LLM-powered Agents in Social Network

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Agent Society

Human Society

Agent-based Social Network

Connections

Traditional Social Network

When Large Language Model based Agents meet User Behavior Simulation

Building a user behavior simulator based LLM-based agents

- Borrowing the human-like capability of LLM

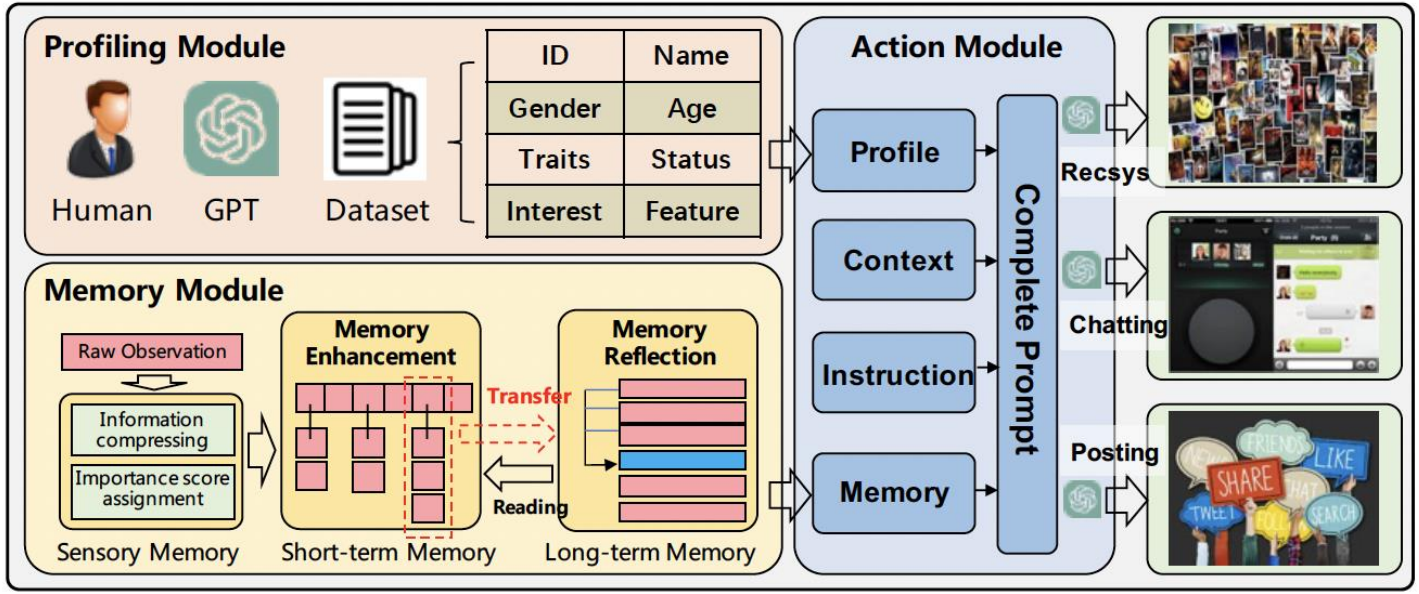
Simulating three online scenarios

- One to one chatting, one-to-many broadcasting and recommendation

Studying social phenomena based on the simulator

- information cocoon and conformity behaviors

Agent = LLM + Profiling Module + Memory Module + Action Module



Profiling Module

ID	Name	Gender	Age	Traits	Career	Interest	Feature
0	David Smith	male	25	compassionate, caring, ambitious, optimistic	photographer	sci-fi movies, comedy movies	Watcher;Critic;Poster
1	David Miller	female	39	Funloving, creative, practical, energetic, patient	writer	action movies, scifi movies, classic movies	Watcher;Explorer;Poster
2	James Brown	male	70	independent, creative, patient, empathetic	engineer	comedy movies, familyfriendly movies, documentaries, thriller movies	Watcher;Critic;Poster
3	Sarah Miller	female	33	independent, compassionate	farmer	romantic movies, comedy movies, classic movies, family-friendly movies	Watcher;Critic;Poster
4	John Taylor	male	68	optimistic	doctor	action movies, thriller movies	Watcher;Poster
5	Sarah Williams	female	51	meticulous	musician	action movies, documentaries, scifi movies, familyfriendly movies	Watcher;Explorer;Chatter
6	James Jones	male	59	practical, funloving, creative, ambitious, caring	farmer	documentaries	Watcher;Poster
7	Jane Brown	female	30	patient, adventurous, fun-loving, optimistic	doctor	documentaries	Watcher;Explorer;Poster
8	David Jones	male	23	analytical, energetic, introspective, independent	scientist	familyfriendly movies, thriller movies, action movies, sci-fi movies	Poster
9	James Brown	female	20	ambitious, analytical, optimistic, energetic, meticulous	designer	familyfriendly movies, romantic movies	Critic; Chatter
10	James Garcia	male	20	practical, energetic, introspective, patient	engineer	documentaries, thriller movies, comedy movies, classic movies, romantic movie	Watcher; Explorer; Poster

Profiling Module

Handcrafting Method

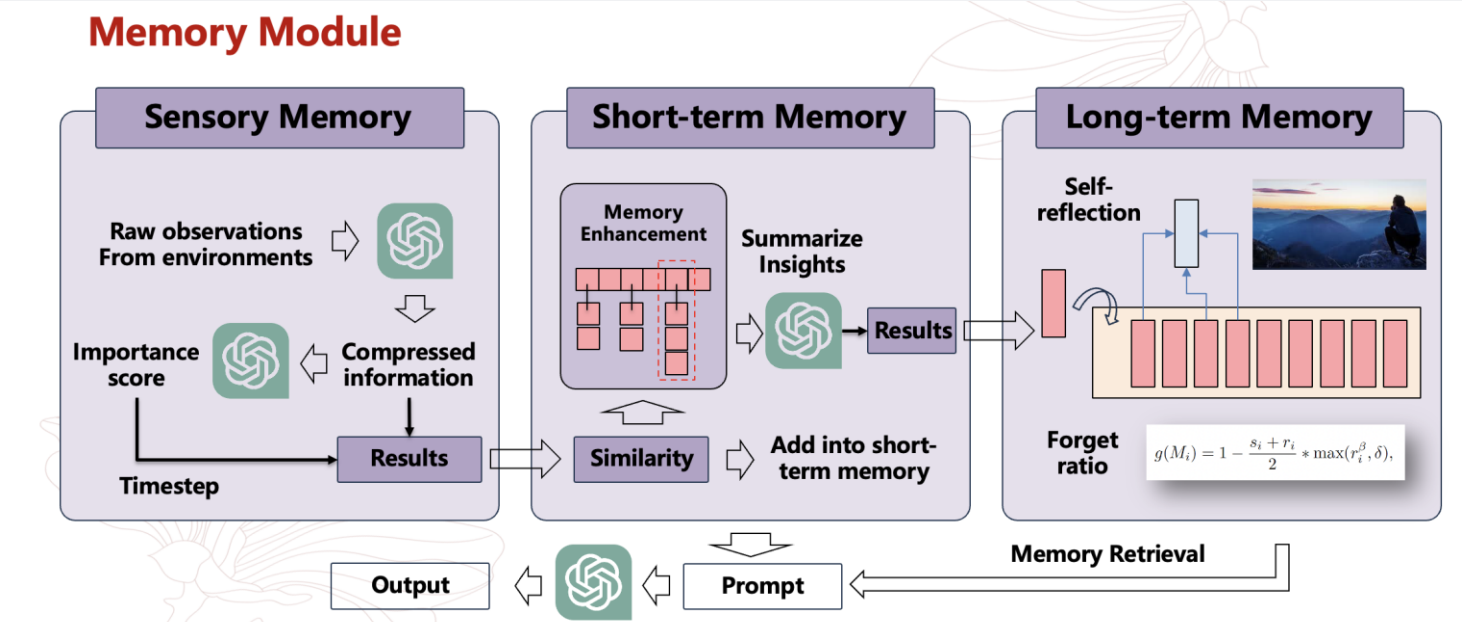
- ✓ More flexible
- ✗ Labor intensive
- ✗ Hard to scale up

GPT-generation Method

- ✗ Less flexible
- ✓ Lower expenses
- ✓ Easy to scale up

Dataset Alignment Method

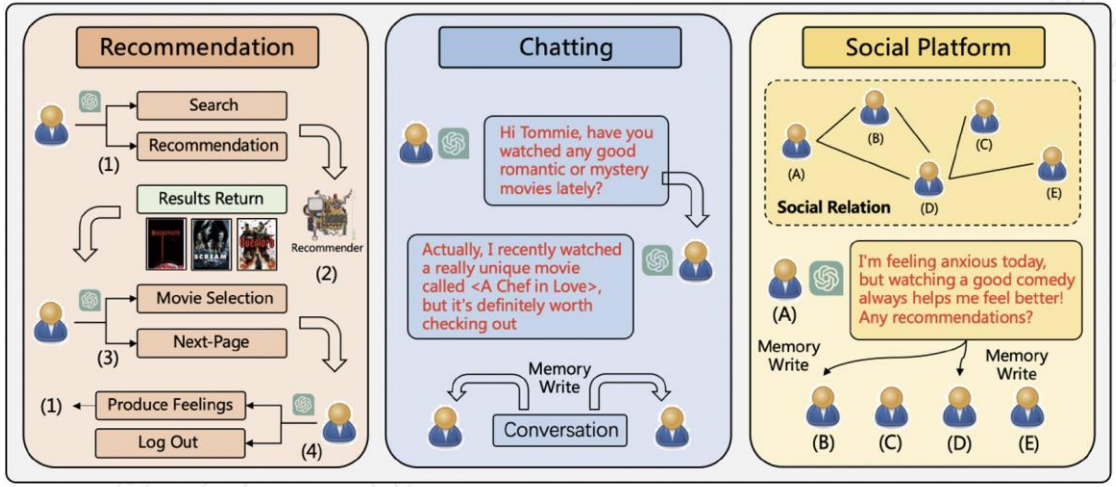
- ✗ Less flexible
- ✓ Lower expenses
- ✓ More real



Richard C Atkinson and Richard M Shiffrin. **Human memory: A proposed system and its control processes**. In Psychology of learning and motivation, volume 2, pages 89–195. Elsevier, 1968.

Action Module

Simulate more complete recommendation ecosystem



Inside Recsys

- Searching behavior
- Browsing behavior
- Watching behavior
- Next-page behavior

Outside Recsys

- One to one chatting
- One to many social broadcasting

Behavior Adaptive Prompt Generation

Name: David Smith (age: 25), David Smith, a 25-year-old male photographer, is compassionate, caring, ambitious, and optimistic. He enjoys watching sci-fi and comedy movies and provides feedback and ratings to the recommendation system. He demands high standards for movies and the recommendation system and may criticize both. The observation about David watching "The Neon Bible" aligns with his interest in drama films and explores themes of faith, family, and coming-of-age. **Profile**

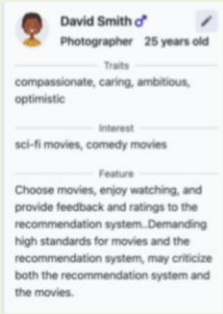
It is August 18, 2023, 12:00 AM. **Context**

Most recent observations: David Smith enjoys and finds captivating films that have captivating plots, humorous elements, thought-provoking themes, delve into complexities of human nature and sexual desire, uplift viewers, and have vibrant and engaging performances by the cast.

Observation: David Smith has just finished watching Neon Bible, The (1995):"The Neon Bible" is a drama film set in the 1940s in a small southern town in the United States. It follows the story of a young boy named David who is struggling to understand the complexities of the world around him. David\'s mother is mentally unstable and his father is absent, leaving him to navigate the challenges of adolescence on his own. As he tries to make sense of his surroundings, he turns to religion and finds solace in the teachings of his local preacher. However, his faith is tested when he discovers the secrets and hypocrisies of those around him. The film explores themes of faith, family, and coming-of-age in a poignant and powerful way. **Memory**

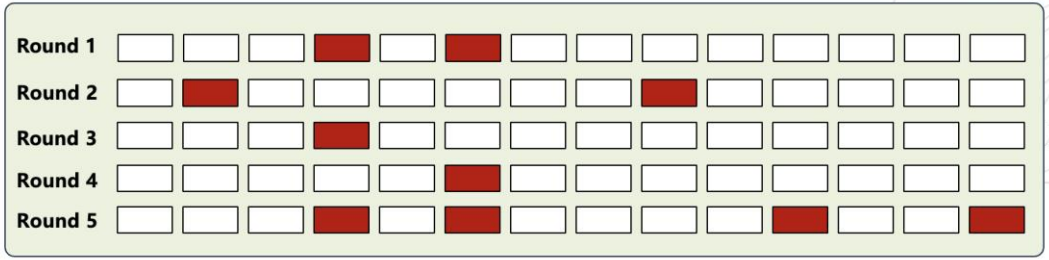
All occurrences of movie names should be enclosed with <>. David Smith has not seen this movie before. Imagine you are David Smith, how will you feel about this movie just watched? Please share your personal feelings about the movie in one line. Please act as David Smith well. **Instruction**

- **Simplified profile according to the current behavior**



- **Adaptive Memory based on the current behavior**

Execution Protocol



Pareto distribution

$$p(x) = \frac{\alpha x_{min}^{\alpha}}{x^{\alpha+1}},$$

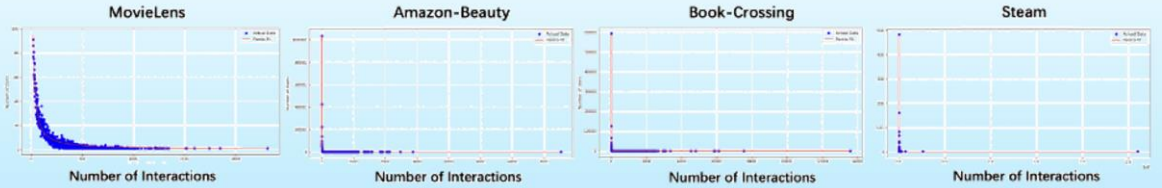
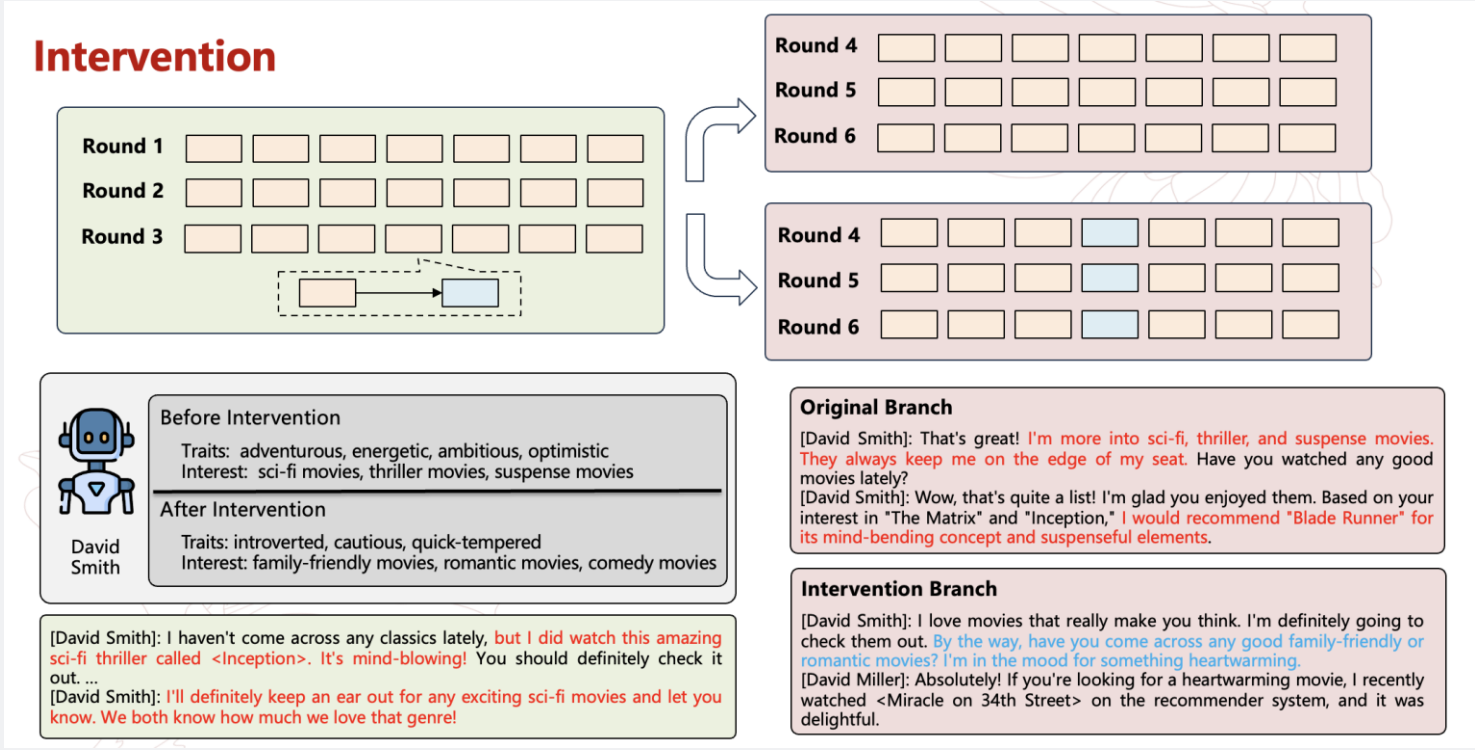
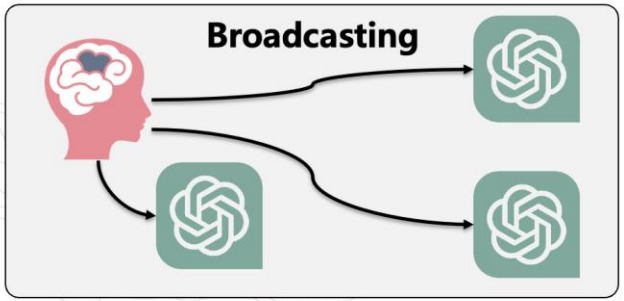


Figure 5: The results of using $p(x)$ to fit real-world datasets. The blue points are the real-world data, and the red lines are the fitted distributions.

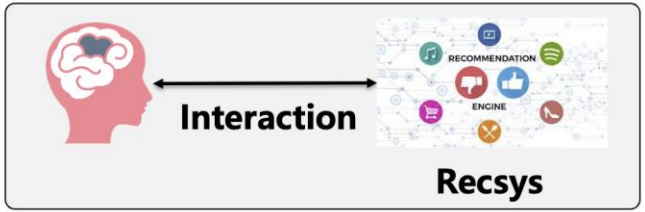


Human-Agent Collaborative Simulation

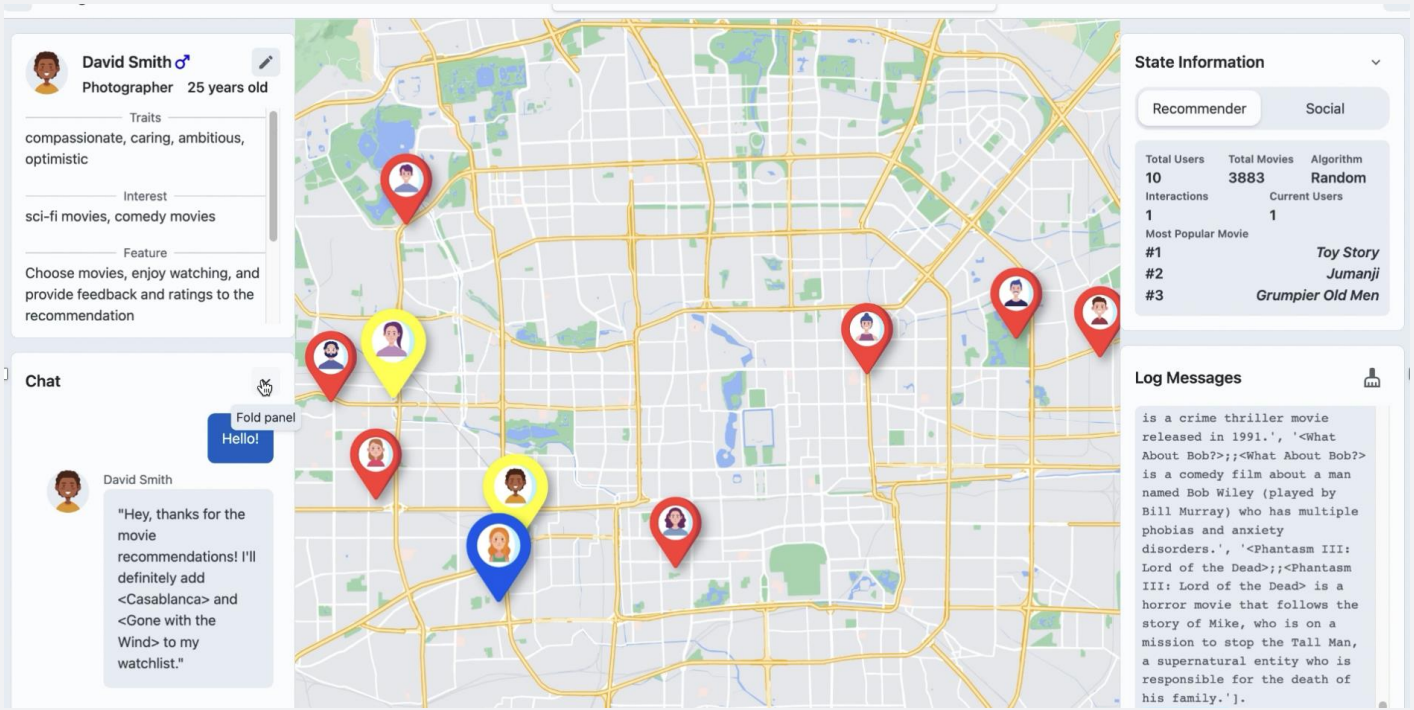
Human-agent Conversation



Human-agent social broadcasting



Human-system Interaction



Experiment Setting

Goal: whether the agent memory can produce reasonable results

- Let the agents and humans finish the same memory-related tasks
- Recruit another group of humans to judge which one is more reasonable

Results

Table 1: The results of evaluating sensory memory (T1), short-term memory (T2), and long-term memory (T3). A and B indicate the results generated by the agent and real human, respectively. ">>", ">", and "≈" mean significantly better, slight better and comparable, respectively.

	$A >> B$	$A > B$	$A \approx B$	$B > A$	$B >> A$
T1	0.6833	0.2500	0.0333	0.0333	0.0000
T2	0.3000	0.3000	0.1000	0.2500	0.0500
T3	0.2500	0.1167	0.2000	0.2500	0.1667

Experiment Setting

Goal: whether the extracted memory are informative and relevant

- Randomly sample 15 agent behaviors
- Recruit three human annotators to evaluate the extracted information
- Consider both informativeness and relevance

Results

Table 2: The results of evaluating the memory module. We use bold fonts to label the best results.

Model	Informativeness	Relevance
Memory module (w/o short)	4.09	4.02
Memory module (w/o long)	**4.55**	3.75
Memory module (w/o reflection)	4.40	3.63
Memory module	4.42	**4.09**

Experiment Setting

Goal: whether the agents can separate real items from irrelevant ones

- 20 Users from Movielens-1M
- Combine the **a** ground truths with **b** negative items
- Comparing the selection accuracy

Results

Table 3: The results of evaluating different models based on different (a, b)'s.

Model	$(a, b) = (1, 5)$	$(a, b) = (3, 3)$	$(a, b) = (3, 6)$	$(a, b) = (1, 9)$
Embedding	0.2500	0.5500	0.4500	0.3000
RecSim	0.2500	0.5333	0.3667	0.1000
RecAgent	0.5500	0.7833	0.6833	0.5000
Real Human	0.6000	0.8056	0.7222	0.5833

Experiment Setting

Goal: whether the agents can generate reliable user behavior sequences

Results

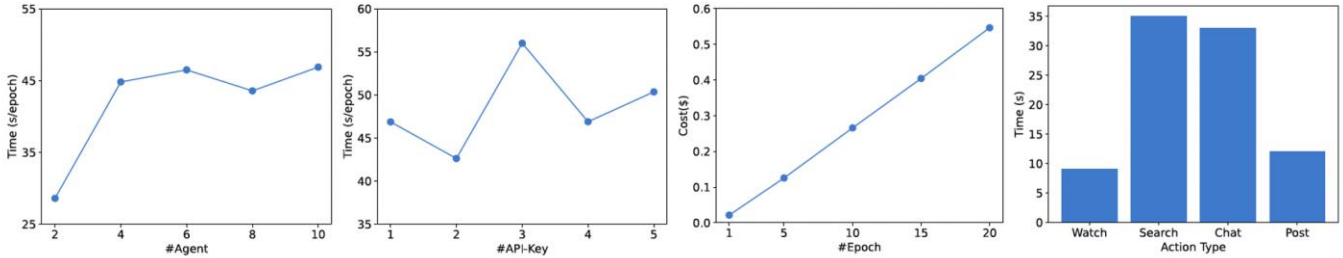
Table 4: The results of evaluating the reliability of the generated user behavior sequences (N=5).

A v.s. B	$A >> B$	$A > B$	$A \approx B$	$B > A$	$B >> A$
RecAgent v.s. RecSim	0.1500	0.3167	0.1833	0.2667	0.0833
RecAgent v.s. GT	0.1333	0.2833	0.1667	0.2667	0.1500
RecSim v.s. GT	0.1167	0.2667	0.2667	0.2167	0.1333

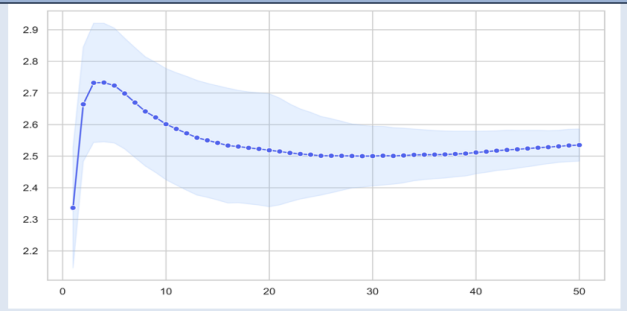
Table 5: The results of evaluating the reliability of the generated user behavior sequences (N=10).

A v.s. B	$A >> B$	$A > B$	$A \approx B$	$B > A$	$B >> A$
RecAgent v.s. RecSim	0.1833	0.4333	0.0667	0.2000	0.1167
RecAgent v.s. GT	0.2000	0.4333	0.0000	0.2000	0.1667
RecSim v.s. GT	0.1333	0.3500	0.1500	0.3000	0.0667

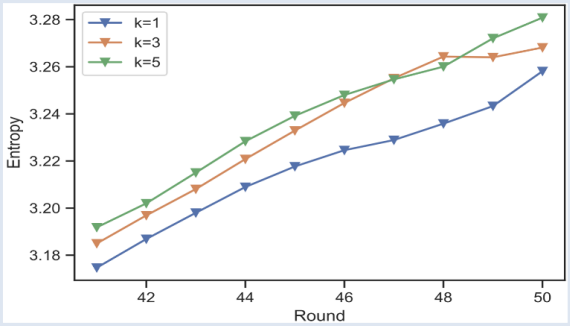
- How does the time cost increase as the number of agents become larger in each epoch?
- How does the time cost increase as the number of API keys become larger in each epoch?
- How does the time cost increase as the number epochs become larger?
- What are the time costs of different agent behaviors?



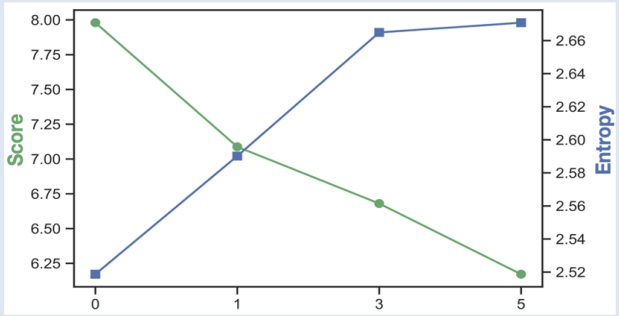
➢ Information Cocoon Room



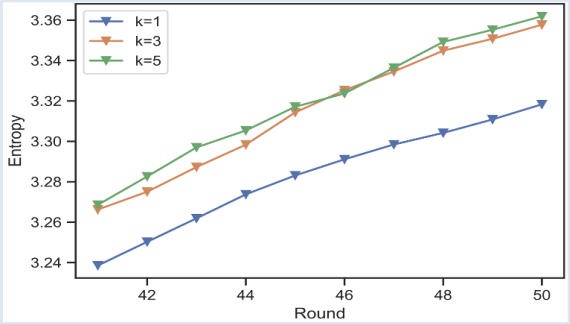
User Entropy



Random Recommendation

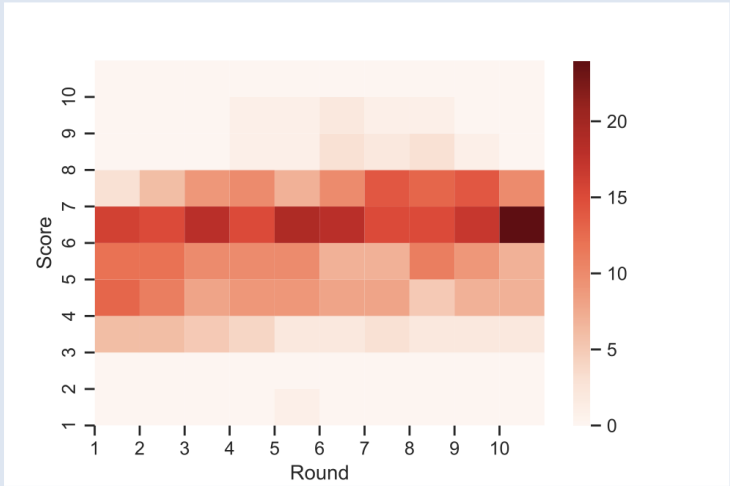


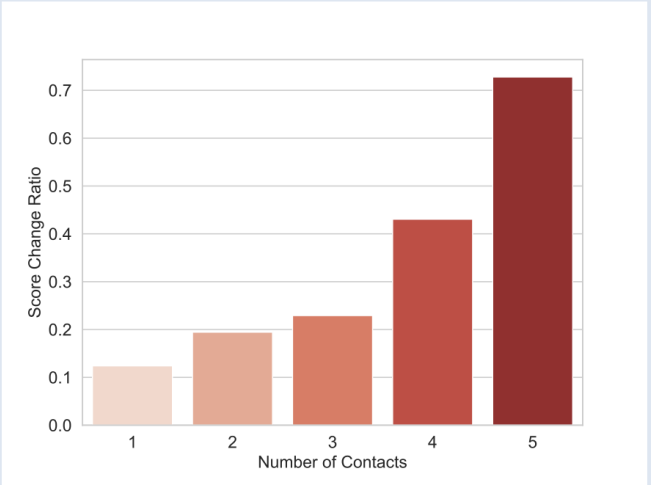
Rec Quality vs Entropy

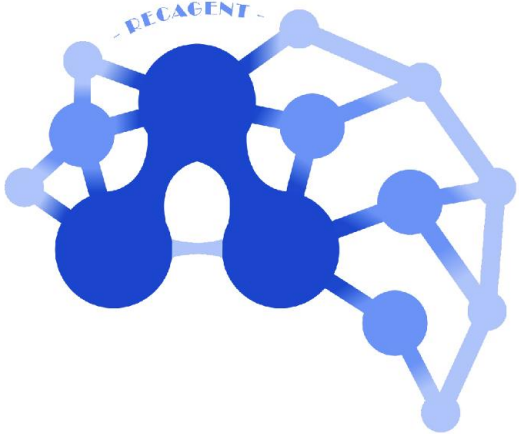


Heterogeneous friends

➢ User Conformity Behaviors



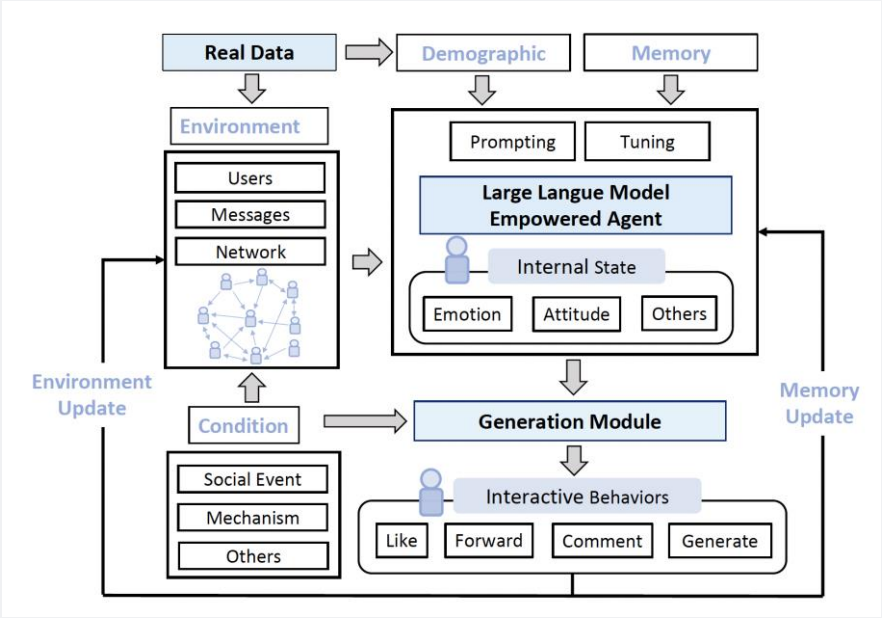




RECAGENT

Project Page: https://github.com/RUC-GSAI/YuLan-Rec
Paper Link: https://arxiv.org/pdf/2306.02552.pdf
Chinese Introduction: https://mp.weixin.qq.com/s/bfES1ieY5pTtmVfdEgX6WQ

S3: Social-network Simulation System with Large Language Model-Empowered Agents



- **Gender discrimination**
- **Nuclear energy**

Individual-level Simulation

Emotion Simulation
- *calm, moderate, and intense*

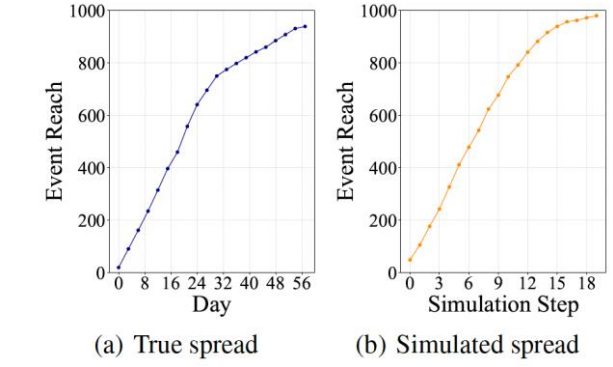
Attitude Simulation
- *negative and positive stances towards an event*

Content-generation Behavior Simulation
- *generate contents*

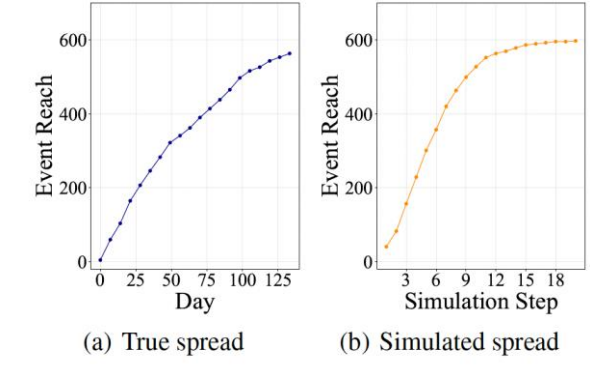
Interactive Behavior Simulation
- *forwarding, posting new content or do nothing*

Population-level Simulation

Information Propagation



Eight-child Mother Event

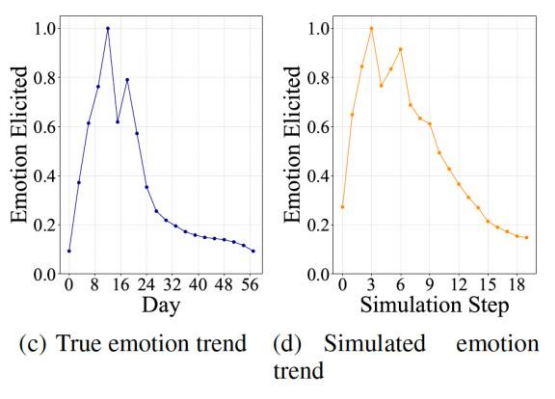


Japan Nuclear Wastewater Release Event

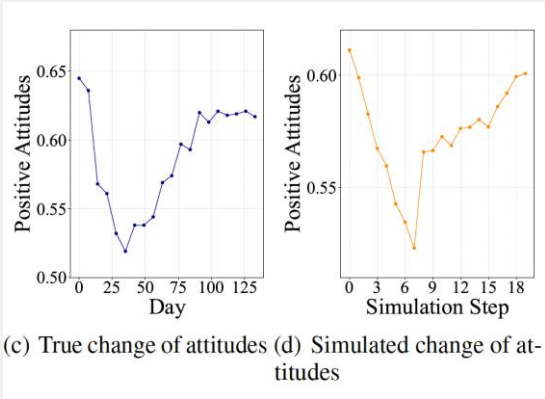
The overall number of people who have known the events at each time step

Population-level Simulation

Emotion Propagation



(c) True emotion trend (d) Simulated emotion trend



(c) True change of attitudes (d) Simulated change of attitudes

Eight-child Mother Event

Japan Nuclear Wastewater Release Event

Extract the emotional density from the textual interactions among agents

Challenges

Generalized Human Alignment

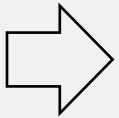
Agent based Simulation

?

Challenges

- Knowledge Boundary

Agent based Simulation



Challenges

Hallucination

The model erroneously outputs false information confidently

Challenges

Efficiency

	#Agent： 100	#Agent： 200
#API key： 10	135.2258811 s	391.95364 s
#API key： 10	395.647825 s	517.9082 s
#API key： 10	333.9154 s	425.1331 s
Avg	288.2630354 s	444.9983133 s

Lei Wang, Jingsen Zhang, Xu Chen, Yankai Lin, Ruihua Song, Wayne Xin Zhao, Ji-Rong Wen: **RecAgent: A Novel Simulation Paradigm for Recommender Systems.** CoRR abs/2306.02552 (2023)

Thanks & QA