

Agent based Simulation Modeling and Application of MAS in Health Care: Prediction of Corona using Euclidean Distance

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Abstract— Coronavirus disease (COVID-19) represents one of the most infectious diseases of the 21st century, significantly impacting public health and societal structures. This study introduces an innovative approach to simulating the virus's spread using a Multi-Agent System, showcasing how the dynamics of infection can be effectively modeled through Euclidean distance. By leveraging Intelligent Agents, which possess properties such as communication and reactivity, we can gain deeper insights into the mechanisms driving transmission. In this work, we create a unique simulation framework that represents a population of one thousand individuals, with one agent initially infected. The simulation not only highlights the role of spatial relationships but also incorporates factors such as resistance and recovery of infection dynamics. To enhance accessibility and reduce memory consumption, we visualize the simulation through an image viewer instead of traditional video formats.

Implemented in Jupyter Notebook, this Multi-Agent Simulation provides an interactive platform for exploring the complexities of viral transmission, paving the way for future research and applications in epidemic modeling. This novel approach emphasizes the potential of agent-based modeling applied in healthcare.

Index Terms—Multi-agent system (MAS), Simulation, Euclidean Distance, Image viewer, COVID-.

I. INTRODUCTION

Coronavirus (COVID-19), remains a leading threat to humanity. Different Simulation models have been developed to predict the outcome of Coronavirus spread. Artificial Intelligence (AI)/Machine Learning (ML) based [1], Complex dynamical network [2] based, NetLogo [3] implemented models are developed to predict the spread of coronavirus. Data driven Predictive model [4], Ambiguous set theory [5] based model, Mathematical autoregressive model [6], Machine [7] Learning based (KNN) model is proposed for quick identification and prediction of risk of corona. Agent based Mathematical simulation model [8][9][10] was developed to measure the probability of epidemic spread. Above mentioned procedures for simulation of dissemination of coronavirus are useful but complex. Any simulation is incomplete without visual implementation. Dissemination of coronavirus can be best demonstrated by showing its visual effect. Actual spread of coronavirus mainly depends on two factors. Euclidean distance between individuals and their self-resistance (mask, vaccination etc.).

Present work has simulated the spread of coronavirus initially from an individual to a population of one thousand people. The simulation has been diagrammatically elaborated with the help of generating one thousand different frames by using the Multi Agent System. Objective of this work is to design a Multi Agent based simulation model implemented using Jupyter notebook to show the spread of coronavirus based on Euclidean distance between every pair of Agents and their inbuilt resistance. Simulation has ended with the method of recovery from infection. Simulation of Multi Agent System is shown with the help of image viewer in place of video as video consumes less space in Memory.

II. LITERATURE SURVEY ON SIMULATION OF SPREAD OF CORONA VIRUS (2020-024)

Different models have been developed to simulate the spread of coronavirus. This section provides a concise overview of the reviewed studies.

A spatiotemporal COVID-19[1] transmission model was proposed based on creating an artificial agent based society. Connection was established between different agents and spreading of coronavirus was demonstrated with transformation rules, and social relations etc..To address [2] the COVID-19 issues at Nanjing “Lukou Airport”, authors have simulated Passenger’s movement and come up with an algorithm to generate the moving traces. “Mobile contact networks” have been developed with “a static network of staff and passengers”. Every individual have been facilitated with complex dynamical network. Agent based [3] simulation model is designed to predict the impact of corona virus on human health. Demonstration of use of different brands of vaccines, respirators, types of masks are implemented using NetLogo in SEIR Framework. A data [4] driven Predictive model is designed to improve COVID-19 cases to improve public policy making. It helped to find the impact of coronavirus on global health and economy .AEDM model [5] is designed based on ambiguous set theory and useful in processing ambiguous pixel information. The proposed model has highlighted the edges of CT scan into three categories low ,moderate and severe infection. By using [6] a Mathematical Model called ARMA, autoregressive moving average model the authors have discussed the effect of corona on the Indian economy, society, and financial sector. A Machine [7] Learning based (KNN) model is proposed for quick identification and prediction of risk of corona so that early prediction can reduce the risk of corona. Prediction accuracy of the algorithm is “98.34%, Recall is 97% and an F1-Score is 0.97”.Agent based [8] Mathematical simulation model was developed to show the evolution and spread of Corona virus .COVID-19 [9]Agent-based Simulator is developed to predict the trends of epidemic and simulate the resource need. This model also have supported the non-pharmaceutical need, hygiene measure, physical distancing etc. Covasim, [10] “an agent-based model (ABM) of COVID-19”, was developed to measure the probability of epidemic spread based on “the region's demographic and geographical features”. Data collection was made on the basis of number of people tested, diagnoses, critical cases, hospitalization etc. and those data was analyzed region wise.

- Artificial Intelligence (AI) /Machine Learning (ML) based Simulation: A spatiotemporal COVID-19 AI based transmission model showed spreading of coronavirus , demonstrated with transformation rules, and social relations([1,7]).
- Complex dynamical network based Model : Algorithmic approach “to generate the moving traces with Mobile contact networks and complex dynamical network” ([2]).
- NetLogo in SEIR Framework: Spread of corona virus is implemented using NetLogo in SEIR Framework([3]).
- Data driven / Set theory based Predictive model: Data driven Set theory based model was developed for quick identification and prediction of risk of corona ([4,5,6])
- Agent Based Mathematical Model: Agent based Mathematical simulation model was developed to measure the probability of epidemic spread ([8,9,10]).

III. METHODOLOGY

Spread of coronavirus is simulated on the basis of the five stages

- Creation of population with the Intelligent Agents
- Creation of Agent class
- Individual initially infected
- Spreading of Infection from one Agent to another based on Euclidean distance and self-resistance
- Recovered from the stage of infection

The way of transformation between all three stages can ultimately decide the actual balance of infectious and recovered population.

A. Creation of population with the Intelligent Agents

The present work has simulated the spread of Coronavirus with the help of a Multi Agent System having one thousand Agents. Every individual in the population presented as an Agent.

B. Creation of Agent Class

Intelligent Agent of Multi Agent System is created with the help of Agent class. one thousand object of Agent class is created initially. Two instance variables x, y are used to initialize and track the position of all the agents. Another two instance variables are used to initialize the value of the number of Agents infected, and the resistance of agents against infection. To count the number of infected Agent, one instance variable named Infected counter is passed as arguments. Infected counter is initialized to zero.

C. Individual initially infected

Infected counter = 1 means positive case. Every time the infected counter is incremented by 50. In every step 10 are getting infected, 10 instances are changing color from green to red approximately. Step size is taken as 5

D. Spreading of Infection from one Agent to another based on Euclidean distance and self-resistance:

X and Y axis value of individual Agents is continuously getting changed randomly to change their position and in turns incorporating mobility. With the movement of Agent iteratively, the Euclidean distance between every two agent changes. After every iteration the number of newly affected Agents need to be measured. One Agent will be initially made as infected and based on the Euclidean distance the nearby agents start getting affected. The number of Agent to be affected depends on the value of Euclidean distance and the value of resistance. All the agents are marked as green. As and when they are getting affected their color is made to change to red. Every movement is recorded in a frame. One thousand frames are generated for One thousand iterations (movements). Number of times the simulation algorithm is executed, number of infected counts in every frame change because movement function is regulated by random number generator.

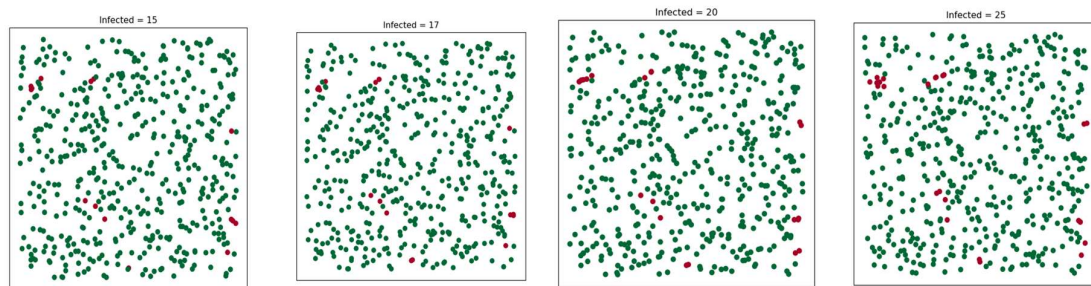


Fig 1: Spreading of Coronavirus based on Euclidean distance and self-resistance (First four frames)

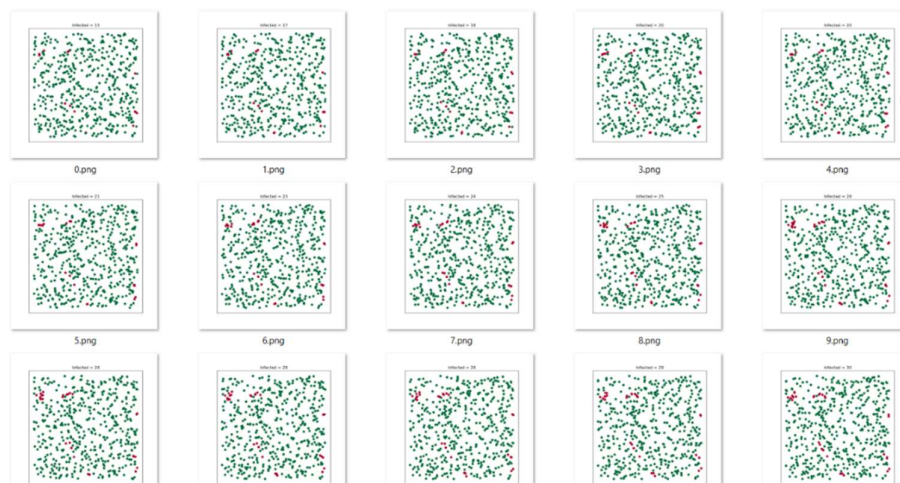


Fig 2: Simulation diagram of spread of coronavirus up to fifteenth iteration

E. Recovered from the stage of infection

Infect function will be executed when one non-infected Agent come in contact with an infected agent. Infect function generates a random number for every interaction between Agents.

If the random number is greater than the Agent resistance then the Agent will move to infectious state.

The present work has experimented with agents having different resistance value, as in our society, people wearing a mask may come near affected people but do not get affected. So, instead of having less Euclidean distance also Agent may not turn into Infectious state.

When the Agent is infected, its infected counter is set to some value and every time step the counter, start ticks down.

After counter becomes zero Agent gets healthy again. Setting high resistance value after the Agent is recovered can ensure the chance of reinfection.

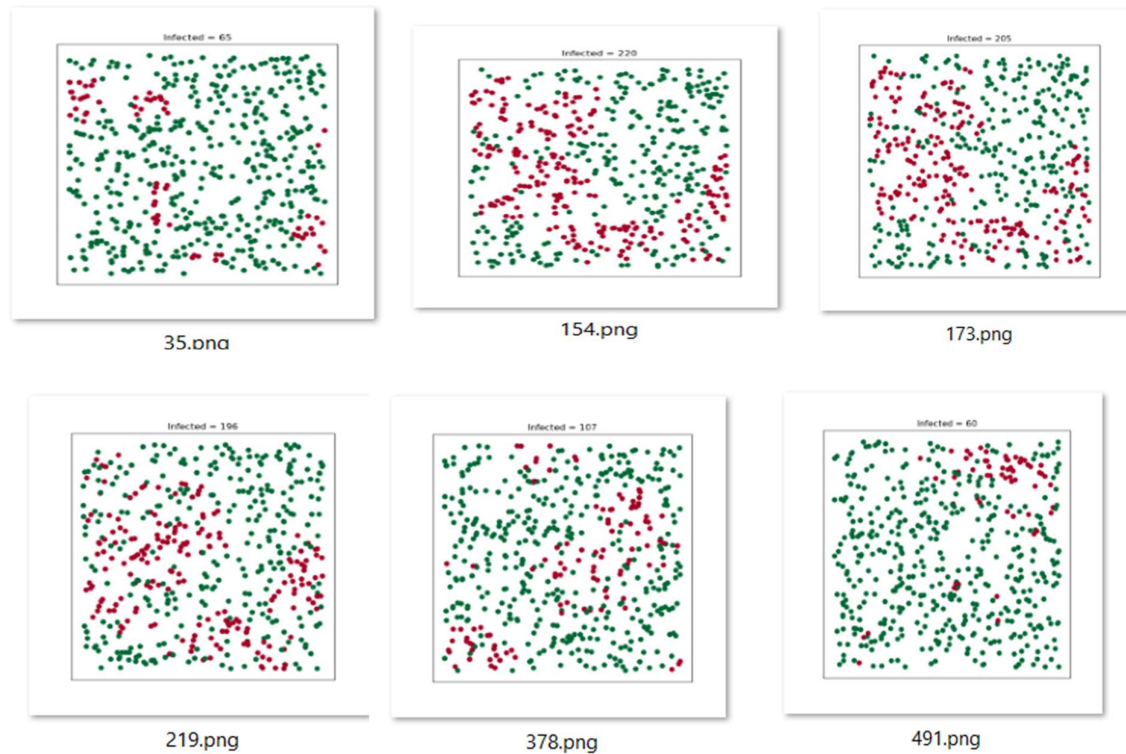


Fig 3: Frame 35 - Infected 65, Frame 154 - Infected 220, Frame 173- Infected 205, Frame 219 - Infected 106, Frame 378 - Infected 107, Frame 491- Infected 60

In Frame number 35, number of infected are 65 where as in Frame 491, the value of infected are 60 which proves that there are huge number of recoveries from coronavirus.

IV. ANALYSIS OF RESULT

Progression of Frame symbolizes spread of coronavirus. Frame number 2 is next step of progression of coronavirus after frame number 1. Figure 1 shows first four Frames which implies the simulated steps of the progression of coronavirus.

It is clear from first four figure that number of infected increases from first to fourth frame.

From the figure 3 it is observed that in Frame 35, 154, 173 number of Infected are 65, 220, 205 and again in Frame 219,378,491 number of infected are 106,107, 60 respectively.

From the above result it is obvious that if Frame number increases spread of Coronavirus does not increase proportionately, it decreases after a certain stage but not equivalently.

In Frame number 35, number of infected are 65 where as in Frame 491, the value of infected are 60 which proves that there are huge number of recoveries from coronavirus.



Fig 4: First 50 Frame

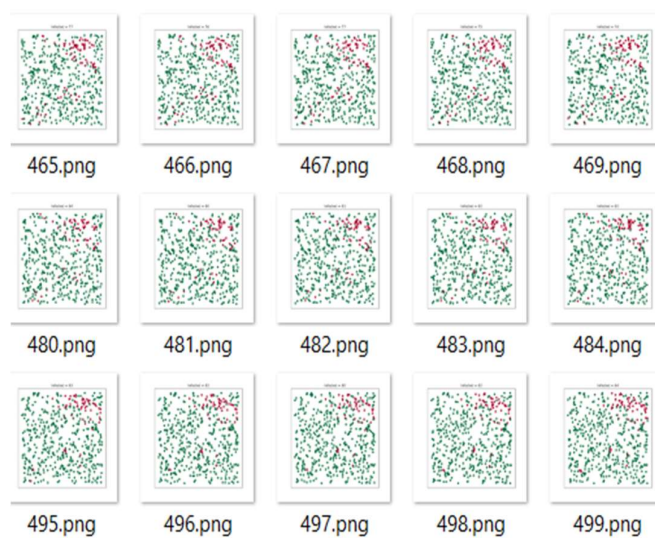


Fig 5: Simulation number 465 to 499

Simulation of Spread of coronavirus is shown above. Infected vs Non-Infected graph is presented below based on one thousand simulation.

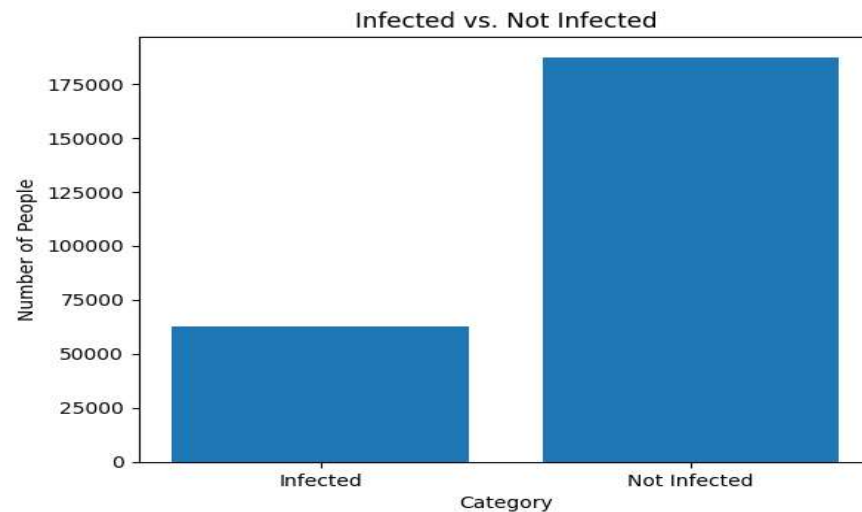


Fig 6: Infected Vs Not Infected graph is generated based on One thousand simulation

V. CONCLUSION

Complete Implementation of spread of corona virus using Multi agent system is the first attempt in the literature of detection of Corona disease. Using python, five hundred simulation frames are generated to visualize the effect of spread of corona virus. This research work is a turning point for future researchers for finding an innovative methodology to envisage the effect of pandemic. Same work can be implemented to apprehend the out-term of other pandemic. This up to the minute work has used makeGif function to create a live simulation video of 499 frames for the viewer to visualize the spread of Pandemic.

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