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COVID-19 Spread Simulation Using NetLogo Documentation

Introduction:

Welcome to the NetLogo-based Covid-19 Spread Simulation Documentation. This project was undertaken as part of the assessment requirements for the "Complex Agent Technology" module. In this documentation, we delve into a NetLogo simulation that models the spread of disease within a population.

Purpose of the Project:

The primary purpose of this project is to gain a deeper understanding of complex agent-based modeling, particularly in the context of disease spread. Our goals encompass a variety of objectives:

- Exploring the dynamics of disease transmission within a population.
- Investigating the impact of various factors, such as mask-wearing, vaccination, and social distancing, on the spread of Covid 19.
- Showcasing the capabilities of NetLogo as a tool for creating and visualizing agent-based models.

Interface Elements:

1. Buttons
   - Setup Button: The "Setup" button initializes the simulation by creating the initial population of agents (representing individuals) in the virtual world. It prepares the simulation environment for the disease spread simulation. Detailed explanations are included in code explanations
   - Go Button: The "Go" button initiates the disease spread simulation, allowing the population of individuals to interact and potentially become infected based on various factors, including mask-wearing, vaccination, and social distancing.
2. Sliders
   - Population Slider: controls the initial size of the population in the simulation. It determines the number of individuals (agents) present in the virtual world.
   - Mask Possibility Slider: influences the probability of individuals wearing masks in the simulation. It controls the likelihood of an individual choosing to wear a mask.
   - Vaccinated Slider: determines the probability of individuals being vaccinated against the disease in the simulation. It represents the vaccination rate among the population.
   - Social Distancing Possibility Slider: controls the probability of individuals practicing social distancing in the simulation. It simulates the effectiveness of social distancing measures.

3. Monitors:

The monitors provide vital information during the simulation. "%Infected" displays the current percentage of infected individuals, while "Days (Ticks)" tracks the number of simulation days elapsed, helping you monitor the disease's progression over time.

4. Colors of People:

I. Blue: Individuals wearing masks.
II. Yellow: Vaccinated individuals.
III. Pink: Individuals not wearing masks and not vaccinated.
IV. Green: Individuals vaccinated and wearing masks.
V. Red: Infected individuals (dynamic color).

Code Explanation:

1. Procedures

'setup' Procedure

Purpose: The `setup` procedure initializes the simulation environment, creating the initial population of agents (individuals) and setting their attributes.

Explanation:

1. `clear-all`: Clears the simulation environment, removing any existing agents and resetting the simulation.
2. `reset-ticks`: Resets the simulation's time counter to zero.
3. `create-turtles population`: Generates a population of individuals represented by agent turtles. Each turtle is placed at a random position on the grid.
4. Within the `create-turtles` block:
   - Sets the turtle's shape to "person."
   - Initializes their infection status (`infected`) as `false`.
   - Sets the initial color to green.
   - Assigns a `social-distancing` attribute with an initial value of `false`.
   - Determines whether each individual is wearing a mask (`wearing-mask`) based on the specified mask-wearing probability.
   - Determines whether each individual is vaccinated (`vaccinated`) based on the specified vaccination probability.
5. `colorize`: Calls the `colorize` procedure to assign colors to individuals based on their mask-wearing and vaccination status.
6. `ask turtle random population [infect]`: Selects a random individual to be the initial infection source by calling the `infect` procedure on that turtle.
7. `ask n-of (population * %social-distancing-possibility / 100) turtles with [color != red] [set social-distancing true]`: Assigns social distancing behavior to a portion of the population, as determined by the specified probability.
8. Calculates and sets `%infected` as the initial percentage of infected individuals based on the number of turtles with the `infected` attribute set to `true` relative to the total population.

`go` Procedure

Purpose: The `go` procedure controls the simulation's dynamics, advancing time (ticks) and simulating the spread of the disease.

Explanation:

1. `tick`: Advances the simulation by one tick (day).
2. Sets various parameters like `infectiousness`, `CoeffM` (coefficient of protection from masks), and `CoeffV` (coefficient of immunity from vaccination). These parameters affect the probability of infection.
3. `ask turtles with [not social-distancing] [...]`: Agents not practicing social distancing move randomly within the simulation grid.
4. `ask turtles with [infected] [...]`: For individuals who are infected, the following actions occur:
    - They interact with other turtles within a radius of 1 patch.
    - The simulation checks the mask-wearing and vaccination status of nearby individuals to adjust the probability of infection accordingly.
    - Infected individuals may infect others based on the calculated probabilities.
5. `heal`: Calls the `heal` procedure to simulate recovery and reduce the number of infected individuals.
6. Updates `%infected` to reflect the current percentage of infected individuals.
7. Checks stopping conditions: If the simulation has run for a specified number of ticks (days) or if the infection reaches a certain threshold (e.g., 100% infected), the simulation stops.

`infect` Procedure

Purpose: The `infect` procedure marks a turtle as infected by changing its color to red and setting its `infected` attribute to `true`.

Explanation: When called, this procedure sets the `infected` attribute of a turtle to `true`, indicating that it is infected, and changes its color to red to visually represent the infection.

`colorize` Procedure:

Purpose: The `colorize` procedure assigns colors to individuals (turtles) based on their mask-wearing and vaccination status.

Explanation:

- It uses conditional statements to set the color of each turtle based on its attributes:

  - Pink: No mask and no vaccination
  - Yellow: No mask but vaccinated
  - Blue: Wearing a mask but not vaccinated
  - Green: Wearing a mask and vaccinated
  - Red: Infected individuals

- `heal` Procedure:

Purpose: The `heal` procedure simulates the recovery of infected individuals by randomly selecting and setting a portion of them as non-infected.

Explanation:

- It calculates the number of turtles to select for healing based on a predefined healing rate and the current population size.
- Randomly selects and sets a portion of infected turtles as non-infected (`infected` attribute set to `false`).
- Calls the `colorize` procedure to update their colors accordingly.

2. Global Variables:

- infectiousness: This global variable represents the infectiousness of the disease in the simulation, expressed as a percentage. It is set to a fixed value of 62% in the go procedure and is used to calculate the probability of disease transmission. The higher the value, the more infectious the disease is in the simulation.
- CoeffM (Coefficient of Protection from Masks): This global variable represents the protective effect of wearing masks, expressed as a coefficient. It is set to a fixed value of 0.55 in the go procedure. The coefficient is used in conjunction with other factors to adjust the probability of infection for individuals wearing masks. Higher values indicate greater protection from masks.
- CoeffV (Coefficient of Immunity from Vaccination): This global variable represents the immunity gained from vaccination, expressed as a coefficient. It is set to a fixed value of 0.30 in the go procedure. The coefficient is used to modify the probability of infection for vaccinated individuals. A higher value indicates stronger immunity conferred by vaccination.

3. Local Variables:

- healing-rate (Local Variable): This local variable represents the rate at which infected individuals recover and become non-infected. It is defined locally within the heal procedure. The heal procedure uses this variable to determine the number of infected individuals to select for recovery based on the healing rate. It's used for controlling the recovery dynamics in the simulation.
- number-to-select (Local Variable): This local variable calculates the number of infected individuals to be selected for healing. It is calculated within the heal procedure and is based on the product of the population size and the healing rate. This variable helps select the specified number of individuals for recovery.
- selected-turtles (Local Variable): his local variable stores a list of turtles (individuals) selected for recovery. It is defined within the heal procedure and is used to keep track of the turtles that will transition from being infected to non-infected. This variable ensures that the healing process affects a subset of infected individuals.- Describe the role of each procedure in the simulation, step by step, and how they interact with each other.

Assumptions:

1. A person practicing social distancing is represented by a stationary turtle.
2. All constants used in the simulation are arbitrarily selected and not based on real-world data.
3. No one dies from COVID-19 in the simulation.
4. No one is added to the population from the outside during the simulation.
5. The simulation always starts with only one infected person.
6. People who have been healed can be infected again, regardless of real-world conditions.

Simulation Process:

- Initial Placement of Individuals:

- The simulation begins by initializing the environment with a population of individuals, each represented by a turtle.
- These individuals are randomly placed on the simulation grid.
- Their attributes, such as infection status, mask-wearing, vaccination, and social distancing, are determined based on specified probabilities.
- The simulation is always started with one randomly chosen individual marked as infected, serving as the initial infection source.

- Infection, Healing, and Color Changes:

- Infection: The spread of the disease is simulated by allowing infected individuals to interact with others within a certain radius.
- The probability of infection is determined based on various factors, including the infectiousness of the disease and the mask-wearing and vaccination status of nearby individuals.
- Healing: Infected individuals may recover over time based on a predefined healing rate, transitioning from infected to non-infected.
- Color Changes: Individuals are color-coded to visually represent their attributes. Colors change based on mask-wearing, vaccination, infection, and recovery status.

- Progression with Each Tick:

- The simulation progresses in discrete time steps called "ticks," where each tick represents one day.
- With each tick, the following events occur:
  - Individuals not practicing social distancing move randomly within the simulation grid.
  - Infected individuals interact with others, potentially spreading the disease.
  - Infection probabilities are calculated, adjusted by mask-wearing and vaccination status.
  - Infected individuals may infect others.
  - Some infected individuals may heal and become non-infected.
  - The percentage of infected individuals (%Infected) is updated in real-time.

- Stopping Conditions:

-The simulation continues to progress until specific stopping conditions are met:
- If the number of ticks (days) reaches 200, the simulation stops.
- If the percentage of infected individuals (%Infected) reaches or exceeds 100%, indicating that the entire population is infected, the simulation stops.

Snapshots of the simulation process:

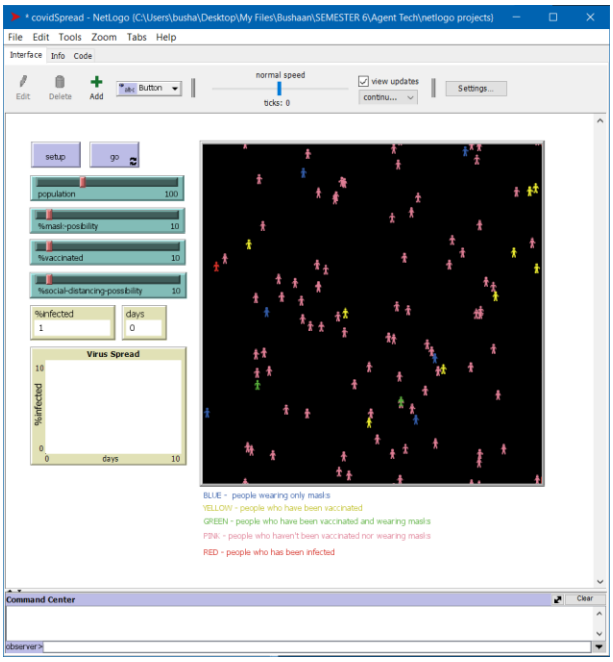

Figure 1

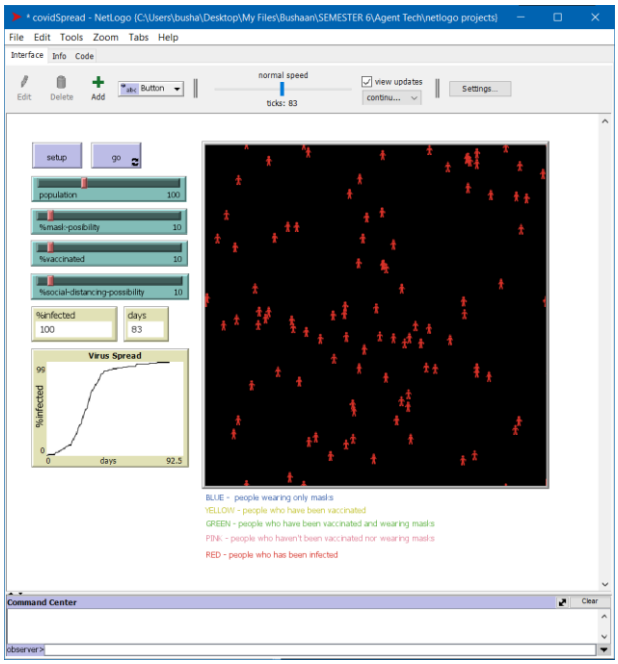

Figure 2

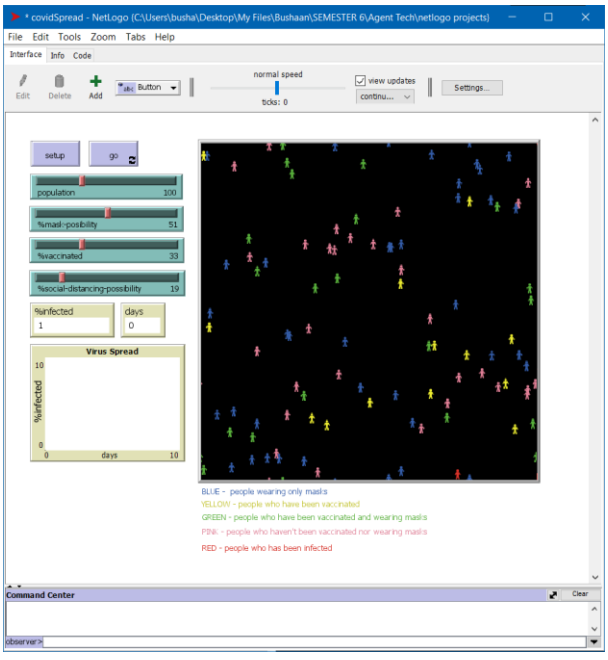

Figure 3

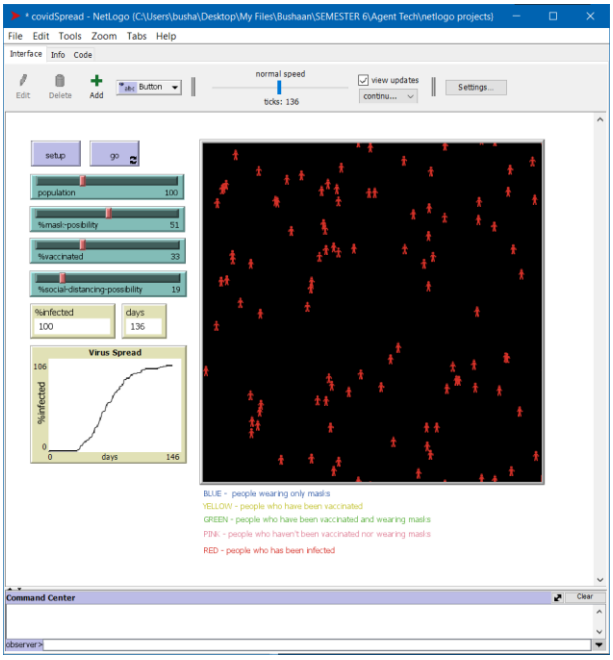

Figure 4

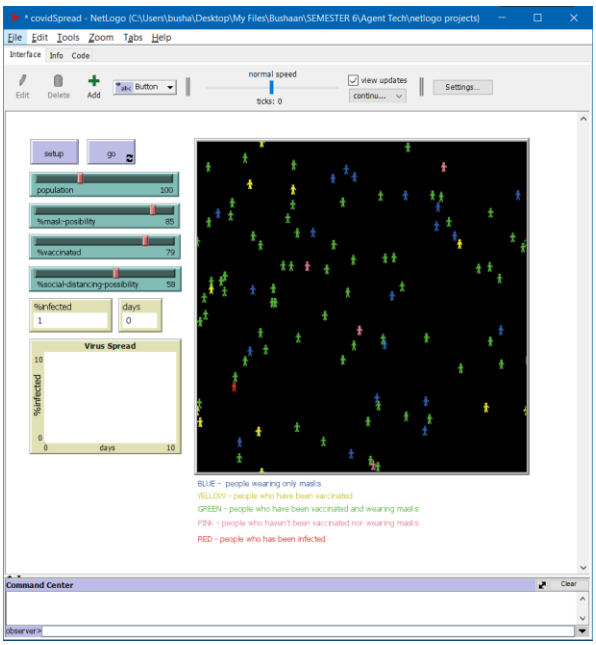

Figure 5

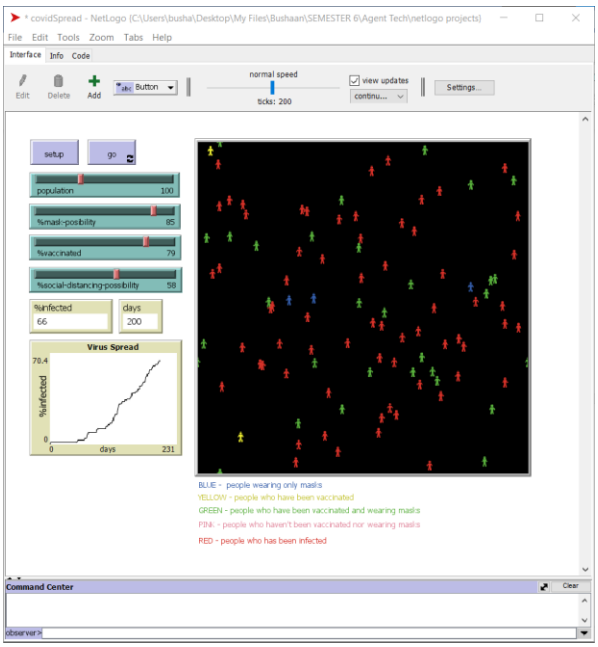

Figure 6

Simulation Code:

```
globals [%infected %infectiousness CoeffM CoeffV]

turtles-own[infected wearing-mask vaccinated social-distancing]

to setup
  clear-all
  reset-ticks
  create-turtles population
  [
    setxy random-xcor random-ycor
    set shape "person"
    set infected false
    set color green
    set social-distancing false
    ifelse (random 100) < %mask-posibility [set wearing-mask true][set wearing-mask false]
    ifelse (random 100) < %vaccinated [set vaccinated true][set vaccinated false]
  ]
  colorize
  ask turtle random population [infect]
  ask n-of (population * %social-distancing-possibility / 100) turtles with [color != red] [
    set social-distancing true
  ]
  set %infected (count turtles with [infected] / count turtles ) * 100
end

to go
  tick
;;**************************************************************************
```

```
 set %infectiousness 62   ;; infectiousness is defined to be 62%
 set CoeffM 0.55       ;; Coefficient of protection gained from wearing Face wearing-masks
 set CoeffV 0.30       ;; Coefficient of immunity gained from vaccinated
 ;;please consider all these constants are defined arbitrarily
;;*************************************************************************
 ask turtles with [not social-distancing]
 [ right random 100 left random 100 forward 10]
 ask turtles with [infected]
 [
  ask other turtles in-radius 1 with [wearing-mask]
  [
    ifelse(vaccinated) [
     if (100 - (random 100)) < %infectiousness * CoeffM * CoeffV  [
       infect]]
    [if (100 - (random 100)) < %infectiousness * CoeffM [
       infect]]
    ]
  ask other turtles in-radius 1 with [not wearing-mask] [
    ifelse(vaccinated) [
     if (random 100) < %infectiousness * CoeffV [
       infect]]
    [if (random 100) < %infectiousness [
       infect]]
 ]
 ]
 heal
 set %infected (count turtles with [infected] / count turtles ) * 100
 if (ticks >= 200 or %infected >= 100) [stop]
end
to infect
 set infected true set color red
end
to colorize
 ask turtles with [not wearing-mask  and not vaccinated][set color pink]
 ask turtles with [not wearing-mask  and vaccinated ][set color yellow]
 ask turtles with [wearing-mask  and not vaccinated][set color blue]
 ask turtles with [wearing-mask and vaccinated][ set color green]
 ask turtles with [infected] [set color red]
end
to heal
 let healing-rate 0.005 ;;please consider that this constant is defined arbitrarily
 let number-to-select population * healing-rate
 let selected-turtles n-of number-to-select turtles
 ask selected-turtles
 [
  set infected false
  colorize
 ]
End
```

Video demonstration link:

https://drive.google.com/drive/folders/1BbwRiX18RGBWP7gtGCSDpTdDJW2LjEA9?usp=sharing