UNIVERSITY OF SCIENCE AND TECHNOLOGY OF HANOI

MASTER

Modeling and simulation of complex systems

PROJECT REPORT

by

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M22.ICT.003

Information and Communication Technology

Title:

Flu Virus

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Hanoi, February 2024

Chapter 1

Introduction

1.1 Subject

In my project, I suggest a model for illustrating the transmission of influenza within the city of Hanoi. Each morning, residents commute to their workplaces, traveling from their residences and returning home in the evening. We assume that the local authorities have the capacity to conduct daily testing on 1% of the population. If an individual tested positive, they are required to self-isolate at home for a duration of 12 days.

1.2 Hypothesis

The project hypothesis proposes that the rate of influenza spread may be influenced by the proportion of vaccinated individuals. To examine this hypothesis, it is necessary to fine-tune the model and conduct batch simulations to determine the effective percentage of the population that should be vaccinated.

Chapter 2

Base model

2.1 Description

This model aims to suggest a mechanism for the transmission of influenza by identifying three primary agents: buildings, roads, and inhabitants. To address various scenarios, I tailor the parameters and methods within these agents. The benefit of this approach is the reduction in programming complexity, time savings, and increased simplicity. Nonetheless, a drawback exists, as altering hypotheses or expanding the scope may require significant modifications to the model's design.

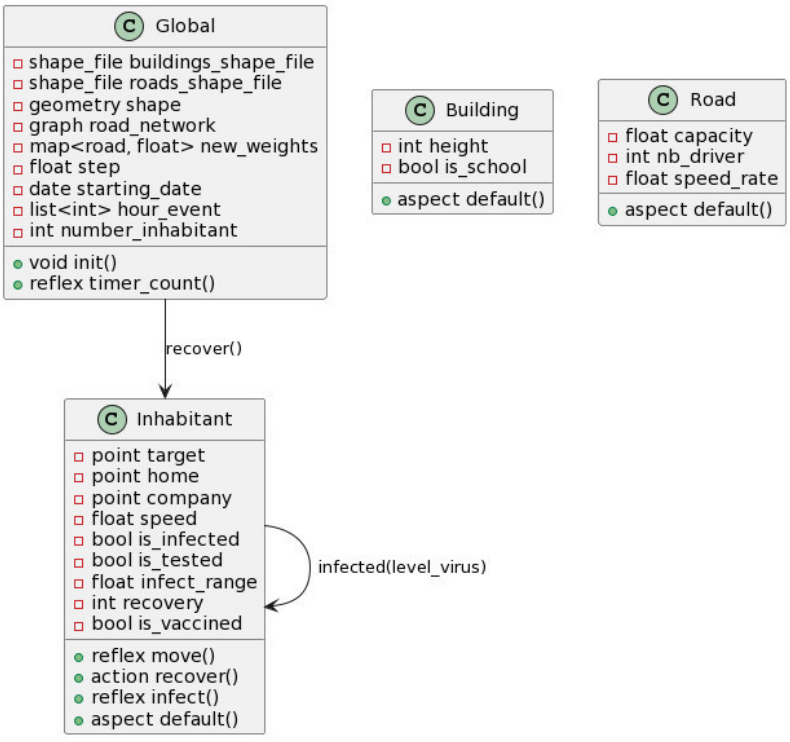

Figure 2.1 – UML of base model

1. **Global**

   - *init()*: create map and route, distribute population to each building, initialize the number of inhabitants, assign the percentage of inhabitants is being infected.

   - *timer_count()*: each specified time period, call the corresponding events such as infection, recovery, vaccination.

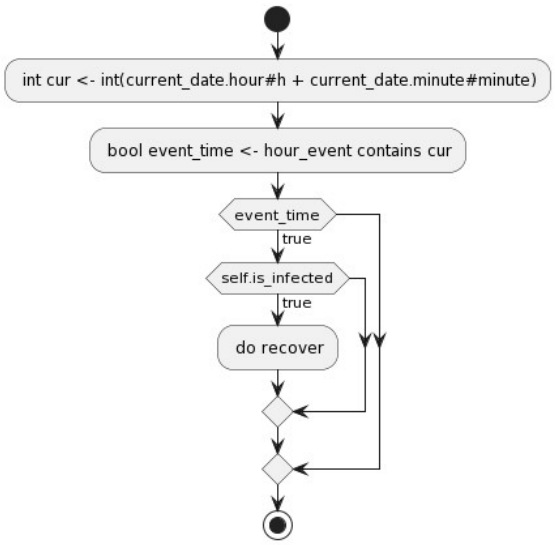

Figure 2.2 – Activity diagram of *reflex infect()*

2. **Inhabitant**

   - *reflex move()*: move to the corresponding target.

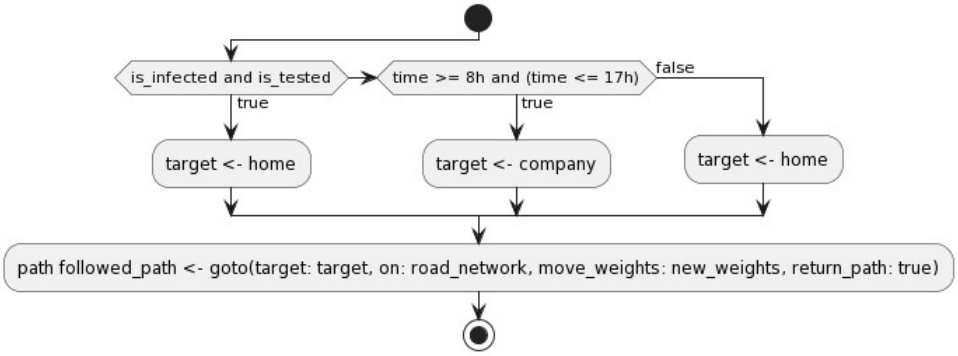

Figure 2.3 – Activity diagram of *reflex move()*

   - *action recover()*: recover after infection.

   - *reflex infect()*: infect others

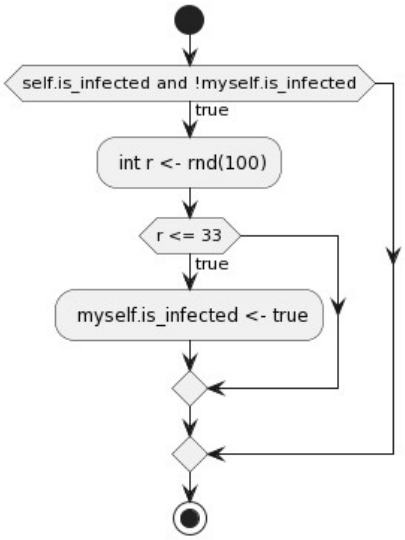

Figure 2.4 – Activity diagram of *reflex infect()*

2.2 Experiment

In this model, a straightforward simulation can be executed.

- It indicates that healthy individuals are in their workplaces from 8:00 AM to 5:00 PM, and otherwise, they are at home.
- Healthy individuals may contract an illness when they are within a specified distance of infected people.
- The graph illustrates the progressive increase in the number of infected individuals over time.

Additional experiments can be conducted by adjusting the following parameters.

1. **Global**
    - *number_inhabitant*
    - *hour_event*
    - *step*
2. **Inhabitant**
    - *speed*

Chapter 3

Extension 1

3.1 Description

To implement this extension, I followed these steps.

- Firstly, within the global "init" function, I designated 50% of the buildings as homes, forming groups of 4 to 6 people, including 0-2 children.
- Secondly, I specified that children attend school instead of other structures (workplace).

3.2 Experiment

In the first extension, despite not establishing a distinct children agent derived from the inhabitant, their behaviors can be examined. For instance, between 8:00 AM and 5:00 PM, adults occupy their workplaces, children gather at the city's largest building, and otherwise, all individuals remain at home.

I also created a chart illustrating the count of individuals categorized as healthy and those identified as sick over the course of time.

Chapter 4

Extension 2

4.1 Description

I address this query using the "timer_count" function globally. The officials are capable of immunizing 0.05% of the populace (limited to those who are not vaccinated). After vaccination, an individual's likelihood of spreading the infection is reduced by a factor of three.

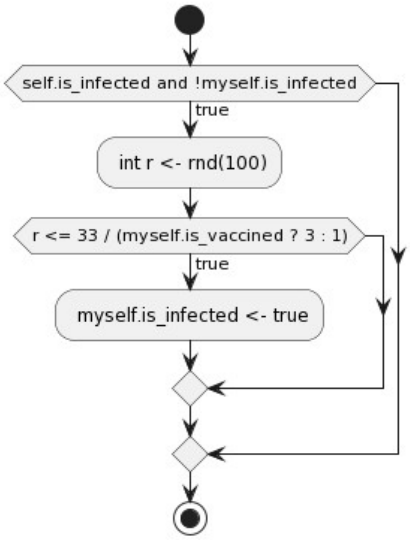

Figure 4.1 – Activity diagram of *reflex infect()*

4.2 Experiment

In the simulation of the second extension, I incorporated the count of vaccinated individuals into the chart to demonstrate its impact on the transmission of influenza.

Chapter 5

Extension 3

5.1 Description

I accomplished this by adjusting the "Inhabitant" agent through the following procedures.

- Initially, I included a level parameter to account for various variations.
- Subsequently, I altered the "infect" function to allow a newly infected individual to potentially contract the acquired variant strain
- Lastly, I implemented the virus_upgrade function, generating new variations derived from the existing virus strain and expanding the infection range by multiplying it by pi * rnd(0.5,1.5) times.

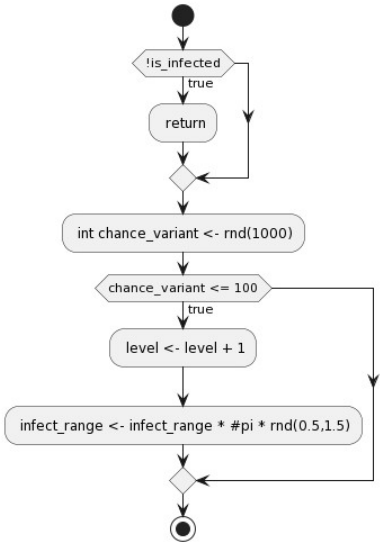

Figure 5.1 – Activity diagram of *reflex virus_upgrade()*

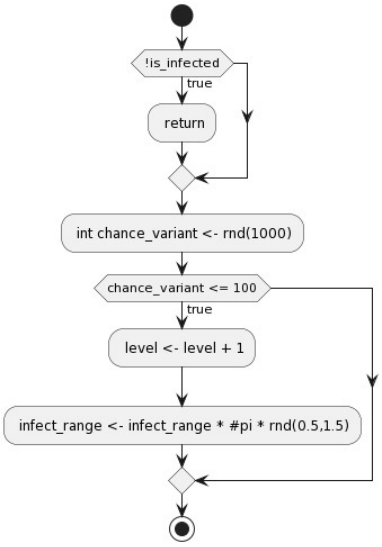

Figure 5.2 – Activity diagram of *reflex infect()*

5.2 Experiment

In the third extension simulation, I integrated the virus level into the chart to illustrate its influence on the efficacy of the influenza vaccine.

We can do more experiments by modifying the following parameters.

Global:

- *percent_vaccine*
- *number_inhabitant*

Chapter 6

Extension 4

6.1 Description

The central inquiry of this hypothesis revolves around the effectiveness of vaccinating different percentages of the population—10%, 50%, or 90%. To address these questions, I conducted a batch simulation to evaluate how the percentage of vaccinated individuals influences the spread of the virus.

The results yielded positive outcomes, demonstrating that as the proportion of vaccinated individuals rose, there was a corresponding decrease in the spread of the virus. A comprehensive breakdown of the results is provided in the subsequent table.

Percentage of vaccinated people (%)	Infected people	Healthy people	Vaccinated people
10	10702	2880	1358
10	11392	3152	1454
10	10508	2490	1299
10	11267	3145	1441
10	11245	2709	1395
50	10205	3377	6791
50	10769	3775	7272
50	9921	3077	6499
50	10668	3744	7206
50	10728	3226	6977
90	9625	3957	12223
90	10066	4478	13089
90	9372	3626	11698
90	9989	4423	12970
90	10160	3794	12558

Table 6.1 – The subsequent table

6.2 Experiment

In this concluding phase, I conducted a batch simulation and exported the results to a CSV file.

Additionally, we can perform a more in-depth analysis by varying the percentage of vaccinated individuals.

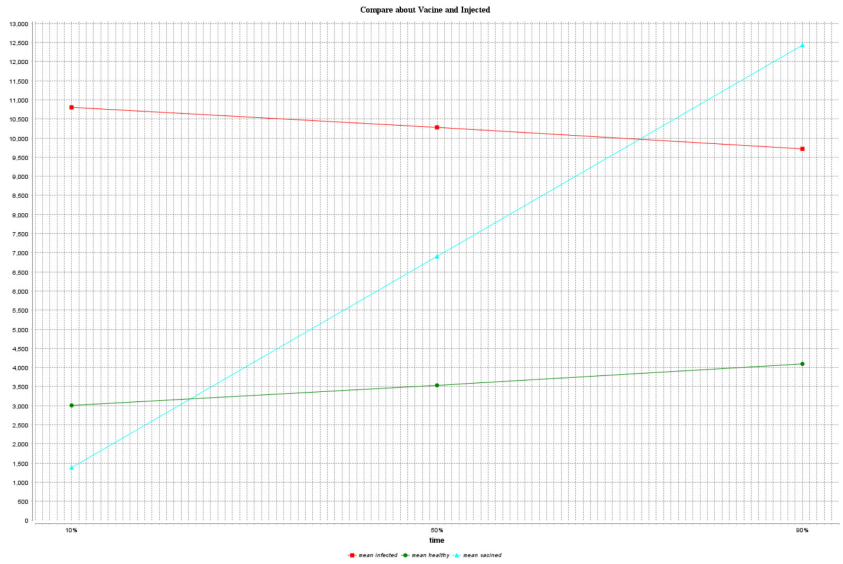

Figure 6.1 – Activity diagram of *The effectiveness of vaccinating*

Chapter 7

Conclusion and future work

7.1 Conclusion

I have completed all the assigned tasks for the project. Through batch simulations, I examined how the proportion of vaccinated individuals affects the rate of influenza spread, and the simulation process was quite seamless.

However, I recommend using a high-performance PC for simulating and running the GAMA platform. There is a notable difference between my laptop and desktop when conducting tests. For instance, with 5000 inhabitants, my laptop took 5 seconds to initialize, whereas the desktop only took 2 seconds.

7.2 Future work

Several concepts are being assessed subjectively as potential new avenues for further trials and experiments.

- The severity of the disease is being evaluated in terms of mortality and recovery rates.
- Various vaccines are under consideration, each exhibiting varying degrees of effectiveness against the disease.