

Using Genetic algorithm to Optimize Social Behaviors in the Pattern-Of-Life simulation

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01

Background Introduction

You can describe the topic of the section here

Social Network



Definition

A graph-based structure representing social entities (e.g. individuals, groups, or organizations) and the relationships or interactions connecting them (e.g. friendship, colleague)



Why important?

Play a crucial role in human well-being, influencing mental health and survival



One method to understand Social Network:

Simulation!

Agent-Based Modeling (ABM)

Agent-Based Modeling (ABM)

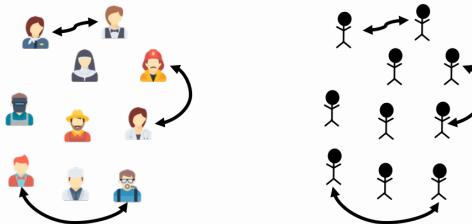


Definition

A method used to simulate the behaviors and interactions of individuals ("agent") to help understand how an overall system operates.



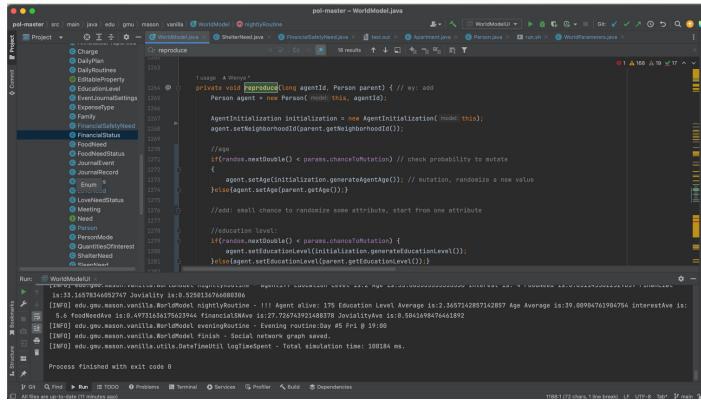
Agent → Real person
System → Society



Agent-Based Patterns-of-Life Simulation (POL)

Agent-Based Patterns-of-Life Simulation (POL)

- Developed by Dr. Joon-Seok Kim and his team
- Agents behave like real people
- Daily activity: working, eating, and visiting recreational sites
- based on their needs and attributes (e.g. income, education, interests, food needs, etc.)



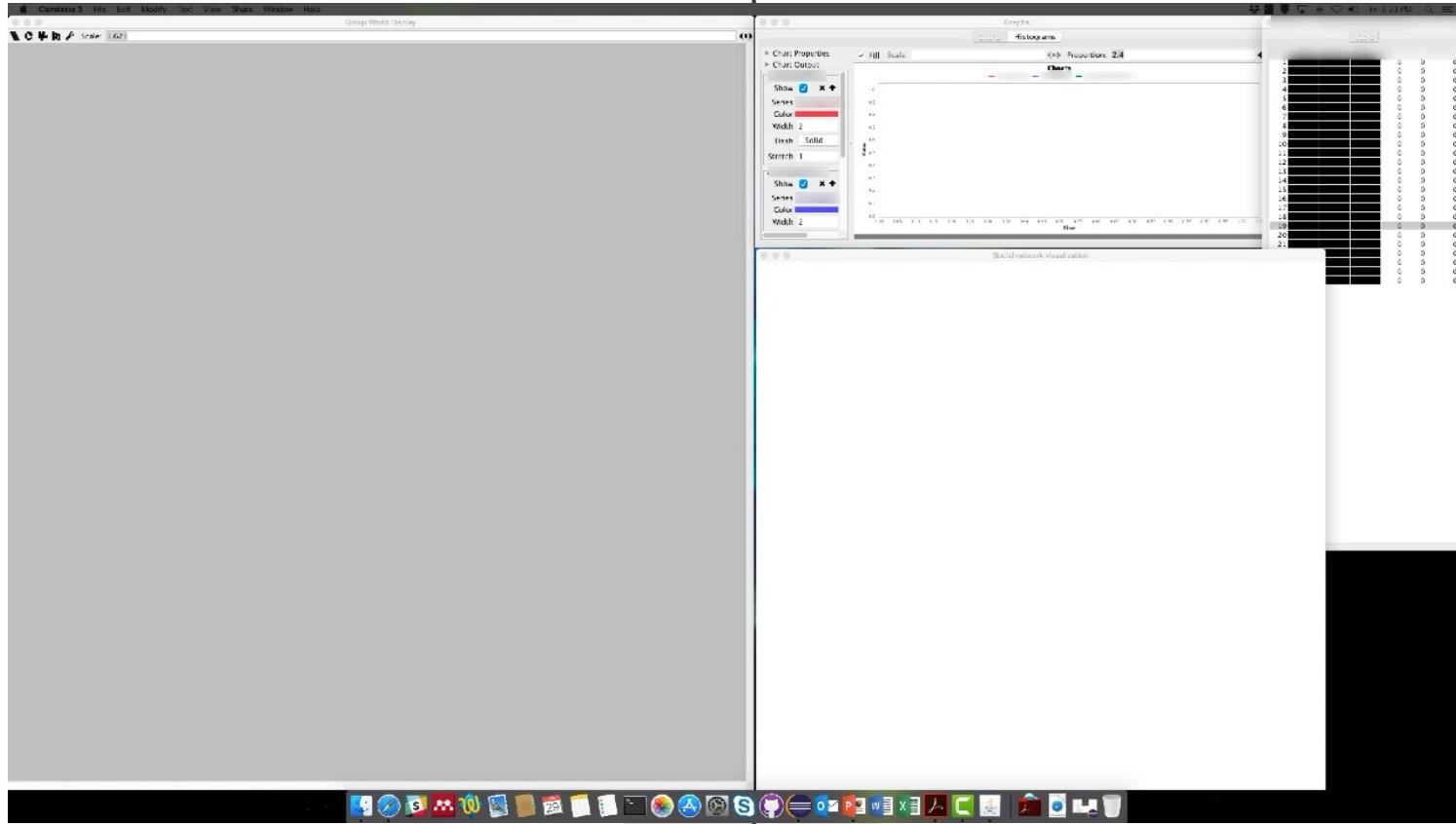
The screenshot shows a Java IDE interface with the file `WorldModel.java` open. The code implements a `reproduce` method for agents. It creates a new `Person` agent, sets its neighborhood ID, and randomizes attributes like education level if a mutation occurs. The code also handles the creation of a new agent and setting its neighborhood ID. The IDE shows various imports and annotations at the top of the class.

```
usage: void reproduce(long agentId, Person parent) { // vy: add
    Person agent = new Person(model, this, agentId);

    AgentInitialization initialization = new AgentInitialization(model, this);
    agent.setNeighborhoodId(parent.getNeighborhoodId());

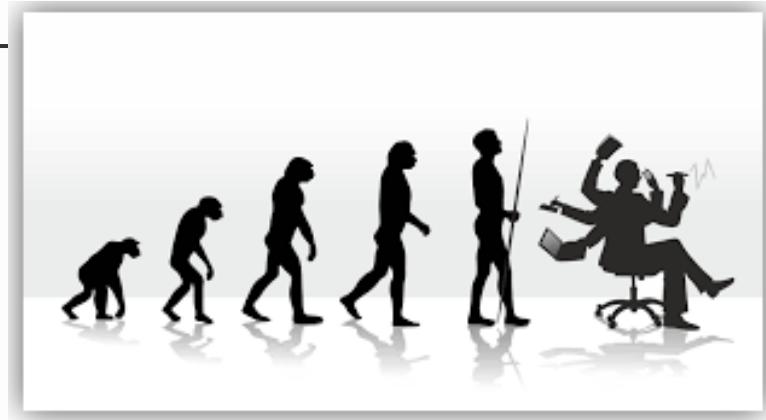
    //pop
    if (rand.nextDouble() < parent.chanceToMutate) {
        agent.setInitialization(initialization.generateAgent());
    } else {
        agent.setInitialization(initialization.generateAgent());
    }
    agent.setAge(parent.getAge());
}

//add: small chance to randomized some attribute, start from one attribute
//education level:
if (rand.nextDouble() < parent.chanceToMutate) {
    agent.setEducationLevel(initialization.generatedEducationLevel());
} else {
    agent.setEducationLevel(parent.getEducationLevel());
}
```



This video is created by Dr. Joon-Seuk Kim.

Motivation



Research Social Network via ABM from an evolutionary perspective?

Is it feasible to include an evolutionary algorithm into a ABM like POL simulation, to explore social network?

Evolutionary Algorithm in ABM



Definition

An optimization algorithm inspired by natural selection:

- ✗ agents with less advantageous attributes (e.g. personality, gene, educational level etc.)
- ✓ agents with more beneficial attributes



Genetic Algorithm

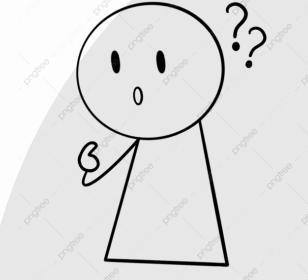
Agents evolve over generations through selection, crossover (recombination), and mutation.

02

Research Question

How to include a genetic algorithm into POL simulation?

By using genetic algorithm into POL, can we find what kinds of individuals (what attributes) are more likely to maintain better social networks?



03

Methodology

Logic of Social Network Dynamics in POL

Social Network is composed by friendships

Friendships Formation and Strengthening:

- When agents meet and interact with others, they become friends
- Friendships are strengthened when friends meet again



Friendships Disconnection:

- Each day, the strength of each friendship weakens
- Once becomes too weak, the friendship is removed from the social network



Agent attributes

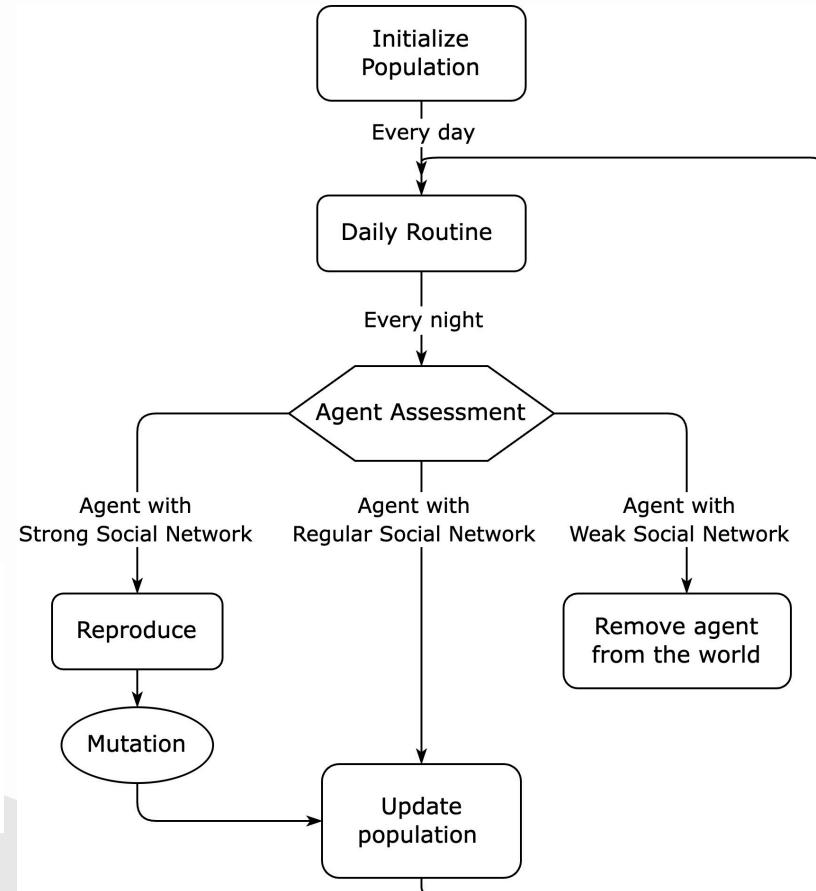
Agent attributes we chose to be included in our genetic algorithm:

Attributes	Definition	Initialization
<u>Age</u>	The agent's age in years, affecting behavior and decisions.	Uniform integer between 18 and 60
<u>Food Need</u>	The agent's hunger level and appetite, influencing eating behavior.	Uniform real value between 0.2 and 0.8
<u>Education Level</u>	The agent's highest level of completed formal education.	Low (10%), High School/College (54%), Bachelors (23%), Graduate (13%)
<u>Interest</u>	The agent's personal preferences, used to choose recreational sites.	Uniform discrete choice from 10 interest categories
<u>Joviality</u>	How likely the agent is to prioritize socializing over working.	Uniform real value between 0.0 and 1.0
<u>Finance</u>	Describes agent's wealth, job status, and ability to afford basic needs.	Initial hourly salary varies by education level, bounded between \$10.00 and \$100.00

Algorithm Design

- ECJ → long running time
- Based on the POL simulator, we added two behaviors of agents:
 - Departure due to weak social network
 - Reproduce

Category	Condition / Value
Strong Social Network	≥ 20 friends for 10 consecutive days
Weak Social Network	< 5 friends for 20 consecutive days
Regular Social Network	Other agents
Mutation Probability	0.08 (8%)



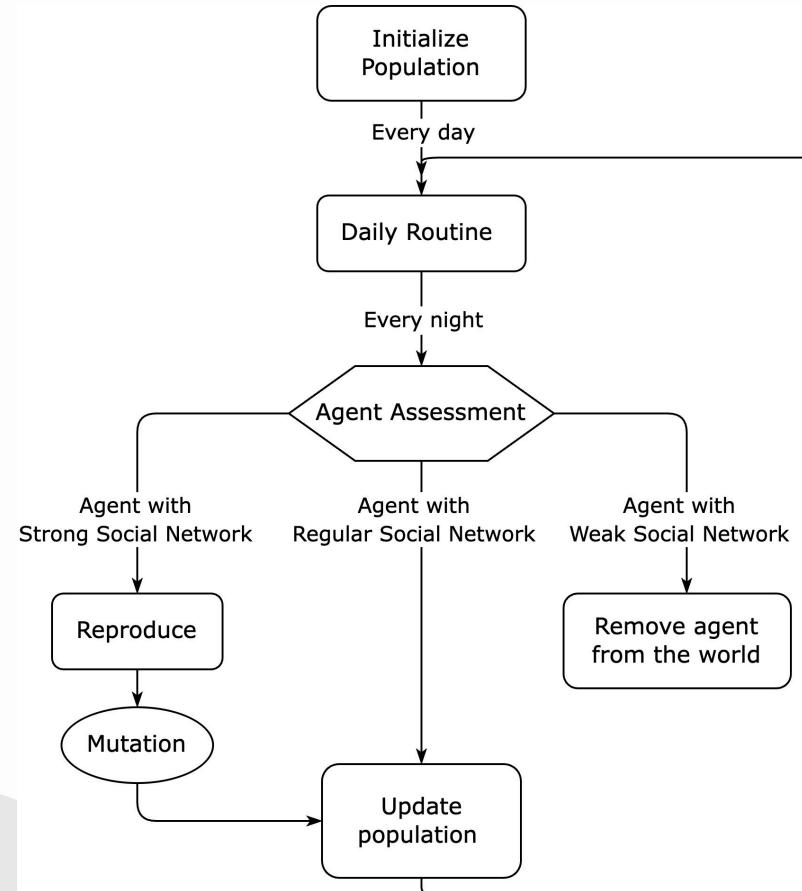
Algorithm Design

- To avoid agents become unrealistic elite, we add threshold:
- Assign score for each attribute based on distribution:

For example:

If more people with young age at the end
aged 20-30 : 3 points;
aged 30-50 : 2 points;
aged 50-70 : 1 point.

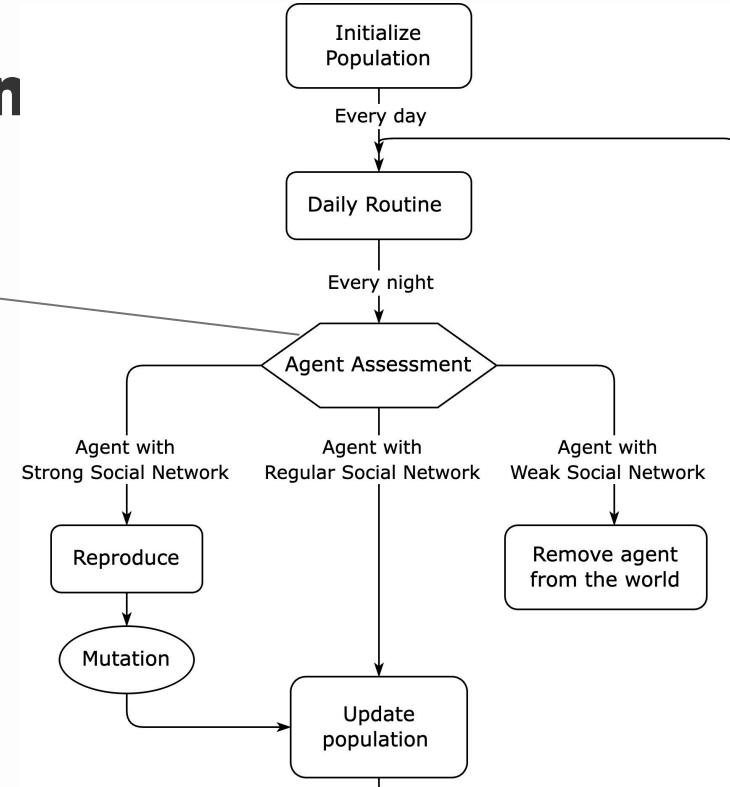
- Overall controls a threshold



Dataset Generation, Processing and Visualization

- Every night calculate :
average of each attributes
the number of living agents
- Create datasets:
agentID vs. date
attributes vs. agentID
- Used ridge plots via kernel density estimates:

$$\hat{f}_h(x) = \frac{1}{nh} \sum_{i=1}^n K\left(\frac{x - x_i}{h}\right)$$

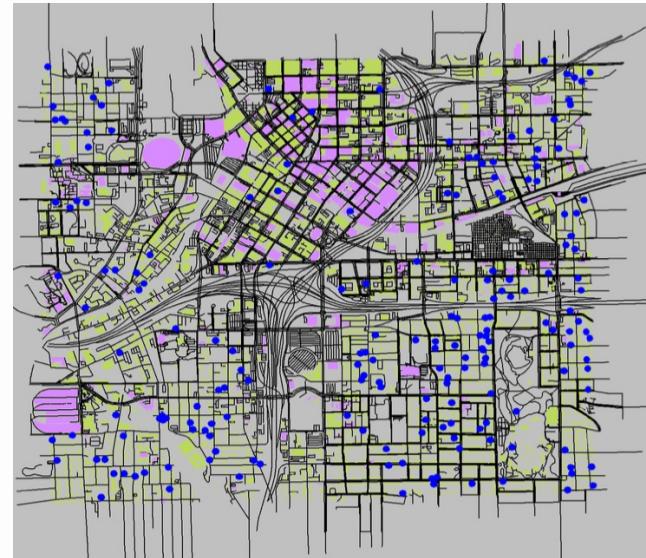


03

Experiments & Results

Experiments

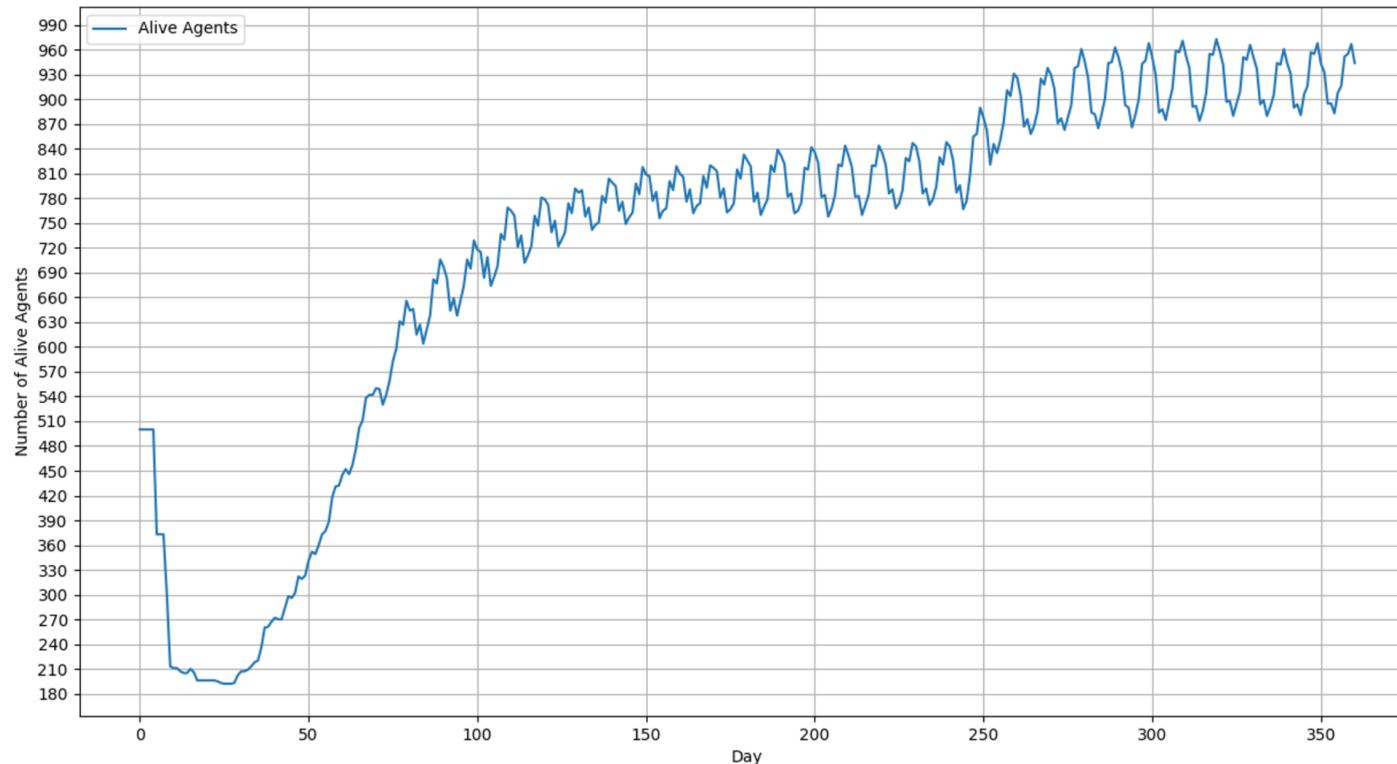
Parameter	Value
Initial Agent Number	500
Time	1 year
Map	Atlanta downtown



Map of Atlanta Downtown

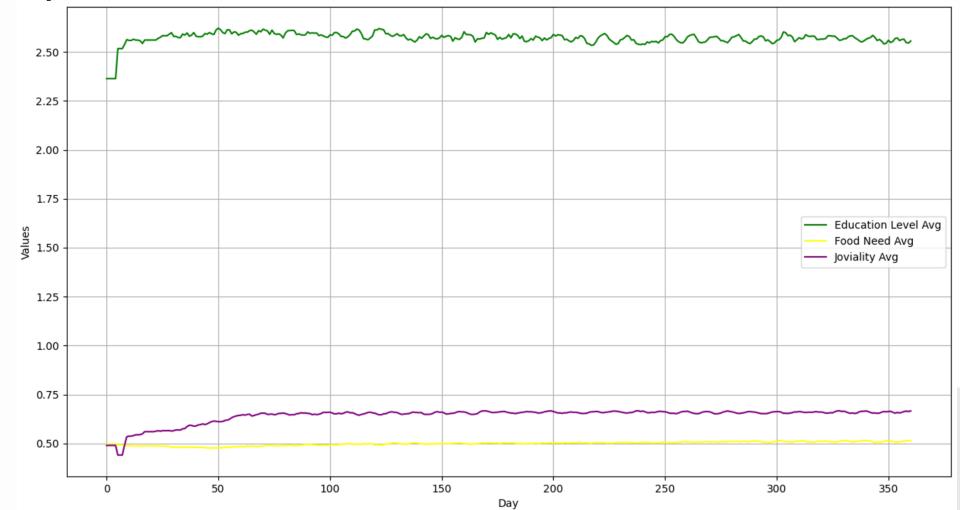
Results

Agent alive over time

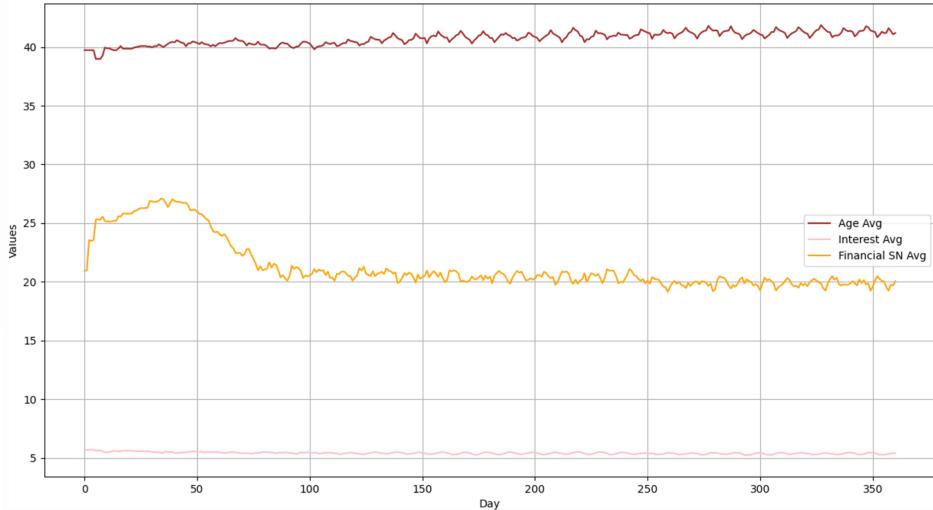


Results

The Average of Agents' Attributes Over Time



The Average of Agents' Attributes Over Time

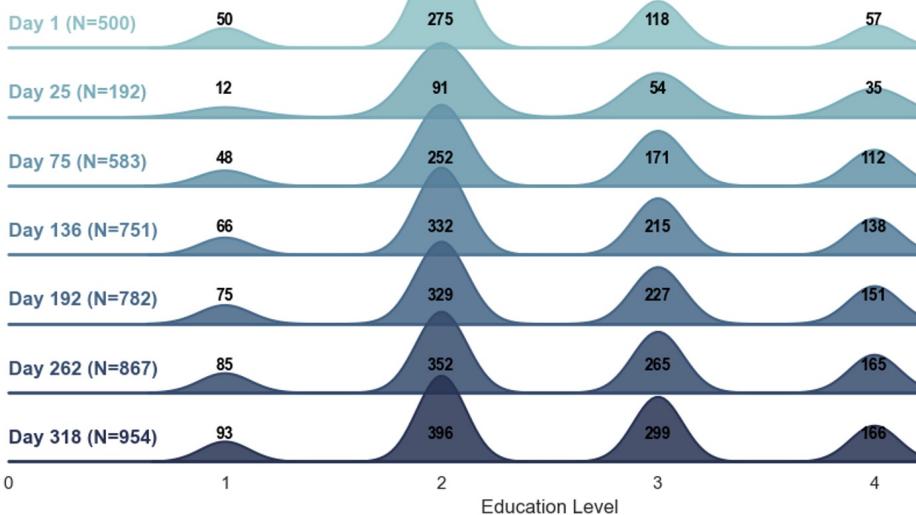


Age
Interest
Finance (hourly salary)
Education Level
Joviality
FoodNeed

Results

Education Level Distribution Over Time

N = Total Alive Agents

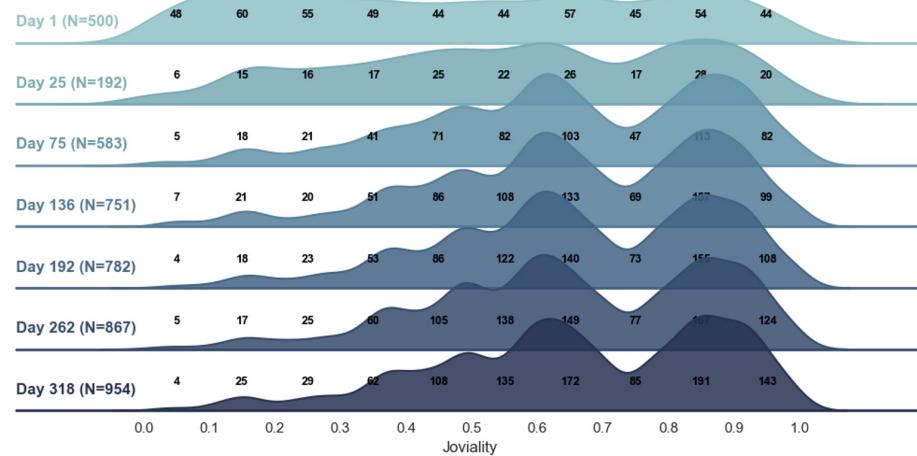


Joviality: How likely the agent is to prioritize socializing over working.

Low (10%)
High School (54%)
Bachelors (23%)
Graduate (13%)

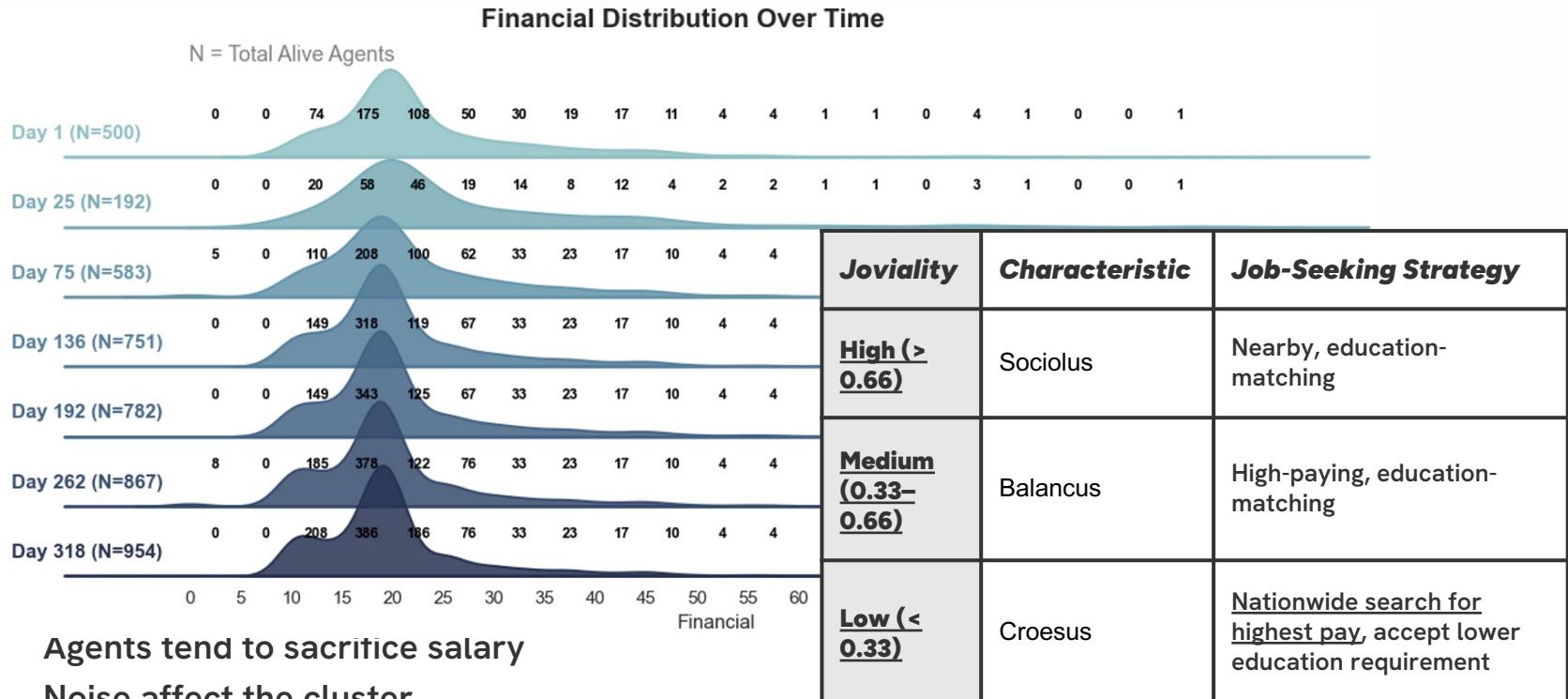
Joviality Distribution Over Time

N = Total Alive Agents

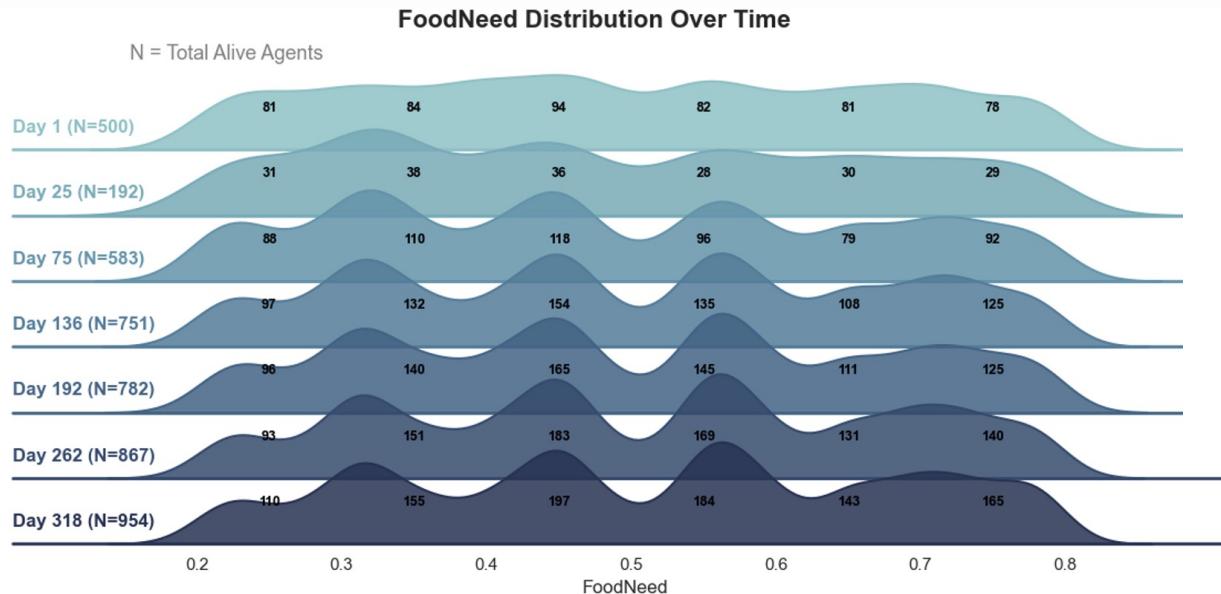


- Overall improvement in education
- The more people prioritize on social over money, the stronger social network they have

Results



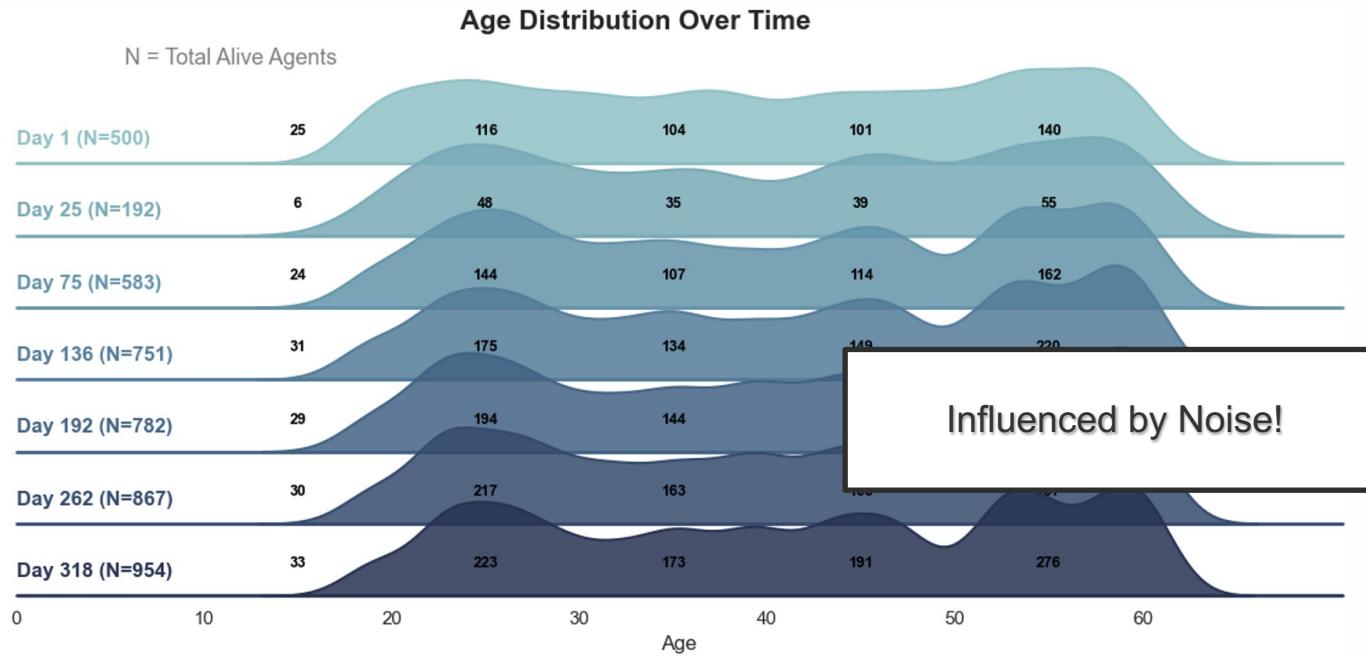
Results



- Excessively high: deplete their financial savings
- Excessively low: miss opportunity to socialize

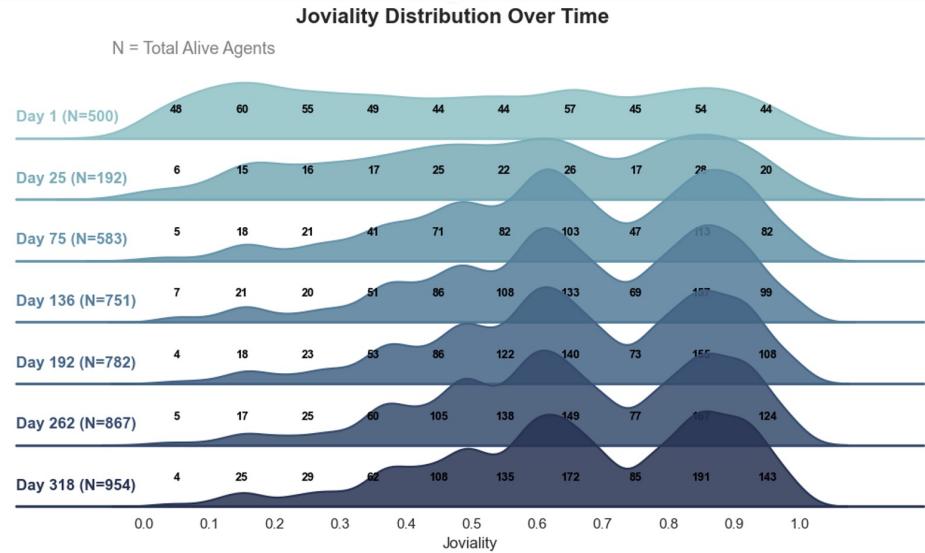
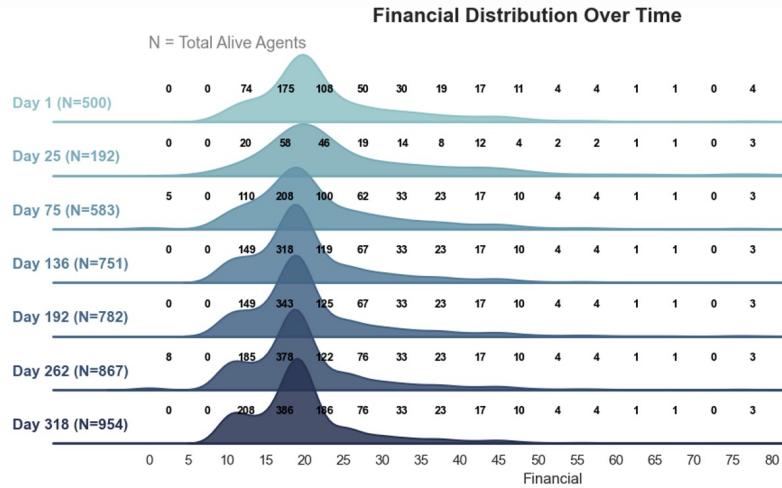
- Agents with a moderate level of food need are more likely to survive in the world

Results



Summary and Limitation

- Winners: high education level, moderate food need, high joviality, low salary (relaxed)
- The initialization phase → introducing noise
- A potential survival issue: No people make money.... Implies: No saving to socialize?



Improvement

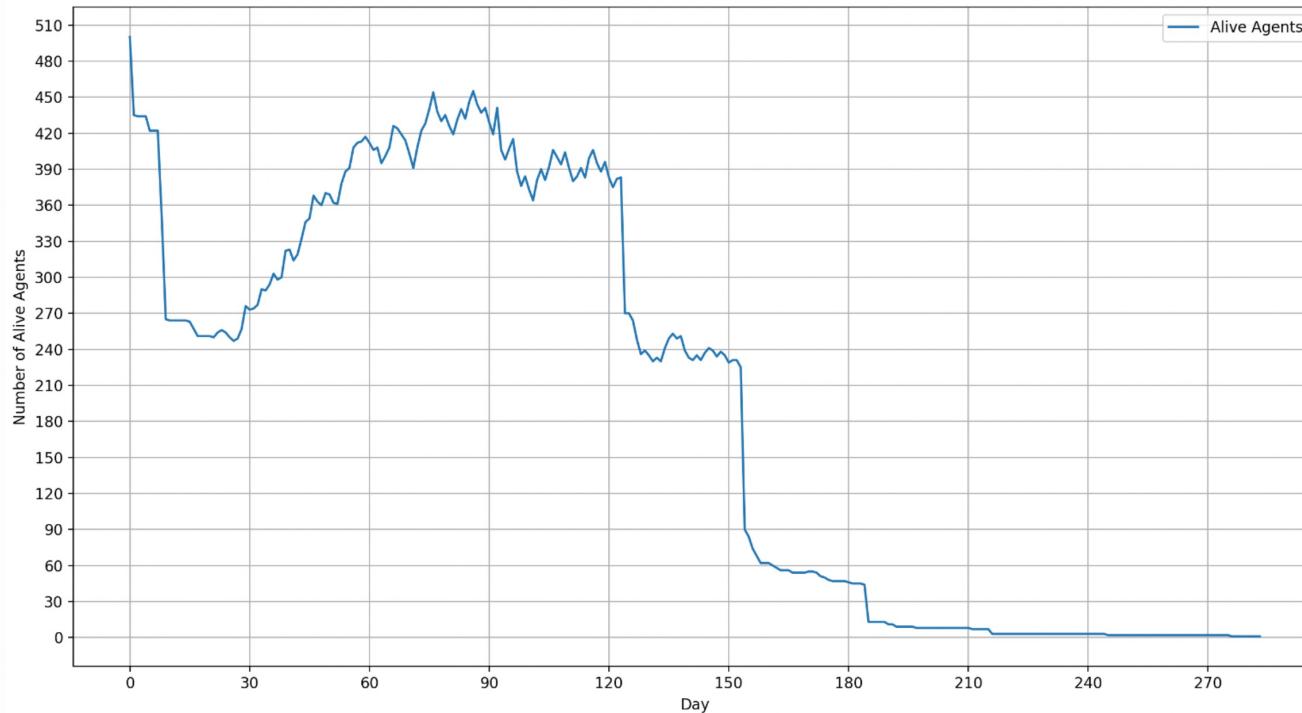
- To improve, introduced an additional financial survival pressure:
With a house price increase periodically!
- Goal:
 1. Select the final survivors: strong social networks + financially capable of living
 2. Small number of agents survive until the end → reduce the noise

$$\text{rentalCost}_{day+10} = 1.2 \times \text{rentalCost}_{day}$$



Results

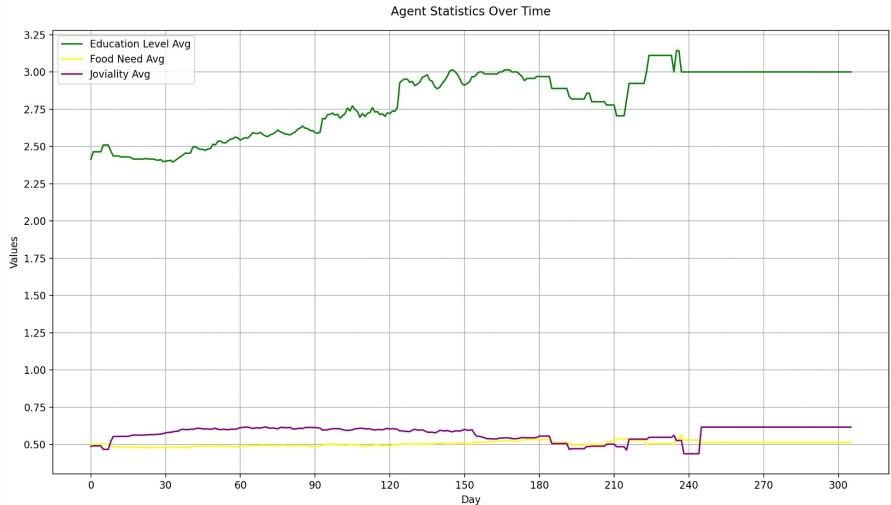
Agent Alive Over Time



Results

The Average of Agents' Attributes Over Time

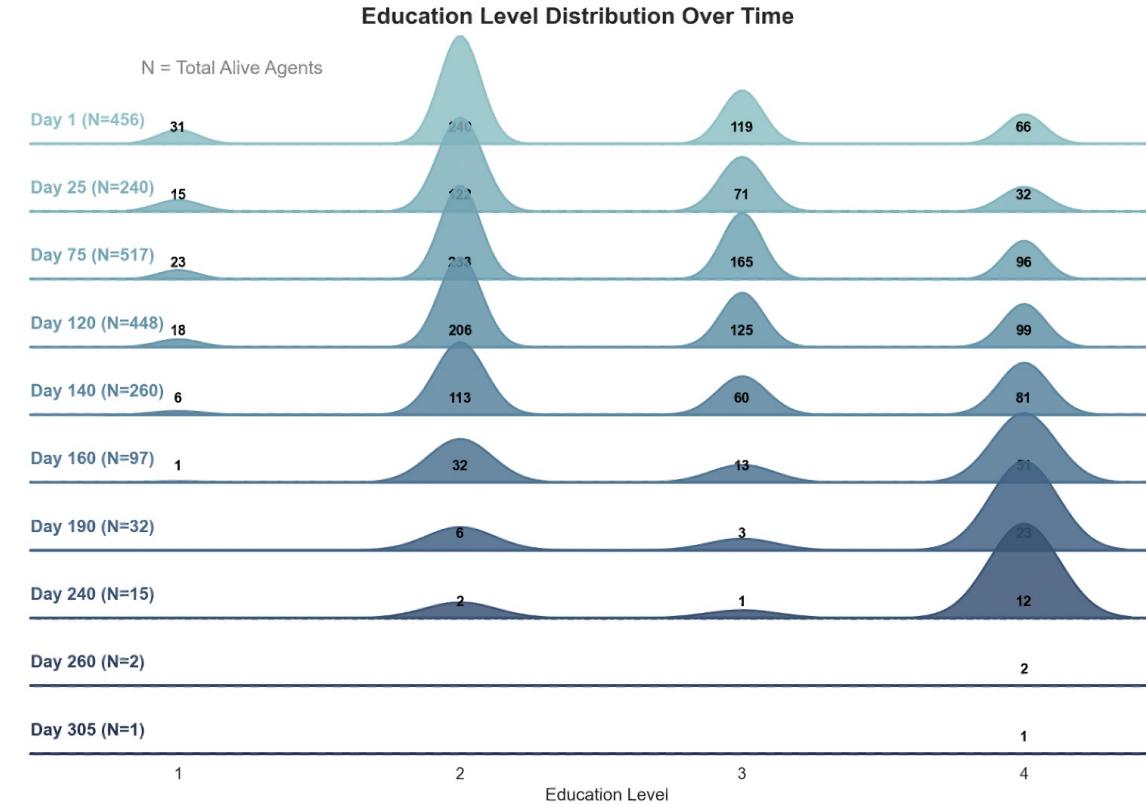
The Average of Agents' Attributes Over Time



Age
Interest
Finance (hourly salary)
Education Level
Joviality
FoodNeed

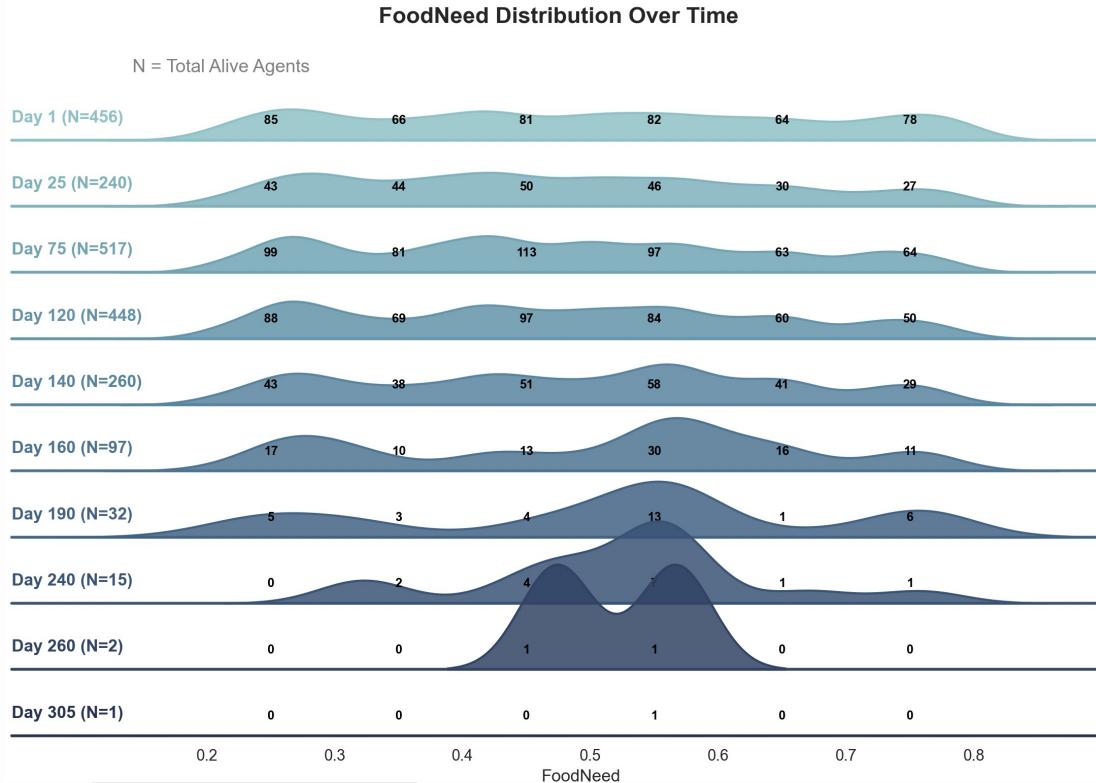
Results

- Obvious trend of shifting toward higher levels



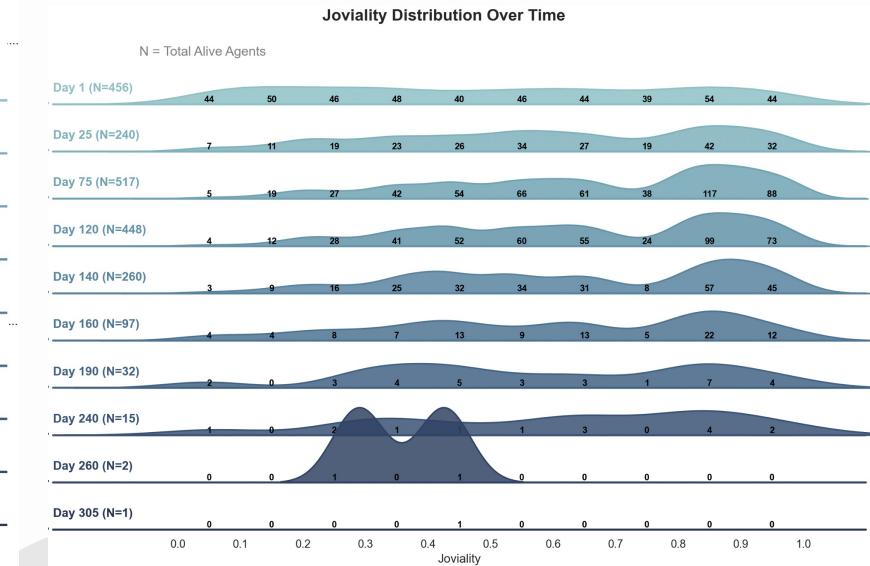
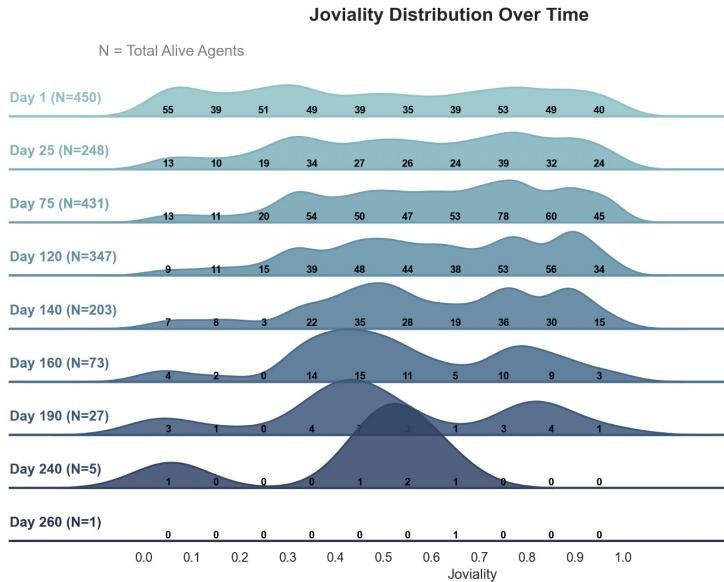
Results

- Food Need still keeps a moderate level



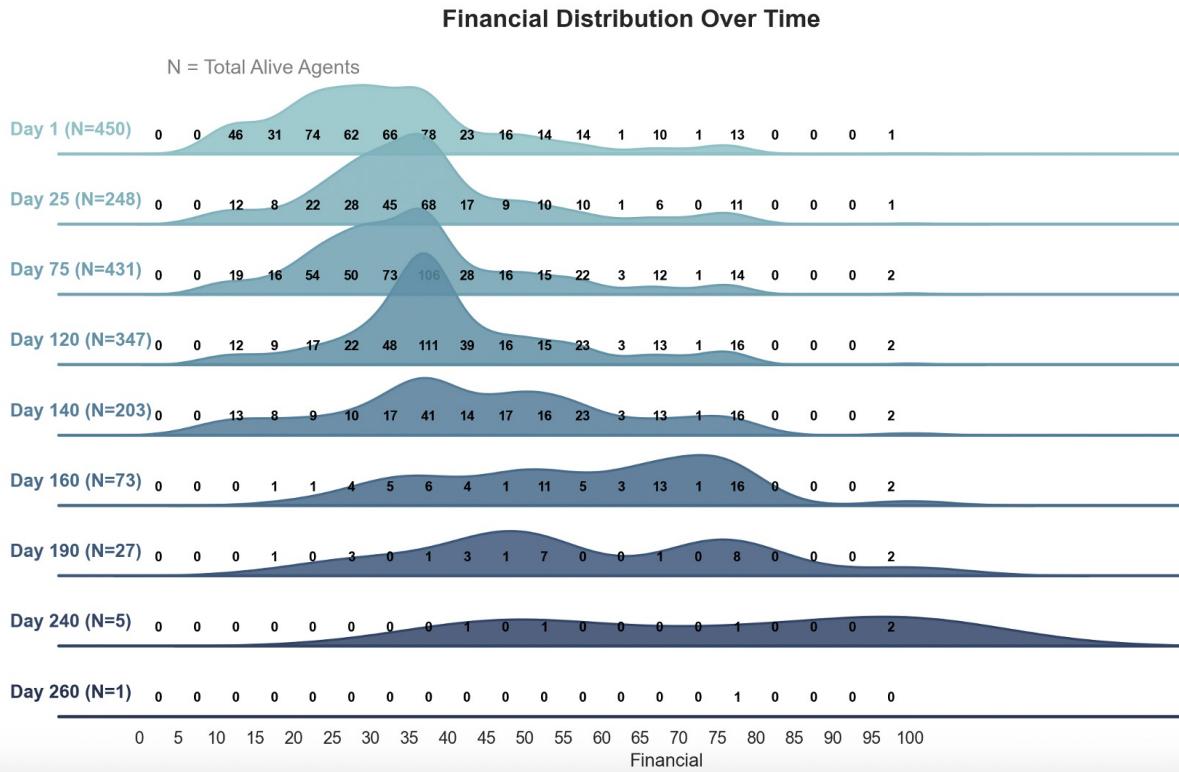
Results

- Increases at first, then concentrate to the middle range
- Reduce concern of limited focus on earning money



The change of the distribution of Joviality over time under different random seeds

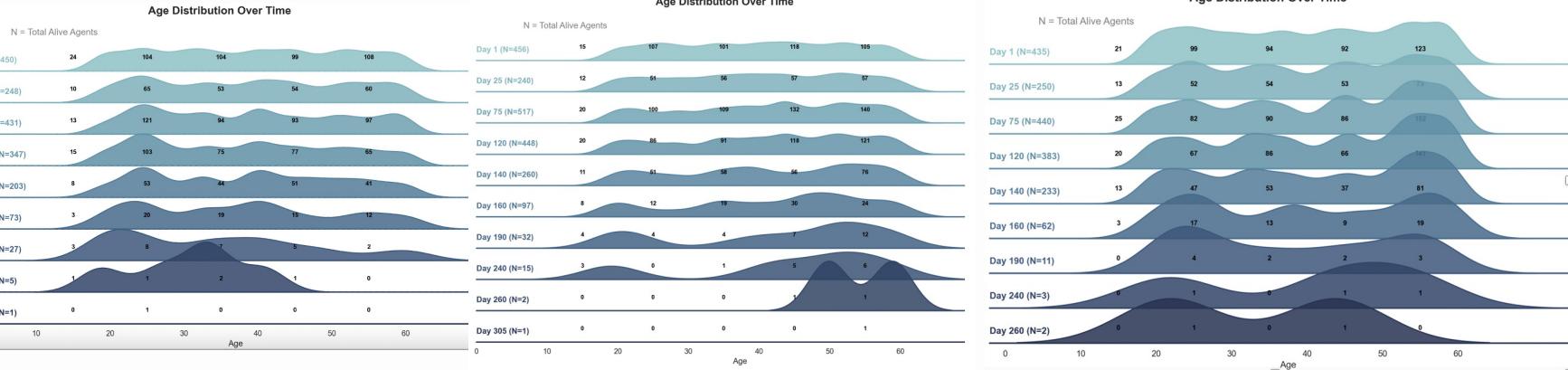
Results



- Rightward shift, agents with high salary could survive

Results

- No significant overall shift in the distribution throughout the evolutionary process
- Age doesn't influence on getting a better social network and economic stability



The change of the distribution of age over time under different random seeds

04

Discussion

Limitation



Add more attributes into the genetic algorithm

Shelter need, Sleep need, Walking speed, etc.



Find more realistic condition

The condition to assess the social networks

The pattern of house price increase



Try different mutation parameter

how mutation would affect on the evolution of the attributes.

04

Conclusion

Summary



Genetic Algorithm

Successfully applied a genetic algorithm to an agent-based modelling simulator!



Attributes

- High education level
- High salary
- Moderate food needs
- Moderate joviality
- Age no significant effect



Possible Exploration

It is a possible way to research Social Network in an evolutionary perspective in ABM.

Thank you very much!

Wenye Song

Acknowledgement

Dr. Andreas Züfle

Dr. Joon-Seok Kim

Dr. Jed Brody

Ruochen Kong

Resources

Photos

- <https://visiblenetworklabs.com/2023/01/06/social-network-analysis-for-foundations/>
- [https://www.google.com/search?q=Agent-Based+Modeling&sca_esv=b657747ebb3c27f5&udm=2&biw=1512&bih=857&ei=dI_sZ_ykJC5wN4P_ayAc&ved=0ahUKEwi8rtb_lbiMAXxwHNAFHX0WAA4Q4dUDCBE&uact=5&oq=%E7%81%AB%E6%9F%B4%E4%BA%BA+%E9%97%AE%E5%8F%B7&sca_esv=b657747ebb3c27f5&udm=2&biw=1512&bih=857&ei=dI_s=EgNpbWciEOeBq-aftOS6uiDpl67j7dlvy5QtBFY7C1wCXgAkAEBmAAB_wiqAQm3LjW4AQPIAQD4AQGYAgggArkBwg!FEAAAYgATCAgcQABiABBgMmAMAiAYBkgcDNI4xoAeaCg&sclient=img#vhid=PMpMQyjqcZEo8M&vssid=mosaic](https://www.google.com/search?q=Agent-Based+Modeling&sca_esv=b657747ebb3c27f5&udm=2&biw=1512&bih=857&ei=j3rsZ_DBDB8q0wN4Prdv_yAk&ved=0ahUKEwiws_2GgrIMAxVKGtAFHa3tH5kQ4dUDCBE&uact=5&oq=Agent-Based+Modeling&gs_lp=EgNpbWciUFnZW50LUJhc2VkJIE1vZGVsaW5nIDFEAAAYgAQyBRAAGIAEMgUQABiABDIFEAAAYgAQyBRAAGIAEMgUQABiABDIFEAAAYgAQyBRAAGIAEMgUQABiABDIFEAAAYgARlqARQ5gJY5gJwAXgAkAEAmAE_oAE_qgEBMbgBA8gBAPgBAfgBApqCAaACQ6gCAJgDApIHATGgB8sF&sclient=img#vhid=gki-7LEciEAE-M&vssid=mosaic)
- https://www.google.com/search?q=%E6%8F%A1%E6%89%8B&sca_esv=b657747ebb3c27f5&udm=2&biw=1512&bih=857&ei=0I_sZ97kld21wN4PuMu-2Qk&ved=0ahUKEjejMCrlriMAXdGtAFHbil5sQ4dUDCBE&uact=5&oq=%E6%8F%A1%E6%89%8B&gs_lp=EgNpbWciBuapoeajzI!FEAAAYgAQyBRAAGIAEMgUQABiABDIFEAAYgARI_A5QoAdYpQ5wAngAkAEAmAG_AaAB_QWqAQmxLjW4AQPIAQD4AQGYAgagAosGqAIAmAMCkgcDMS41oAenDg&sclient=img#vhid=TKsWaBlzV-EsM&vssid=mosaic