COVID-19 A HEURISTIC STUDY

Learning objectives: CLO 1, CLO 3, CLO 4, CLO 5
Does the lockdown work to reduce the number of deaths due to COVID-19 during the Corona virus pandemic? In this assignment you will apply the concepts of the course to answer the question. Specifically, you have to simulate and predict the spreading of COVID-19. First, you have to create a graph called *interaction graph* that models the interactions between individuals. We observe that some people interact with too many people meanwhile some other with few people. Therefore, the graph follows a Power Law distribution. We consider the following parameters:
$INTERACTION$: models the number of interaction per day. Greater than 50 is for life without lockdown meanwhile less than 5 for lockdown.
$ALPHA \in [0, 1]$: Small values will leave fewer nodes with high degree (or contacts) than larger values. The following procedure creates the desired graph with n nodes (people).

```
getInteractionGraph(n)
   Let g be a graph with n vertices
   Repeat  INTERACTION times
      For j in 0,1,...,n-1 Do
           Let i be any random node in [0,1,...,j-1]
           If random(0,1) < ALPHA Then
               graph.add_edge(j,i)
           Else
               Let k be any random node that node i points
               graph.add_edge(j,k)
   Return graph
```

Each node of the graph contains two variables:

```
Node
   state    : Int    // CLEAN=0, INFECTED=1,DEAD=2,RECOVERED=3
   recover  : Int   // Number of days left to recover
```

To simulate the spreading of COVID-19, every day an infected person may infect a CLEAN person who is interacting with. After the recover time, an infected person can either die or recover. The following table summarizes the parameters to be used:

Parameter	Value	Description
n	10000	Number of Nodes
ALPHA	0.01	Small values few nodes with high degree
RECOVERY_DAYS	14	Number of days to recover
TRANSMISSION_RATE	1.5%	Transmission rate (Probability of infecting)
FATALITY_RATE	3%	Some people may die (Fatality)
INITIAL_SETTING	1%	Initial number of infected

To contrast two strategies (Lockdown vs no Lockdown) we create two graphs, one with INTERACTION=60 that simulates no Lockdown and the other with INTERACTION=5 to simulate Lockdown. Now, we can simulate the behavior of COVID-19 as follows:

```
simulation(day)
     Print the number of INFECTED and DEAD nodes.
     For each node v that is INFECTED Do   # Check the infection
          For each neighbor w of v that is CLEAN Do
               If rand(0, 1) < TRANSMISSION\_RATE  Then
                    w.state = INFECTED
                    w.recover = RECOVERY_DAYS
          v.recover = v.recover - 1
          If v.recover == 0 THEN
                 If rand(0,1) < FATALITY_RATE Then  # Either it dies
                     v.state = DEAD
                 Else                                                    #or recovered
                     v.state = RECOVERED
```

Initially, some nodes are infected.

```
For each node v  Do
   If rand(0, 1) < INITIAL_SETTING Then # Probability of being infected
      v.state = INFECTED
      w.recover = RECOVERY\_DAYS
   else                                                    # Probability of not being infect
      v.state = CLEAN
```

To simplify the implementation you can create a node class that contains the state, the recover days and its adjacent list. You initialize according to the probability $INITIAL\_SETTING$. The Adjacency list creates an array of Nodes, thus you can use indexes from 0 to $n-1$ for the links. You have to run the simulation for 30 days and plot the number of infected people per day and the accumulated number of dead people in lockdown and no lockdown. Use the module matplotlib to plot the outputs.
Submit a pdf file of the plot and the code.

RUBRICS

	Level 4 2 Pt	Level 3 1.5 Pt	Level 2 1 Pt	Level 1 0.5 Pt
Interaction graph	It is always correct without crashes	Eventually it crashes or return incorrect results	It frequently crashes and/or return incorrect results	It is not correct or incomplete
Plot of the number of infection	It is always correct without crashes	Eventually it crashes or return incorrect results	It frequently crashes and/or return incorrect results	It is not correct or incomplete
Plot of the number of deaths	It is always correct without crashes	Eventually it crashes or return incorrect results	It frequently crashes and/or return incorrect results	It is not correct or incomplete