Fuzzy Rule Based System to predict COVID19 - A Deadly Virus

Deepak Painuli, Divya Mishra, Suyash Bhardwaj, Mayank Aggarwal

Abstract: Around four lakh confirmed cases and more than one lakh eighty nine thousand death worldwide due to a virus called Coronavirus causing a respiratory disease "COVID19" were registered from 1st December 2019 to 25th March 2020 and it has been declared as pandemic by World Health Organization. This paper proposed a fuzzy rule based system which is used with MATLAB tools for simulations to give predictions related to whether one is suffering from Covid19 or not. At present, the testing kits of Covid19 are very limited and they take lot of time to give results but our proposed system can be used in initial predictions, which can save both time and money. This system is based on fifteen rules developed on the basis of guidelines given by World Health Organization and other Health agencies. The results given by the system are very promising and can be used to prevent testing and save time which is very crucial to save life of one and stop it from spreading further.

Keywords: COVID19, Virus, Respiratory Disease, Fuzzy Logic, Simulation Fuzzy rule based system, Expert System, MATLAB.

I. INTRODUCTION

During the month of December 2019 all of us were unaware of the danger that had already came into existence in Wuhan, China in the form of a dangerous virus, Coronavirus, COVID19. It is a novel coronavirus (SARS-CoV-2) emerged from China with more than four lacs of confirmed cases from December 1st 2019 to March, 25th 2020 [1]. COVID19 is the family of viruses with MERS (Middle East Respiratory Syndrome) and SARS (Severe Acute Respiratory Syndrome). People suffering from COVID19 might feel mild to moderate respiratory illness. And it might be more fatal for people who are above 60 and having any medical history like-cardiovascular disease, cancer, diabetes, chronic respiratory disease.[2] In SARS and MERS two factors which were important were age and sex, as it was observed by the health agencies that these type of viruses reflects mostly in aged persons and male, which plays very important role in changing these symptoms into Acute Respiratory Disorder Syndrome (ARDS). MERS affect mostly on persons suffering from chronic conditions like diabetes mellitus, hypertension cancer, renal and lung diseases, and co-infections include additional risk factors associated with severe illness.

It was noted by WHO and other health organizations that SARS-CoV and MERS-CoV are primarily spread from human to human. After the treatment of MERS patients, the ubiquitous presence of infectious virus was demonstrated by analysis of hospital surfaces. Middle East Respiratory Coronavirus Syndrome (MERS-CoV) circulates in dromedary camels, causing serious human respiratory illness [3,4,5].

The way Covid-19 is spreading has resulted to its announcement as pandemic. Countries along the globe are fighting together to curb the disease but there are limited and time taking kits which can test for patients being infected or not. Fuzzy logic and MATLAB have been widely used in Medical fields before also we have used the same by proposing a model, which can be trained using Artificial Neural Network to predict about the presence in early stages within no time to prevent further spread of disease to other persons.

II. PROPOSED FUZZY RULE BASED SYSTEM

In this paper a rule based model is proposed under fuzzy inference system (FIS). This system uses 11 symptoms like age, sex, fever, dry cough, breathing problem, flu and cold, medical history, travel history and two recently identified symptoms by some infected patients Anosmia (lost sense of smell), Loss of hearing ability[6,7]. This system predicts whether the patient is suffering from coronavirus or not by comparing his symptoms with the symptoms of COVID19 as declared by World Health Organization [2]. The main aim of this model is to avoid exertion and to make people check their symptoms and can find what the probability of being infected by COVID19.

A. Research Design

Following are the components of proposed rule based system. Figure 1 shows the model with all components and their linkages.

1. Knowledge Base, which stores expertise in the form of rules.
2. Inference Engine, which is the heart of the system. It takes action based on the input given by the user. Inference engine works based on match-resolve -act cycle.
3. Fuzzifier, which is used to convert crisp input, which we have given as symptoms of coronavirus into crisp values (between 0 and 1). In this paper, triangular fuzzifier is used.
4. Defuzzifier is then used to convert crisp fuzzy output to crisp value .[8,9,10,11]

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B. Proposed Model

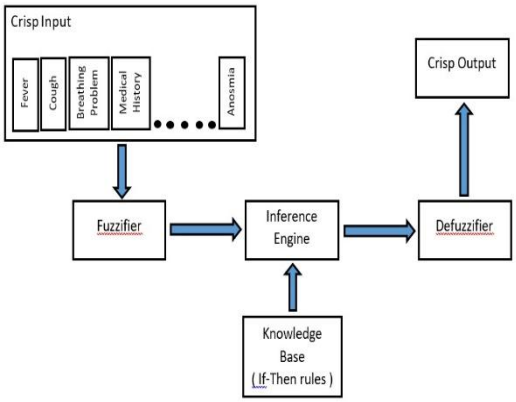


Figure 1: Fuzzy Inference System (FIS)

III. DISCUSSION

The paper proposed a system, which will help doctors to predict about the possibility of a person infected by Coronavirus, or not. This will facilitate in making right decision and save time. Model can be used by people to self-monitor themselves and quarantine themselves if the results are positive. Self-monitoring is the key to avoid the virus so that if anyone is affected by the virus he might check the symptoms himself by this self-assessment model and can isolate himself without making others life in danger.[7]

There are various symptoms that can affect any person of any age if his or her immunity is week. Like fever, cough, cold, flu, autoimmune diseases, cardiovascular disease, difficulty to smell, loss of hearing. [6,7,13,14]

So if anyone is having any of these symptoms then it is suggested by WHO to do self-assessment and to avoid any kind of further complications proper precautions should be taken [2].

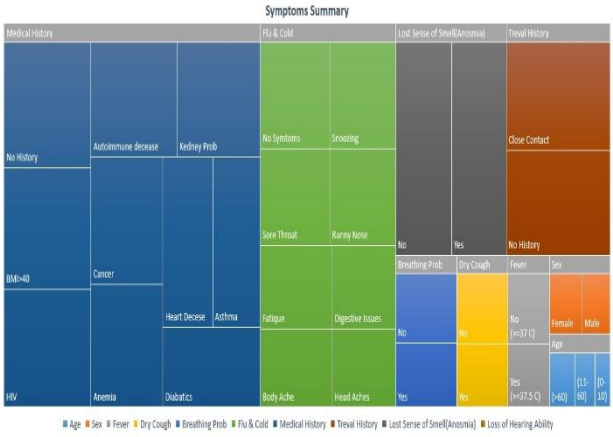


Table 1: Symptom Summary

precautions as suggested by WHO are also included in this proposed model, as when any infected person do his self-assessment and if there is any possibility of coronavirus then the model suggests what kind of precautions should be taken care of.

Following are the precautions that should be taken:

1. Wash your hands frequently
2. Maintain social distancing
3. Use mask if suffering from cough or co
4. Do not touch eyes, nose or mouth
5. Hygiene should be taken care of
6. If having high fever with cough and cold then go for check-up[2,19]

IV. IMPLEMENTATION

For the implementation of the model MATLAB was used with fuzzy logic inference designer tool. The inference designer tool is used to design rules on the basis of the symptoms identified. For representation in MATLAB input is taken in the form of membership function (MF) represented between [0-1] intervals.

A. Membership Function

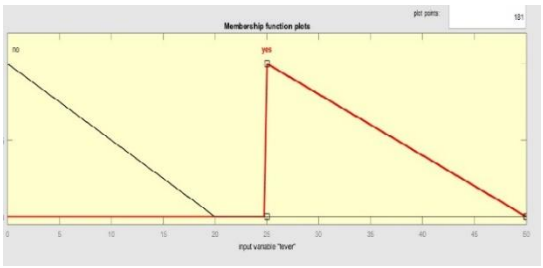
Membership function (MF) is used to represent how much the value is true in fuzzy logic, means degree of truth as shown in Figure 2(a), 2(b) & 2(c). With the help of Membership functions a graphical representation of fuzzy set is possible. In the representation there are two axis-x and y which are universe of discourse and degree of membership between [0,1].

MF is designed on the basis of input given which are the symptoms of the disease. In the paper Triangular Membership Function (trimf) is used for defining MF within the range (0-1).[18]

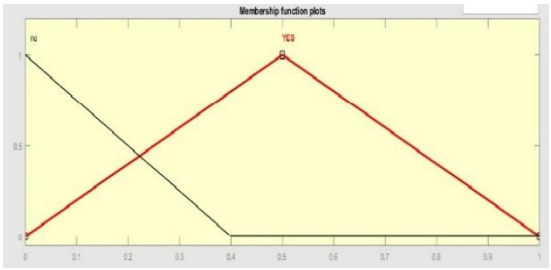
*Mathematical representation of trim*f is:

$$\mu A(x) = \begin{cases} 0, & if\ (x <= v) \\ \dfrac{x-v}{w-v}, & if(v < x \leq w) \\ \dfrac{u-x}{u-w}, & if(w < x < u) \end{cases}$$

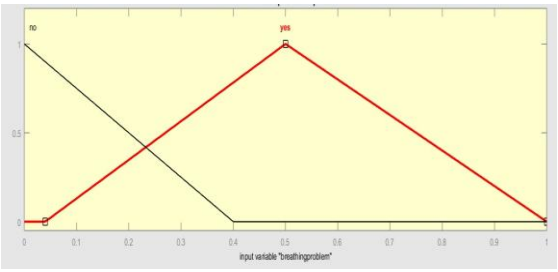
$$v = lower\ limit$$
$$u = upper\ limit$$
$$w = value$$



(a) MF for fever



(b) MF for Cough



(c) MF for Breathing Problem

Figure 2: Graphical Representation of Membership Function

B. Input Values

In this paper, different input functions are used as the statistical values, which are useful in predicting the benefit of this Fuzzy Inference System (FIS) for corona-virus. The paper predicts about coronavirus using eleven different types of fuzzy variables for fever, cough, age, diabetes, travel history, breathing problem, flu, hearing problem, loss of smell, body ache and sore throat as shown in Table 2. Table 2 contains the descriptions of these input variables.

Table 2: Parameters of Input Variables

Symptoms	Parameter	
	Yes	NO
Fever	25-50	0-20
Cough	0-1	0-0.4
Age	45-80	0-40
Diabetes under medical history	0-1	0-0.4
Travel history to infected country	0-1	0-0.4
Breathing Problem	0.04-1	0-0.4
Flu	0.4-1	0-0.5
Hearing Problem	0-1	0-0.4
Loss of smell	0-1	0-0.2
Body ache	0-1	0-0.4
Sore Throat	0.4-1	0-0.2

C. Rules for the proposed model

1. If (fever >38) and (cough is dry) then take precautions.
2. If (fever>38) and (cough is dry) and (hard to breathe) and (travel to infected country) then coronavirus strong positive.
3. If (fever >38) and (throat is sore) and (age>60) then take precautions and shall be quarantined.
4. If (fever >38) and (age<45) and (no cough) then coronavirus negative.
5. If (fever <38) and (age<40) and (No travel history) then coronavirus negative.
6. If (Sense_of_smell is lost) and (fever>38) and (chest is tight) then coronavirus might be positive.
7. If (Loss of hearing) and (age>50) and (travel to infected country) and (fever>38) them coronavirus positive.
8. If (No flu) and (No Body ache) and (No cough) and (No sore throat) then coronavirus negative.
9. If (Flu) and (cough) and (sore throat) then take precaution.
10. If (Diabetes) and (fever>38) and (Travel history is NO) and (Breathing Problem) then coronavirus may be positive and needs special attention.
11. If (Travel to infected country) and (No medical history) and (No breathing problem) and (fever is Yes) coronavirus positive.
12. If (NO Travel History) and (contact with infected person) and (fever>38) the coronavirus positive.
13. If (fever) and (age>70) and (breathing problem) then coronavirus positive and needs special attention.
14. If (age<50) and (fever <38) and (No cough) then NO coronavirus.
15. If (age<10) and (fever >38) and (cough is dry) then coronavirus positive.

V. RESULT

Result shows the defuzzification part of the model which makes outcome in Crisp logic by taking input as fuzzy sets and then comparing membership degrees. This method is used to make a fuzzy set to a fresh set. In MATLAB various kinds of De-Fuzzifiers are used. In the proposed model centroid kind of De-Fuzzifier is applied. De-Fuzzifier graphical description of FIS is as follows:

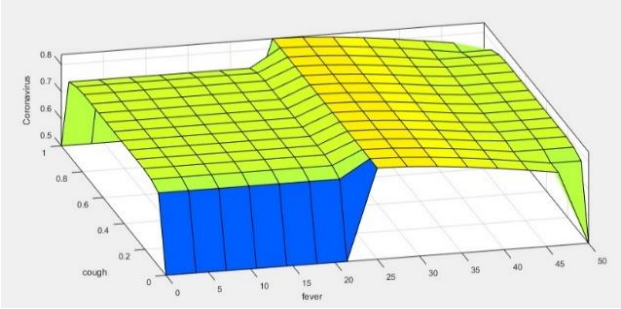


Figure 3: Rule surface (Cough and Fever)

Figure 3 shows the representation in 3D form as a rule surface performed in MATLAB on cough and fever. The colour Blue represents as simulation is weak, Green as satisfied and yellow as good that means according to the membership function this surface shows that if patient is suffering from fever and have dry cough then the possibility of being infected by coronavirus is positive.

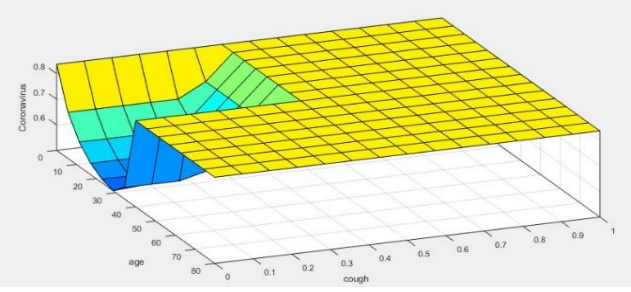


Figure 4: Rule surface (Age and Cough)

Figure 4 shows the representation in 3D form as a rule surface performed in MATLAB on Cough and Age. The colour Blue represents as simulation is weak, Green as satisfied and yellow as good that means according to the membership function this surface shows that if patient is is having dry cough and the age of the patient is

greater than 60 then the possibility of being infected by coronavirus is positive.

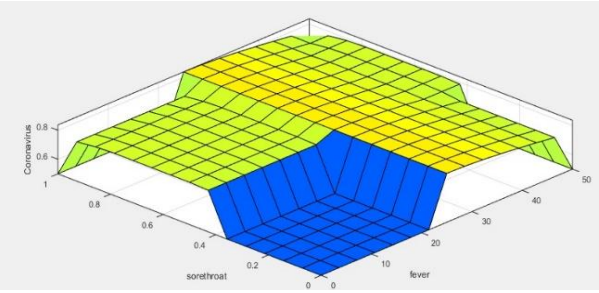


Figure 5: Rule Surface (Fever and Sore Throat)

Figure 5 shows the representation in 3D form as a rule surface performed in MATLAB on Sore Throat and Fever. The colour Blue represents as simulation is weak, Green as satisfied and yellow as good that means according to the membership function this surface shows that if patient is suffering from fever and have sore throat then the possibility of being infected by coronavirus is positive but in this case it is very low as visibility of yellow colour is less.

A. Simulation

For simulation MATLAB tool is used. In this model for producing the result 11 data sources and one output is used. In the below result it is shown that if fever is yes, cough is yes then the probability of coronavirus infection seems to be positive, similarly if fever is greater than 38 and cough is dry which comes in category of Yes and patient is facing difficulty in breathing and he has also a travel history to some infected countries than the result shows the positive probability of coronavirus infection.

Figure 7: Simulation result

The above figure is the rule viewer that shows the description of the rules that were defined by the possible symptoms of the coronavirus. It is the complete roadmap of inference process defined for the prediction of the virus. With the help of rule viewer, the fuzzy inference system diagram of the model can be viewed. In this yellow coloured portion defines the membership function of that symptom which is taken as input variable. With the help of red line between the graphs we can change the value of the symptom in the simulation viewer and can check the variation in the result. The blue colour in the result part that is output viewer shows the probability of coronavirus. This is important part of the MATLAB tool as this viewer shows how individual MF diagram affects the output. [17] In this , one of the rule shows variation in fever as it is taken if (fever>38) then the output changes if the value of fever changes from 0 -37 or more than 37 .This change can be viewed in rule viewer and the output can be monitored. In the above diagram in the first rule only three input variables are taken and others are neglected so only three variables are shown with the colour yellow which shows positive value and others are blank. With the change in these three variable's value, the output value is monitored and gives result on the basis of rules defined underneath. Similarly all other rules work. This viewer can adjust the input values and based on these values corresponding output can be viewed.

VI. CONCLUSION AND FUTURE WORK

Novel Coronavirus remains on human body for 14 days so it might be possible that during early stages of infection there are no symptoms but if the patient have any medical history or might travel to infected country or might come in contact with infected person the he or she have to do this assessment daily up to 14 days . This model can only help those who can identify their symptoms but if someone is unaware about the virus and been exposed to other persons then it is highly believed that those persons might be infected by that person.

This model predicts 0.837 % coronavirus within the range 0-1. We have used MATALAB to simulate our model in future Artificial Neural Network, Machine Learning can be used to train the model and give more accurate results.

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