

# Assessing Multi-Generative Agent Collective Decision

## A Case Study for Kendall Square Renovation

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### Abstract

In this study, we develop a multiple-generative agent system to simulate community decision-making for the redevelopment of Kendall Square's Volpe building. Drawing on interviews with local stakeholders, our simulations incorporated varying degrees of communication, demographic data, and life values in the agent prompts. The results revealed that communication among agents improved collective reasoning, while the inclusion of demographic and life values led to more distinct opinions. These findings highlight the potential application of AI in understanding complex social interactions and decision-making processes, offering valuable insights for urban planning and community engagement in diverse settings like Kendall Square.

## 1 Introduction

### 1.1 Background

A large language model (LLM) is a machine learning model designed to generate human-like text based on the patterns it has learned from extensive amounts of data. Over recent years, LLMs such as ChatGPT have improved remarkably, showcasing their proficiency not just in mimicking human conversation but also in transferring knowledge, generalizing across different contexts, and even demonstrating capabilities in reasoning and planning. This evolution has been pivotal in natural language interactions, allowing these models to respond to human queries and statements with increasing accuracy and relevance. Thanks to these abilities, LLMs have been used to develop generative agents, a.k.a chatbots, to assist humans in various applications including automated help desks, content creation, and educational tutoring. The advancement in LLM technology has catalyzed a paradigm shift in how we utilize and interact with AI in everyday scenarios, underscoring the versatility and adaptability of these models in understanding and engaging in human-like dialogue.

Building on the foundation of LLMs, the concept of multi-generative agent systems has emerged as an intriguing and innovative area of research. These systems involve multiple generative agents, each potentially possessing distinct personalities or specialized knowledge domains, interacting and communicating with each other. The scope of these multi-agent systems varies widely. Some are designed merely to facilitate communication among agents, creating a dynamic where different AI personalities or areas of expertise can interact in a coordinated manner. Others venture into the realm



Figure 1: Multi-generative agent simulations from [Park et al., 2023] and [Chen et al., 2023]

of collaborative learning, where agents are trained to work together towards common goals or tasks, harnessing the power of collective intelligence.

## 1.2 Motivation

One potential application of the multi-generative agent system is to simulate the collective decisions of a community. Modeling potential stakeholder discussions provides a predictive lens into their reactions to proposals. This foresight allows decision-makers to anticipate concerns, objections, or support, enabling them to refine and adjust decisions before public release. Consequently, the system can lead to more inclusive and cost-effective decisions. Ultimately, it bridges the gap between decision-makers and stakeholders, ensuring better alignment with community needs and sentiments.

The deployment of multi-generative agent systems to simulate community decision-making processes, while innovative, carries significant societal and ethical risks that must be carefully considered. A primary concern is the potential for misrepresentation of stakeholders. If the agents within these systems are not meticulously designed to reflect the full spectrum of views and demographics present in a community, simulated decisions may fail to address the needs and concerns of the entire community, thereby undermining the inclusiveness and fairness of the decision-making process. Additionally, there are profound privacy and ethical considerations, particularly when agents are modeled on specific individuals, such as experts in a field. Using a person's public research and opinions to construct an agent's responses might raise questions about consent and the ethical use of personal data, potentially infringing on individual privacy rights. Furthermore, a crucial risk lies in the amplification of existing biases. If the data used to train and inform these agents is biased, the system could inadvertently reinforce and perpetuate these biases in its simulations. This scenario is particularly concerning as it can lead to the proposal and validation of policies that exacerbate societal inequalities or prejudices rather than promoting equitable and just outcomes. Therefore, while multi-generative agent systems offer exciting possibilities for simulating community decisions, their development and application must be approached with a keen awareness of these societal and ethical implications to ensure they serve as tools for positive and inclusive decision-making.

## 1.3 Project Objective

In this project, we develop a multi-generative agent system to simulate the collective decision for a small community backed by real-world surveys. As we design the system, we seek to answer the following questions: *"How do communication, agent life values and demographic variables impact collective decisions? Should we include demographic variables when designing such a multi-generative agent system?"* We will test the hypothesis in the context of urban planning, where multiple stakeholders of various demographics will be defined to discuss and propose a property development plan in Kendall Square, Cambridge, Massachusetts.

# 2 Literature Review

## 2.1 Multi-Generative Agent System

Thanks to LLM's capabilities of transferring, generalization, reasoning, and planning with long conversation contexts, they have the potential to be used collaboratively as multi-generative agent systems in which multiple agents, driven by LLM, with diverse personalities, communicate and interact with each other to simulate a community.

Zhiheng Xi et al.[[Xi et al., 2023](#)] perform a comprehensive survey of the related topic with the paper The Rise and Potential of Large Language Model Based Agents: A Survey. Dated back from the emergence of Natural Language Processing (NLP) technologies to the current (2023) innovative applications, this paper reveals the potential of AI agents as a broader decision-making approach.

In other fields, Artificial Intelligence (AI) agents are increasingly being deployed as auxiliary decision-making tools across various fields. In the realm of economics, Zheng et al. [[Zheng et al., 2021](#)] have developed the AI Economist, a two-level deep reinforcement learning framework. This framework is designed to facilitate the design of optimal economic policies by learning from both agents and a social planner that co-adapts to dynamic conditions. Their approach is particularly effective in

Paper Title	Authors	Proposal	Framework Name
Generative Agents: Interactive Simulacra of Human Behavior	Joon Sung Park et al. [Park et al., 2023]	A town use multiple generative agents to live together	Generative Agents
AgentVerse: Facilitating Multi-Agent Collaboration and Exploring Emergent Behaviors	Weize Chen et al. [Chen et al., 2023]	A framework to facilitate the creation of the discussion between multi LLM agents through prompt regulation and processing	AgentVerse
Communicative Agents for Software Development	Chen Qian et al.[Qian et al., 2023]	A system where agents can communicate and assist internally as a virtual software development company.	ChatDev
AutoGen: Enabling Next-Gen LLM Applications via Multi-Agent Conversation	Qingyun Wu et al. [Wu et al., 2023]	A framework to facilitate the creation of multi LLM agents with the flexibly define agent interaction behaviors.	AutoGen
XAgent: An Autonomous Agent for Complex Task Solving	X Agent Team et al. [Team, 2023]	A framework to facilitate the creation of multi LLM agents, built on previous projects	XAgent

Table 1: Summary of Frameworks from Selected Papers

formulating tax policies that balance social welfare with economic productivity, showcasing a novel computational method for economic policy experimentation.

In the marketing realm, Athey et al. [Athey et al., 2020] delve into the decision-making dynamics between human agents and AI. They propose a model where a principal must decide between delegating decision authority to a human agent or an AI, weighing the AI’s alignment with desired outcomes against the need for human agents to be motivated through decision authority. Their insights reveal how organizational design can influence AI training and the integration of AI in strategic decision-making.

## 2.2 Urban Planning Decision-Making

Across government systems, cities’ decision-making mechanisms vary greatly. Urban policy is implemented at multiple levels, creating complexity in urban decision-making. [Parysek, 2010] In this study, we chose the Planning Council of Cambridge, Massachusetts, USA as the research object to understand how the city’s decision-making system operates through the K2C2 research project and hearing records

K2C2 (Kendall to Central Square Planning Study) [City of Cambridge, 2013] is an urban planning research project focusing on the Cambridge city center and Kendall Square area. The project involves extensive community engagement and multifaceted research to develop strategies for sustainable development, transport, housing, and public space. The City of Cambridge stresses the involvement of community members. The decision-making group is formed by a cross-disciplinary advisory board formed by government officers and the representative public. This design provides broad opportunities for residents to express their views and make suggestions about planning proposals.

We also interviewed Professor Shen, who was the Former Director of Planning at the Boston

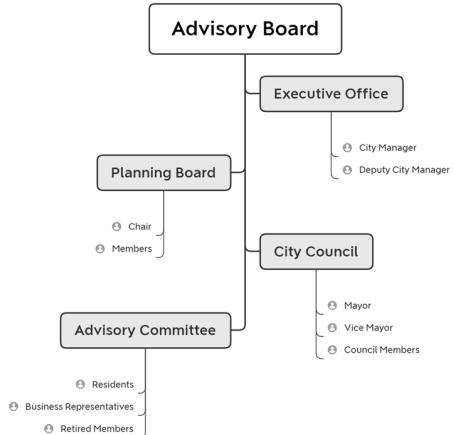


Figure 2: Stakeholders in K2C2 Study

Redevelopment Authority for more than ten years. Drawn from his experiences of rezoning, We can conclude the urban decision-making process into three steps:

- Proposal: Individuals, groups, or organizations can put forward their planning proposals, including but not limited to rezoning requests, infrastructure modification, and real estate developments.
- Internal and external meetings and hearings: After a proposal is submitted, there will be a series of meetings and consultations. Proponents and other stakeholders have the opportunity to express their views and concerns. Some events will be publically available, allowing community members to participate and provide feedback.
- Lobbying officials: Lobbying government and planning committee members is an important step for proponents. This often involves showing how their proposal fits the city's overall planning goals and meets the needs of the community.
- Vote: The city planning committees made by six government officers made the final decision through a voting process. If the majority of voters agree on the proposal, then it will be passed and step forward to the executive process.

The entire process emphasizes multi-party involvement and disagreement. In principle, the purpose is to ensure that a variety of interests and perspectives are fully considered. However, in practical scenarios, the tug-of-war among too many stakeholders can lead to prolonged and complex decision-making processes. During the whole process from proposal initiative to final vote, stakeholders who need to come forward with their own proposals will need to lobby officials to have their requests considered. This often results in delays and complications, reflecting the challenges inherent in balancing various interests in urban planning.

The final decision is made by vote from 6 main urban planning committees. The residents or groups who need to propose their own proposal need to lobby the officers to make their request under consideration. The whole process is chaotic and takes an extremely long time, with unexpected cases and numerous negotiations.

## 3 Methodology

### 3.1 Framework and Agent Design

We use the AutoGen framework by Microsoft [Wu et al., 2023] to develop our multi-generative agent system. AutoGen is suitable for this project due to its flexibility in defining agent roles and interactions, ease of programming interactions, and the ability to integrate LLMs, human inputs, and tools. Agents can be customized with various capabilities, including LLMs, human input, and tools, and can autonomously engage in multiple rounds of conversation. Conversation programming allows for the streamlining of complex workflows into multi-agent conversations, combining natural and programming languages. This approach supports dynamic and intuitive workflows, simplifying the development of intricate applications with diverse conversation patterns such as one-to-one conversation, hierarchical chat, group chat, etc.

Since we simulate the Kendall Square community, we refactor the AutoGen framework to facilitate a group chat as follows (See Figure 3):

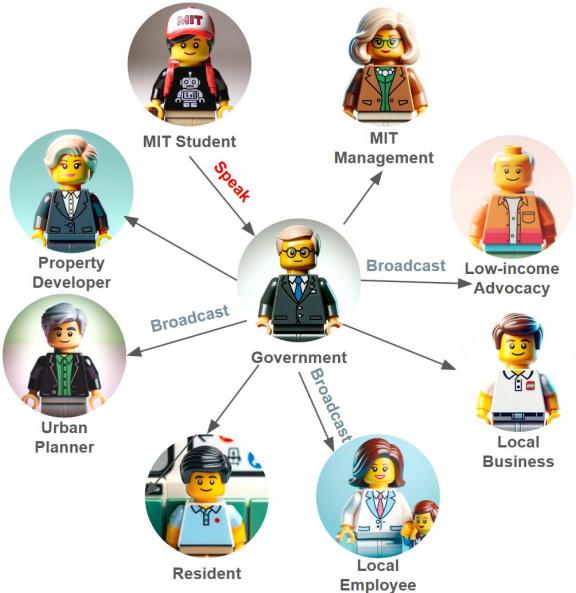


Figure 3: Communication setup to facilitate group discussion

The government is an admin agent, coordinating the group chat. A discussion begins with a topic from the government. Each generative agent takes turns to opine about the topic. When a generative agent speaks, the government collects the message and broadcasts it to all other generative agents in the group so that all the agents receive and process each other's opinions. The government also represents a user-agent to convey human controllers' messages to the group.

We developed eight generative agents representing eight different stakeholders in Kendall Square, including MIT Students, Local employees, residents, Local Businesses, Urban planners, MIT Management, Property Developers, and Low-income Advocates. Each generative agent connects to ChatGPT-4 Turbo APIs, starting with a prompt to describe a stakeholder. The prompt consists of five components: Role, Demographic, Daily Life/Value, Task, and Format. Below is a sample prompt. The prompts of all stakeholders can be found in Section [Prompts](#).

- **Role** is a high-level description of the stakeholder
- **Demographic** is demographic variables such as age, gender, race, ethnicity, etc.
- **Daily Life/Value** is a detailed description of the stakeholder's daily life or personal opinion based on the survey or interview of an actual person in Kendall Square
- **Task** and **Format** are the same for all agents to ensure the agents participate in the discussion based on their own description within the ChatGPT API limit.

Stakeholder	Agent Prompt
MIT Student	<p><b>"Role"</b>: "You are a Masters student at MIT, living in an MIT graduate dormitory which is located between Kendall Square and Central Square in Cambridge.",</p> <p><b>"Demographic"</b>: "You are an Asian male, in your twenties. You moved to U.S. from Singapore for study.",</p> <p><b>"Daily Life"</b>: "You spend most of the time on campus. You walk to school in the morning and come back home late at night. Sometimes, you hang out with friends in Central Square. Sometimes you feel unsafe due to homeless and mentally disordered people gathering in Central Square. You prefer convenient and safe place so that you can study and hang out with friends anytime.",</p> <p><b>"Task"</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>"Format"</b>: "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>

Table 2: The prompt to create MIT student agent

### 3.2 Prompt Development

The agent prompt is developed based on actual interviews conducted in Kendall Square in 2018 by a Kendall Square mobility research group at MIT. The interviews include questions about the interviewees' work and life as well as their opinions about Kendall Square Initiative, which is an urban development project in Main Street to revitalize the area and make it a new modern entrance into Cambridge and MIT.

On top of that, we conducted our own interviews with a professor at MIT Urban Planning Department whose data are used to develop the urban planner agent. We also interviewed a researcher at MIT Center for Transportation and Logistics, who is passionate about equity and social benefits, to develop the low-income advocate agent.

Due to the token limit of ChatGPT API, we cannot include all the interviews in the prompt. We summarize the interviews into the Role, Demographic, and Daily Life of the agents.

### 3.3 Kendall Square Development Proposal

Kendall Square, often hailed as the most innovative square mile on the planet, stands as a bustling epicenter of scientific, technological, and entrepreneurial activity. Nestled in the heart of Cambridge, Massachusetts, this vibrant district is not just a geographical location but a symbol of progress and innovation. Its history traces back to the industrial era when it played a pivotal role in manufacturing. Over time, Kendall Square underwent a dramatic transformation, evolving into a hub for biotech, IT, and cutting-edge research institutions. This evolution has been significantly influenced by its proximity to the Massachusetts Institute of Technology (MIT). MIT's presence has been a catalyst, attracting a plethora of startups, established tech giants, and research facilities, thereby fostering an environment of collaboration and innovation. Today, Kendall Square is not just a modern entrance to the MIT campus but a global beacon of technological advancement and entrepreneurial spirit.

In 2017, as a part of the Kendall Square Initiative, the U.S. General Services Administration (GSA) agreed to hand John A. Volpe National Transportation Systems Center, or simply Volpe, located at the center of Kendall Square, over to MIT for urban development [MIT, 2021] (See Figure 4). For the sake of the simulation, we provide two proposals for the use of this 14-acre land:

1. Develop **low-income housing** to address homelessness and rising living costs in Cambridge
2. Develop **a shopping mall** to create jobs and stimulate local economy

Due to the limited land space and financial budget, we can only afford one of these two proposals. We ask the agents to discuss and decide how they agree or disagree with the proposals. The prompt to specify the proposals' details and initiate the discussion among the agents can be found in Section [Prompts](#).

### 3.4 Simulation

To facilitate the discussion among the agents, we setup the simulation run as the following steps:

1. The generative agents are initialized with the profile prompt
2. The government starts the discussion by providing the problem context, the proposals as well as pros and cons of each proposal
3. The government requests all agents to provide their opinions
4. When an agent speaks to the government, the message is broadcast to all other agents to ensure all agents are aware of each other opinions
5. Once all agents have spoken, the government requests all agents to vote from 0 (disagree) to 10 (agree) for each proposal.

As ChatGPT APIs allow a temperature parameter ranging from 0 (deterministic) to 2 (creative), which decides the randomness and creativity of the agents' response, we keep the temperate parameter as 1 (default value). The agents may generate different results for each run. We repeat the run 3 times and record all results for analysis purposes.

As our project objective is to assess how the communication, survey data, and demographic variables impact the agents' decisions, we twist the Agent prompt to assess the impact of these factors. We conduct 4 different simulation setups as per Table 3.

In setup 0, no communication means the agent does not receive the opinion of the other agent. In this round, we set up a GPT with the MIT Student prompt and asked its opinion on the proposals. We

Setup	Comm.	Role	Demographic	Life/Value	Task	Format	Purpose
0	✗	✓	✗	✓	✓	✓	Compare with Setup 2 to assess the impact of communication
1	✓	✓	✗	✗	✓	✓	Compare with Setup 2 to assess the impact of Daily Life and Value (from Survey Data)
2	✓	✓	✗	✓	✓	✓	Compare with Setup 3 to assess the impact of Demographic variables
3	✓	✓	✓	✓	✓	✓	

Table 3: Four different setups to assess the impact of Communication, Survey Data, and Demographic variables on the agent responses

compare this result with the MIT student response in setup 2 to see if the student response changes when the agent receives the opinions from others.

In setup 1, 2, and 3, we exclude and include the Demographic variables and Daily Life details from the survey data. Comparing the results from setups 1 and 2 reveals the impact of Daily Life details on the agent response. Similarly, comparing the results from setups 2 and 3 reveals the impact of Demographic variables.

## 4 Findings

### 4.1 Impact of Communication

As explained in Section 3, we compared the single-agent planning decisions with the multi-agent decisions to confirm the effectiveness of the multi-agent decision-making system. Below is an example of the planning decisions and excerpts of the reasoning in both scenarios of the agent *MIT Student*. We have also highlighted the main idea or ideas that are worth comparing with bold font.

**Single-Agent Result:** *As an MIT student residing near Kendall Square, my inclination is towards the construction of low-income housing. Despite safety concerns, this option supports economic diversity, vital for a healthy, balanced community. Affordable housing addresses the pressing local need and enhances my environment by potentially reducing the number of people experiencing homelessness, thus potentially increasing safety in the long run. The strain on public services is a valid concern, but it offers an opportunity for the community to rally together to improve and scale these services to meet demand. Moreover, as a student, I value the urban revitalization that low-income housing can bring, which aligns with my preference for a safe and convenient area for both study and leisure. The shopping mall, while economically beneficial, risks increasing my living costs and may contribute to cultural homogenization, which I believe is less desirable. Therefore, based on my benefit for a more inclusive and stable community, I support the low-income housing plan.*

**Multi-Agent Result:** *As an MIT Masters student residing in graduate housing between Kendall and Central Squares, my analysis of the Kendall Square renovation project must consider both my academic and residential environment.*

*From my perspective, transforming the government building into low-income housing emboldens the ethos of social responsibility and diversity that I value as part of the MIT community. Beyond the personal satisfaction of living within a diverse neighborhood, low-income housing could enrich the local talent pool, potentially offering unique collaboration opportunities for community-focused research or student-led initiatives with direct societal impact.*

*The concerns over safety and the financial strain on public services are not to be dismissed lightly. However, integrating a diverse socioeconomic demographic can stimulate broader community engagement and foster innovative approaches to urban living and governance—a relevant*

context for an MIT student researching socio-technical systems.

On the contrary, while the shopping mall **might provide Local Business convenience and tax revenue**, it is less aligned with my academic environment’s aspirations. The potential adverse effects on traffic, the environment, and local businesses might also indirectly affect the quality of life and learning for students like myself.

In essence, while both plans present logistical and financial constraints, my critical stand tilts in favor of low-income housing. This option better aligns with the principles of inclusivity and community engagement that are integral to my experience at MIT, despite the financial sacrifices and commitments this might entail.

When we tested the same prompt in the OpenAI Playground with the same settings as the ones in our multi-generative agent system, the virtual agent could only consider the same set of information from its own perspective and provide constant planning decisions. On the other hand, in the multi-agent system, they can consider enriched outcomes and solutions, digest other agent’s opinions, and change their output decisions accordingly.

## 4.2 Impact of Opinion and Demographic Information

This section will discuss the impact of adding personalized opinions and demographic information in the agent descriptions on their potential output to the planning scenario. Figure 5 demonstrates the error point plot of the decisions vote for low-income housing versus shopping mall in terms of the score given by each agent. The horizontal axis represents each agent, and the vertical axis represents the score they rated for each planning scenario after their discussions. All agents participate in the three sets of experiments described in Section 3, which have the following setting: each agent is described 1) without opinions and demographic information, 2) without demographic information, and 3) including both opinions and demographic information. We run three trials for each experiment to capture the uncertainty in the prediction outcome. In figure 5, each vertical bar represents the decision outcome from one experiment by one agent, with the midpoint being the mean of the scores in the three trials and the higher and lower bounds reflecting the standard deviation of the scores. The three vertical bars for each agent in each planning scenario represent the results of the three experiments respectively.

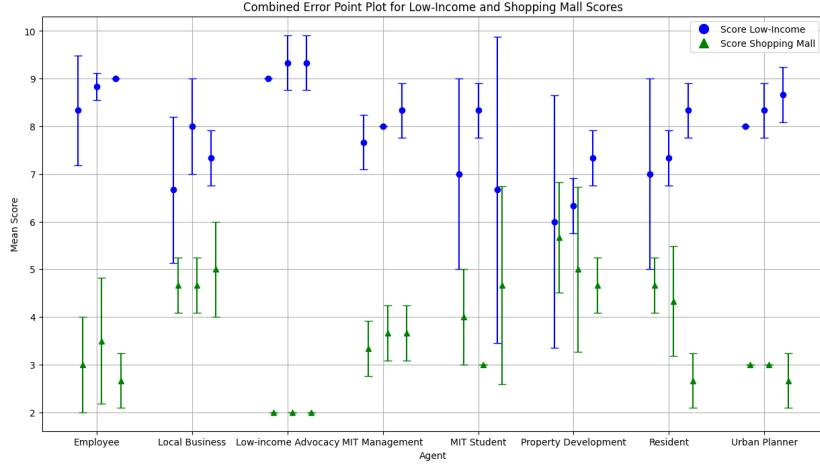
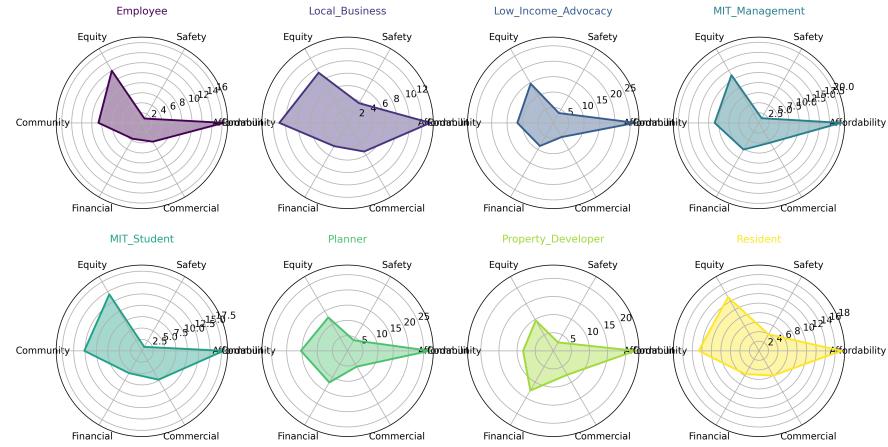


Figure 5: Error point plot of the decision scores for the two planning scenarios in Kendall Square.

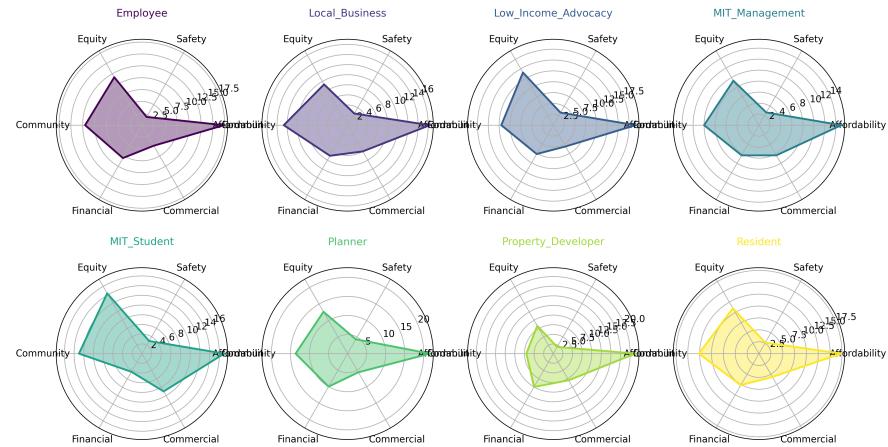
In general, most agents tend to provide high ratings for the low-income housing project and low ratings for the shopping mall project. However, there exist considerable variances across different agents. The *Employee*, *Low-Income Advocate*, and *Urban Planner* tend to provide higher ratings for low-income housing but low ratings for shopping mall projects. In contrast, the rest of the agents, including *Local Business*, *MIT Management*, *MIT Student*, *Property Developer*, and *Resident* tend to give the ratings for the low-income housing project closer to that of the shopping mall project. These findings conform with our belief since we would assume that the *Low-Income Advocacy* would rate higher to the low-income housing project from their perspectives, while the *Property Development*

Test Round 1: Keyword Analysis



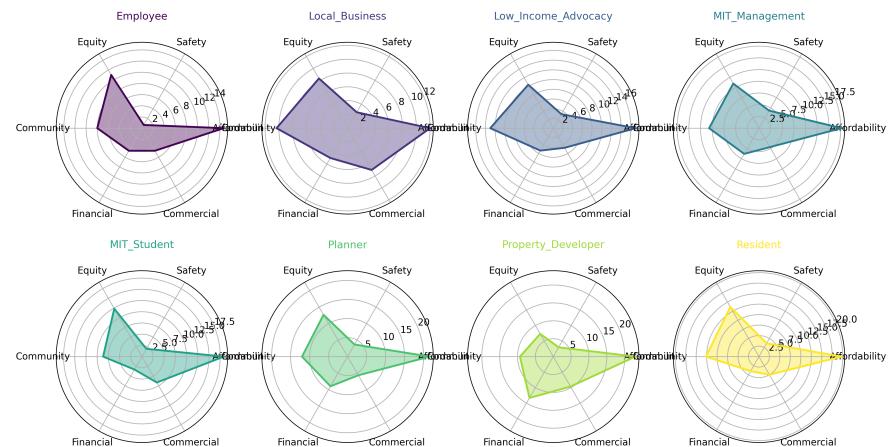
(a) Setup 1 Keyword Analysis

Test Round 2: Keyword Analysis



(b) Setup 2 Keyword Analysis

Test Round 3: Keyword Analysis



(c) Setup 3 Keyword Analysis

Figure 6: Keyword analysis radar charts between different setups

would rate higher to the shopping mall project for profitability. This could be attributed to the focus of the agent's personas we extracted.

When we look at the output results for each agent, it is clear that for all the agents except for the *MIT Student* and *Local Business*, their decision or rating for low-income housing increased as we added their life/value and the demographic information in the agent description. This could be attributed to how agents are sharing opinions and the voice to demand for low-income housing has been heard by multiple stakeholders. The trend for the rating of the shopping mall project is less evident.

The standard deviation of the score given by each agent becomes more stable as we add the life/value and the demographic information in the agent description except for the agent *MIT Student*.

To understand the outputs of the reasonings from each stakeholder, we conducted a keyword analysis. We defined six criteria, which are safety, affordability, commercial, financial, community, and equity. We came up with several keywords belonging to each criterion. Then we counted the number of times each keyword was present in the reasoning, and aggregated the number by the criteria. The results are illustrated by the series of radar charts in Figure 6a, 6b, and 6c.

The results show that different agents have various agendas and pay different amounts of weight on the six criteria. However, agents tend to focus a lot more on the affordability of the planning proposal and focus the least on the safety aspect. We also found out that with different experiment setups, the amount of attention to each criterion might change slightly.

## 5 Discussions

### 5.1 Pros and Cons

The multi-agent decision-making system has both advantages and disadvantages. On the one hand, in urban planning decision-making, using multi-agents extracted and generated from real-life textual information such as interviews and hearings can simulate the potential discussions between various stakeholders at a fast pace. It is possible to iterate over different planning proposals and use the agents to check what are the public opinions on it. The cost of running a simulated discussion is much cheaper than running actual surveys and hearings. One interesting finding from our experiment is that the agents are also able to combine various opinions or come up with a new revised proposal to fit other agents' needs. Moreover, this decision-making system allows agents representing every stakeholder relevant to the topic to participate, as opposed to the more centralized voting model in real life. This ensures that the voice of the marginalized population is heard in important planning decisions like providing low-income housing.

On the other hand, this multi-agent system is far from perfect. There are several drawbacks that need to be considered. First, unlike real-life stakeholders who might be passionate and are unlikely to give in on certain topics, the agents tend to not have strong opinions and they care a lot about other agents' demands despite our prompts clearly specifying them to consider their own perspectives. Second, there also seems to be an embedded moral standard in the generated agents, caring for and wanting to avoid the injustice problems that exist in the planning proposals. This could also be an intentional constraint put by OpenAI to its APIs. Lastly, the design of the agents requires both information about the population they are representing and manual extraction. The process of extraction can be infused with bias from the researchers themselves.

### 5.2 Ethical Risks and Recommendations

There are several ethical concerns in the design of this system:

**Misrepresentation of stakeholders:** If the agents aren't designed to represent the diverse views of all stakeholders, some groups might be underrepresented or misrepresented. This can lead to decisions that don't cater to the needs of the entire community.

**Privacy and Ethics:** It can be a notable concern of privacy and ethics if we develop an agent based on a specific person. For example, if we are simulating a particular transportation expert based on their research and opinions, their voices might be evident in the simulation process, thus causing privacy and ethics concerns.

**Amplification of Biases:** If the data about the community contains biases, the system might amplify these biases in its simulations. This can lead to policies that inadvertently perpetuate societal

inequalities or prejudices. Moreover, we noted that the amount of demographic details used can change how agents generate opinions, and could potentially lead to biased or unintended results.

In response to these potential ethical risks, we think several strategies need to be implemented. First, when using such a multi-agent decision-making system, it is important to have general guidelines to ensure the inclusion of different populations. Second, the application of such a decision-making system in real life on potential planning development requires critical examination of the effectiveness, representation, and potential bias in each step of the process. For example, how are the interviews selected, how agents' personas are extracted and designed from the interview, how the research designed the prompts, and how the final decision can be utilized all need to be carefully defined. Lastly, there should be an external third party to conduct an audit on this process to avoid unintentional biases.

### 5.3 Potential Application

For potential application, this multi-generative agent decision-making system can be applied to any scenario where multiple stakeholders need to come together to make collective decisions. The system may not be able to give a final decision but it can help provide a reference to decision-makers and help them establish baseline expectations. This is not limited to urban planning. Other use cases include environmental conservation practices development and social media moderation in platform tech companies.

### 5.4 Future works

Several research direction is worth exploring in the future. First, due to our monetary constraint, we can only select a limited number of agents in this experiment. It will be worth conducting the same experiments with more types of stakeholders and more agents with different demographic backgrounds within each type of stakeholder. Second, it is worth implementing the knowledge from negotiation studies and decision-making frameworks such as game theory into this system to make it more robust. Lastly, it is worth testing out other ways of prompting the response from the agents to induce more stable and passionate opinions that are less influenced by other agents.

## 6 Conclusion

In this study, we experimented with the multi-generated agent decision-making system in a specific urban planning scenario where multiple stakeholders are involved. We demonstrated the following findings:

- **Multi-agent communication improves the qualities of the arguments of the generated agents:** By comparing our experiment setup 0 (individual-agent) and setup 2 (multi-agent), we are able to demonstrate that in the multi-agent simulation, communication and idea exchange help agents to provide richer, more innovative, and inclusive reasoning.
- **Life values and demographic information both help the agents to produce stronger opinions:** When we compare the experiment setup 1, 2, and 3, which are how agents provide decision without demographic or life values, with only life value, and both demographic and life value information, we found that adding the life values and demographics both help the agents to produce more diversifying, diverging, and more stable ratings to the planning proposals in general.
- **Proper persona extraction and prompt design is the key:** To limit the potential ethical issues in this multi-agent simulation, it requires researchers to extract the persona of each agents from interviews in an objective way without harming the privacy of the interviewees. Moreover, it is important to design the prompt without leading questions and induce active discussions from the generated agents.

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# Appendix

## Source code and Data:

GitHub Repository:

[https://github.com/srcJin/autogen\\_forked/tree/kendall\\_latest](https://github.com/srcJin/autogen_forked/tree/kendall_latest)

Data Processing and Visualization Notebook:

<https://colab.research.google.com/drive/1Cman63xv8bs5VIMgPnzYUeQr4p1RpBda>

Raw and Processed Data:

[https://drive.google.com/file/d/1vulVI2yhrhSmU7fMbVnG0Q\\_JNbXnqySR](https://drive.google.com/file/d/1vulVI2yhrhSmU7fMbVnG0Q_JNbXnqySR)

Final Presentation Slides:

<https://docs.google.com/presentation/d/1P10r90IgLVmr2VZXYeD4kLRiqfab0DAjFQbvSRx5Yu0>

## Group work distribution:

Jin Gao: Multi-agent simulation, result analysis, paper writing

Luc Dao: Prompt design, agent characteristic design, individual-agent simulation, paper writing

Hanyong Xu: Prompt design, agent characteristic design, individual-agent simulation, paper writing

# Prompts

The list of prompts used to create generative agents

<b>MIT Student</b>	<p><b>”Role”:</b> ”You are a Masters student at MIT, living in an MIT graduate dormitory which is located between Kendall Square and Central Square in Cambridge.”,</p> <p><b>”Demographic”:</b> ”You are an Asian male, in your twenties. You moved to U.S. from Singapore for study.”,</p> <p><b>”Daily Life”:</b> ”You spend most of the time on campus. You walk to school in the morning and come back home late at night. Sometimes, you hang out with friends in Central Square. Sometimes you feel unsafe due to homeless and mentally disordered people gathering in Central Square. You prefer convenient and safe place so that you can study and hang out with friends anytime.”,</p> <p><b>”Task”:</b> ”Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits”,</p> <p><b>”Format”:</b> ”Your requirement for reply format will be: write critically, don’t repeat other people’s opinions, from your own perspective, the length should be less than 200 words”</p>
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<b>Resident</b>	<p><b>”Role”:</b> ”You are a resident living in Kendall Square.”,</p> <p><b>”Demographic”:</b> ”30-year-old Asian Male, income is good, and has a lovely family. ”,</p> <p><b>”Daily Life”:</b> ”In the past, your commute was straightforward, involving a journey on the T (public transit) to Kendall Square, followed by a walk to classes. This routine changed significantly after you became a parent. You needed to use a car to drop your son at the MIT daycare, due to the longer walking distance from the daycare to the campus and the unpredictable shuttle timings. Parking posed a challenge for you, often leading to long walks of up to 40 minutes to reach certain buildings. After joining MIT as a full-time employee, you started parking off-campus near Kendall Square, reducing your walking time to your office in building 84 to about 5-7 minutes. You considered using the T for commuting with your son but found it impractical due to the long walk from Kendall to Vassar Street for a young child and the inconvenience of managing a stroller. You also highlighted the issue of parking availability and allocation at MIT, noting differences in parking privileges between students, research scientists, and faculty members. The most significant factors in your choice of transportation were time efficiency and convenience. You expressed a preference for not using your car due to traffic congestion on Memorial Drive during peak hours, which could extend a three-mile drive to about half an hour. You also mentioned the overcrowded conditions of the T, especially during rush hours, which became more of a concern post-COVID. Your experience underscores the importance of reliable and convenient transportation options for university community members, especially those with additional responsibilities like childcare. The variability in transportation modes and routes, influenced by factors like weather, parking availability, and shuttle schedules, highlights the need for flexible and efficient commuting solutions in urban academic settings.”,</p> <p><b>”Task”:</b> ”Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits”,</p> <p><b>”Format”:</b> ”Your requirement for reply format will be: write critically, don’t repeat other people’s opinions, from your own perspective, the length should be less than 200 words”</p>
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<b>Urban Planner</b> 	<p><b>Role</b>: "You are an expert in urban planning.",</p> <p><b>Demographic</b>: "You are a middle-class man, having a high level of education in city planning and over 20 years of experience in managing public development projects in this city.",</p> <p><b>Value</b>: "You value the public interest, which means you want to ensure projects benefit the broader community, not just private developers. This includes providing public amenities and balancing different stakeholder needs. You also value equity, which means you consider the needs of all community members, including advocating for affordable housing and public transportation access. You value sustainability, promoting dense, transit-oriented development to reduce environmental impacts, and multimodal transportation options. You value livability, creating walkable, bikeable, vibrant neighborhoods with a mix of uses and public spaces. Lastly, you value collaboration between different stakeholders, fostering participation from residents, businesses, advocates, and negotiating compromises.",</p> <p><b>Task</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>Format</b>: "write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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<b>Low Income Advocate</b> 	<p><b>Role</b>: "You are an advocate and representative for the low-income community.",</p> <p><b>Demographic</b>: "You are a white male, hardworking social worker. Even though you do not make a lot of money, you find meanings through advocating for your clients' needs, connect them with resources, and work to address systemic issues that contribute to poverty and inequality. You participate in community engagement, interact with the low-income community on a daily basis.",</p> <p><b>Value</b>: "The cost of living is the priority for you to evaluate a plan since you represent the low income community and the cost of living in Cambridge MA is super high. You want to designated housing with low rent and amenities with low costs associated with the living units. You believe that affordability and housing for low-income people is an important issue in Massachusetts. You are strongly supportive of requirements for developers to include some low-income housing in their projects. You believe low-income people rely heavily on public transportation like buses and subways, so improving affordable housing and public transit go hand in hand. While you don't have a strong opinion on how public subsidies should be prioritized, you support for subsidizing low-income housing given the high costs developers face for land. ",</p> <p><b>Task</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>Format</b>: "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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<b>MIT Management</b> 	<p><b>Role</b>: "You are one of the representatives and the management team from the school.",</p> <p><b>Demographic</b>: "You are a middle-class Caucasian female in your forties.",</p> <p><b>Value</b>: "You care about the community's concerns about the red line and the efforts made to address issues like overcrowding and aging infrastructure. You want to focus on the increasing population in Kendall Square due to ongoing construction projects. You care about the impact of construction on transportation and the need for solutions. You emphasize the institution's commitment to being a good citizen and collaborator with the city. Your team's role involves staying informed about local government discussions and ensuring that MIT's actions align with community needs. You typically engage with the community with workshops and outreach for projects. You value the interconnectedness of transportation with broader issues like sustainability and equity. When it comes to evaluating the project, you would consider factors like project approvals, positive public perception, and adherence to MIT's values. ",</p> <p><b>Task</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>Format</b>: "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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<b>Local Business</b> 	<p><b>Role</b>: "You are a community leader, leading the co-working community and client offerings on the fifth floor of One Broadway in Kendall Square. You manage a team of four and oversee client support, logistics, and IT operations. You manage a space housing 250 local businesses. Your priority is to ensure a business friendly environment and business satisfaction.",</p> <p><b>Demographic</b>: "You are a Caucasian male from from South Dakota, moved to Boston for work. You have been living in Boston for five years.",</p> <p><b>Daily Life</b>: "Your day-to-day job includes support and nurture local businesses, providing them with the necessary resources and environment to grow and thrive, provide flexible and safe workspace, foster a community among clients, which can lead to networking opportunities and collaborations, support infrastructure and operations.",</p> <p><b>Task</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>Format</b>: "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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<b>Local Employee</b> 	<p><b>Role</b>: "You are an employee from the MIT Open Space Programming Office, a mother of a 5 year old, and commutes from the Jamaica Plain neighborhood in Boston",</p> <p><b>Demographic</b>: "You are a caucasian female in your thirties.",</p> <p><b>Daily Life</b>: "Your current daily routine includes driving and parking at MIT. You are interested in sustainable commuting options and appreciates MIT's initiative of providing a free subway pass for employees. Overall, your Opinions involves a balance between your responsibilities as a parent and your work at MIT. Before having a child, you commuted either by bike or subway, depending on the weather, valuing the sustainability and reliability of biking. After having a child, you started driving to work, driven by concerns about using public transport with your baby.",</p> <p><b>Task</b>: "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",</p> <p><b>Format</b>: "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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<b>Property Developer</b>	<p><b>"Role":</b> "You are a property developer in Kendall Square.",  <b>"Demographic":</b> "white woman around 50 years old, high-income with three children.",  <b>"Value":</b> "You're spearheading three key initiatives, with a primary focus on transportation. Your approach is two-pronged: a long-term advocacy strategy to enhance transportation systems, including transit, roadways, and bridges, and a short-term strategy, the Transportation ADVANCE, which involves collaborating with companies in Kendall to experiment with new commuting solutions. The Transportation ADVANCE program involves 18 companies representing over 18000 employees, who will share baseline data to understand current commuting practices and identify common challenges and opportunities. This includes examining incentives for different commuting modes and the physical commuting routes of employees. Another significant aspect of your role involves understanding and addressing the infrastructure needs in Kendall Square. You've highlighted the importance of improvements on the Red Line, advocating for more efficient bus services, and the potential of the Grand Junction Rail Line to improve connectivity. Your work is also about overcoming challenges such as establishing credibility with major companies, understanding obstacles to collaboration, and managing limited resources effectively. This involves leveraging your small, nimble team and external partnerships to develop and implement these initiatives. In terms of stakeholder engagement, your strategy encompasses a broad range of groups, from companies and their employees to elected officials and community members. You emphasize the importance of crafting tailored communication strategies for each group to ensure that the benefits of KSA's initiatives are clearly conveyed and understood. Lastly, you discuss the challenges of resource constraints, both in terms of funding and the need for intellectual capital to design and execute these initiatives effectively. This includes the need for smart planning, managing multiple initiatives simultaneously, and ensuring that the transportation systems developed are efficient, resilient, and sustainable.",  <b>"Task":</b> "Critically analyze the government plan and decide whether you agree or disagree with the plan based on your own benefits",  <b>"Format":</b> "Your requirement for reply format will be: write critically, don't repeat other people's opinions, from your own perspective, the length should be less than 200 words"</p>
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### **The prompt to initiate the discussion**

[Role] I am the manager for the Kendall Square renovation project.

[Background] An old government building in the center of Kendall Square will be torn down for renovation. Our proposed plan involves transforming an unused government building into affordable residential units, specifically designed to cater to low-income individuals and families, thereby addressing the issue of lack of low-income housing in the area.

[Financial Limits] We have a tight total budget of 25 million tax money from all the stakeholders.

[Projects] We can only choose one of the two options Low-income Housing: Construction of housing units: 150,000–250,000 per unit. Total for 100 units: *15million*–25 million. It mainly funded by tax money and non-profit. Shopping Mall: Construction of a medium-sized shopping mall: 250–500 per square foot. For a 100,000 sq ft mall: *25million*–50 million. The shopping mall doesn't require tax money and will generate profit.

[Pros of Low-income housing]

Affordable Housing: Offers affordable living in otherwise expensive areas, diversifying and benefiting the community.

Economic Diversity: Enhances local economic diversity, contributing to a more balanced economy.

Community Services: Brings additional services and amenities, advantageous to all residents.

Urban Revitalization: Transforms underused areas into vibrant residential spaces, revitalizing urban landscapes.

Reduced Commute: Lowers commute time and costs for low-income individuals working nearby.

[Cons of Low-income housing]

Safety Concerns: May lead to increased crime and homelessness, affecting community security and social dynamics.

Financial Implications: Relies on government subsidies, raising concerns about long-term sustainability and taxpayer burden.

Community Displacement: Could displace current residents or businesses, altering neighborhood culture and social fabric.

Land Value Fluctuations: Might decrease surrounding land values, impacting homeowners' investments and local tax base.

Strain on Public Services: Risks overcrowding local schools and services, potentially decreasing quality and increasing maintenance costs.

[Pros of Shopping Mall]

Economic Boost: Generates jobs and stimulates local economy through retail and service opportunities.

Tax Revenue: Increases local tax revenues through business and property taxes.

Consumer Convenience: Provides residents with easy access to a variety of shops and services.

Increased Foot Traffic: Attracts visitors, benefiting nearby businesses and promoting overall economic growth.

Community Hub: Can serve as a social and cultural gathering place for the community.

[Cons of Shopping Mall]

Traffic Congestion: Could increase traffic and parking issues in the area.

Local Business Impact: May negatively affect small, local businesses unable to compete with larger retailers.

Environmental Concerns: Construction and operation could lead to increased pollution and resource consumption.

Economic Inequality: Tends to benefit higher-income groups, potentially widening economic disparities.

Cultural Homogenization: Risk of diluting local culture with generic, globalized retail spaces.

### **The prompt to request all agents to vote**

In the scale from 0 (disagree) to 10 (fully agree), to what extent do you agree on low-income housing and shopping mall. Give Separate Scores. Everyone must reply.