

Topics for Projects

Algorithmic Problems Around the Web #1

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CalTech, Fall'07, CS101.2, <http://yury.name/algoweb.html>

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Outline

- 1 Administrative Staff / Idea of the Course
- 2 Challenges in Web Technologies
- 3 Existing Theory: Nearest Neighbors
- 4 List of Project Topics

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Part I

Administrative Staff

Idea of the Course

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About Instructor

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Registration Policy

You can

- Join at any time
- Leave at any time
- Attend “just for fun”

Give me your [name](#), [email](#) and current [status](#) if you want to be informed about all course-related events

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Grading Policy (Updated)

- 20% Problem Setting / Literature Review
Short seminar talk at the end
- 40% Work on Project
- 40% Results Presentation
Seminar talk at the end

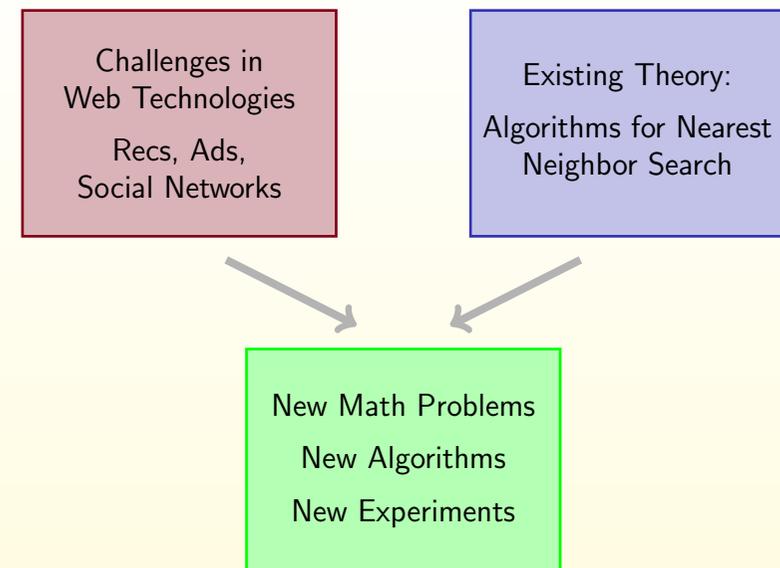
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Feedback / Promotion

- Please report me my mistakes
Slides, English, etc. . .
- Any ideas how to improve the course?
- Is the time slot MW 11-12 ok? Any better option?
- [Tell your friends about this course](#)
- Give me a [hyperlink](#)

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Course Philosophy



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Course Schedule

- 5 more lectures
- 12-14 class hours for seminars
- weekly team meetings

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Part II Challenges in Web Technologies

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Recommendation Systems

Recommendation systems attempts to present information items (movies, music, books, news, web pages) that are likely of interest to the user

System compares the user's profile to some reference characteristics. These characteristics may be from the information item (the content-based approach) or the user's social environment (the collaborative filtering approach)

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Behavioral Targeting

Ad targeting:

Ancient: broadcasting

Current: contextual

Future: behavioral

The idea is to observe a users online behavior anonymously and then serve the most relevant advertisement based on their behavior

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Personalized News Aggregation

A feed aggregator is a Web application which aggregates syndicated web content such as news headlines, blogs, podcasts, and vlogs in a single location for easy viewing

Challenge: personalized aggregation

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Social Networks Analysis

Social network:

Nodes

Edges

Examples of relations: financial exchange, friends, dislike, conflict, trade, web links, sexual relations, disease transmission, airline routes, etc.

Our focus

Community discovery

Burst detection

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Part III Theory of Nearest Neighbors

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Nearest Neighbors Informally

To preprocess a database of n objects so that given a query object, one can effectively determine its nearest neighbors in database

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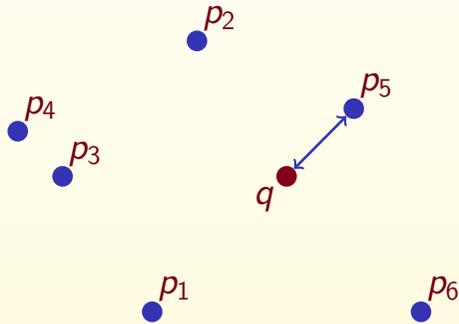
More Formally

Search space: object domain \mathbb{U} , similarity function σ

Input: database $S = \{p_1, \dots, p_n\} \subseteq \mathbb{U}$

Query: $q \in \mathbb{U}$

Task: find $\operatorname{argmax}_{p_i} \sigma(p_i, q)$



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Some Solutions for NN Problem

Sphere Rectangle Tree Orchard's Algorithm LAESA
k-d-B tree Geometric near-neighbor access tree
Excluded middle vantage point forest .mvp-tree Fixed-height
fixed-queries tree AESA **Vantage-point**
tree R*-tree Burkhard-Keller tree BBD tree
Navigating Nets Voronoi tree Balanced aspect ratio tree Metric tree
vp^s-tree **M-tree** **Locality-Sensitive Hashing**
SS-tree **R-tree** Spatial approximation tree Multi-vantage
point tree Bisector tree mb-tree
Generalized hyperplane tree
Hybrid tree Slim tree Spill Tree Fixed queries tree X-tree k-d
tree Balltree Quadtree Octree Post-office tree

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Part IV

List of Project Topics

5 Theoretical / 4 Experimental

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T1 Nearest Neighbors for Sparse Vectors

Database: n vectors in \mathbb{R}^m each having at most $k \ll m$ nonzero coordinates

Query: vector in \mathbb{R}^m also having at most $k \ll m$ nonzero coordinates

Similarity: scalar product

Is there an algorithm for solving nearest neighbors on sparse vectors within following constraints:
 $\text{poly}(n, m)$ preprocessing, $\text{poly}(k, \log n, \log m)$ query?

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T2 LD Embeddings for Social Networks

Input:

Friendship graph / Co-authorship graph

Similarity:

Number of joint friends
Length of shortest path

How to construct embedding into 2D (Euclidean plane)
that put similar people close to each other?

Workflow:

Define social network model
Define distortion of 2D embedding
Find embedding algorithm with least possible distortion

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T3 Disorder Method for Nearest Neighbors

Sort all objects in database S by their similarity to p
Let $\text{rank}_p(s)$ be position of object s in this list

Disorder inequality for some constant D :

$$\forall p, r, s \in \{q\} \cup S : \text{rank}_r(s) \leq D \cdot (\text{rank}_p(r) + \text{rank}_p(s))$$

Minimal D providing disorder inequality is called **disorder constant** of a given set

What is the most efficient algorithm for nearest neighbor
search in terms of n and D ?

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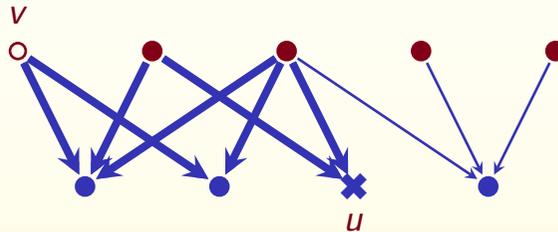
T4 3-Step Nearest Neighbors

3-step similarity between boy and girl in some bipartite
boys-girls graph is equal to number of paths of length 3
between them

n boys

boy degrees $\leq k$

m girls



Construct an algorithm for solving nearest neighbors in
bipartite graphs with 3-step similarity

Constraints: $\text{poly}(n, m)$ preprocessing, $\text{poly}(k, \log n, \log m)$ query

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T5 Probabilistic Nearest Neighbors

Probabilistic Analysis in a Nutshell

- Define a probability distribution over databases
- Define probability distribution over query objects
- Construct a solution that is efficient/accurate with high probability over “random” input/query

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E1 Recommendations for Blog Posts

Available information:

Friendship graph
Comments, hyperlinks
Keywords of interests, post content

Task: For every user recommend 10 posts from last day that seems to be the most interesting for him/her

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E2 CTR Prediction

Available information:

Click-or-not bipartite graph

Task: Predict click-through rate for given pair “user-ad”

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E3 Social Networks Visualization

Input:

Friendship graph

Similarity:

Number of joint friends
Length of shortest path

Task:

Construct embedding into 2D
that put similar people close to each other

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E4 Disorder Analysis

Disorder inequality for some constant D :

$$\forall p, r, s \in \{q\} \cup S : \text{rank}_r(s) \leq D \cdot (\text{rank}_p(r) + \text{rank}_p(s))$$

Tasks:

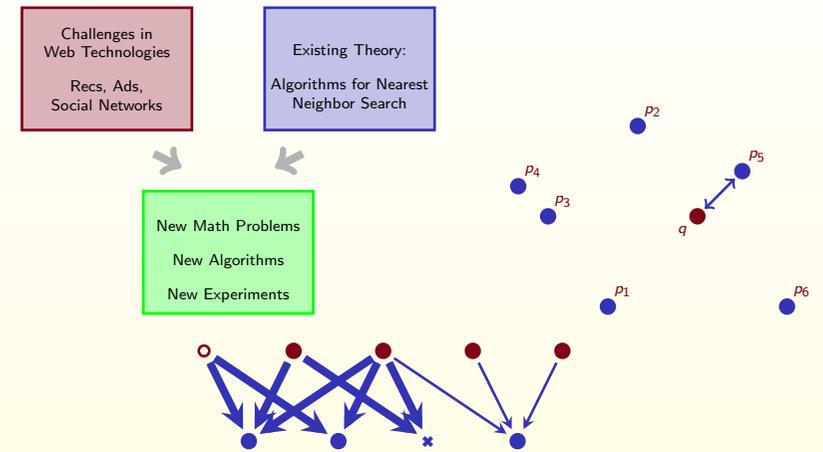
- Compute disorder values for various datasets
- Implement disorder-based algorithms for NNS
- Study their performance

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ToDo List

- Choose a project, form a team
- Make a quick look at corresponding references
- Schedule a meeting with me on this week
- Recommend this course to friends

Last Slide



Thanks for your attention! Questions?