



Simulating Human Society with Large Language Model Agents: City, Social Media, and Economic System

Chen Gao
Tsinghua University
Beijing, China
chgao96@gmail.com

Fengli Xu
Tsinghua University
Beijing, China
fenglixu@tsinghua.edu.cn

Xu Chen
Renmin University of China
Beijing, China
xu.chen@ruc.edu.cn

Xiang Wang
University of Science and Technology
of China
Hefei, Anhui, China
xiangwang1223@gmail.com

Xiangnan He
University of Science and Technology
of China
Hefei, Anhui, China
xiangnanhe@gmail.com

Yong Li
Tsinghua University
Beijing, China
liyong07@tsinghua.edu.cn

ABSTRACT

This tutorial will delve into the fascinating realm of simulating human society using Large Language Model (LLM)-driven agents, exploring their applications in cities, social media, and economic systems. Through this tutorial, participants will gain insights into the integration of LLMs into human society simulation, providing a comprehensive understanding of how these models can accurately represent human interactions, decision-making processes, and societal dynamics from cities to social media and to economic systems. The tutorial will introduce the essential background, discuss the motivation and challenges, and elaborate on the recent advances.

CCS CONCEPTS

• **Computing methodologies** → **Agent / discrete models**; *Multi-agent systems*.

KEYWORDS

Agent-based Modeling and Simulation, Large Language Model Agents

ACM Reference Format:

Chen Gao, Fengli Xu, Xu Chen, Xiang Wang, Xiangnan He, and Yong Li. 2024. Simulating Human Society with Large Language Model Agents: City, Social Media, and Economic System. In *Companion Proceedings of the ACM Web Conference 2024 (WWW '24 Companion)*, May 13–17, 2024, Singapore, Singapore. ACM, New York, NY, USA, 4 pages. <https://doi.org/10.1145/3589335.3641253>

1 TOPIC AND RELEVANCE

1.1 Tutorial topic

The main topic of this tutorial is about using large language model agents to simulate human society, with their applications in cities,

social media, and economic systems. Specifically, the tutorial will help the audience understand how LLM agents can accurately represent human interactions, decision-making processes, and societal dynamics [4, 7]. The content will cover the social simulation in urban environments, the emulation of social media dynamics, user interactions and content propagation in both online and offline communities, the modeling of economic systems, examining market behaviors, consumer choices, and the overall economic landscape [9, 19]. By the end of the tutorial, participants will also acquire practical knowledge in implementing and customizing LLMs to simulate human society.

1.2 Why the tutorial is important and how it is relevant to the Web Conference

This tutorial holds paramount importance as it addresses the intersection of cutting-edge technologies and societal simulations, offering participants a unique opportunity to grasp the intricacies of simulating human society using Large Language Model (LLM)-driven agents. In an era dominated by digital transformation and rapid technological advancements, understanding the implications of these models on human behavior, cities, social media, and economic systems is crucial.

In recent times, the artificial intelligence domain has witnessed a surge in the prominence of large language models (LLMs)[18]. Leveraging this progress, agents powered by these LLMs have demonstrated remarkable capabilities in interaction, reasoning, and decision-making. Firstly, LLM agents exhibit autonomous behavior, adeptly reacting and executing tasks based on the environment without explicit instructions[8, 15]. Secondly, the intelligence embedded in LLM agents enables them to respond akin to humans, proactively engaging in actions with self-oriented planning and scheduling [10, 13]. Lastly, LLM agents possess the capability to interact and communicate, not only with humans but also with other AI agents [6]. This confluence of autonomous adaptability, human-like responses, and interactive prowess positions LLM-based agents as powerful contributors to the evolving landscape of macroeconomic simulations.

Furthermore, the large language models have provided an opportunity for research in urban society and economics, by empowering the agents to simulate various behaviors, including both online and

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

WWW '24 Companion, May 13–17, 2024, Singapore, Singapore

© 2024 Copyright held by the owner/author(s). Publication rights licensed to ACM.

ACM ISBN 979-8-4007-0172-6/24/05...\$15.00

<https://doi.org/10.1145/3589335.3641253>

offline environments. The tutorial’s significance lies in its ability to bridge the gap between LLMs’ power and practical Web-related application, empowering participants to harness the capabilities of LLMs for accurate and insightful societal simulations.

Relevance to The Web Conference is evident through the tutorial’s emphasis on the digital aspects of human society. Given the conference’s focus on web-related technologies and their impact on various domains, this tutorial (which is about social media, economic systems, etc.) aligns seamlessly with the conference’s overarching themes. The tutorial provides a platform for researchers, practitioners, and enthusiasts to explore novel applications of LLMs in the context of the Web, fostering a deeper understanding of the intricate relationship between technology and human society.

1.3 Why the presenters are qualified

The presenters are from three top-tier universities, with strong research and teaching experience in the relevant area.

1.3.1 Research Experience. The presenters have rich experience in Web-related research, with more than 50 papers published in The Web Conference in recent years. Dr. Xiangnan He and Dr. Xu Chen have co-authored a paper that won the Best Paper Award Honorable Mention Award of WWW (TheWebConf) 2018. As for the topic of this tutorial, the presenters have published many relevant papers.

- **Tsinghua Team.** Recently, Dr. Chen Gao has developed a simulation system named S^3 [3] (short for Social Simulation System). It leverages the capabilities of large language models in the realms of perception, cognition, and behavior to establish a framework for social network emulation. Dr. Chen Gao has also developed a system [5] for simulating economic behaviors with LLM-driven agents. The work designed LLM-empowered agents based on the context of real-world economic environments. Through the simulation, classic macroeconomic phenomena are reproduced and more reasonable compared to traditional rule-based or AI agents. Dr. Yong Li [17] released a system for city simulation, which provides a strong basis for more complex simulation, including both online and offline behaviors.
- **RUC Team.** Dr. Xu Chen has rich experience in LLM and LLM-driven agents. He wrote the first survey [10] for LLM-driven agents. He has also released a framework named RecAgent [11] for simulation user-recommendation interaction behaviors.
- **USTC Team.** Dr. Xiangnan He has published high-quality papers about large language models [1, 16] in top-tier venues, and has organized a workshop about generative AI in CIKM 2023 [12]

1.3.2 Teaching Experience. All the presenters have rich experience in giving tutorials in top-tier conferences. The covered venues include TheWebConf 2022, WSDM 2022, TheWebConf 2021, KDD 2021, IJCAI 2021, SIGIR 2020, SIGIR 2019, SIGIR 2018, etc. Besides, all the presenters have taught classes about machine learning, data mining, or artificial intelligence in their universities.

2 STYLE AND SCHEDULE

This tutorial is a **LECTURE-STYLE** tutorial, which is organized into five parts. In Part I, we present preliminaries of human society simulation and large language models, including the problem formulation and those common paradigms. In Part II, we aim to

explain why large language models are required in human society simulation. In Part III, we present the fourfold challenges for human society simulation with large language models. In Part IV, we discuss how to address the above challenges based on carefully presenting the recent advances in this area. In Part V, we conclude the tutorial, launch open discussions in human society simulation with large language models, and discuss promising directions for further research. The overall structure and schedule of the tutorial are as follows.

- (1) **Part I: Background (Dr. Chen Gao and Dr. Xiangnan He, 0.5 hour)**
 - Background of human society simulation
 - Background of large language models
- (2) **Part II: Why LLMs are required in human society simulation (Dr. Yong Li, 0.4 hour)**
- (3) **Part III: Challenges for human society simulation with LLMs (Dr. Xiang Wang, 0.4 hour)**
 - Environment construction and inception
 - Internal mechanism of the simulation
 - Action generation and simulation
 - Evaluation of simulation
- (4) **Part IV: Advances in human society simulation with LLMs (Dr. Chen Gao, Dr. Fengli Xu, and Dr. Xu Chen, 1.5 hour)**
 - City: Physical world and mobility behaviors (Dr. Fengli Xu)
 - Social Media: Social science and population-level behaviors (Dr. Xu Chen)
 - Economic System (Dr. Chen Gao)
- (5) **Part V: Conclusion and Open Discussions (Dr. Chen Gao, 0.2 hour)**

3 AUDIENCE

The tutorial targets a broad audience from academia and industry who are interested in large language models and human society simulation, especially for simulation for urban, social media, and economics. While we welcome participants with a relevant background to join our discussion, this tutorial should interest any Web-community participants who want to learn about next-generation human society simulation. As to prerequisites, a basic background in large language models and human society simulation would be sufficient. Since we will introduce the basic concepts of large language models and human society simulation, the background is not a strict requirement.

4 PREVIOUS EDITIONS

This section does not apply to our tutorial since it is new and has never been presented in any other venues before.

5 TUTORIAL MATERIALS AND VIDEO TEASER

We provide extensive materials that can help the attendees better understand the content listed as follows.

- Website: we build an official website (<https://sites.google.com/view/simu-www2024tutorial>) which includes the detailed information of this tutorial.
- Slides: The slides in our presentation will be released publicly.

- Related Papers: the above website will present a list of important related papers; besides, we have also released a survey paper about agent-based modeling and simulation with large language model agents [2].
- System: We have released a system named UGI [14], which is a foundational platform for large language model agents-based simulation in an embodied city environment.
- Video Teaser: the video teaser is provided on the above website.

6 BIOGRAPHY OF PRESENTERS

- **Dr. Chen Gao** is now a Research-Track Assistant Professor with Tsinghua University. He obtained his Ph.D. Degree and Bachelor Degree from the same department in 2021 and 2016, respectively. He obtained his Ph.D. Degree and Bachelor's Degree from the Department of Electronic Engineering, Tsinghua University in 2021 and 2016, respectively. His research primarily focuses on data mining and machine learning, with over 60 papers in top-tier venues, including WWW, KDD, SIGIR, ICLR, NeurIPS, etc., attracting over 2000 citations. His work on received the Best Short Paper Honorable Mention Award in SIGIR 2020. He serves as the PC member for conferences such as WWW, KDD, SIGIR, WSDM, CIKM, NeurIPS, ICLR, ICML, MM, RecSys, AAAI, IJCAI, AISTATS, ECML-PKDD, etc., and the regular reviewer for journals including IEEE TKDE, ACM TOIS, IEEE TNNLS, etc. He was a visiting research scholar (advised by Prof. Tat-Seng Chua) at NExT Center of National University of Singapore in 2018. He was selected as one of Top 100 Chinese Rising Stars in Artificial Intelligence by Baidu Scholar in 2021. He was also at the finalist of 2021 China Computer Federation (CCF) Outstanding Doctoral Dissertation Award. He has organized and presented the tutorial on "Graph Neural Networks for Recommender System" in WSDM 2022, "Advances in Recommender System" in KDD 2020 and the tutorial on "Towards Automated Recommender System" in IJCAI 2021.
- **Dr. Fengli Xu** currently is an Assistant Professor at Tsinghua University. Prior to current position, he was a postdoc researcher at the University of Chicago. He received his Ph. D. degree in Electronic Engineering from Tsinghua University in 2020. His research interests lie in the interdisciplinary area of Artificial Intelligence, Data Science, Urban Science and Human Dynamics, aiming to develop scientific methods and artificial intelligence tools to address the long-standing puzzles in complex networks arise from human behavior and social interactions. His research aims to fully exploit the opportunities offered by recent data explosion and push forward the boundary of computational social science research with novel Data Science/AI techniques. Dr. Xu's works have been published in several high-profile journals, including PNAS, Nature Human Behaviour and Nature Computational Science, and 30+ top computer science conferences, e.g., NeurIPS, WWW, KDD, etc. His research was recognized by selective academic awards, including CAAI rising star in social computing, MSRA Fellowship, ACM Sigspatial China Doctoral Dissertation Award, UbiComp 2016 Honorable Mention Award.
- **Dr. Xu Chen** is a Tenure-track Associate Professor with Renmin University of China. His research focuses on large language models, causal inference, recommendation systems, and more. He has published over 70 papers in renowned international conferences/journals such as TheWebConf, NeurIPS, AIJ, WSDM, SIGIR, TOIS, TKDE, with over 4600 citations on Google Scholar. His research achievements have been recognized with nominations for the Best Paper Award at TheWebConf 2018, Runner-Up for the Best Resource Paper at CIKM 2022, and the Best Paper Award at AIRS 2017. He co-led the development of the recommendation system toolkit Bole, the construction of the interpretable user behavior analysis dataset REASONER, and the establishment of the recommendation simulation environment RecAgent based on LLM-based agents. He has presented the tutorial on "Explainable Recommendation and Search" in SIGIR 2019.
- **Dr. Xiang Wang** Xiang Wang is a full professor University of Science and Technology of China. His main research interests include information retrieval and recommendation, data mining, and turstable AI. He has published over 70 papers in prestigious international conferences and journals, such as TPAMI, NeurIPS, and WWW. He won the Frontier of Science Award at the International Congress of Basic Science. He has presented the tutorial on "Learning and Reasoning on Graph for Recommendation" in CIKM 2019 and WSDM 2020, and the tutorial on "Bias Issues and Solutions in Recommender System" in WWW 2021.
- **Dr. Xiangnan He** is a professor with the University of Science and Technology of China. He received the Ph.D. degree in Computer Science from the National University of Singapore in 2016. His research interests span information retrieval and data mining, with over 60 publications appeared in top conferences such as SIGIR, WWW, and KDD, and journals including TKDE, TOIS, and TNNLS. His works on recommender systems have received the Best Paper Award Honorable Mention in SIGIR 2021, WWW 2018, and SIGIR 2016. Moreover, he has served as the PC chair of CCIS 2019, area chair of MM 2019 and CIKM 2019, and PC member for several top conferences including SIGIR, WWW, KDD etc., as well as regular reviewer for journals including TKDE, TOIS, TMM, etc. He has rich teaching experience, especially for presenting tutorials: "Conversational Recommendation: Formulation, Methods, and Evaluation" in SIGIR 2020, "Deep Learning for Matching in Search and Recommendation" in WWW 2018 and SIGIR 2018, "Information Discovery in E-commerce" in SIGIR 2018, and "Recommendation Technologies for Multimedia Content" in ICMR 2018.
- **Dr. Yong Li** is currently a Tenured Associate Professor of the Department of EE, Tsinghua University. He received the Ph.D. degree in Electronic Engineering from Tsinghua University in 2012. His research interests include data mining and machine learning. He serves as (S)PC of major DM/AI conferences, including WWW, KDD, WWW, IJCAI, AAAI, SIGIR, and UbiComp. He has published over 100 papers on first-tier conferences and journals, including Nature Human Behavior, Nature Machine Intelligence, WWW, KDD, NeurIPS, ICLR, SIGIR, etc. He has rich teaching experience, including teaching two classes "Mobile Data Mining" and "Big Data Technology and Application" at Tsinghua University for years, presenting the tutorial on "Smartphone App Usage Understanding, Modeling, and Prediction" in UbiComp 2019, the tutorial on "Advances in Recommender System" in KDD 2020 and the tutorial on "Towards Automated Recommender System" in IJCAI 2021.

REFERENCES

- [1] Keqin Bao, Jizhi Zhang, Yang Zhang, Wenjie Wang, Fuli Feng, and Xiangnan He. 2023. Tallrec: An effective and efficient tuning framework to align large language model with recommendation. *arXiv preprint arXiv:2305.00447* (2023).
- [2] Chen Gao, Xiaochong Lan, Nian Li, Yuan Yuan, Jingtao Ding, Zhilun Zhou, Fengli Xu, and Yong Li. 2023. Large Language Models Empowered Agent-based Modeling and Simulation: A Survey and Perspectives. *arXiv preprint arXiv:2312.11974* (2023).
- [3] Chen Gao, Xiaochong Lan, Zhihong Lu, Jinzhu Mao, Jinghua Piao, Huandong Wang, Depeng Jin, and Yong Li. 2023. S3: Social-network Simulation System with Large Language Model-Empowered Agents. *arXiv preprint arXiv:2307.14984* (2023).
- [4] Dale W Jorgenson. 2001. Information technology and the US economy. *American Economic Review* 91, 1 (2001), 1–32.
- [5] Nian Li, Chen Gao, Yong Li, and Qingmin Liao. 2023. Large Language Model-Empowered Agents for Simulating Macroeconomic Activities. *arXiv preprint arXiv:2310.10436* (2023).
- [6] Joon Sung Park, Joseph C O'Brien, Carrie J Cai, Meredith Ringel Morris, Percy Liang, and Michael S Bernstein. 2023. Generative agents: Interactive simulacra of human behavior. *arXiv preprint arXiv:2304.03442* (2023).
- [7] Frank Schorfheide and Dongho Song. 2015. Real-time forecasting with a mixed-frequency VAR. *Journal of Business & Economic Statistics* 33, 3 (2015), 366–380.
- [8] AutoGPT Team. 2022. AutoGPT: the heart of the open-source agent ecosystem. <https://github.com/Significant-Gravitas/AutoGPT>. (Accessed on 01/10/2023).
- [9] Alexander Trott, Sunil Srinivasa, Douwe van der Wal, Sebastien Haneuse, and Stephan Zheng. 2021. Building a foundation for data-driven, interpretable, and robust policy design using the ai economist. *arXiv preprint arXiv:2108.02904* (2021).
- [10] Lei Wang, Chen Ma, Xueyang Feng, Zeyu Zhang, Hao Yang, Jingsen Zhang, Zhiyuan Chen, Jiakai Tang, Xu Chen, Yankai Lin, et al. 2023. A survey on large language model based autonomous agents. *arXiv preprint arXiv:2308.11432* (2023).
- [11] Lei Wang, Jingsen Zhang, Xu Chen, Yankai Lin, Ruihua Song, Wayne Xin Zhao, and Ji-Rong Wen. 2023. RecAgent: A Novel Simulation Paradigm for Recommender Systems. *arXiv preprint arXiv:2306.02552* (2023).
- [12] Wenjie Wang, Yong Liu, Yang Zhang, Weiwen Liu, Fuli Feng, Xiangnan He, and Aixin Sun. 2023. The 1st Workshop on Recommendation with Generative Models. In *Proceedings of the 32nd ACM International Conference on Information and Knowledge Management*. 5300–5303.
- [13] Zhiheng Xi, Wenxiang Chen, Xin Guo, Wei He, Yiwen Ding, Boyang Hong, Ming Zhang, Junzhe Wang, Senjie Jin, Enyu Zhou, et al. 2023. The Rise and Potential of Large Language Model Based Agents: A Survey. *arXiv preprint arXiv:2309.07864* (2023).
- [14] Fengli Xu, Jun Zhang, Chen Gao, Jie Feng, and Yong Li. 2023. Urban Generative Intelligence (UGI): A Foundational Platform for Agents in Embodied City Environment. *arXiv preprint arXiv:2312.11813* (2023).
- [15] Yoheinakajima. 2023. BabyAGI. <https://github.com/yoheinakajima/babyagi>. (Accessed on 01/10/2023).
- [16] Jizhi Zhang, Keqin Bao, Yang Zhang, Wenjie Wang, Fuli Feng, and Xiangnan He. 2023. Is chatgpt fair for recommendation? evaluating fairness in large language model recommendation. *arXiv preprint arXiv:2305.07609* (2023).
- [17] Jun Zhang, Depeng Jin, and Yong Li. 2022. Mirage: an efficient and extensible city simulation framework (systems paper). In *Proceedings of the 30th International Conference on Advances in Geographic Information Systems*. 1–4.
- [18] Wayne Xin Zhao, Kun Zhou, Junyi Li, Tianyi Tang, Xiaolei Wang, Yupeng Hou, Yingqian Min, Beichen Zhang, Junjie Zhang, Zican Dong, et al. 2023. A survey of large language models. *arXiv preprint arXiv:2303.18223* (2023).
- [19] Stephan Zheng, Alexander Trott, Sunil Srinivasa, David C Parkes, and Richard Socher. 2022. The AI Economist: Taxation policy design via two-level deep multiagent reinforcement learning. *Science advances* 8, 18 (2022), eabk2607.