IE 206 - Term Project I

Spring 2024

Deadline: May 6^{th}, until 11:59 pm

Soft-copy report and codes should be submitted via ODTUClass. LATE submissions will not be accepted.

General Rules about Term Project

This project is a group work, and each group should have ***two members****. Make sure* ***you make only*** ***one submission per group*** *and name your submission properly according to the provided instructions; see the last page.*

Please adhere to METU Code of Academic Integrity. Here, "you" refers to "your group." You may discuss background issues and general strategies with your instructor and TAs and seek their help, but the work you submit must be your own. It is **NOT OK** for you to see or hear another student's code, and it is certainly **NOT OK** to copy code from another person or from published/Internet sources.

METU Policy Making on Corona Virus Spread

As an Industrial Engineer, you are hired by the government for a consultancy on the recent coronavirus outbreak. The government wants to get some lessons from the recent outbreak and be prepared for the next possible spreads. Your task is to create a computational framework for understanding the outbreak conditions and testing the effectiveness of the different policies for preventing the spread by the help of simulation. You are expected to create a model for the Corona virus spread and perform computational analysis for developing different policies and their effectiveness under several settings to control the spread of a disease.

You are required to present a report based on your findings. In your report you should not only present the numerical results but also present your comments on the policies based on your findings.

Representation of the System and the Spread of the Pandemia

Given a $T \times T$ grid as in Figure 1, we have N people in the population that are distributed on the grid randomly. Initially, each cell must contain only one individual, and Δ_1 % of N people (denoted by N_s) are assumed to be infected.

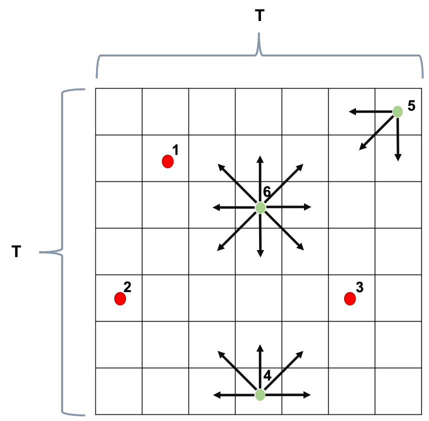

Figure 1: Representation of the problem. Green and red points represent healthy and infected people, respectively.

Each individual (for the rest of the text, **point** refers to an individual) can randomly move with equal chances, as in Point 6 in Figure 1. In each direction, a point can move with a random amount of step(s) distributed with U[0,3]. While moving, if a point hits a boundary or a corner, it cannot move along all directions, but it can move in certain directions with equal chances in the next move. (In Figure 1, Points 4 and 5 have five and three available directions, respectively.)

If an infected and a non-infected point coincide at a cell, the non-infected point will be infected with a probability of p, which is the *contagiousness* of the virus. Also, each infected point will be healed with a 0.95 probability after M iterations of *infectious period*. It is assumed that infected points can infect non-infected points during the infectious period, M. The point that cannot be healed after M iterations will be dead.

Isolation Policy

Isolation means that an infected point can only move to neighbors of the cells where *it gets infected*. For example, as shown in Figure 2, a point infected at cell A can only be found in cells A to I with equal probability in any iteration until it gets healed. In this policy, a newly infected point will be isolated with a probability of q_s and stays isolated for M iterations. Since not all people obey the rules, they may ignore the isolation rule with $(1 - q_s)$ probability and continue to move around as regular individuals. Initially, Δ_2 % of the infected people are accepted to be isolated until they are healed (for M iterations). Once a point is infected but not isolated, it will not be isolated in the following iterations.

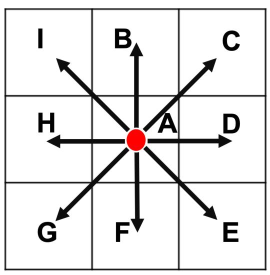

Figure 2: Representation of the isolation.

Vaccination Policy

In this policy, the government procures two doses of vaccination for each individual. The first vaccination starts after the iteration t_s. At each iteration after t_s, $\Delta_3\%$ of healthy individuals at that time who have not been vaccinated yet will be vaccinated. The individuals who are vaccinated once can have the second vaccination after t_{sec} period of their first vaccination with probability w.

Individuals with only one vaccination can be infected with probability r_s until having the second vaccination. After the second vaccination, an individual's infection probability r_s will reduce to 0, and s/he will be considered fully protected. However, if an individual has not been vaccinated for the second time after the t_{sec} period, its infection probability will increase to p. Note that if an individual is infected after the first vaccination, s/he will not be vaccinated for the second dose.

Model Parameters

Model parameter values are given in Table 1 below.

Table 1: Model Parameters

Parameter	Explanation	Parameter Values
T:	grid size	25 x 25
N:	population size	200
Δ_1:	percentage of infected people initially	10%
p:	infection probability in scenario of encounter	0.5
Δ_2:	percentage of isolated infected people at the initialization	50%
q_s:	isolation probability of a newly infected person	[0.0 - 1.0]
M:	duration of infectious period (in number of iterations)	25
t_s:	iteration number where vaccination starts	20
r_s:	infection probability of vaccinated healthy people	0.1
t_{sec}:	number of iterations between two vaccinations	10
w:	second vaccination probability of healthy people	[0.4 - 0.8]
Δ_3:	rate of vaccination of healthy people	$\frac{1}{k*(t_v-19)}$, for $t_v = t_s, t_s+1, t_s+2, ...$ $k = \{1.5, 2, 3, 4\}$

To observe how the system behaves, we consider the following performance criteria listed below. Note that not all criteria may be applicable to all situations. For each case, you should determine which ones to use. (Do not add additional performance criteria.)

- total number of infected people in the system in each iteration,
- total number of infected people in the system,
- total number of healed people in the system in each iteration,
- total number of healed people in the system,
- total number of vaccinated people in the system in each iteration,

- total number of infected people who are vaccinated in the system in each iteration,
- total number of dead people in the system in each iteration,
- total number of dead people in the system.

To consult the government on how the COVID outbreak spreads, different cases are studied (see below), and the results will be reported to the decision-makers.

You are expected to make analyses using the computational environment you will generate and improve our understanding of the dynamics of the spread under different cases. Analyze the following cases and present your results by providing related graphs.

0. The base case for the government is to DO NOTHING (that was considered as a policy in some countries); that is, the government will implement no policy and let the spread of the pandemic be stopped in natural ways. So it will be natural to consider this case to test the effectiveness of any other policy.

1. Considering there is no vaccination available, what is the impact of the implementation of different isolation policies on the spread of the pandemic?

2. Suppose the government implements a single vaccination policy without an isolation policy due to economic considerations. Under this policy, vaccination starts after t_s iterations, and at each iteration after t_s, $\Delta_3\%$ of healthy individuals at that time who have not been vaccinated yet are vaccinated. Once an individual gets vaccinated, its infection probability reduces to r_s and remains in r_s for the following 20 iterations, then rises back to p. Considering the vaccination rate, discuss the impact of the vaccination policy on the spread of the pandemic.

3. Suppose the government decides to implement the vaccination policy (as in Page 2) without an isolation policy. What is the impact of the vaccination rate and the willingness of people for the second vaccination on the spread of the pandemic?

4. Suppose the government decides to implement a policy in which vaccination and isolation are implemented together. You should discuss the performance of such a mixed policy, considering the impact of vaccination rate and strictness of isolation on the spread of the pandemic. You should further compare the performance of the mixed policy with the cases where the government implements a vaccination (without isolation) policy and an isolation (without vaccination) policy. Note that in the vaccination case, $w = 0.5$.

5. Consider that the government aims to control the spread such that at most 25% of the population is infected at any iteration. Here the aim of the government is to keep the healthcare system afloat in order to provide a sustainable health service. For possible future pandemics, your team should propose prevention policies for the cases of different infection probabilities p as **0.25 (low case)**, **0.5 (moderate case)**, and **0.75 (high case)**. In this part, you should design an experimental setting to try different values for some of the model parameters and observe the behaviour of the necessary performance measures to understand the effectiveness of the policies **for each case**. Based on your findings, you should have a detailed discussion for your suggestions and demonstrate them with the supporting graphs.

Write scripts to simulate each policy explained above for $t = 250$ iterations using the computational environment you create. Report the performance criteria which are applicable for each case using charts. You can use line charts, bar charts, 3-dimensional charts, or similar ones.

Note: In this project, you are supposed **NOT** to use Object-Oriented Programming.

Reporting

You are required to write a project report to present your results and discuss your findings.

The report should be written in Calibri with a font size of 11 (1.15 space). Use standard page margins (i.e., 2.5 cm from both top/bottom and left/right) and justified text (i.e., the text should be distributed evenly between margins). It needs to include a cover page, table of contents, and page numbers. The number of pages (excluding the cover page and table of contents) should not exceed 10 pages. Please pay attention to report requirements since you will also be getting points from the format.

What to submit?

You are going to submit all your files (including the project report) to ODTUClass. As a comment, at the top of each file you submit, please write each member's

- name and surname
- studentID

and submit only one folder as a group of two. You need to follow the same submission regulations as you follow in homeworks. However, since this is group work, you need to write both members' student ID numbers.

You should name your report as Project1_ID1234567_ID9876543.pdf and upload it to Turnitin Submission on ODTUClass. Then, put all your files in one folder and compress them as a .zip folder as below:

Project1_ID1234567_ID9876543.zip

i. Create 5 folders and name them as Case 1, Case 2, etc. Put your Matlab files for the cases in the corresponding folders.

ii. Put your report, named as Project1_ID1234567_ID9876543.pdf

iii. Add other files with appropriate names (if they exist)

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DEPARTMENT OF INDUSTRIAL ENGINEERING

IE206 Project Report

2023-2024 Spring

Policy Making on Corona Virus Spread

Academic integrity is expected of all students of METU at all times, whether in the presence or absence of members of the faculty.

Understanding this, we declare that we shall not give, use, or receive unauthorized aid in this project.

Group ID#	*Student ID Number*	*Full Name*	*Signature*