

# LLM-powered Agents in Social Network

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## Background

### RecAgent

### S3

### Conclusion



Agent Society



Human Society

Agent-based  
Social Network



Connections

Traditional  
Social Network

# When Large Language Model based Agents meet User Behavior Simulation



Background



RecAgent



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Conclusion

## 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

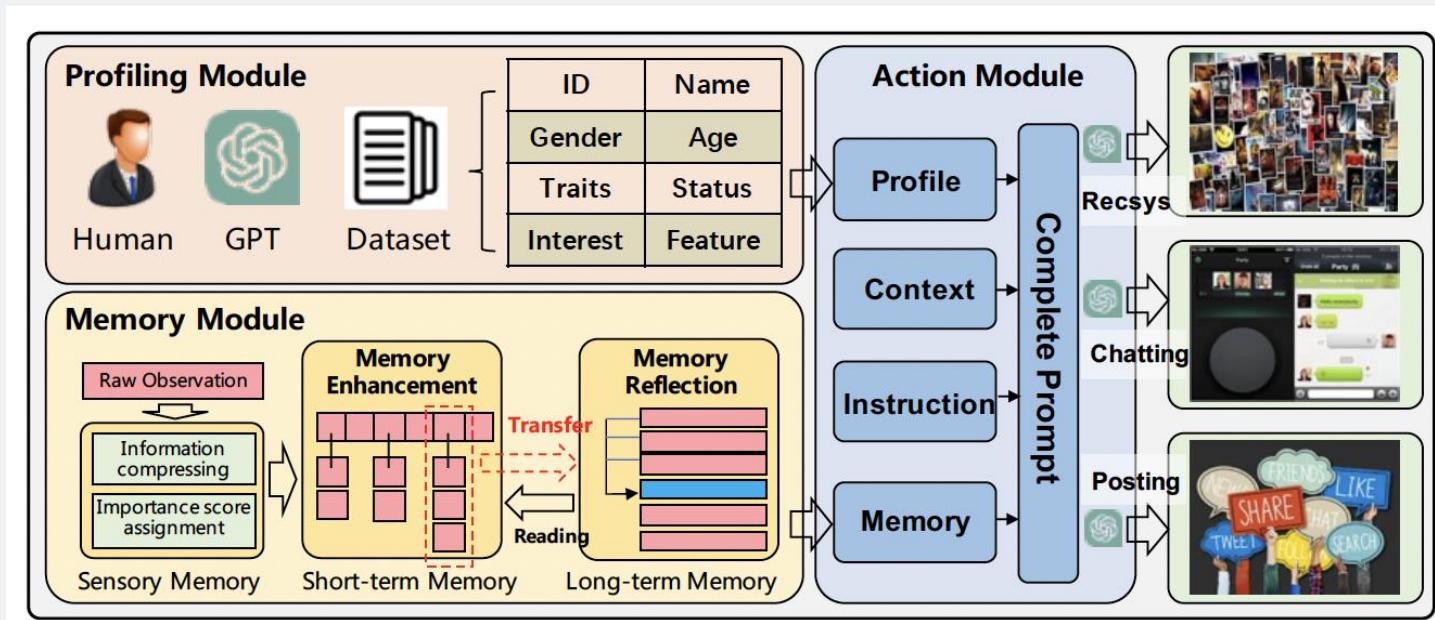
Agent = LLM + Profiling Module + Memory Module + Action Module

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# Profiling Module

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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, optimist ic, energetic, meticulous	designer	familyfriendly movies, romantic mov ies	Critic; Chatter
10	James Garcia	male	20	practical, energetic, introspect ive, patient	engineer	documentaries, thriller movies, comedy movies, classic movies, romant ical 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



Background



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Conclusion

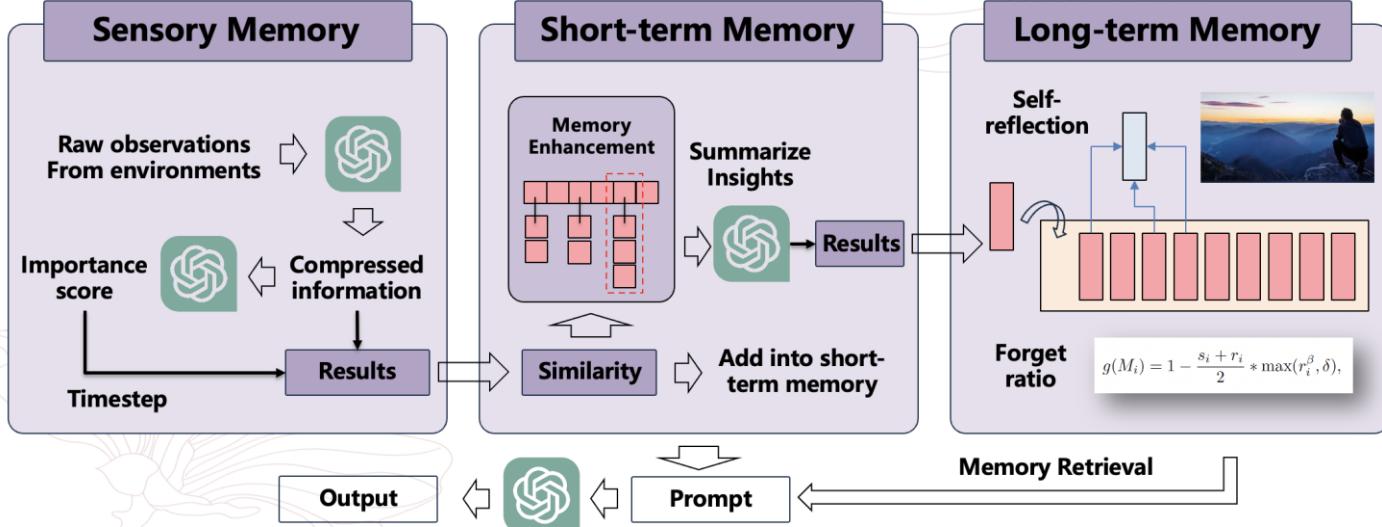
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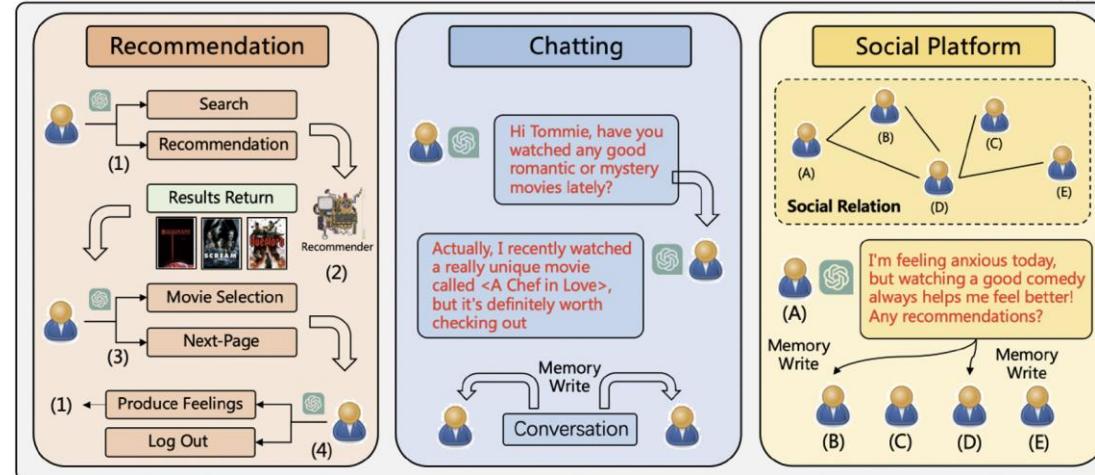
## Memory Module



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



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#### 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.

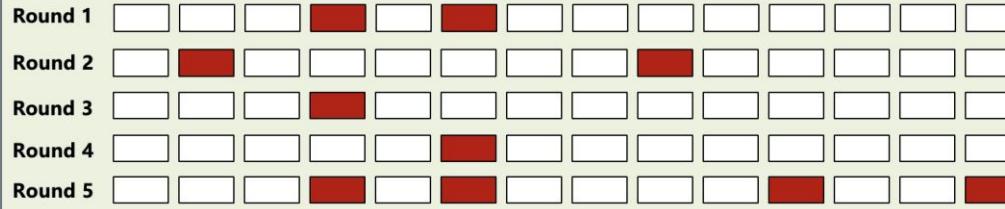
[Instruction](#)

➤ Simplified profile according to the current behavior

 David Smith ♂	Photographer 25 years old	
<b>Traits</b>		
compassionate, caring, ambitious, optimistic		
<b>Interest</b>		
sci-fi movies, comedy movies		
<b>Feature</b>		
Choose movies, enjoy watching, and provide feedback and ratings to the recommendation system. Demanding high standards for movies and the recommendation system, may criticize both the recommendation system and the movies.		

➤ 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.

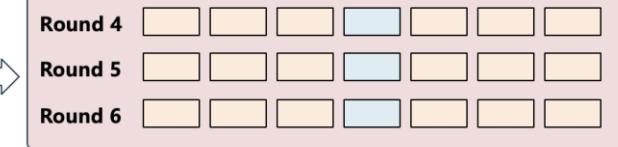
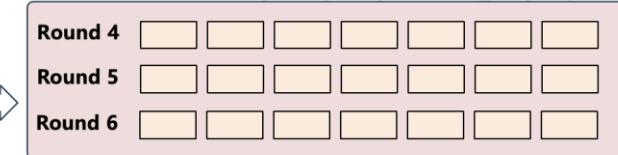
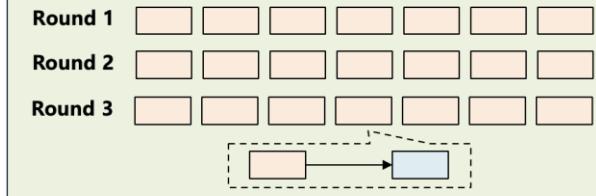
Background

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## Intervention





**Before Intervention**

Traits: adventurous, energetic, ambitious, optimistic  
Interest: sci-fi movies, thriller movies, suspense movies

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**After Intervention**

David Smith

Traits: introverted, cautious, quick-tempered  
Interest: family-friendly movies, romantic movies, comedy movies

[David Smith]: I haven't come across any classics lately, but I did watch this amazing sci-fi thriller called <Inception>. It's mind-blowing! You should definitely check it out...  
 [David Smith]: I'll definitely keep an ear out for any exciting sci-fi movies and let you know. We both know how much we love that genre!

### Original Branch

[David Smith]: That's great! I'm more into sci-fi, thriller, and suspense movies. They always keep me on the edge of my seat. Have you watched any good movies lately?

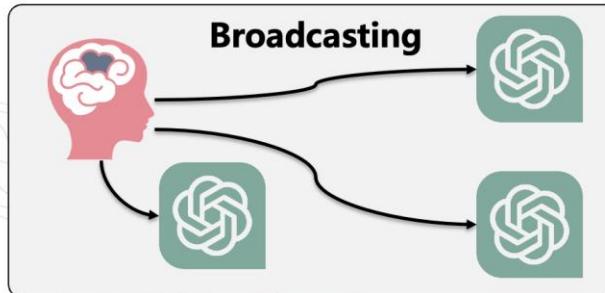
[David Smith]: Wow, that's quite a list! I'm glad you enjoyed them. Based on your interest in "The Matrix" and "Inception," I would recommend "Blade Runner" for its mind-bending concept and suspenseful elements.

### Intervention Branch

[David Smith]: I love movies that really make you think. I'm definitely going to check them out. By the way, have you come across any good family-friendly or romantic movies? I'm in the mood for something heartwarming.

[David Miller]: Absolutely! If you're looking for a heartwarming movie, I recently watched <Miracle on 34th Street> on the recommender system, and it was delightful.

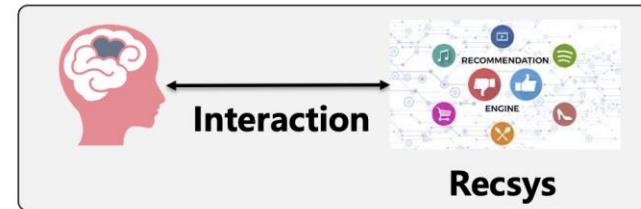
## Human-Agent Collaborative Simulation



Human-agent social broadcasting



Human-agent Conversation



Recsys

Human-system Interaction

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## Background

## RecAgent

## S3

## Conclusion

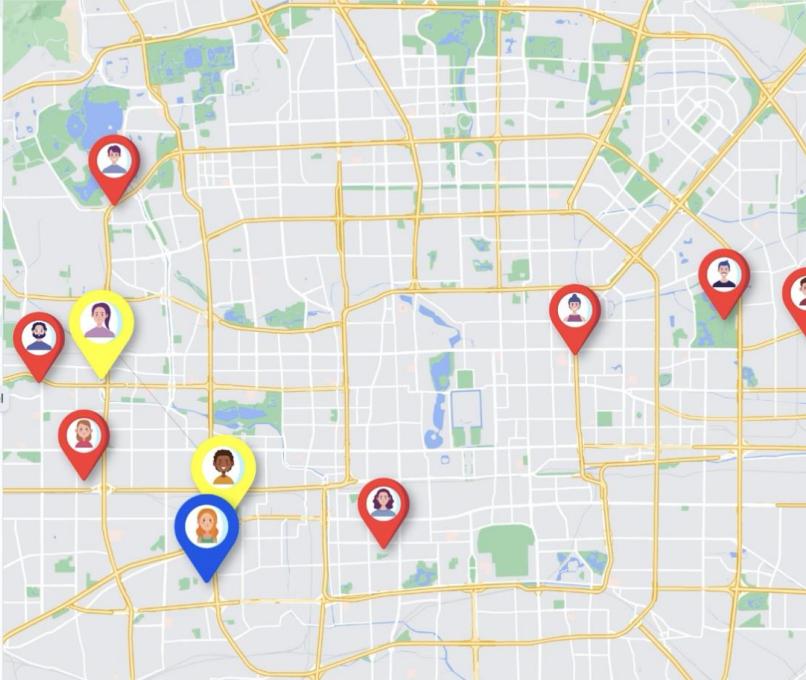
**Profile:** David Smith ♂  
Photographer 25 years old

- Traits:** compassionate, caring, ambitious, optimistic
- Interest:** sci-fi movies, comedy movies
- Feature:** Choose movies, enjoy watching, and provide feedback and ratings to the recommendation

**Chat:**

Fold panel Hello!

David Smith  
 "Hey, thanks for the movie recommendations! I'll definitely add <Casablanca> and <Gone with the Wind> to my watchlist."



**State Information**

Recommender	Social
Total Users 10	Total Movies 3883
Interactions 1	Algorithm Random
Current Users 1	
Most Popular Movie #1 Toy Story	
#2 Jumanji	
#3 Grumpier Old Men	

**Log Messages**

```

is a crime thriller movie
released in 1991.', '<What
About Bob?>;<What About Bob?>
is a comedy film about a man
named Bob Wiley (played by
Bill Murray) who has multiple
phobias and anxiety
disorders.', '<Phantasm III:
Lord of the Dead>;<Phantasm
III: Lord of the Dead> is a
horror movie that follows the
story of Mike, who is on a
mission to stop the Tall Man,
a supernatural entity who is
responsible for the death of
his family.'].

```

## 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 “ $\approx$ ” 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)	<b>4.55</b>	3.75
Memory module (w/o reflection)	4.40	3.63
Memory module	4.42	<b>4.09</b>

## 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

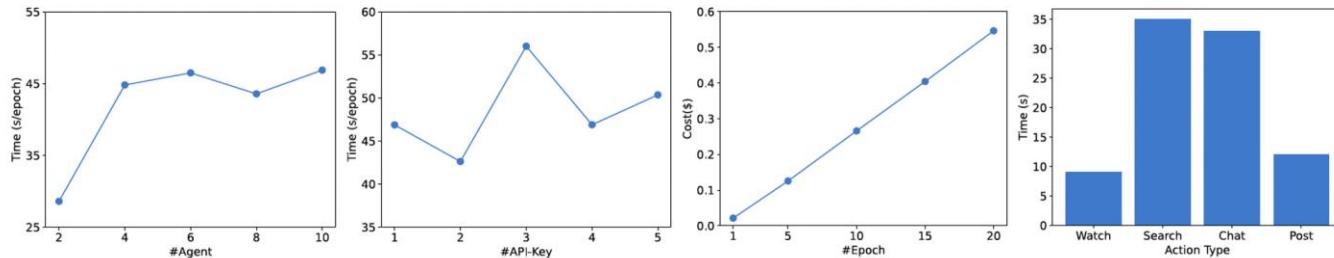
Table 4: The results of evaluating the reliability of the generated user behavior sequences (N=5).

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?



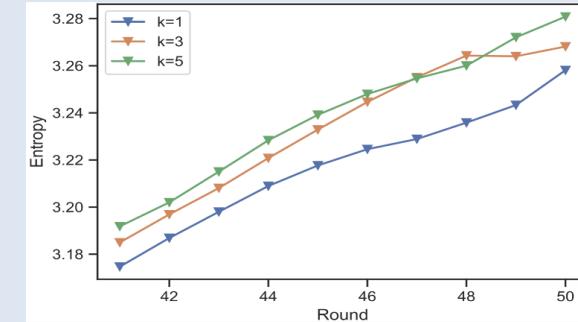
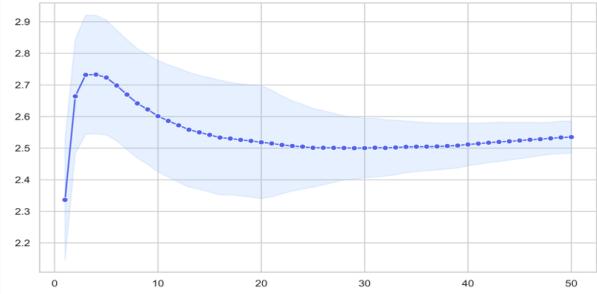
Background

RecAgent

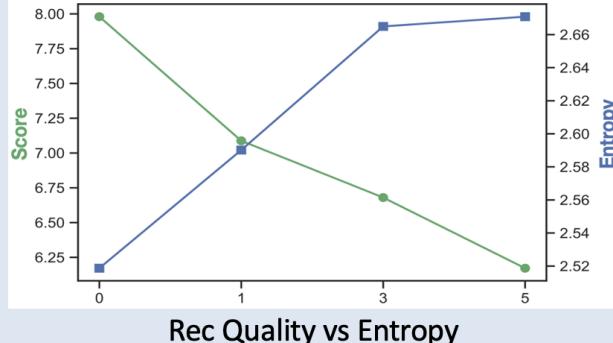
S3

Conclusion

## ➤ Information Cocoon Room

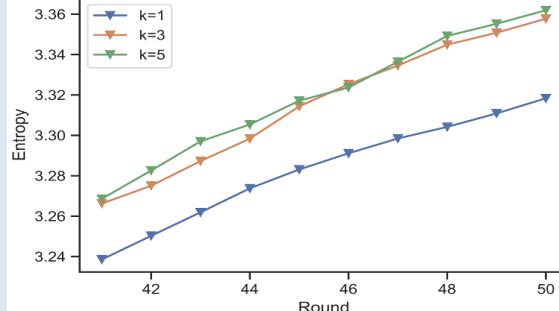


## User Entropy



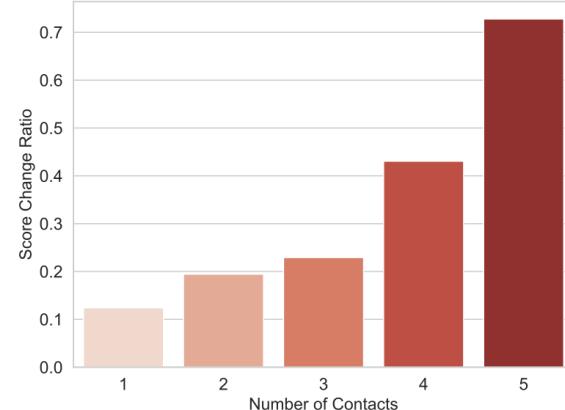
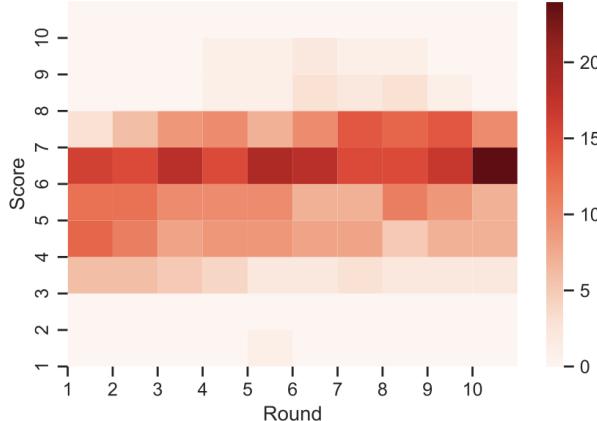
## Rec Quality vs Entropy

## Random Recommendation



## Heterogeneous friends

### ➤ User Conformity Behaviors

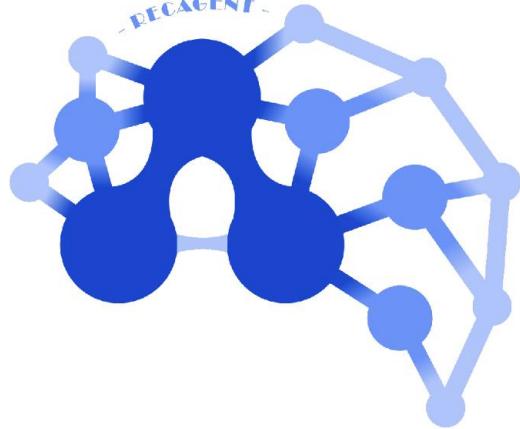


Background

RecAgent

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# 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>

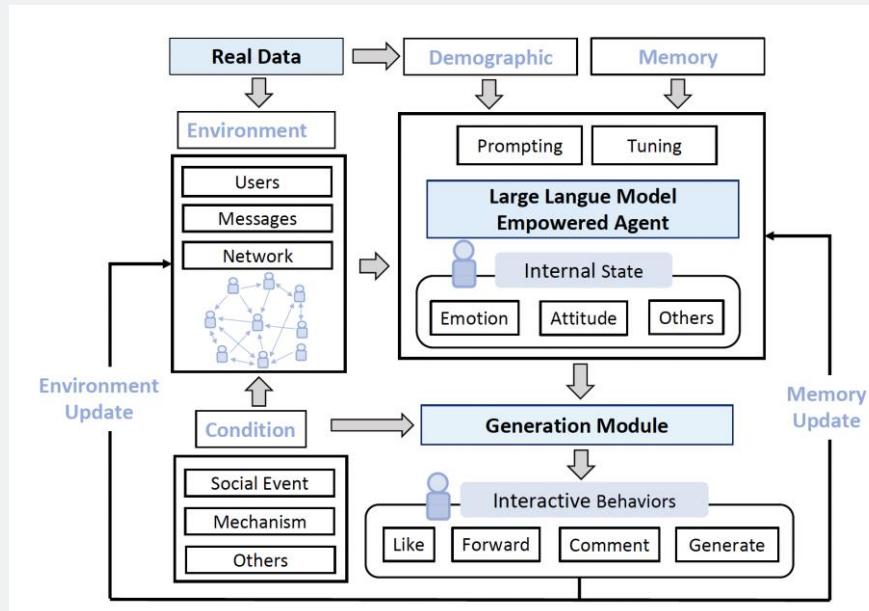
## S3: Social-network Simulation System with Large Language Model-Empowered Agents

Background

RecAgent

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Conclusion



- **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*



Background



RecAgent



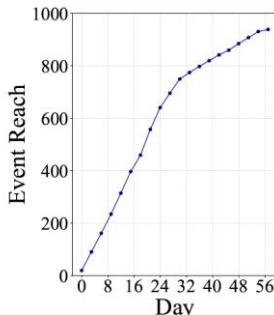
SS



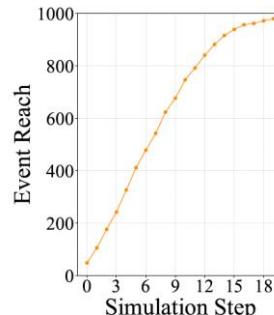
Conclusion

## Population-level Simulation

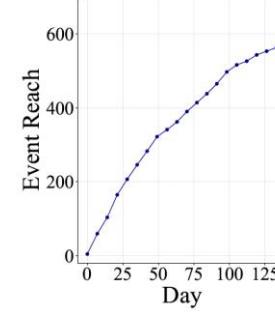
### Information Propagation



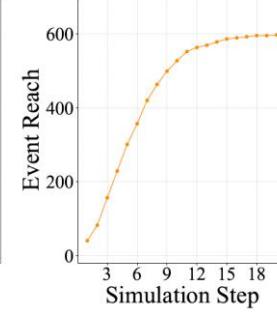
(a) True spread



(b) Simulated spread



(a) True spread



(b) Simulated spread

### 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

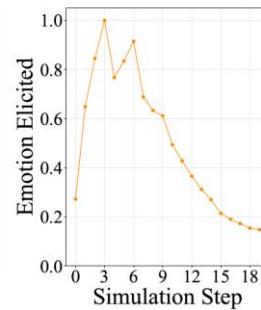
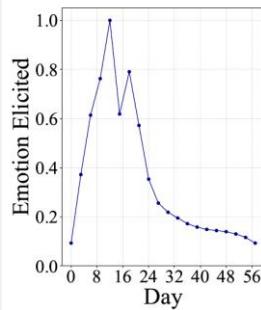
### Emotion Propagation

Background

RecAgent

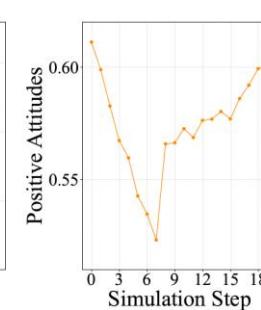
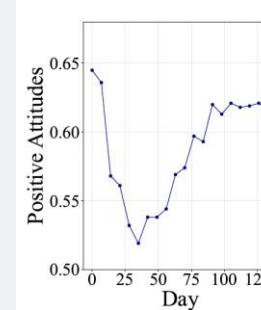
S3

Conclusion



Eight-child Mother Event

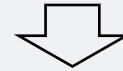
Extract the emotional density from the textual interactions among agents



Japan Nuclear Wastewater Release Event

# Challenges

- Generalized Human Alignment



## Agent based Simulation



?



Background



RecAgent



S3



Conclusion

## Challenges

- Knowledge Boundary

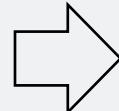
Background

RecAgent

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## Agent based Simulation



## Challenges

### └ Hallucination



**The model erroneously outputs false information confidently**



Background



RecAgent



S3



Conclusion

## Challenges

### Efficiency

Background

RecAgent

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Conclusion

	#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

# Thanks & QA

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