

Data Mining

Course Overview and Logistics

<https://data-mining.github.io/winter-2026/>

CS 453/553 – Winter 2026
Yu Wang, Ph.D.
Assistant Professor
Computer Science
University of Oregon



Self-Introduction



**Yu (Jack) Wang
(You)**

Contact:
yuwang@uoregon.edu

<https://yuwang0103.github.io/>

Research Interests:

- Data Mining and Machine Learning
- Neural-Symbolic Learning
- Graph and Network
- LLM + Structured Knowledge
- AI/ML/DM Applications
 - Document Intelligence
 - Social Computing
 - Networking Physical Infrastructure

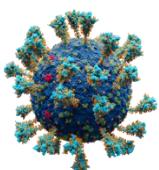
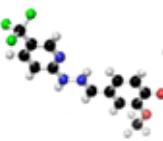
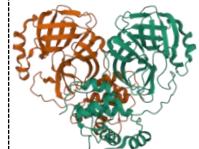


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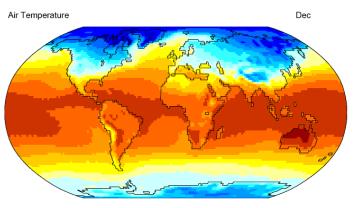
Science



Protein

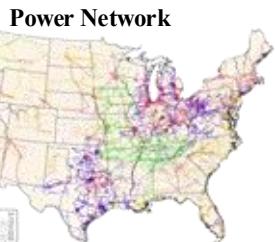
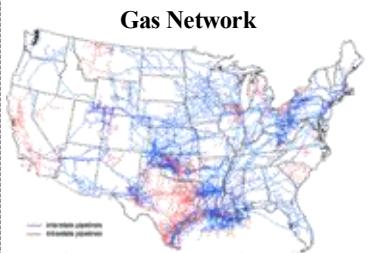


Small Molecule



Virus

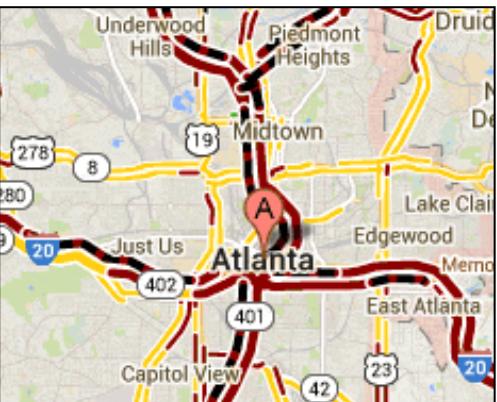
Brain Neural



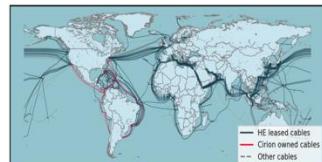
Power Network

Infrastructure

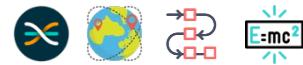
Transportation Network



Submarine Cable



Terrestrial Cable



Social Network



Citation Network

Transaction Network

User-Entity Interaction Graph

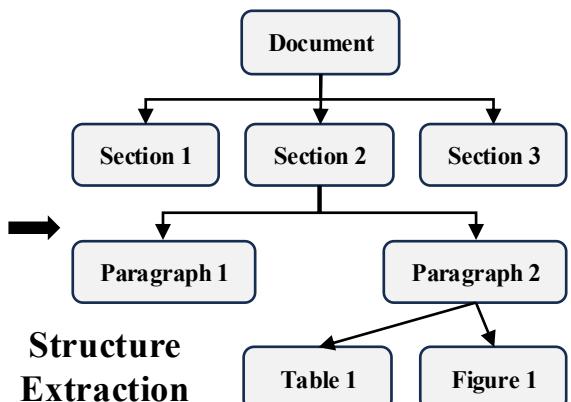


Virtual Village with AI Agents

Document



Structure Extraction





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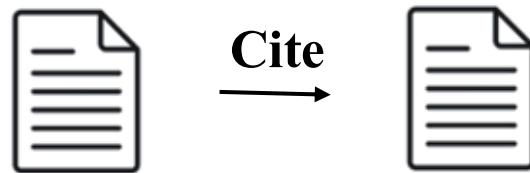
Art of Problem Solving. Aime problems and solutions, 2025. URL https://artofproblemsolving.com/wiki/index.php/AIME_Problems_and_Solutions. 8, 22

Mingyang Chen, Tianpeng Li, Haoze Sun, Yijie Zhou, Chenzheng Zhu, Haofen Wang, Jeff Z Pan, Wen Zhang, Huajun Chen, Fan Yang, et al. ReSearch: Learning to reason with search for llms via reinforcement learning. *arXiv preprint arXiv:2503.19470*, 2025. 2, 4, 7, 10, 21

Zihao Cheng, Hongru Wang, Zeming Liu, Yuhang Guo, Yuanfang Guo, Yunhong Wang, and Haifeng Wang. ToolSpectrum: Towards personalized tool utilization for large language models. In *Findings of the Association for Computational Linguistics: ACL 2025*, pp. 20679–20699, 2025. 10

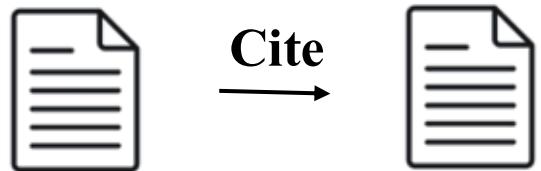
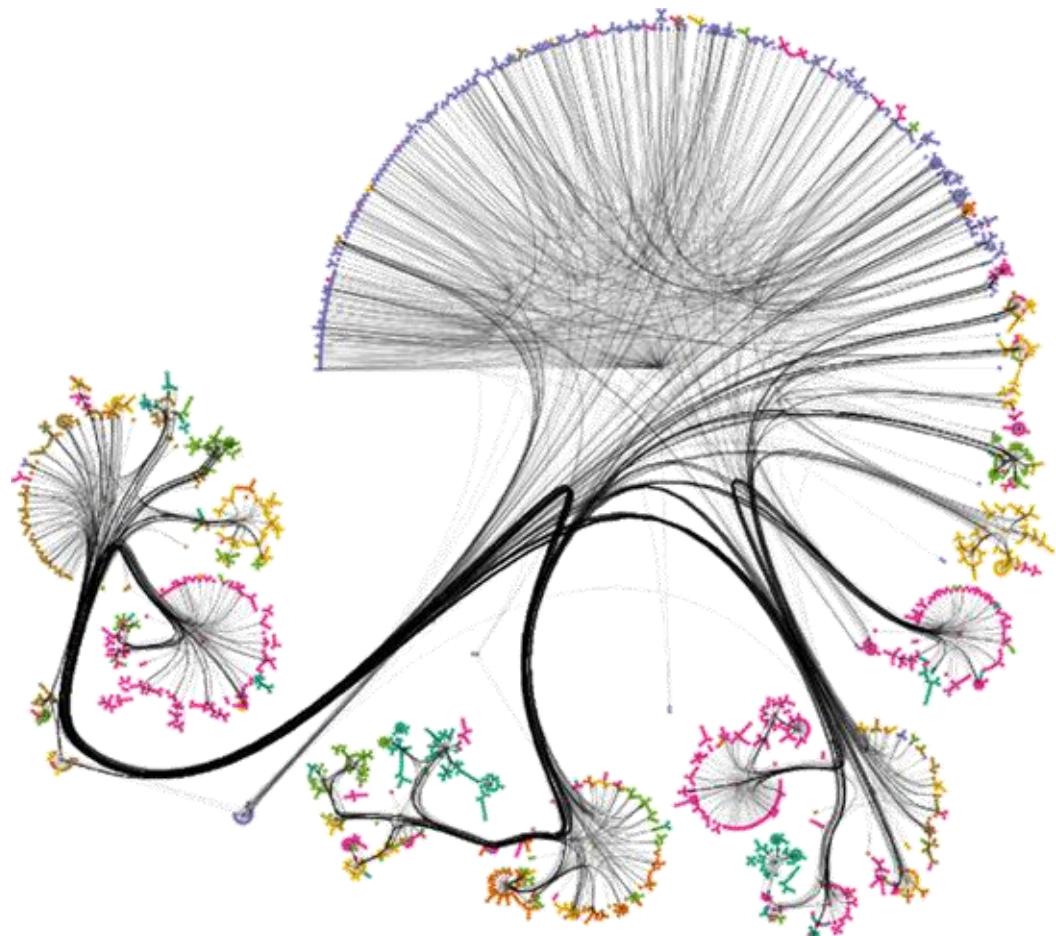
Yingfan Deng, Anhao Zhou, Yuan Yuan, Xian Zhang, Yifei Zou, and Dongxiao Yu. Pe-ma: Parameter-efficient co-evolution of multi-agent systems. *arXiv preprint arXiv:2506.11803*, 2025. 11

Guanting Dong, Yifei Chen, Xiaoxi Li, Jiajie Jin, Hongjin Qian, Yutao Zhu, Hangyu Mao, Guorui Zhou, Zhicheng Dou, and Ji-Rong Wen. Tool-star: Empowering llm-brained multi-tool reasoner via reinforcement learning. *arXiv preprint arXiv:2505.16410*, 2025. 2, 10





Why Analyze Data? – Paper Management



$$\frac{\sum_{e_{ij} \in \mathcal{E}} \mathbf{1}[y_i == y_j]}{|\mathcal{E}|}$$

\mathcal{E} - Total Number of Edges

e_{ij} - Edge between node i/j

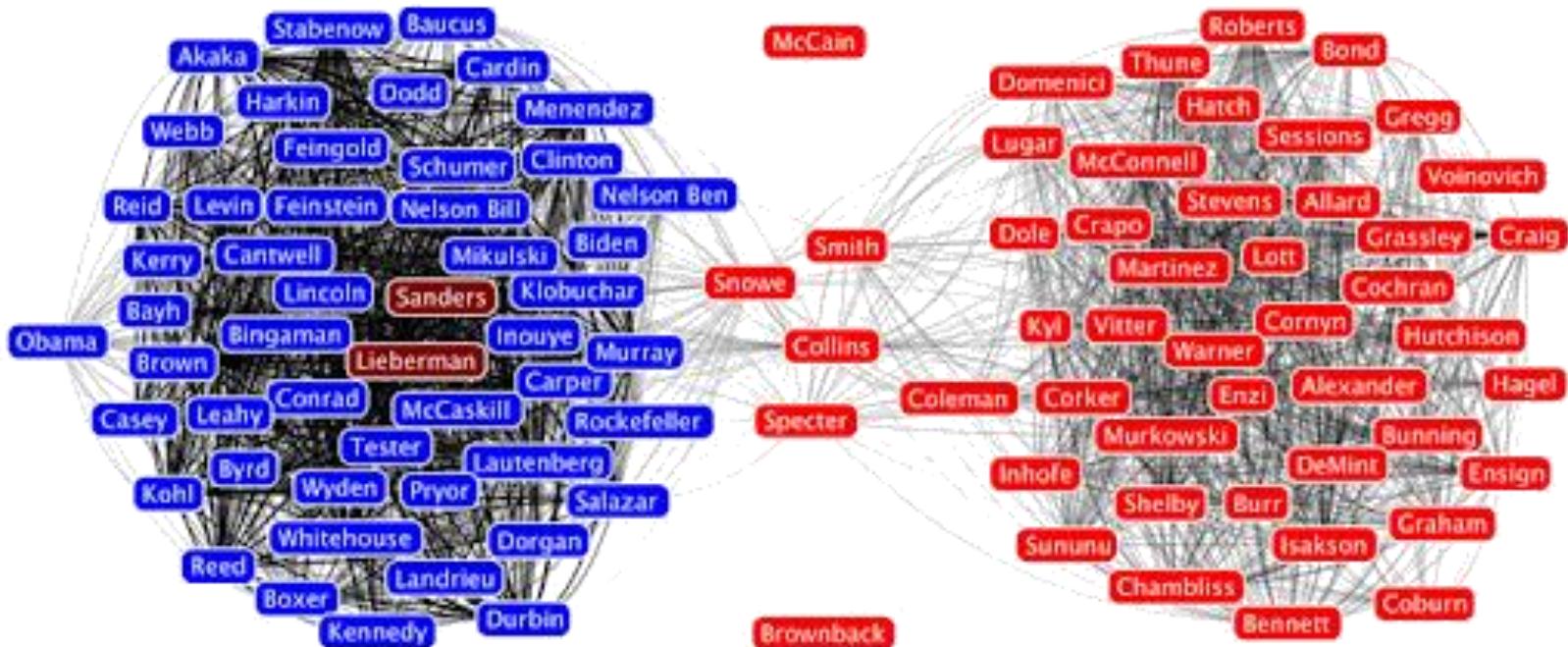
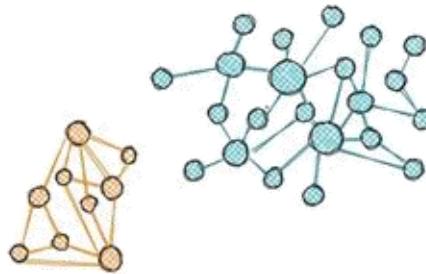
y_i - Label of i



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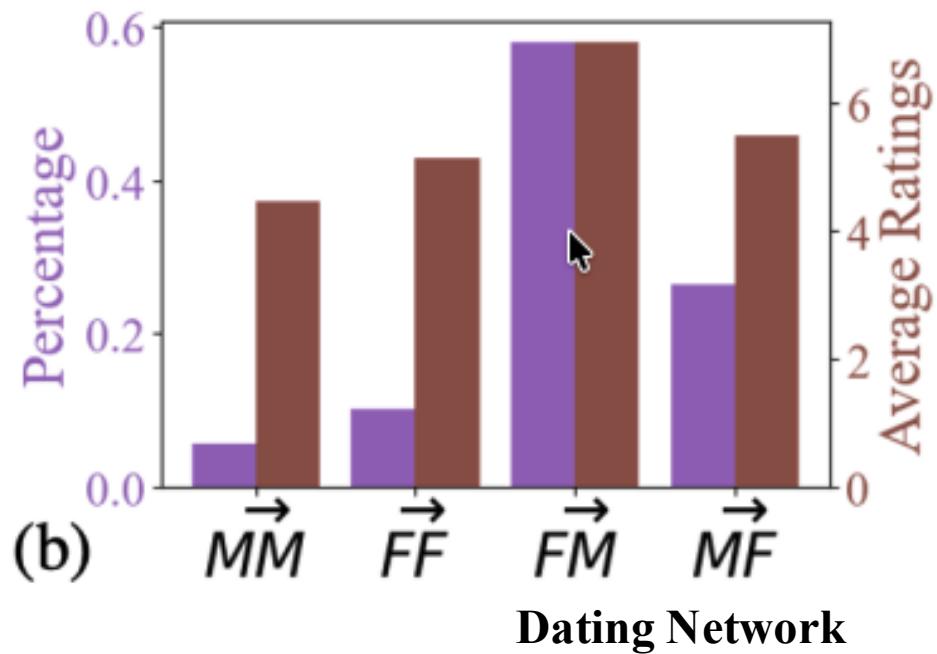
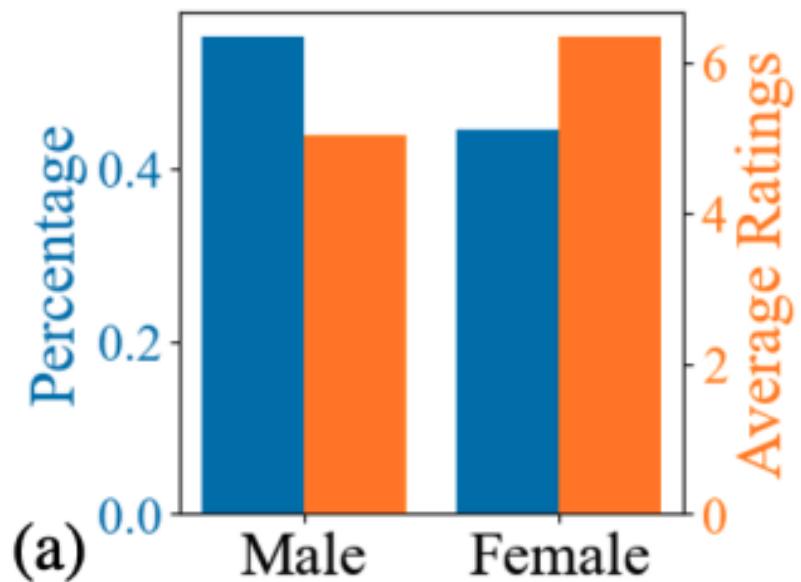
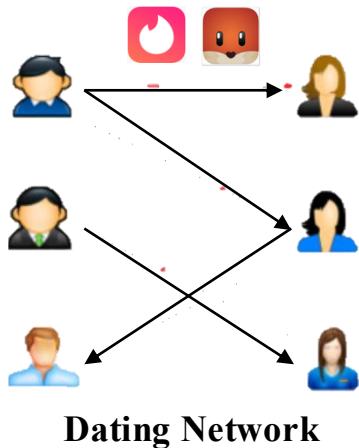
Birds of a feather flock together



Gun Control Belief Network



Why Analyze Data? – Paper Management





Why Analyze Data? – Paper Management

IN-THE-FLOW AGENTIC SYSTEM OPTIMIZATION FOR EFFECTIVE PLANNING AND TOOL USE

Zhuofeng Li^{*1,2}, Haoxiang Zhang^{*1,3}, Seungju Han¹, Sheng Liu¹, Jianwen Xie⁴,

Yu Zhang², Yeqin Choi¹, James Zou^{†1}, Pan Lu^{†1}

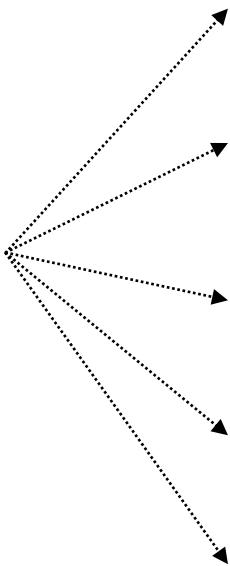
¹Stanford University, ²Texas A&M University, ³UC San Diego, ⁴Lambda



Website: <https://agentflow.stanford.edu>
🔗 Code 💡 Model 📦 Demo ▶ Visualize

ABSTRACT

Outcome-driven reinforcement learning has advanced reasoning in large language models (LLMs), but prevailing tool-augmented approaches train a single, monolithic policy that interleaves thoughts and tool calls under full context; this scales poorly with long horizons and diverse tools and generalizes weakly to new scenarios. Agentic systems offer a promising alternative by decomposing work across specialized modules, yet most remain training-free or rely on offline training decoupled from the live dynamics of multi-turn interaction. We introduce AGENTFLOW, a trainable, *in-the-flow* agentic framework that coordinates four modules (planner, executor, verifier, generator) through an evolving memory and directly optimizes its planner inside the multi-turn loop. To train on-policy in live environments, we propose *Flow-based Group Refined Policy Optimization* (Flow-GRPO), which tackles long-horizon, sparse-reward credit assignment by converting multi-turn optimization into a sequence of tractable single-turn policy updates. It broadcasts a single, verifiable trajectory-level outcome to every turn to align local planner decisions with global success and stabilizes learning with group-normalized advantages. Across ten benchmarks, AGENTFLOW with a 7B-scale backbone outperforms top-performing baselines with average accuracy gains of 14.9% on search, 14.0% on agentic, 14.5% on mathematical, and 4.1% on scientific tasks, even surpassing larger proprietary models like GPT-4o. Further analyses confirm the benefits of in-the-flow optimization, showing improved planning, enhanced tool-calling reliability, and positive scaling with model size and reasoning turns.



In-the-flow agentic system optimization for effective planning and tool use

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Which category does this paper belong to?

Tool Learning

Agentic Learning



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IN-THE-FLOW AGENTIC SYSTEM OPTIMIZATION FOR EFFECTIVE PLANNING AND TOOL USE

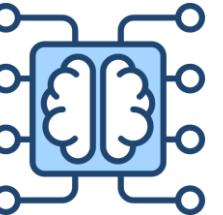
Zhuofeng Li^{1,2*}, Huaolang Zhang^{1,3}, Sengtai Han¹, Sheng Liu¹, Jianwen Xie¹, Yu Zhang¹, Yulin Choi¹, James Zou¹, Pan Li^{1,2}
¹Stanford University, ²Texas A&M University, ³UC San Diego, *Lambda

Website: <https://agentflow.stanford.edu>

Code Model Demo Visualize

ABSTRACT

Outcome-driven reinforcement learning has advanced reasoning in large language models (LLMs), but prevailing tool-augmented approaches train a single, monolithic policy that interleaves thoughts and tool calls under full control; this scales poorly across long-horizon and diverse domains,亟需 to decompose work across specialized modules. Agentic systems offer a promising alternative by decomposing work across specialized modules, yet most remain training-free or rely on offline training decoupling the dynamics of model interaction. We introduce AGENTFLOW, a trainable, *in-the-flow* agentic framework that coordinates four roles (planner, executor, verifier, generator) through an evolving memory and directly optimizes its planning inside the multi-turn loop. To train on-policy in live environments, we propose *Flow-based Reinforcement Policy Optimization* (F-GPO), which tackles long-horizon, sparse-reward credit assignment by converting multi-turn optimization into a sequence of tractable single-turn policy updates. It broadens the scope of agentic systems to real-world tasks with complex dependencies, achieves decisions with global success and stabilizes learning with group-normalized advantages. Across ten benchmarks, AGENTFLOW with a 7B-scale backbone outperforms GPT-4o by 1.4% on mathematical, 1.9% on scientific, and 4.9% on search, 14.0% on agentic, 14.5% on mathematical, and 4.1% on scientific tasks, even surpassing larger proprietary models like GPT-4o. Further analyses confirm the benefits of *in-the-flow* optimization, showing improved planning, enhanced tool-calling reliability, and positive scaling with model size and reasoning turn.



IN-THE-FLOW AGENTIC SYSTEM OPTIMIZATION FOR EFFECTIVE PLANNING AND TOOL USE

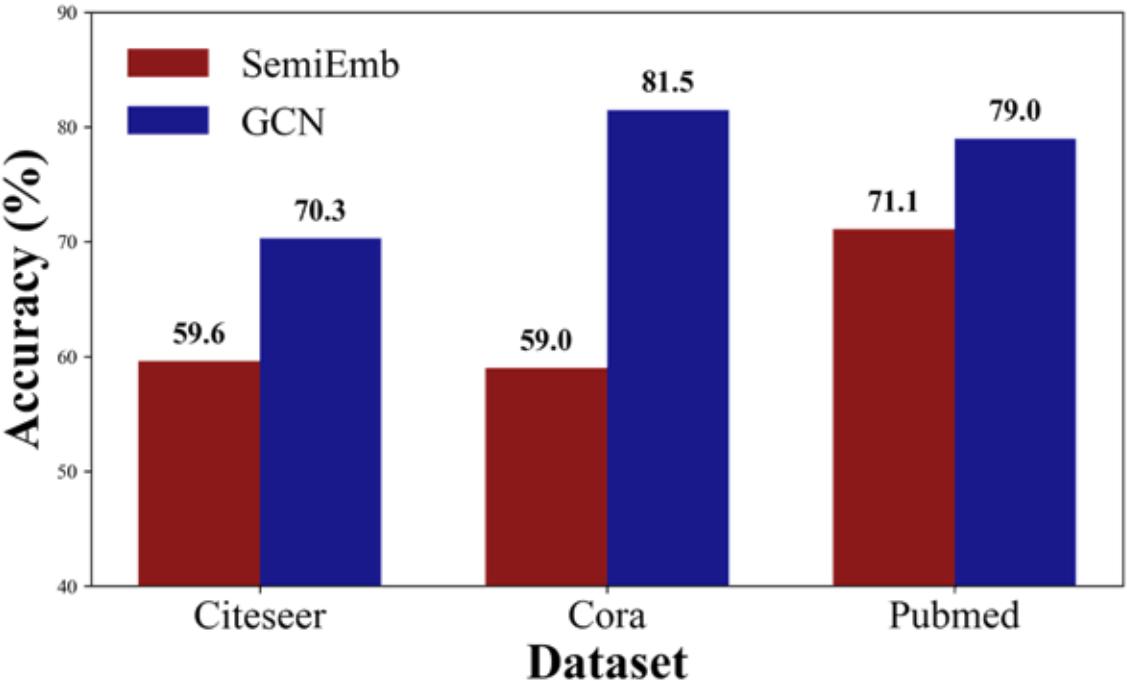
Zhuofeng Li^{1,2*}, Huaolang Zhang^{1,3}, Sengtai Han¹, Sheng Liu¹, Jianwen Xie¹, Yu Zhang¹, Yulin Choi¹, James Zou¹, Pan Li^{1,2}
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In-the-flow agentic system optimization for effective planning and tool use

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JZou, X.Zhang, RLGu, GLi, SCLeu, P.Liu, K.Wang ... - arxiv.org - 2025 - arxiv.org
 Multi-agent systems have shown great promise in solving complex problems. LLMs have independent single-model reasoning to coordinate system-level intelligence. While existing LLM agents

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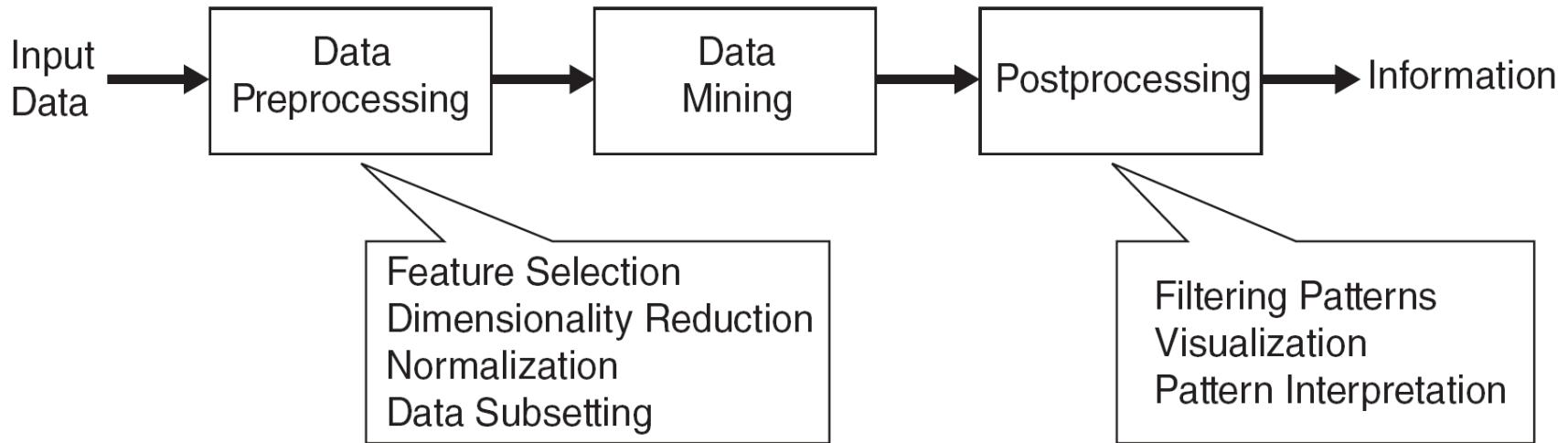
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ZY ... - 2025 - verifiable-rewards.pdf
 In this paper, we develop a set of practical algorithms for language model to self-play, by actively and strategically creating and controlling learning experiences themselves ...

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What is Data Mining?



Many Definitions

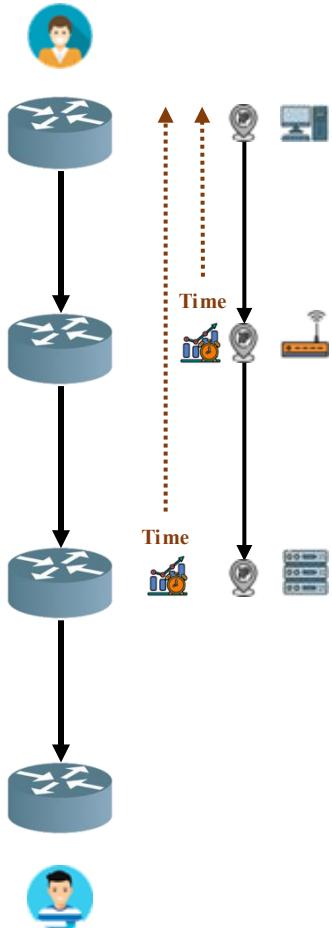
Non-trivial extraction of implicit, previously unknown and potentially useful information from data

Exploration & analysis, by automatic or semi-automatic means, of large quantities of data in order to discover meaningful patterns

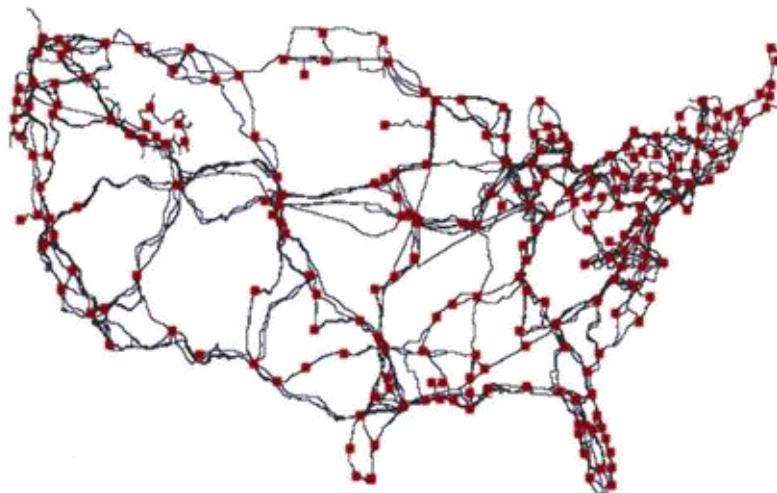
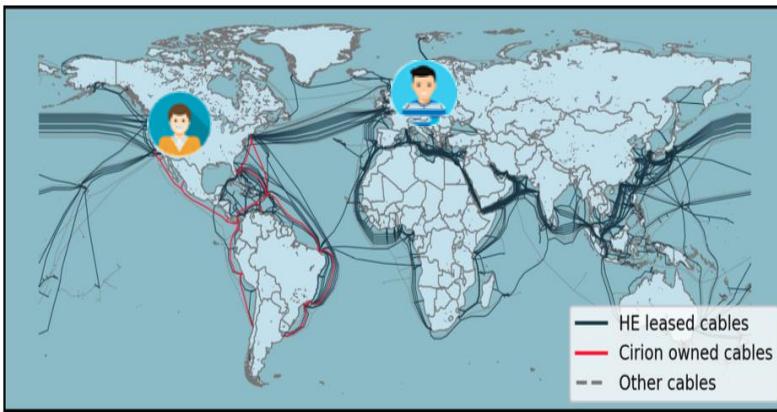
Why Data Mining? – Networking Infra Risk ONRG



Logical Layer

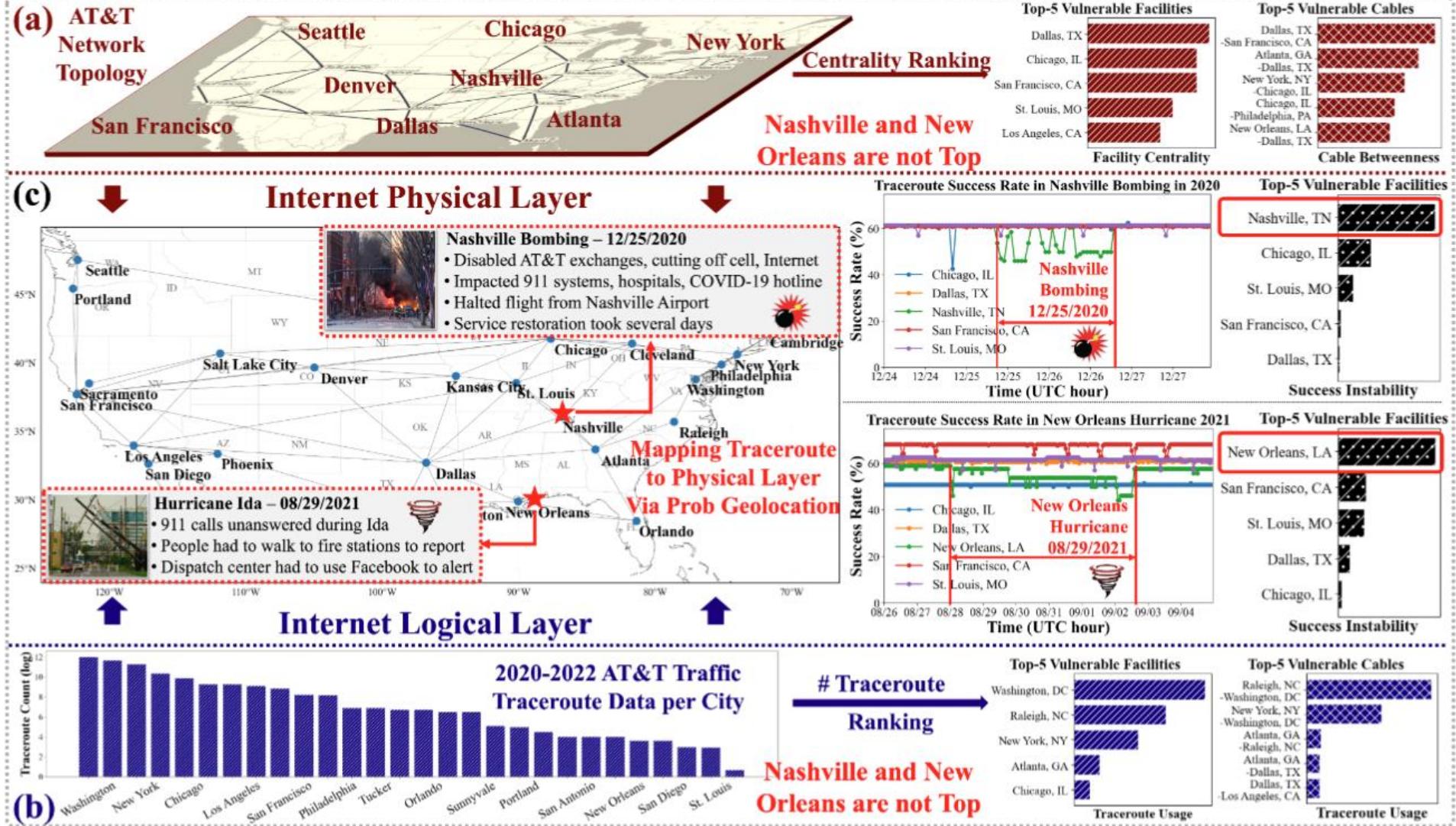


Physical Layer



Which physical cable path does this logic signal traverse?

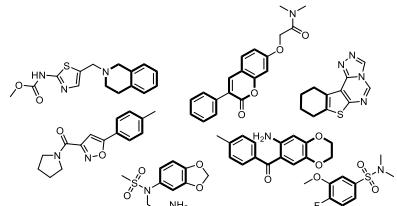
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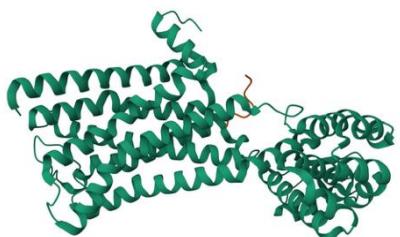
Why Data Mining? – Drug Design

Chemical Libraries

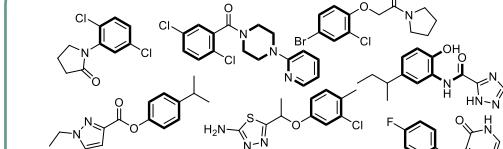


Number of Molecules: 103-106

Protein Target



Virtual Libraries



e.g., 10^9 Virtual Molecules on the REAL database in Enamine Ltd.

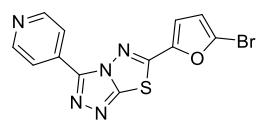


High Throughput Screening (HTS)

Training



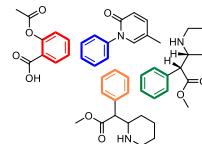
Deep Learning Models



Hit Rate: 0.05%-0.5%

Evaluating

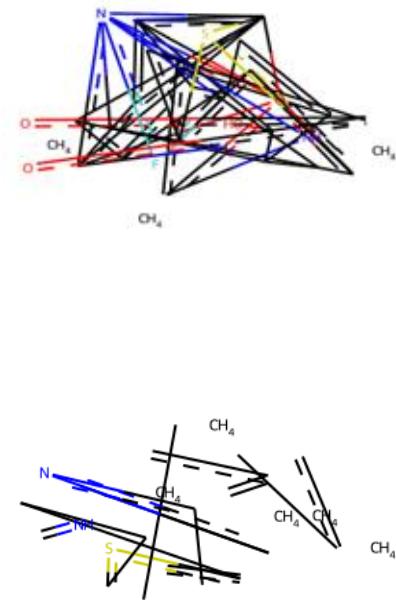
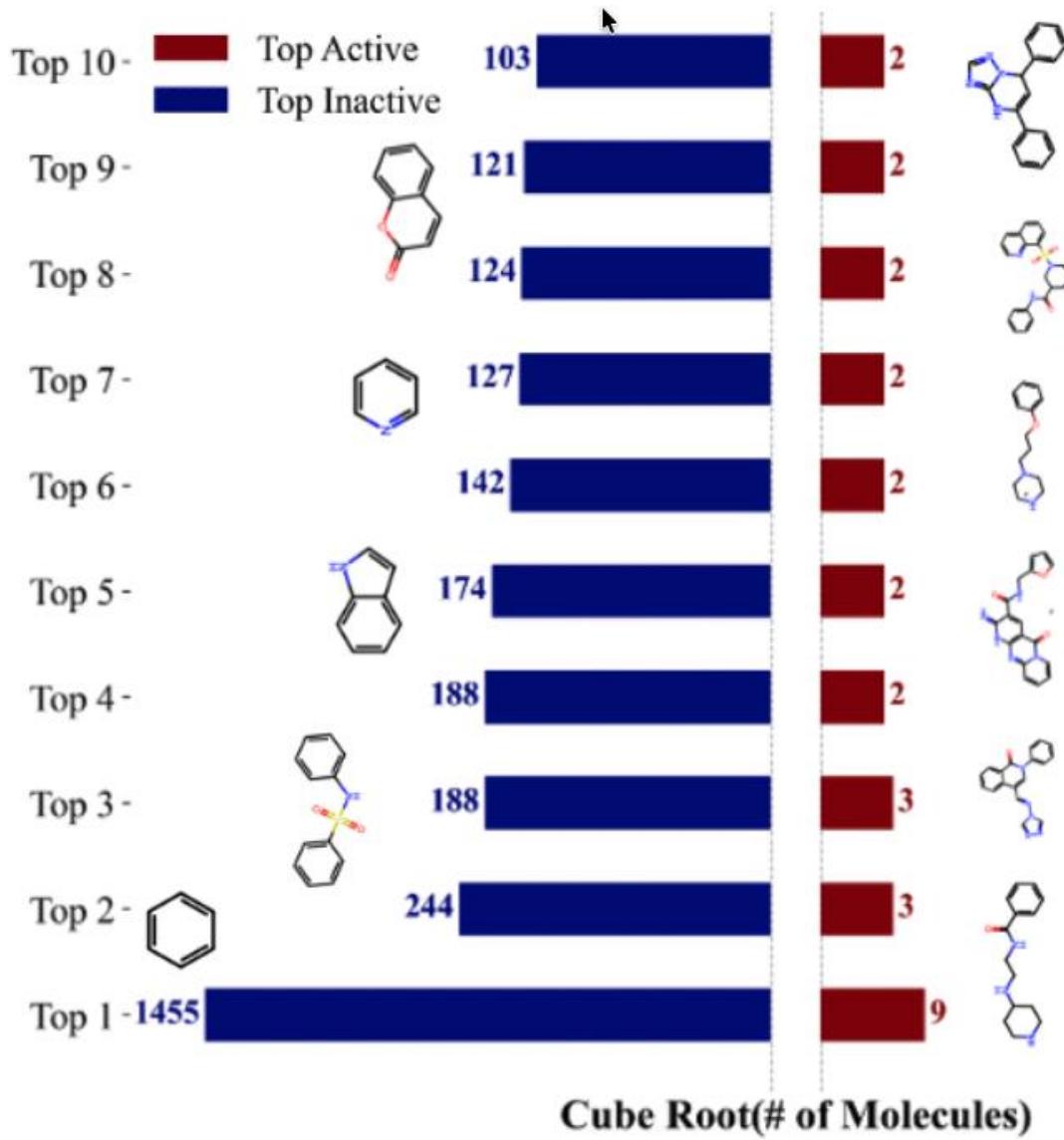
Predicted Actives



Number of Molecules: 500-1000



Why Data Mining? – Drug Design





Why Data Mining? – Commercial Perspective

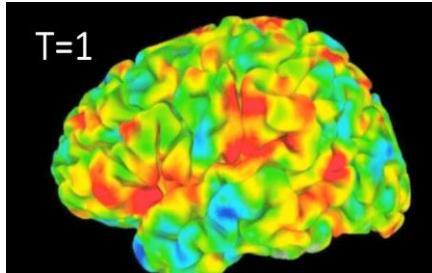
- Lots of data is being collected and warehoused
 - Web data $1,000,000,000,000 = 1,000 \text{ terabytes}$
 - Google has Peta Bytes of web data
 - Facebook has billions of active users
 - purchases at department/grocery stores, e-commerce
 - Amazon handles millions of visits/day
 - Bank/Credit Card transactions
- Computers have become cheaper and more powerful
- Competitive Pressure is Strong
 - Provide better, customized services for an edge (e.g. in Customer Relationship Management)





Why Data Mining? – Scientific Perspective

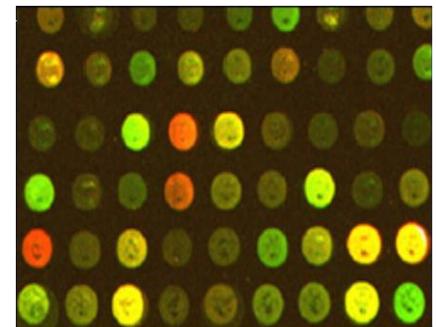
- Data collected and stored at enormous speeds
 - Remote sensors on a satellite
 - NASA EOSDIS archives over petabytes of earth science data / year
 - Telescopes scanning the skies
 - Sky survey data
 - High-throughput biological data
 - Scientific simulations
 - terabytes of data generated in a few hours
- Data mining helps scientists
 - in automated analysis of massive datasets
 - In hypothesis formation



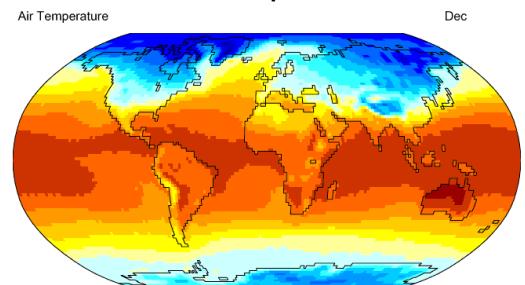
fMRI Data from Brain



Sky Survey Data

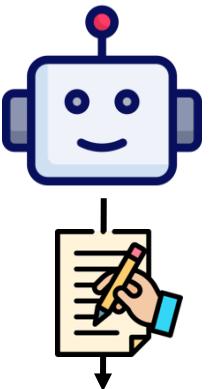


Gene Expression Data



Surface Temperature of Earth

Why Data Mining? – Social Good



The screenshot shows an email inbox with one new message from "Jane Doe". The message subject is "Re: Business cards". The body of the email contains a note about sending business cards to attendees at the GreenTech conference and includes a link to a Google Docs document titled "Business cards - content marketing". The email client interface includes standard controls like back, forward, and search.

Email Generation

CYCILP: Cyclic Contrastive Language-Image Pretraining	
Shubham Garg ¹ UCI shubhamgarg.github.io	Brett Bernstein ² University of Illinois Urbana-Champaign brettbernstein.com
Ryan A. Rossi ³ University of California, San Diego www.cs.ucsd.edu/~rossi/	Samarjit Bisht ⁴ MDTB, India MDTB, India
Kyle Kastner ⁵ DeepMind deepmind.com/research/people/kyle-kastner	Aldoja Ghermezi ⁶ University of California, Berkeley alodjaghermezi.com
Abstract	
<p>Recent advances in contrastive learning have leveraged large paired image-text datasets to learn models with state-of-the-art CLIP performance. These models often achieve state-of-the-art performance on downstream NLP tasks. Such models typically learn to encode images and text in a shared latent space, where they can be compared across tokens. Conversely, in pre-training, we demonstrate that the image and text modalities are better learned separately, and then fused together at test time. This approach, CYCILP, achieves state-of-the-art CLIP performance on downstream NLP tasks while maintaining modality-specificity and property CYCILP's. In contrast, we show that when the image and text modalities are learned together, they are less modality-specific and less property-preserving in the image and text space. To partially address this shortcoming, we propose a two-stage multi-task learning scheme that alternates between the two modalities to share parts (modality consistency) and then performs joint learning to learn modality-specific properties (property consistency). CYCILP outperforms the state-of-the-art CLIP model on downstream NLP tasks, and achieves state-of-the-art modality consistency and property consistency.</p>	
Abstract Generation	

Abstract Generation

Customer Reviews

★★★★★ **World's best!**
By [Courtney](#) on August 26, 2012
Total votes: 1

I have had these on the original design, I liked several points: one headband and the other for another lightning port (a great idea). - Novelties - they do not work, even just headphones jacks. We return to these are their own work when a good sound system.

Now I have the new design, the original app works at least a very good expet and work like the original. The new one is better, it has a better sound and a better look.

★★★★★ **This band will give you all the space for your activities! ...**
By [Fely Ony](#) on February 6, 2013
Total votes: 1

Who never got old? This makes my life easier. I don't have to hold my body anymore, just my back on my lap or couch, trying to use my computer and charging with one of the similar phones, this band will give you a better experience. I am not a fan of the original design, because it is not comfortable, but this one is much more comfortable, of course, someone can even when your phone is changing, they will be broken, but also to participate in rehearsals, I like to charge more things in mobile, it will keep available charges and jumproses.

★★★★★ **Great product**
By [KATHY LYNN TAYLOR](#) on November 16, 2017
Total votes: 1

My husband got my first Ray Ban flip-charging the headphones on a plane, as he expects me to buy his own... They are too expensive and I will spend a whole cable charging while using the new ones, the class of the Amazon; they because I could not stop shopping, why was not surprised? do not expect these things, because they are so cheap!!!!

Review Generation

RAG 2.0: Future of LLMs

Discussion: There have been plenty of articles written about Retrieval-Augmented Generation (RAG) pipelines, which as a technology is quite cool. But what's next for the technology of RAG.

What if we can create models with trainable retrievers, or in short, the entire RAG pipeline is customizable like fine-tuning an LLM?

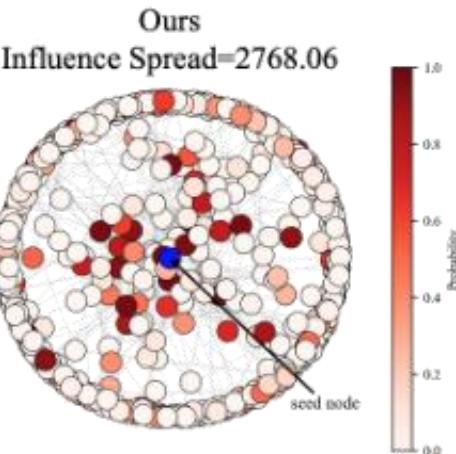
The problem with current RAGs is that they are not fully in tune with its submodules, it's like a Frankenstein monster, it somehow works, but the parts are not in harmony and quota suboptimally together. So, to tackle all the issues with Frankenstein in RAG, let's take a deep dive into RAG 2.0.

But why does this solve the issue?

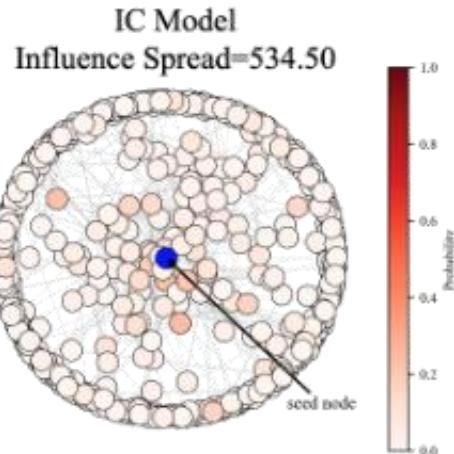
Read more →

Topic Writing

Text: "Breaking: NASA confirms first-ever human colony on Mars will begin next year — tickets for civilians already being sold out in minutes!"

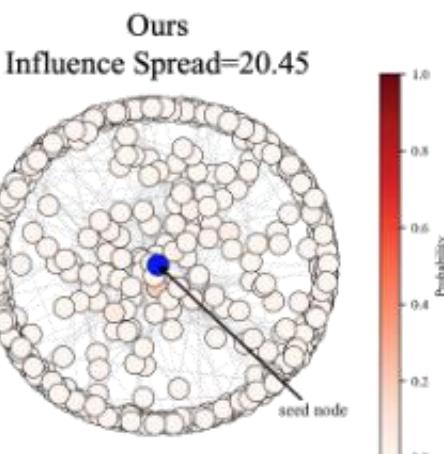


Ours
influence Spread=2768.06

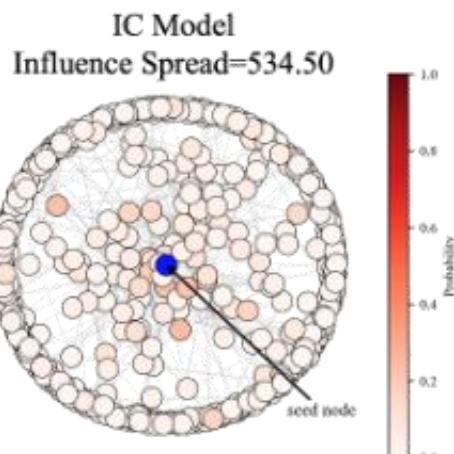


IC Model
Influence Spread=534.50

Text: " Today I bought a new pencil."



Ours
Influence Spread=20.45



IC Model
Influence Spread=534.50

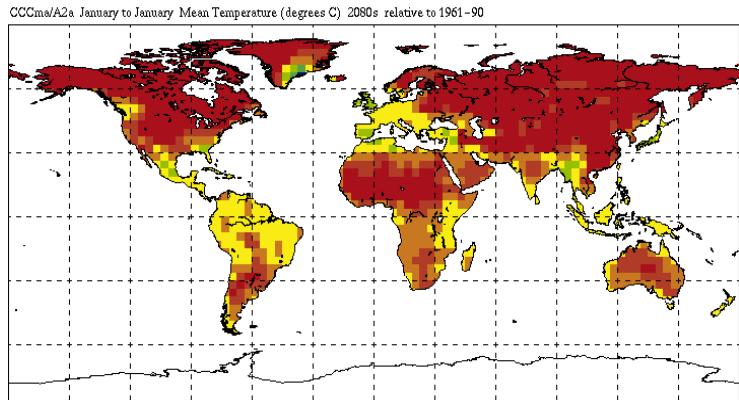


However, we have challenges – Question

What kind of data mining question you want to answer?



Improving health care and reducing costs



Predicting the impact of climate change



Finding alternative/ green energy sources



Reducing hunger and poverty by increasing agriculture production



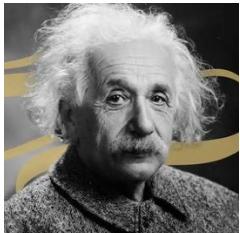
However, we have challenges – Question

What kind of data mining question you want to answer?



Judge a man by his questions rather than his answers.

----- Voltaire



The important thing is not to stop questioning.

----- Albert Einstein



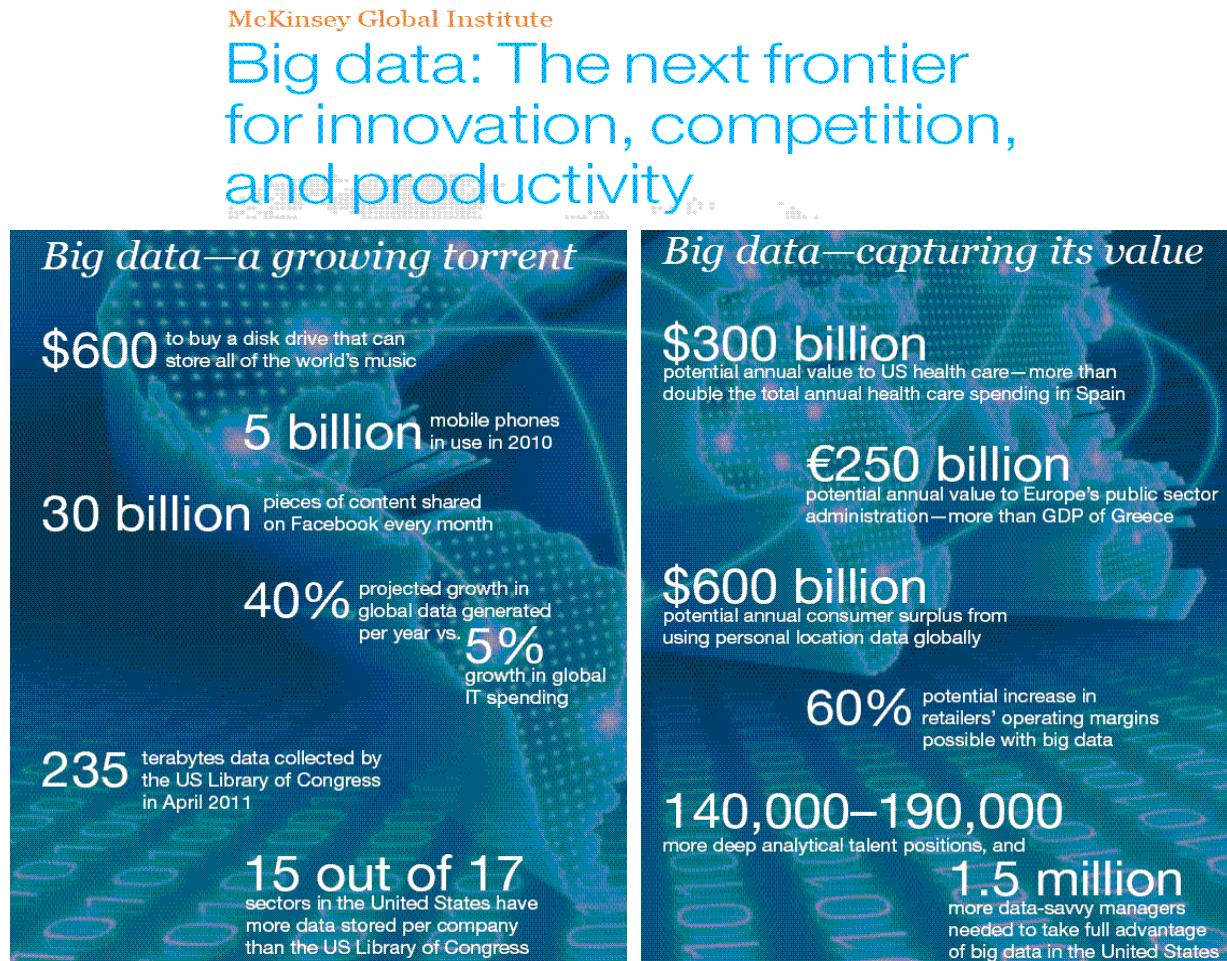
He who asks a question is a fool for five minutes; he who does not ask a question remains a fool forever.

----- Confucius



However, we have challenges – Data

Data is usually in a very large scale!

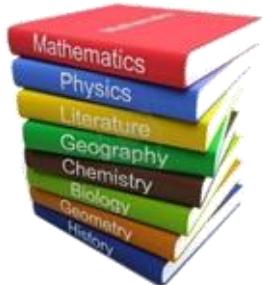




However, we have challenges – Data

Data is usually in a very large scale!

**Textbook
Knowledge Base**



158 million books

[ISBN DB 2023](#)



**Internet
Knowledge Base**



1.1 billion websites

[Musemind 2024](#)



**Neural
Knowledge Base**



405 billion parameters

[Hugging Face 2024](#)



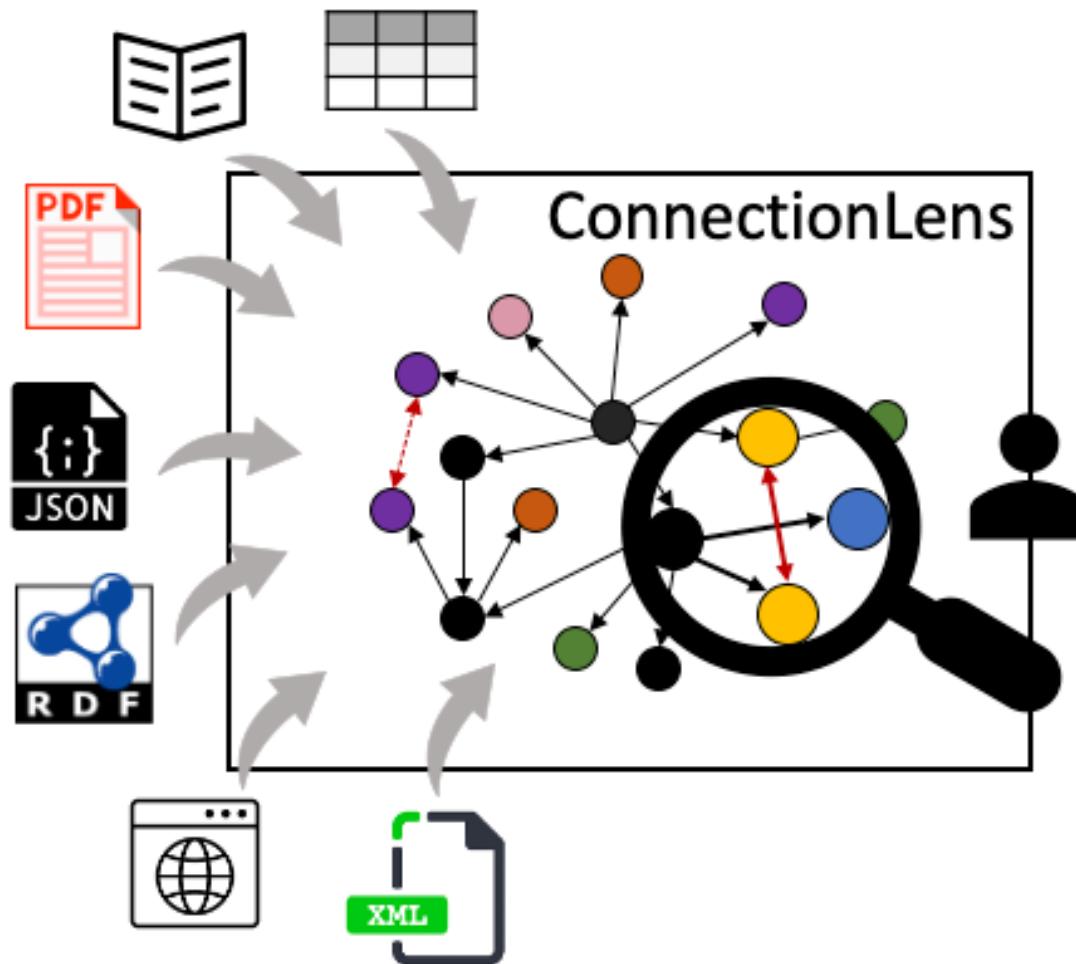
2.5 petabytes, 1 billion books

- We remember meanings, not details.
- We forget on purpose.
- Tiny active memory, Larger long-term memory.



However, we have challenges – Data

Data is diverse and heterogeneous





Summary

- **Data is everywhere**
- **Data Mining brings scientific advancement and social wellness**
- **However, there are challenges**
 - (1) What are good questions to ask?
 - (2) Data is scattered around the world, how to find them?
 - (3) Data is very large-scale, how to analyze them efficiently, space/time?
 - (4) Data is very heterogeneous and specialized

This is the reason for taking data mining!



Question Time!



Course Logistics



 ml-graph.github.io/winter-2025/

 Department of Computer Science, University of Oregon
Data Mining
Winter-2025

 SYLLABUS  SCHEDULE  PAPER  PROJECT  MATERIALS  GRADE



Course Description

Welcome to the fascinating field of data mining, a discipline at the intersection of computer science, statistics, and intelligence. Throughout this course, we'll explore various data mining techniques, from regression to classification to clustering to association analysis. You'll learn how to prepare data, select appropriate algorithms, and interpret results. Real-world examples and case studies will illustrate the practical applications of data mining across diverse industries.

Students will complete two quizzes, a team-based (optional) course project and paper presentation.

Coding notebooks will be provided when necessary for some important topics.

Goals

- Broad overview of Data Mining
 - Data Mining Skills – Knowledge and Code
 - Machine Learning Skills – Knowledge and Code
 - Real-world GML/DM applications

<https://ml-graph.github.io/winter-2025/>

All information will be available on the website!

Prerequisite

- Linear Algebra, Probability /Statistics, Calculus
 - Programming – Python, PyTorch
 - Curiosity – Critical Thinking
 - Diligence – Hard Working



Course Logistics - Time

Times:

- **Classes:** Monday/Wednesday 12:00-1:20 pm PST, Gerlinger 302
- **Office hours:** Wednesday 1:20-2:00 pm PST, other time by appointment
- **Zoom:** <https://uoregon.zoom.us/j/4052006678>



Course Logistics – Quizz

Times:

- **Classes:** Monday/Wednesday 12:00-1:20 pm PST, Gerlinger 302
- **Office hours:** Wednesday 1:20-2:00 pm PST, other time by appointment
- **Zoom:** <https://uoregon.zoom.us/j/4052006678>

Components:

Course Assessment and Grading Scale

Category	CS-453 (%)	CS-553 (%)
Quizz 1	20%	15%
Quizz 2	20%	15%
Project	40%	45%
Participation	5%	5%
Paper Presentation	15%	20%
Overleaf Bonus	5%	5%

- As long as you are **active thinking** and **understand the content**, you will be good



Question Time!

