COVID-19 Transmission Risks Assessment using Agent-Based Weighted Clustering Approach

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Abstract—**Coronavirus is a pandemic disease spreading from human-to-human rapidly all over the world. This virus is origin from common cold to severe disease such as MERS-CoV and SARS-CoV. Initially it was identified in China, December 2019. The main aim of this research is used to identify the COVID-19 transmission risks assessment from human-to-human within a cluster. The agent-based weighted clustering approach is used to identify the corona virus infected people rapidly within a cluster. In the weighted clustered approach, the normal agents are consisted as susceptible node and the corona virus infected people are considered as malicious node. The Cluster Head (CH) is elected based upon some weighting factors and the trust value is evaluated for all the agents within the cluster. The cluster head were periodically transfers the malicious node information to all other nodes within the cluster. Finally, the agent-based weighted clustering machine learning model approach is used to identify the number of corona virus infected people within the cluster.**

Keywords—COVID-19; machine learning; weighted clustering; malicious node; susceptible node; head; trust

I. Introduction

A corona virus was initially recognized in human lungs in 2012. The novel corona virus is not same as Severe Acute Respiratory Syndrome (SARS) in 2003. However, similar the SARS virus, the novel corona virus is most related to those originate in bats. In 2012 the novel corona virus is happened in two clustered regions like Jordan and Saudi Arabia. Now World Health Organization (WHO) announced corona virus disease 2019 (COVID-19) is a pandemic. A pandemic defines spreading the disease wide range of area and affecting exceptionally high proportion of the population. This novel corona virus was named Corona virus Disease 2019 (COVID-19) by WHO in February 2020. The virus is referred to as SARS-CoV-2 and the associated disease is COVID-19. As of 10September 2020, over 28,050,253 cases have been identified globally in 188 countries with a total of over 908,434 fatalities. Also 20,117,616 were recovered. The primary symptoms for Corona virus are mild fever, Fatigue, Aching muscles, Breathing problem, Dry cough along with less typical symptoms of Headache, Diarrhea, Phlegm buildup and Hemoptysis [24]. The person is having all above symptoms then the person is affected with COVID-19 virus. The virus gets into human lungs and it affect lung functionality with the impact increases up to 14 days. The corona virus can transferred through droplets with different particle size. Respiratory droplet particle sizes are >5-10μm and droplet nuclei particle size is <5μm. The respiratory droplets are spreading easily through direct contact compare to droplet nuclei. The droplet transmission occurs within 1m direct contact with COVID-19 infected people [25].

The shape of the Corona virus is shown in Fig. 1. The gray surface is a spherical envelope that surrounds the nucleus of the virus, containing genetic material. Orange bits are a “membrane proteins,” or M proteins, the most abundant structural protein in the virus and one that gives it form, says Eckert. These and other proteins vary from one type of virus to another and can be used to help understand or identify one virus from another. Yellow bits are envelope proteins (E proteins), the smallest of the structural proteins. They “play an important role either in regulating virus replication — such as virus entry — assembly and release,” research. Red spikes: These clumps of proteins (called S proteins) are “what the virus uses to gain entry into and attach to the cell,” says Eckert. They also create the effect of a halo, or corona, around the virus.

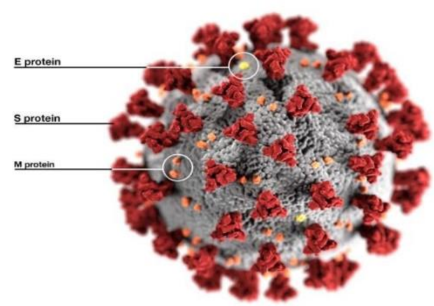


Fig. 1. The Shape of COVID-19 Virus.

II. Literature Review

To reduce the spreading of corona virus with the help of recognizing cases and clusters, patient isolation, contact tracing, and community transmission prevention. The small number of clusters which identify 22 probable primaries COVID-19 cases rapidly [1]. The agent-based model is used to identify the contact rates between agents and structure of in-person contact network [2]. The agent based fine-grained computational simulation model is used to identify the COVID-19 cases from children to adult. The simulation model compares numerous interference policies isolation, air travel, home quarantine and social distancing [3]. The COVID-ABS, a new SEIR agent-based model is used to simulate the pandemic situation from agent-agent contact, business, and government. The COVID-ABS model was implemented in python programming language [4]. The INFEKTA agent-based model combines individual agent virus spread to complex network with Euclidean space is measured within a city [5].

The REINA agent-based model which is used to simulate different categories of plan action on timeline. The result combines that utilizing complete testing, contact tracing and targeted isolation measures [6]. The cluster based mathematical model to forecast the rough trail of COVID-19. The COVID-19 spread is analyzed for three countries like Italy, United States of America and India the results show that the spread of each country is high accuracy [7]. The agent-based model considered few parameters like social distance restrictions, business opening, quarantine, control approaches on the infection progression. The result shows that the social distancing restricts the business activity participation [8]. The agent-based model applies for cluster planning and each agent is allocated for three key attributes like intelligence, talkativeness, and credibility. The problem-solving ability is better for small groups compared to large groups [9]. The fully computable model is utilized for two-state model which is used to identify the healthy or infectious people permitting for in environment simulation and risk assessment [10]. The two crucial methods are utilized for spread of an infected disease. They are agent-based model and equation-based model. The result shows that the equation-based model gives better performance compared to agent-based model [11].

The agent-based model is a feasible and powerful modeling tool for both biology and mathematics classrooms [12]. The Covasim (COVID-19 agent based simulator) is an open source model to include demographic information on age structure and population size, social distance, schools, workplaces, hygiene measures etc. to apply and inspect virus dynamics and policy decisions in European countries [13]. The simulation model could help the individuals to take better decision during COVID-19 pandemic situation. The simulation decision maker provides better decision-making results for individuals [14]. The COVID-19 infected people spread their virus within their family and the person mobility infection goes to other families to form a new cluster [15]. The virus infection outbreak is influenced by many factors like immunity level, population density and age structure of the population. These factors are considered to evaluate COVID-19 risk assessment using agent-based model [16]. The individuals are considered as agent that move, become infected and spread the virus to others. The simulation model is used to restrict the agent movement and mandatory to wear a mask on the spread of COVId-19 [17]. The RT-PCR testing is used to diagnosis the COVID-19 virus rapidly. In cluster-based approach the COVID-19 positive cases are identified using RT-PCR testing in Singapore [18,19]. The age based social contact virus spread is assessed using simulation model. The result shows that mid-elder age people affected more compared to child or young people [20,21]. The Bats-Hosts-Reservoir-People transmission network model is used to identify the human infection. Reservoir-People (RP) transmission network model is used to assess the transmissibility of the SARS-CoV-2 [21,22]. The mathematical model is used to assess the transmission risk of COVID-19 in various facilities. The agent-based simulation model which is used to take better decision for prevention of COVID-19 [22,23]. The synergic deep model is used to learn and predict various metrics like duration of days, discharge disposition, and inpatient expense for total hip arthroplasty [24,25]. The attribute-based health record protection algorithm is used to protect healthcare service information access like control confidentiality, credibility, and secrecy [26,27].

III. Methodology

A. Transmission Mode of COVID-19 Virus

CoVID-19 virus spread can be classified into two categories: close contact and Airborne. Lung infections can be spread through droplets of dissimilar sizes: while the droplet particles are >5-10 µm in diameter they are stated to as respiratory droplets, and when they are <5µm in diameter, they are stated to as droplet nuclei. The COVID-19 virus spread primarily spread between publics through respiratory droplets and contact routes.

The droplet spread occurs between a person is in close contact within 1m with someone having respiratory symptoms. The transmission also occurs through infected person surrounding environment. So, the virus spread happened in two ways: direct and indirect contact. In direct contact the infected people contact other people directly and in indirect contact the people touching with virus surfaces indirectly. The direct and indirect contacts are shown in Fig. 2 and 3.

Airborne transmission is dissimilar from droplet spread as it refers to the occurrence of bacteria within droplet nuclei, which are usually measured to be particles <5µm in diameter, can persist in the air for long periods of time and be spread to others over distances larger than 1 m.

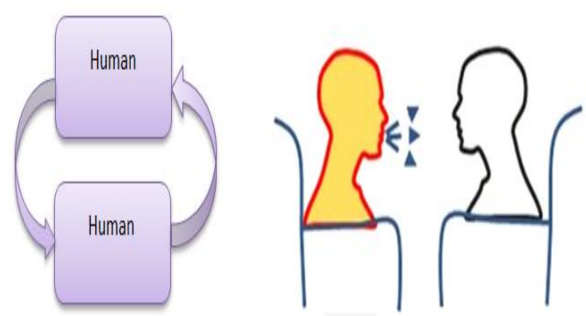


Fig. 2. Direct Contact or Close Contact.

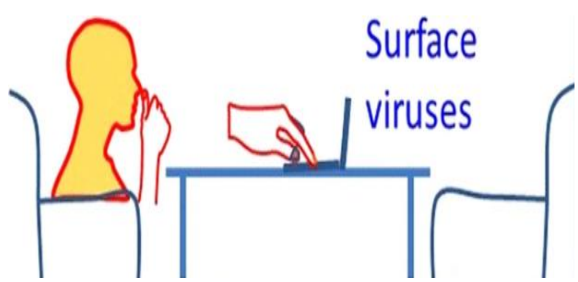


Fig. 3. Indirect Contact.

B. Agent based Weighted Clustering Approach

The agent based weighted clustering proposed model is used to find the transmission risk within a cluster. Every individual are considered as agent to perform predefined operations. The agents are interacting with the environment in multidimensional space. The agents can freely move from one cluster to another cluster freely. Here clusters are considered as city. Every cluster have cluster head which is elected based upon the agent weighting parameters like immunity, age group, and mobility. The cluster head is used to monitor the agents within the cluster. Within a cluster the normal people are considered as normal node and corona virus infected people are considered as malicious node. If any malicious node is found within a cluster, then the malicious node is removed from the cluster immediately.

The set of A agents [a_1,….$a_{A.}$] Each agent $a_{i,}$ (i belongs to1…. A) is selected randomly. Each agent a_i is applied for set of rules to change its position, state or relationship with agents. In the proposed model two different types of agents A(k)= {a_1(k),…$a_{A(K)}$} and B(k)= {b_1(k),…b_B(K)} are defined. The agent A and B change their position in each iteration k of the simulation. The agent A signifies the susceptible elements in the environment and B signifies the infected individuals. The aagents A and B behaviors are characterized by two rules to simulate COVID-19 transmission. They are Rule I and Rule II. The Rule I defines the agent a_i infected or not. The Rule II defines mobility of the agent is identified.

Rule I: The random number r is generated between 0 and 1. If the value of r is less than or equal to threshold value, then the agent a_i is considered to be infected, otherwise it is not affected. The value of R can represent the radius of the cluster range. Here value of R=1mt. When the agent a_i is recognized as infected, a_i is deleted from A and added as new agent b_{new} within the infected agents B. Fig. 4 illustrates the operation process of Rule I [28,29].

In Fig. 4 set of 8(A) susceptible elements and 2 infected agents A= a_1,…, $a_8$and B= b1,b2. In figure a_3 and a_5 maintain close relationship between b_1 and b_2. Assume the probability of infection for a_3 and a_5 are 0.2 and 0.9, respectively. The probability of a_5 infected value is high and $a_3$is value is low compared to predefined threshold value 0.5. This virus can be identified with the help of following formula:

$$COVID-19\ Diagnosis = \left\{ \begin{matrix} COVID-19+Veif\ (1).5 < T \\ COCID-19-veif\ 0.5 \geq T \end{matrix} \right\} \quad (1)$$

Where, T is threshold value. The agent infected value is less than threshold value then it considered as COVID-19 positive otherwise it is negative [30,31].

Rule II: In this rule mobility between the agents A and B determined. This is illustrated in Fig. 5.

In Fig. 5, set of 2(A) susceptible agents and 1(B) infected agent A= a_1, a_2 and B= b1. In fig the mobility probability of a_1= 0.8, a_2=0.1 and b_1=0.1. Due to low mobility probability of a_2 is very low. So, it is not affected. But the contact and mobility probability of a_1 and b_1 is high. So the infected probability chance is high for both a_1 and b_1. In figure, a_1 mobility is considered for a_1(k) to a_1(k+1) and b1 mobility consisted for b_1(k) to b_1(k+1). The a_2 mobility is same position [32,33].

The following weighting parameters are considered for electing a cluster head within a cluster. They are mobility of the agent, immunity level of the agent and age group of the agent.

Cluster Head=W1 (MA) + W2 (IA) + W3 (AA) (2)

Where W1 (MA) = Weighing factor of Mobility of the Agent

W2 (IA) = Weighting factor of the Immunity level of the agent

W3 (AA) = Weighting factor of the Age group of the agent

The agent has low mobility, high immunity level and the middle age group, then the agent considered as cluster head for within a cluster. The cluster head is a health inspector agent to monitor the other agent behaviors periodically. If any malicious agent node is found within a cluster, then the node the node is removed from the cluster immediately. The trust value between two agents can be represented as $T_{xy.}$ The trust value between two agents can be calculated as below equation.

T_{xy}= LM+WM+MSD (3)

Where T_{AB}=Trust value between agent A to B

LM = Low Mobility

WM = Wearing Mask

MSD = Maintain Social Distance

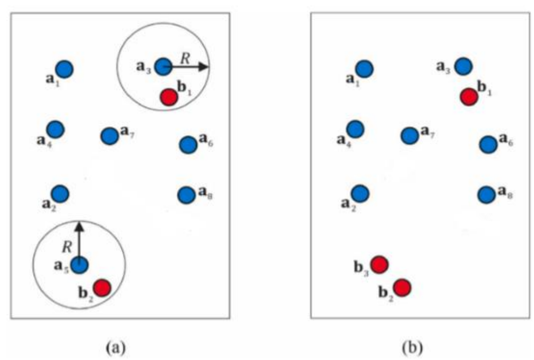


Fig. 4. Operation of Rule I (a) Initial Configuration and (b) Final Configuration.

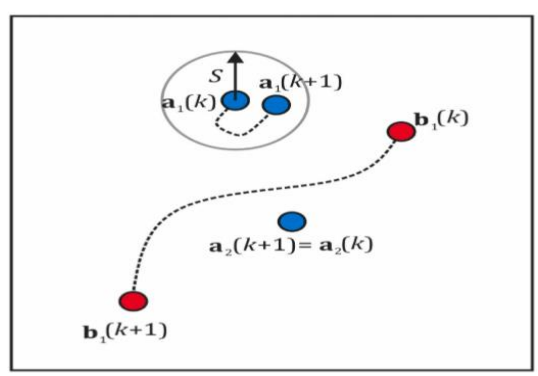


Fig. 5. Operation of Rule II.

The above three parameters are satisfied between agents A and B, then the agent A trust B. The virus infection can be identified within a cluster with the help of Aarogya Setu App in Fig. 6. In Fig. 6(a) agents is installed Aarogya Setu App using Bluetooth to identify the COVID+ agent. In Fig. 5(b) identify the location of COVID+ agent and send alerts message to all other agents within a cluster. If the agent is not having Bluetooth feature mobile phone, then the trust value will be calculated for that particular agent.

In Fig. 7, the cluster head (health official) to monitor all other agents periodically within a cluster. If any agent is identified COVID+, then the infected agent removed from the cluster immediately and the infected agent history is recorded in the application server. The COVID+ agent alert information is passed to all other agents immediately within cluster. The agent based weighted clustering algorithm works as follows:

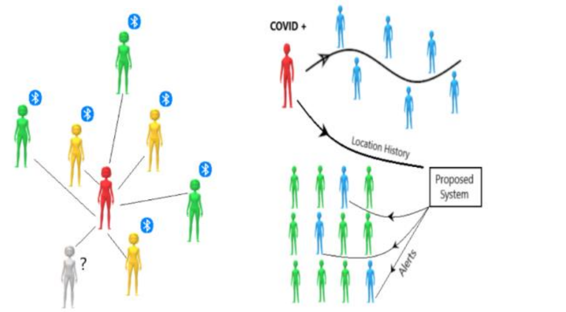
Agent based weighted clustering algorithm

1. Initialize the number of agents and clusters

   A=susceptible Agent, B= Infected Agent
2. Elect a cluster head with weighting parameters

   Cluster Head (CH) = W1 (MA) + W2 (IA) + W3 (AA)
3. Find the trust value between two agents A and B

   T_{xy}= LM+WM+MSD
4. Install Aarogya Setu App for all the agents within a cluster
5. If the agent is not having Bluetooth features mobile then
6. Calculate the trust value of that particular agent
7. Apply the operation of Rule I
8. Check the agent infection result is COVID +ve or COVID –ve
9. If COVID +ve then
10. Remove the infected agent from the A group and added into B group
11. Else
12. Continue with A group
13. Apply the operation of Rule II: Mobility
14. Check the agent infection result is COVID +ve or COVID –ve
15. If COVID +ve then
16. Remove the infected agent from the A group and added into B group
17. Else
18. Continue with A group
19. Stop



(a) (b)

Fig. 6. (a) Agent using Aarogya Setu App using Bluetooth (b) COVID + agent Location Discovery.

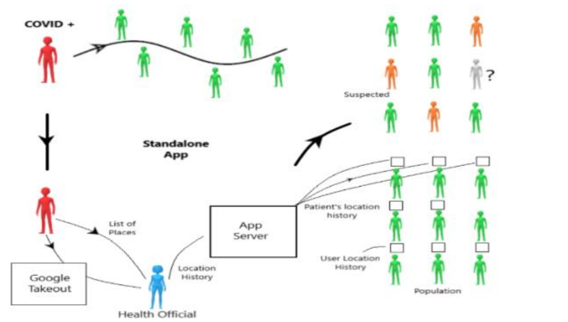


Fig. 7. Cluster Head (Health Official) to Monitor All other Agents within a Cluster.

IV. Experimental Results

The simulations are conducted for 400 (A) susceptible agents and 2 infected individual (B). The 300x300 dimension is utilized for environment simulation. Fig. 8 shows the agents contact results in dissimilar iteration of the simulation process.

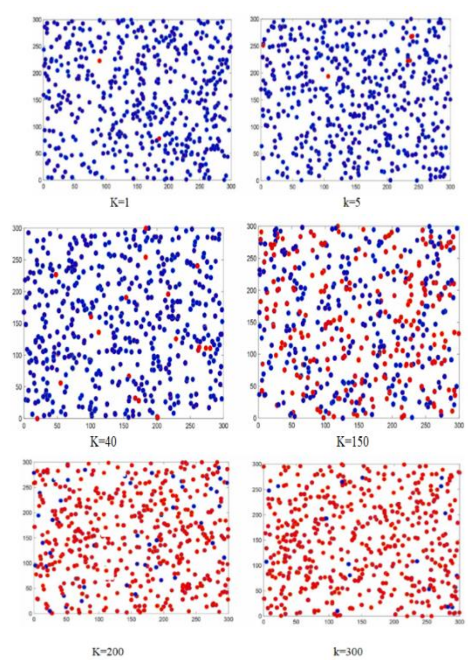


Fig. 8. Results in different Iteration of the Simulation Process. Blue Circle Represents Susceptible Agents and Red Circle Represents Infected Agents [34, 35].

The number of infected agents with iterations is illustrated in Fig. 9.

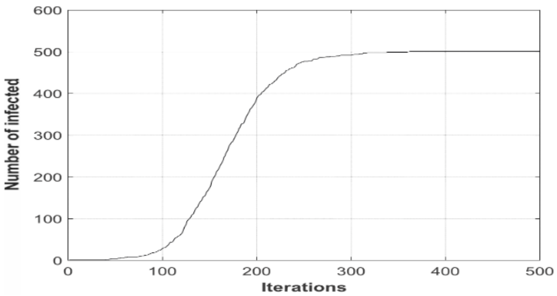


Fig. 9. Progression of the Simulation in Terms of the Number of Infected Agents [36].

V. CONCLUSION

The agent based weighted clustering approach to evaluate the COVID-19 transmission risk in environment has been presented. The cluster head is elected based upon the weighting parameters. The Aarogya Setu App is utilized for identify the location of COVID-19 positive agents. The behavior of every individual is characterized by set of rules and trust calculation between agents. The simulations are conducted for different iterations to identify the COVID-19 transmissions risk are evaluated. In future this, work will be implemented in global level transmission risk.

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