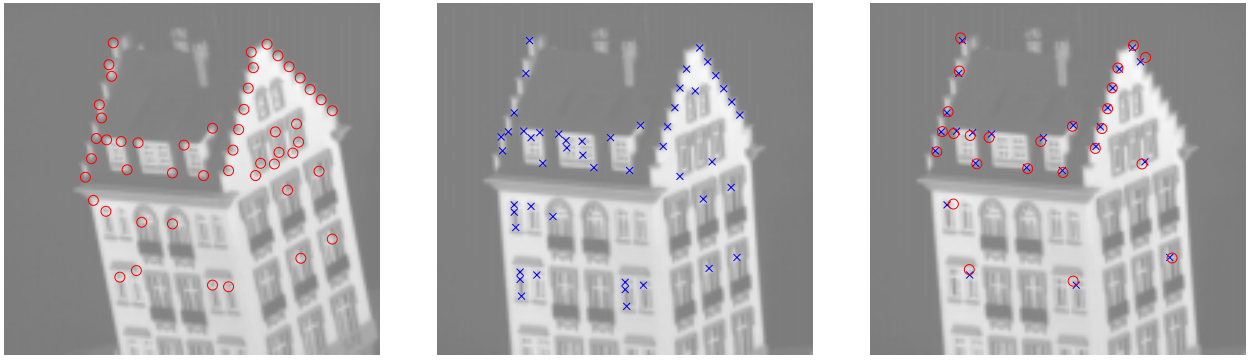

Pattern Matching, Recognition, and Retrieval

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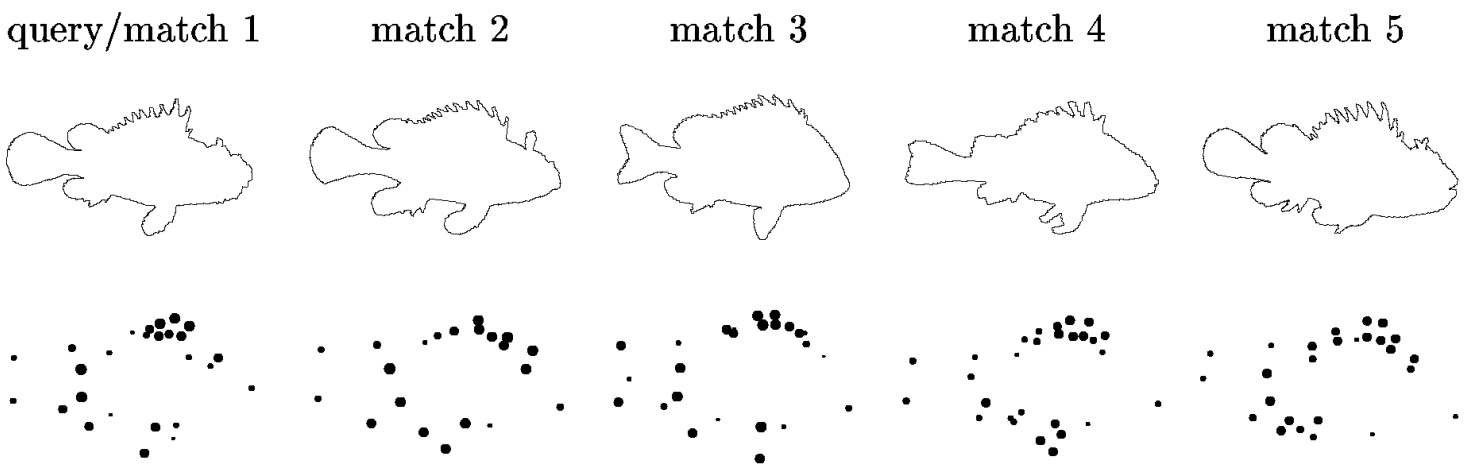

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  - Image retrieval [Rubner *et al.* IJCV00]

Pattern Matching, Recognition, and Retrieval (cont.)

Our results:

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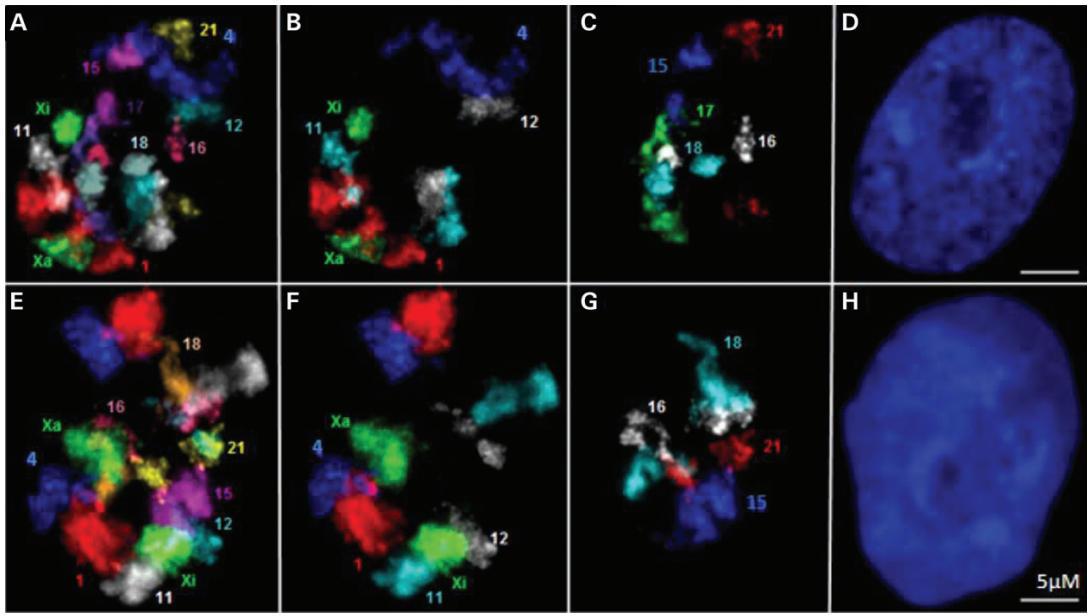
Our results:

- The first FPTAS for minimizing EMD under certain transformation in any fixed dimensional space.
- **Prototype learning** algorithms for association graphs, rigid structures, and affine deformable structures
  - Based on geometric techniques and EMD
  - Avoiding encoding and decoding between geometry and graph domains.
  - More robust and efficient for pattern recognition and retrieval.

Pattern Matching, Recognition, and Retrieval (cont.)

Our results (cont.):

- Applications of prototype learning algorithms: Extracting inter-chromosomal association and chromosome topological patterns from a population of cells:
  - Determine the difference in normal and cancer cells
  - Reveal the dynamics of the association pattern during cancer progression.
- Published in **CVPR'13** and **Plos Computational Biology**.



My Feelings and Advices

- **What I really like:** solving a real world problem
- **What's the challenging:** finding a really good research topic.
- **My suggestions:**
  - Open mind.
  - Intuition is much more important than mathematics.

Thank you!

Question?