

Algorithms for Modern Artificial Intelligence (NeoScholar Spring Program)

Lec0: Overview and Logistic

Haifeng Xu

Professor in Computer Science
University of Chicago



Introduction: About Me

Lecturer: Haifeng Xu

- Professor in computer science and data science at University of Chicago
 - Also a (part-time) research scientist at Google



Introduction: My Research

Research on designing intelligent AI agents (i.e., *agentic AI*) and *data-driven decision making*, machine learning and algorithm design

- How to design market mechanisms for emerging technology such as GenAI, cloud computing, data sharing?

Generative Advertising

A screenshot of a search results page for "trip to Hawaii". The search bar at the top contains the query "trip to Hawaii". Below the search bar are various filters: All, Images, Videos, Forums, News, More, Tools, Cost, All inclusive, Packages, Plane, Open now, Online appointments, Cheap, and Ess. The results section starts with a sponsored ad for Hilton Hotels, which includes a logo, the text "Experience the magic of Hawaii at Stingray Resort, where stunning views, luxurious accommodations, and endless activities await. Book your stay today and create unforgettable memories in the heart of paradise.", and a link to the Hilton website. Below this is another sponsored ad for China Airlines, featuring the airline's logo and the text "Fly to Hawaii with Maui Airlines and experience the beauty of the Aloha State. We offer affordable flights to all the major islands, so you can start your Hawaiian vacation sooner. Book your flight today and let the island spirit take over". At the bottom of the page, there is a Quora post titled "What is the estimated cost for a vacation in Hawaii for two ..." with a snippet of text about the cost of an excursion.

Currently, advertisers bid to have fixed ad creatives placed in certain slots in the page.

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What is the estimated cost for a vacation in Hawaii for two ...

A excursion in Hawaii for two people will likely cost round \$3000-\$5000 for airfare, motel, food, and sports for 5-7 days.

1 answer · 15 votes: My wife and I spent two weeks on Maui last month (June, 2019), so I can p...

In the future, it could be a creative co-branding ads!

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Our Goals:

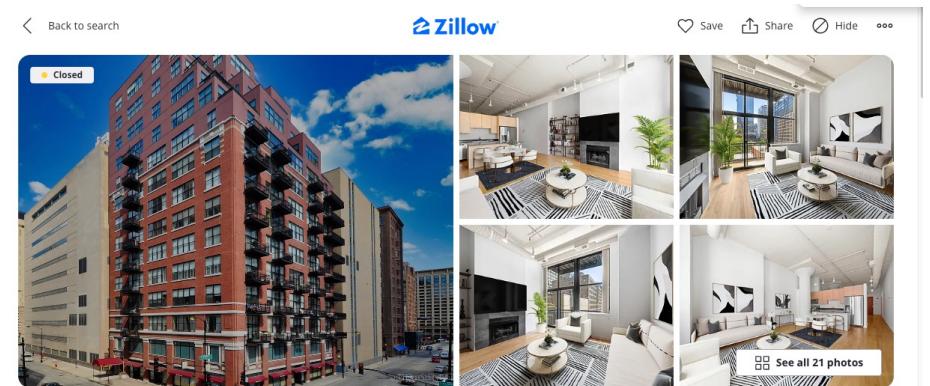
- A technique to auto-generate ad creatives with co-branding
- Moreover, advertisers can influence generated results via bidding to express preferences

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- How to design intelligent AI agents to automate strategies such as negotiation and marketing?

Discover the splendid charm of urban living at 547 S Clark St APT 405, a chic one-bedroom, one-bathroom ~~win~~ condo in the heart of Chicago's desirable Printers Row. Priced at an enticing \$297,500, this condo harmonizes affordability with luxury. Enjoy culinary delights with new stainless steel appliances and eye-catching granite countertops in the kitchen. The huge bedroom suite boasts a walk-thru closet area, offering ample built-in cabinet space and additional storage — a rarity in similarly priced listings. Revel in the tranquility of your spacious private balcony, perfect for unwinding with views of the bustling cityscape. Keep convenience at your fingertips with in-unit side-by-side laundry and parking in a secure garage. Built in 1998, this condo is a stone's throw away from Millennium Park and surrounded by



Facts & features

Interior

Bedrooms & bathrooms

- Bedrooms: 1
- Bathrooms: 1
- Full bathrooms: 1

Rooms

- Room types: Balcony/Porch/Lanai, Walk In Closet, Gallery

Walk in closet

- Level: Main
- Area: 45 Square Feet
- Dimensions: 9X5

Dining room

- Level: Main

Living room

- Level: Main
- Area: 272 Square Feet
- Dimensions: 17X16

Heating

- Natural Gas

Cooling

- Central Air

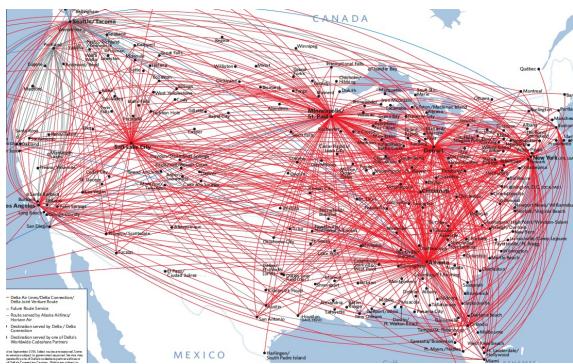
Appliances

- Included: Range, Microwave, Dishwasher, Refrigerator, Washer, Dryer, Stainless Steel Appliance(s), Humidifier
- Laundry: Electric Dryer Hookup, In Unit

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- How to design intelligent AI agents to automate strategies such as negotiation and marketing?
- How to learn decisions in economic/adversarial setups?
- ...



Optimize US flight scheduling



Optimize content recommendation policy

Introduction: My Research Lab

Sigma Lab

HOME PEOPLE RESEARCH PUBLICATIONS TEACH

Faculty



Haifeng Xu
Assistant Professor in Computer Science
University of Chicago

Student



Seyed A. Esmaeli (Postdoc Fellow)
About: Interested in interactions between algorithms, data, individuals and society specifically in fairness and incentive issues.



Ganghua Wang (Postdoc Fellow)
About: Passionate for statistical learning methods and their real-world applications, particularly on trustworthy AI. Enjoy Badminton & Steam.



Andrzej Kaczmarczyk (Postdoc Fellow)
About: A tenacious adept armed with algorithms, data science, and axiomatization to solve decision-making riddles.



Minbiao Han (PhD Student)
About: Exploring the interplay of economics, algorithms, and machine learning, traversing both anticipation and aspiration.



Jibang Wu (PhD Student)
About: Interested in interactions and mechanisms in multi-agent systems, looking ahead at both hype and hope.



Fan Yao (PhD Student, co-advised with Prof. Hongning Wang)
About: A theory-obsessed pragmatist, a crazy tennis player, and an underachieving daydreamer.



Questions?

Introduction

TA Intro: Rey

Goal of This Course

Objective.

- ✓ Familiarize you with fundamental tools for modern AI
- ✓ Equip you with “research thinking” to advance AI technology

Some universities have their own traditional AI courses, but this one should be different

- **More focus on modern methods:** we discarded classic topics such as search and hidden Markov models
- **More emphasis on research:** (1) more cutting-edge topics; (2) big pictures > technical details
 - Feel free to let me know if you want to dive deeper
- **Goal is to train your vision and innovative thinking,** which becomes more and more important in today’s AI research

Syllabus: Algorithms for Modern AI

- **Lecture 1: Background and Classic AI Techniques**

We will see where AI comes from and what are classic AI problems and techniques

Syllabus: Algorithms for Modern AI

- **Lecture 1: Background and Classic AI Techniques**
- **Lecture 2: Deep Neural Networks**
- **Lecture 3: Backpropagation and Stochastic Gradient Descent**

We will see the core techniques that enabled the birth of “modern AI” – **deep neural networks** and their training methods



The New York Times

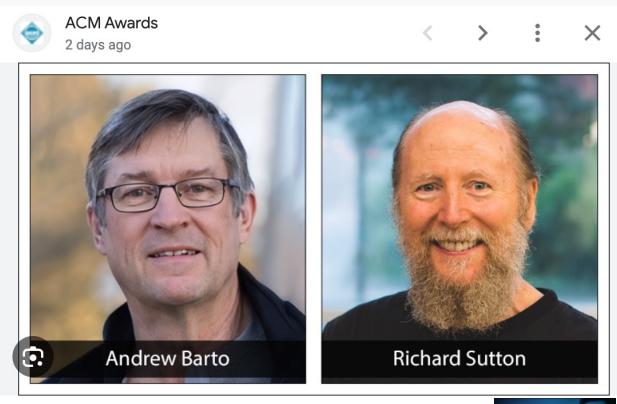
Turing Award Won by 3 Pioneers in Artificial Intelligence - The New York Times

A screenshot of a news article from The New York Times. The article is about three pioneers in artificial intelligence who won the Turing Award. The image shows three men: John McCarthy, Marvin Minsky, and Ray Kurzweil. The New York Times logo is in the top left corner. The bottom right corner features the ACM A.M. TURING AWARD logo.

Syllabus: Algorithms for Modern AI

- Lecture 1: Background and Classic AI Techniques
- Lecture 2: Deep Neural Networks
- Lecture 3: Backpropagation and Stochastic Gradient Descent
- Lecture 4: Markov Decision Processes
- Lecture 5: Reinforcement learning (RL)

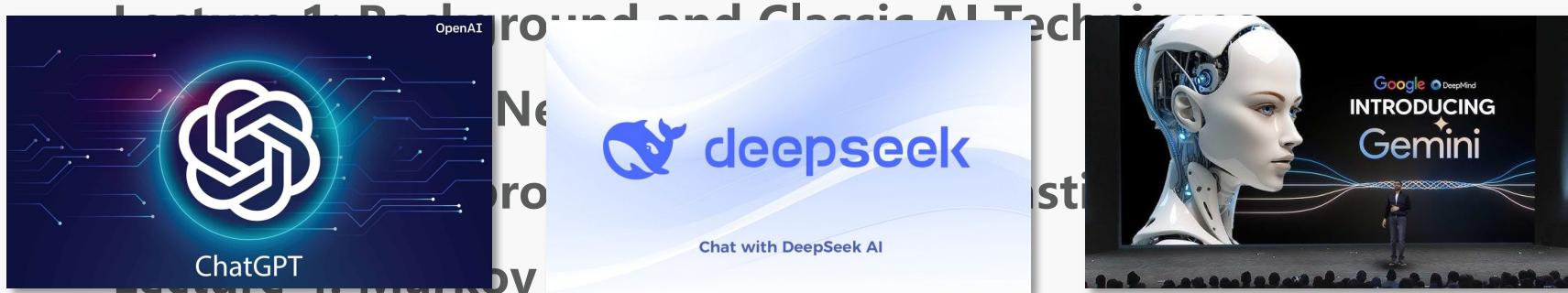
We will see the core techniques that enabled the second wave of breakthroughs in modern AI – **reinforcement learning**



2024 Turing Award



Syllabus: Algorithms for Modern AI



- **Lecture 5: Reinforcement learning (RL)**
- **Lecture 6: Introduction to Large Language Models**
- **Lecture 7: Reasoning of LLMs, Chain of Thought**
- **Lecture 8: Multi-agent Reasoning**

We will see how deep learning and RL technology enabled the success of **Large Language Models (LLMs)**, and remaining cutting-edge challenges

Syllabus: Algorithms for Modern AI

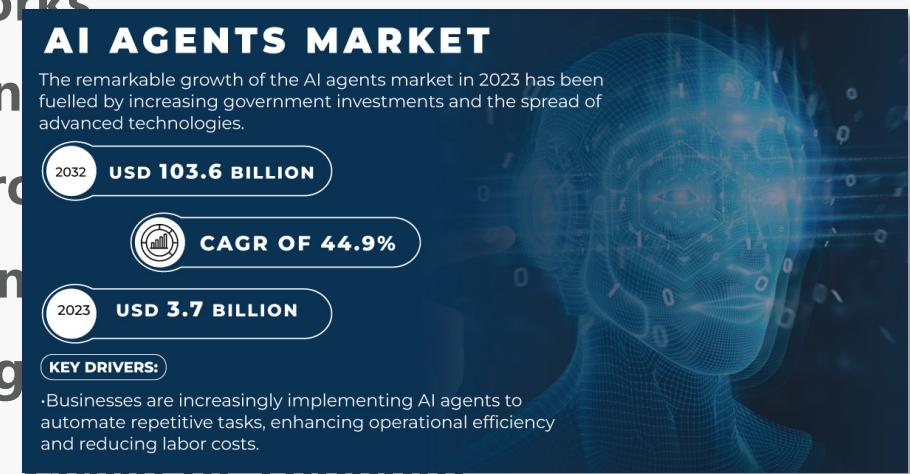
- Lecture 1: Background and Classic AI Techniques

Lecture 2: Deep Neural Networks



Lecture 7: Reasoning of LLMs, Chain of Thought

- Lecture 8: Multi-agent Reasoning
- Lecture 9: Language Model Agent Design
- Lecture 10: Market algorithms for AI platforms



Finally, we will envision a future together – a world of **AI agents**

Lecture Structure

Each lecture has 120 mins, divided into two parts

- ~45 mins for each lecture
- ~10 mins break at the middle
- Last 10 mins for questions, before TA starts the TA session

Course Work

- **Homework**, around Lec 3&4, and 8&9 (multi-choice questions)
- **Mid-term** is between Lec 5 and 6
- **Final research proposal:**
 1. Identify a research question/challenge that you are interested in addressing
 2. Justify/motivate why you would want to work on it, and what is your strength on tackling this research
 3. Identify related works in this research direction
 4. Propose initial thoughts or prototype solutions for the problem

Questions?

Haifeng Xu

University of Chicago

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Goal of This Course

Ideally, we expect high-quality research papers produced from this class

Time Heals Unfairness: Efficient Dynamic Routing at an Autonomous Society

Sijia Wei¹(✉) and Yishen Peng²

¹ Dalian University of Technology, Dalian, Liaoning, China
Scarlet.Wei@outlook.com

² East China Normal University, Shanghai, China

Abstract. With the continuous advances in AI, the vision of fully automated driving is not far away. However, it remains a key challenge to understand what kind of multi-agent systems will these intelligent cars shape, when being deployed on the road. This paper examines a key question of societal importance along this line. That is, will each self-driving car's intelligent/selfish behavior lead to unfair societal outcomes and, if so, how could we mitigate such unfairness.

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Advances and Trends in Artificial Intelligence. Theory and Applications

37th International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems, IEA/AIE 2024, Hradec Kralove, Czech Republic, July 10–12, 2024, Proceedings

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Introduction

