International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-6, April 2020

Fuzzy Logic Inference System for Identification and Prevention of Coronavirus (COVID-19)

Nitesh Dhiman, M.K. Sharma

Abstract: ***Now a days Novel Coronavirus named COVID-19 becomes major health concern causing severe health issue in human beings and it becomes a pandemic. It's a kind of zoonotic that means it can transmit animals to humans. It may spread via polluted hands or metals. No specific treatment is available so far for COVID-19, so initial identification and preventions for COVID-19 will be crucial to control or to break down the chain of COVID-19. For this purpose, we have proposed a fuzzy inference system to diagnose the COVID-19 disease by taking six input factor like as; Ethanol, Atmospheric Temperature (AT), Body Temperature (BT), Breath Shortness (BS), Cough and Cold and the output factor has divided into three linguistic categories which denotes the severity level of the infected patients.***

Keywords: Coronavirus (COVID-19), Gaussian Membership Function, Fuzzy Inference System, Medical Diagnosis

I. INTRODUCTION

Coronavirus is the virus that may causes Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). After the study it has been found that the SARS-CoV was transmitted from wild cat to human. Chang *et al.* [1] shows in his study that the SARS-CoV is a novel virus that may causes the emerging and reemerging infection. Few of the studies [2] & [3] described that SARS-CoV novel virus caused the first pandemic of the paradise. The novel coronavirus called SARS-CoV-2, causes the disease COVID-19 and has never been encountered/found before. It is originated from Wuhan a city of china and till now it effects more than 180 countries and territories. Currently many scientists and researchers of different countries are doing hard work to find the appropriate vaccine for COVID-19 disease. It effects more than 180 countries and territories,
scientists and researchers are not certain about the origination of COVID-19. COVID-19 is the kind of zoonotic, initially it was transmitted from animals to humans [4] & [5] but now it is rapidly spreading from person to person and the spread rate of the infection increasing exponentially, according to this theory each infected person may infect more than 2 people and each may further infect more than 2 and so on. A study by Harvard T.H. Chan School of Public Health epidemiologist state that disease COVID-19 could infect major part of worldwide population and according to the world health organization (WHO) COVID-19 has affected more than 697,244 people globally with 33,257 death cases till now (by 31-03-2020). In china about 81,285 confirmed cases over 74,051 patients have recovered and about 3,295 have died. COVID-19 includes symptoms like; cough, fever, breathing difficulties and it may cause pneumonia and kidney failure or patient may death, in some cases patient might show no symptoms at all. According to the study of the Centers for Disease Control and Prevention (CDC) [6] these symptoms usually appear between two days and two weeks of exposure to the virus. Journal of the American Medical Association reports say that out of all COVID-19 patients 11-44% has fatigue, 76-82% has coughed and 98% have a fever. The severity level of the disease increases in the human of age between 28 to 85 years-old. Currently more than fifteen Italian citizens cases test have been found positive in India by March 2020.

Present research paper has been divided into five sections; in the second section, we have shown the effects of COVID-19 in different types of metal. In the third section of the research paper, we have given a survey on COVID-19 and in the fourth section, we have defined some fuzzy rules as shown in tab. 3 for the proposed fuzzy expert system with six inputs as shown in tab. 2 and one output which define the severity level of the infected patient as shown in fig. 5. Fifth and last section of the research paper contains conclusion part of the work.

II. BASIC CONCEPTS

A. Effects of COVID-19 on Metals

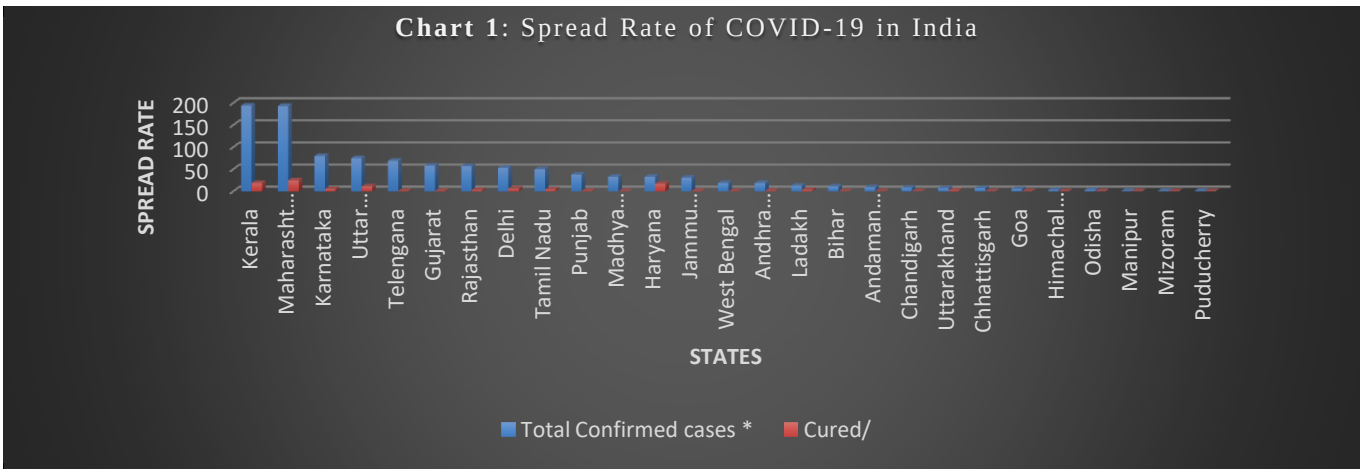
On different kind of material and surfaces like; Steel, Aluminum, Metal, Wood, Paper, Glass, Plastic Silicon and Rubber, the coronavirus may alive or it may remain infectious from 2 hours up to couple of weeks. Kampf *et al* [7] summarized the persistence of the coronavirus on inanimate surfaces and this study also shows inactivation of the coronaviruses by biocidal agent through suspension and carrier tests.

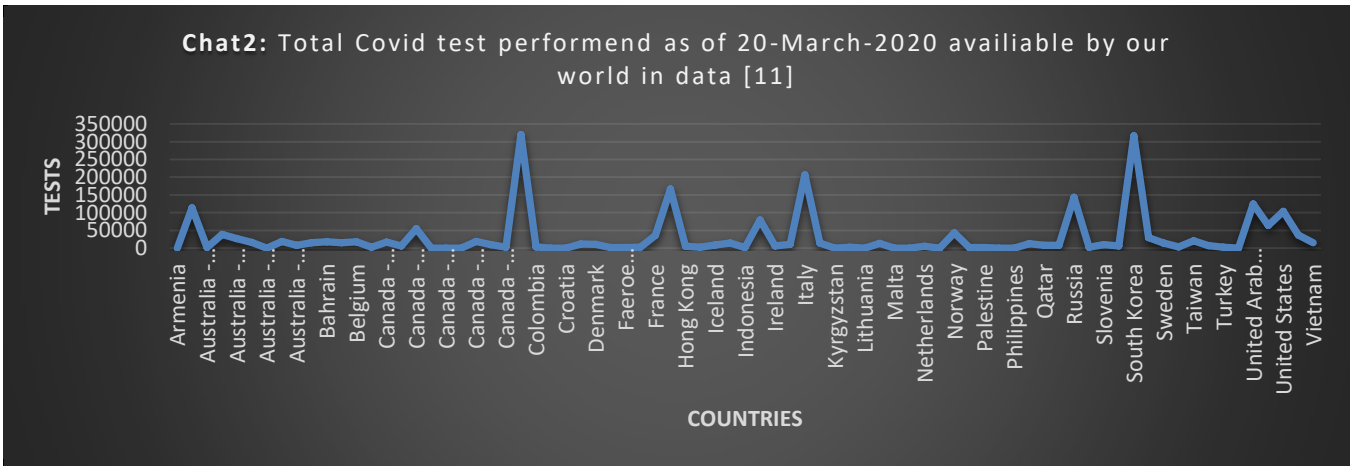
B. Fuzzy Logic in Medical Diagnosis

Fuzzy logic is a kind of computational archetype which gave us a mathematical tool for human reasoning for handling the various type uncertainties. The capability of fuzzy logic provides us to express the human knowledge in linguistic way. The framework of fuzzy logic used in different kind of disease diagnosis [8, 9, 10] in which the physicians and expert's knowledge is represented on the behalf of symptoms and diseases. In which we can frame the different type membership function for the symptoms depending upon the trend of the patient data and they have used to form a suitable fuzzy expert system

Revised Manuscript Received on April 30, 2020.
***** Correspondence Author
M. K. Sharma*, Associate Professor, Department of Mathematics, Chaudhary Charan Singh University, Meerut, India. -250004 Email: drmukeshsharma@gmail.com
Nitesh Dhiman, Research Scholar, Department of Mathematics, Chaudhary Charan Singh University, Meerut, India. – 250004 Email: niteshdhiman91@gmail.com

III. A SURVEY ON COVID-19





According to the Ministry of Health & Family Welfare [12] (by 30-03-2020) the spread rate of coronavirus in different states of India like; Maharashtra, Kerala, Delhi, Uttar Pradesh, Karnataka, Ladakh, Telangana, Rajasthan, Jammu and Kashmir, Andhra Pradesh, Gujrat, Punjab, Chhattisgarh, Odisha, Puducherry, Chandigarh, Uttarakhand, West Bengal has been shown by chart 1. and chart 2. shows that the spread the spread rate of COVID-19 in different countries like; Armenia, Australia (New South Wales, Australia – Australian Capital Territory, Australia – Western Australia, Australia – Victoria, Australia – South Australia, Australia – Tasmania) , Austria, Bahrain, Belarus, Belgium, Brazil, Canada – National lab, Canada , China– Guangdong, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Faeroe Islands, Estonia, Finland, France, Germany, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Kuwait, Kyrgyzstan, Latvia, Lithuania, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Pakistan, Palestine, Panama, Philippines, Poland, Qatar, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States – CDC samples tested, United States and Vietnam.

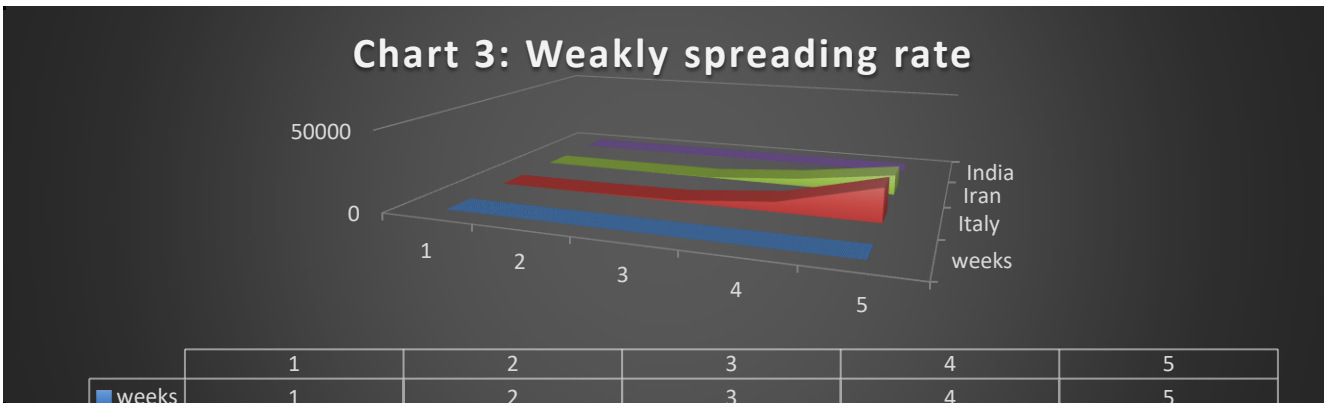


Table 1: COVID-19 Checklist by IAF Med Services					
1	International Travel History or Contact History	No	More than 14 days	Less than 14 days	Direct contact with confirmed cases
2	Fever	98-100F	100-102F	102-104 F	above 104F
3	Breathing Difficulty	No	Mild	Moderate	Severe
4	Body Pain	No	Mild	Moderate	Severe
5	Fatigue	No	Mild	Moderate	Severe
6	Sore Throat	No	Mild	Moderate	Severe
7	Cough	No	Mild	Moderate	Severe
8	Diarrhoea	1-2 episodes (in last 24 hours)	3-5 episode	5-7 episodes	more than 7
9	Other Medical Conditions	None	High BP	High BP & Diabetes	Reduced Immunity
10	Status (last 48 hours)	Improved	No change	Worsened	Worsened a Lot
11	Age	15-50years	5-15years	0-5years	above 50

Weekly spread rate of COVID-19 has shown by chart 3. between three different countries Italy, Iran and India. This chart shows that spread rate of COVID-19 increases rapidly in Italy as compare to Iran and India. As COVID-19 cases increases in India Indian Air Force (IAF) recently creates many quarantine facilities at its nodal bases [13] across the country and the interpretation given by the various sections of tab. 1 which has divided into three different color section in which green color indicates the Safe Zoon amber indicates Caution Zoon and red indicates Danger Zoon.

Chart 4: Currently available list of private laboratories in India to test COVID-19 developed by Indian Council of Medical Research

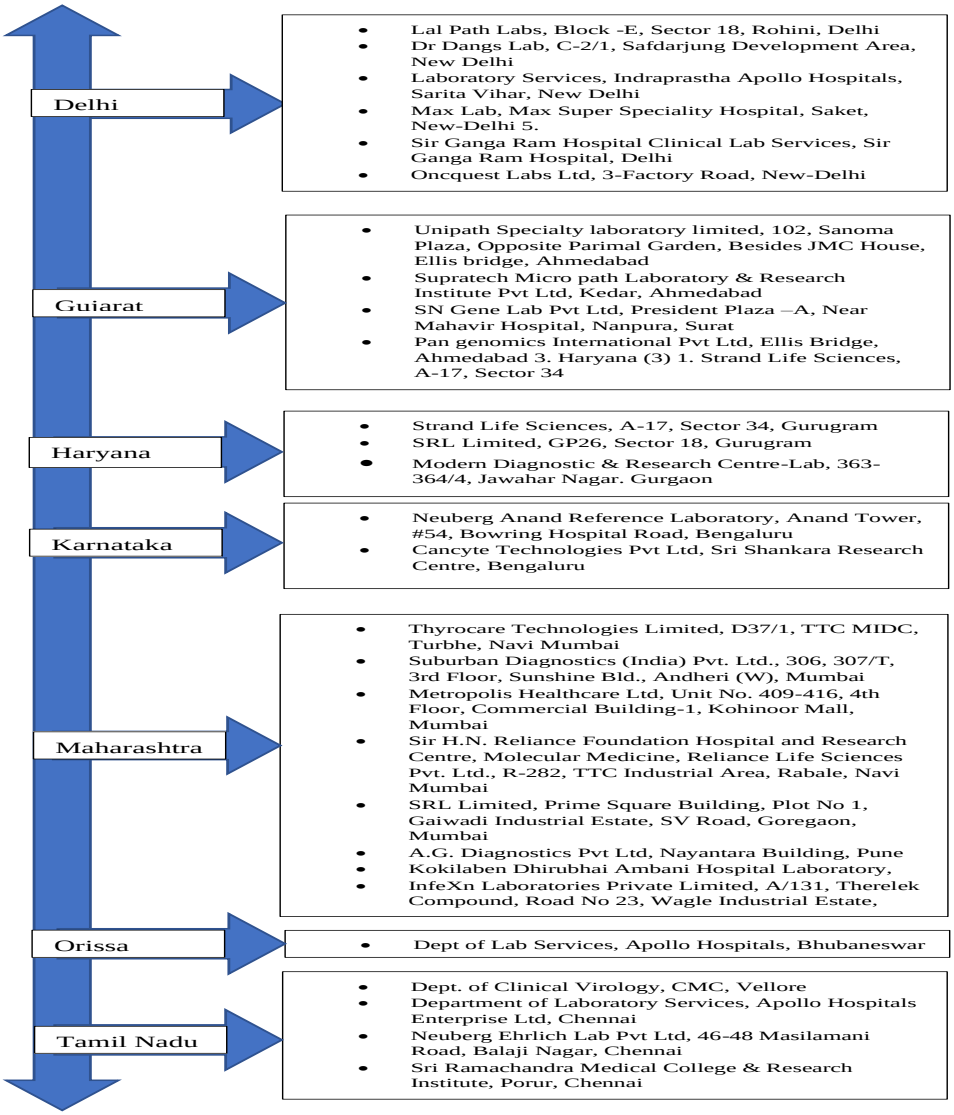


Chart 4 shows that the list of currently available private laboratories in different states of India to test COVID-19 [14].

IV. FUZZY INFERENCE SYSTEM (MAMDANI)

We have designed a fuzzy inference system (as shown in fig. 1) to diagnose the COVID-19 disease by taking six input factors like as; Ethanol, Atmospheric Temperature (AT), Body Temperature (BT), Breath Shortness (BS), Cough and Cold with one output factor which has further divided into three linguistic categories which denotes the severity level of the patient. We will construct membership functions for the included factors. In this article, we propose a structure of fuzzy inference system which is based on fuzzy rules for the inference.

Table 2: Factors for COVID-19 disease

Including Factors	Linguistic ranges		
Atmospheric Temperature (AT)	Low (°C)	Medium	High
Breath Shortness (BS)	1 Yes	0 No	
Ethanol	Low (mg/dl)	Medium	High
Body Temperature (BT)	Low (°F)	Medium	High
Cold	1 Yes	0 No	
Cough	1 Yes	0 No	
Severity	Less-Severe	Normal	Severe

A. Structure of fuzzy inference system

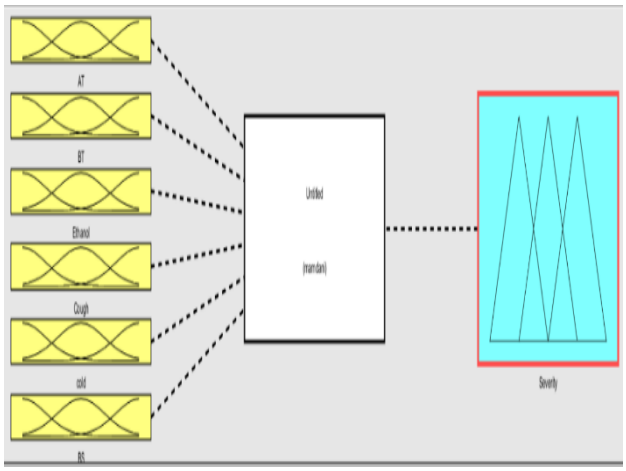


Figure 1: Structure of fuzzy inference system with six inputs and one output

B. Fuzzy rules for Inference

Table 3: Fuzzy rules for inference system with six input and one output

1	If (AT is Low) and (BT is Low) and (Ethanol is Low) and (Cold is No) and (Cough is No) and (BS is No) then (Severity is Less Severe)
2	If (AT is Low) and (BT is High) and (Ethanol is Low) and (Cold is Yes) and (Cough is Yes) and (BS is Yes) then (Severity is Severe)
3	If (AT is Low) and (BT is Low) and (Ethanol is Low) and (Cold is No) and (Cough is Yes) and (BS is Low) then (Severity is Less Severe)
4	If (AT is Medium) and (BT is Medium) and (Ethanol is Medium) and (Cold is No) and (Cough is No) and (BS is No) then (Severity is Normal)
5	If (AT is High) and (BT is Medium) and (Ethanol is High) and (Cold is Yes) and (Cough is Yes) and (BS is Yes) then (Severity is Less Severe)
6	If (AT is Medium) and (BT is Medium) and (Ethanol is Medium) and (Cold is No) and (Cough is No) and (BS is No) then (Severity is Normal)
7	If (AT is Low) and (BT is High) and (Ethanol is Low) and (Cold is Yes) and (Cough is No) and (BS is Yes) then (Severity is Severe)
8	If (AT is Medium) and (BT is Medium) and (Ethanol is Medium) and (Cold is No) and (Cough is No) and (BS is No) then (Severity is Normal)
9	If (AT is High) and (BT is Medium) and (Ethanol is High) and (Cold isYes) and (Cough is Yes) and (BS is No) then (Severity is Less Severe)
10	If (AT is Low) and (BT is High) and (Ethanol is High) and (Cold is No) and (Cough is No) and (BS is Yes) then (Severity is Less Severe)

C. Membership functions for the factors

We will construct membership functions for the input variables by using gaussian membership function as shown in fig.2,3 &4.

i. Atmospheric Temperature (AT)

```
x = 0:0.1:60;
y = gaussmf (x, [8.493 -2.22e-16]);
y1 = gaussmf (x, [3.61 26.5]);
y2 = gaussmf (x, [4.247 40]);
plot (x, y, x, y1, x, y2)
xlabel ('Input variable "AT"');
ylabel ('Membership grade');
title ('Membership functions plots for AT');
ylim ([-0.05 1.05]);
legend ('Low', 'Medium', 'High');
```

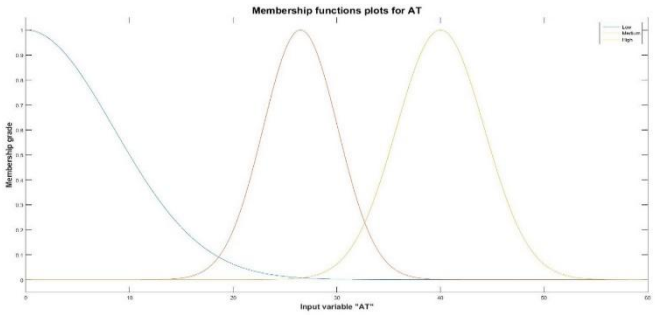


Figure 2: Gaussian membership function for Atmospheric Temperature in three linguistic categories; Low, Medium and High

ii. Body Temperature

```
x = 95:0.1:105;
y = gaussmf (x, [0.4247 97]);
y1 = gaussmf (x, [0.4247 98]);
y2 = gaussmf (x, [1.274 101]);
plot (x, y, x, y1, x, y2)
xlabel ('Input variable "BT"');
ylabel ('Membership grade');
title ('Membership functions plots for BT');
ylim ([-0.05, 1.05]);
legend ('Low', 'Medium', 'High');
```

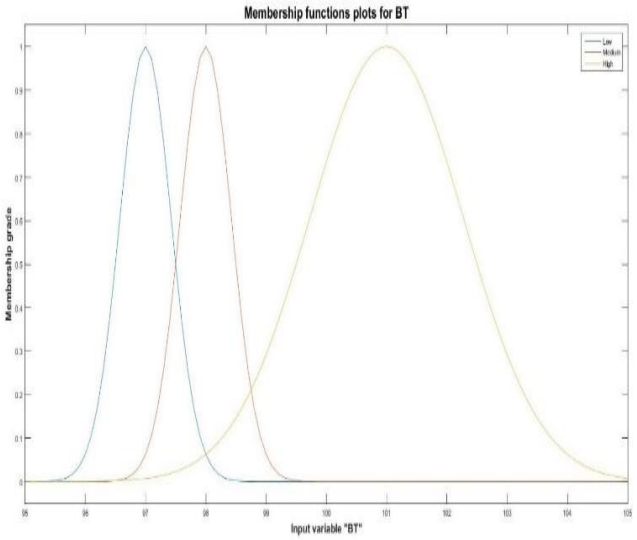


Figure 3: Gaussian membership function for Body Temperature in three linguistic categories; Low, Medium and High

iii. Ethanol

```
x = 0:0.1:190;
y = gaussmf (x, [19.11 2.5]);
y1 = gaussmf (x, [12.74 75]);
y2 = gaussmf (x, [16.99 140]);
plot (x, y, x, y1, x, y2)
xlabel ('Input variable "Ethanol"');
ylabel ('Membership grade');
title ('Membership functions plots for Ethanol');
ylim ([-0.05, 1.05]);
legend ('Low', 'Medium', 'High');
```

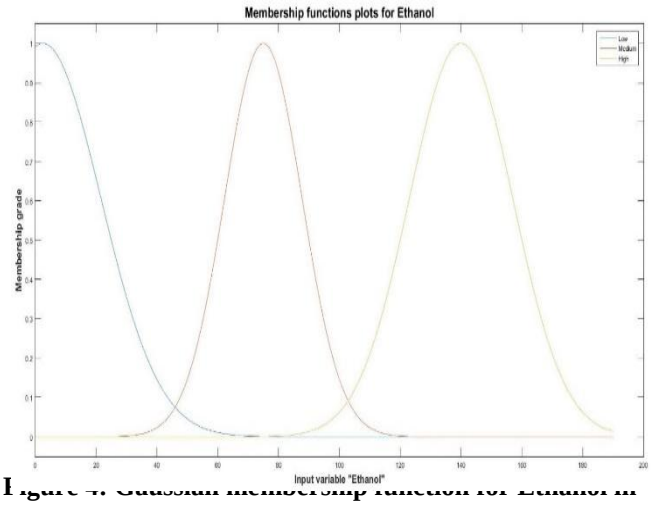


Figure 4: Gaussian membership function for Ethanol in three linguistic categories; Low, Medium and High

D. Severity level for COVID-19 in the infected patients

```
x = 0:0.001:1;
y = gaussmf (x, 0.1699 6.939e-18]);
y1 = gaussmf (x, [0.1699 0.5]);
y2 = gaussmf (x, [0.1699 1]);
plot (x, y, x, y1, x, y2)
xlabel ('Output variable "Severity"');
ylabel ('Membership grade');
title ('Membership functions plots for Severity');
ylim ([-0.05, 1.05]);
legend ('Less-Severe', 'Normal', 'Severe');
```

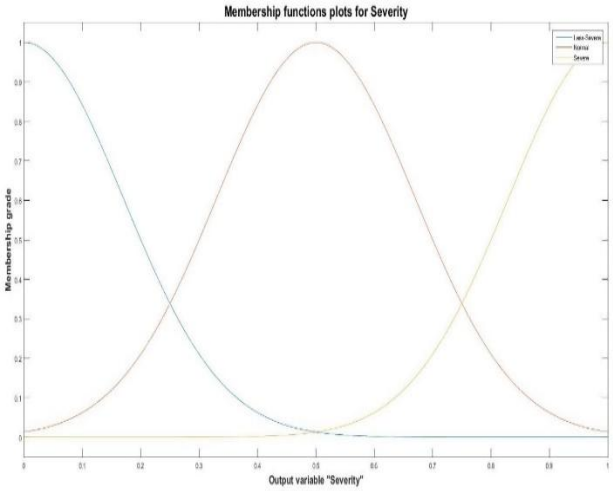


Figure 5: Gaussian membership function for Severity in three linguistic categories; Less- Severe, Normal and Severe

E. Output

Table 4: Normal Severity level of the infected patient

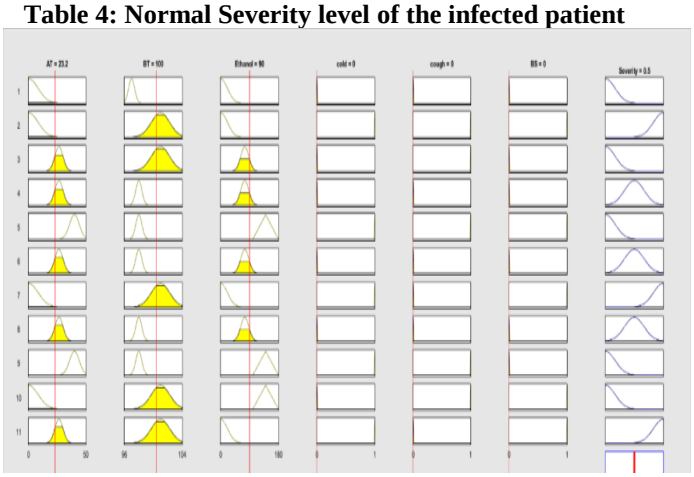


Table 5: Less Severe level of infected patient

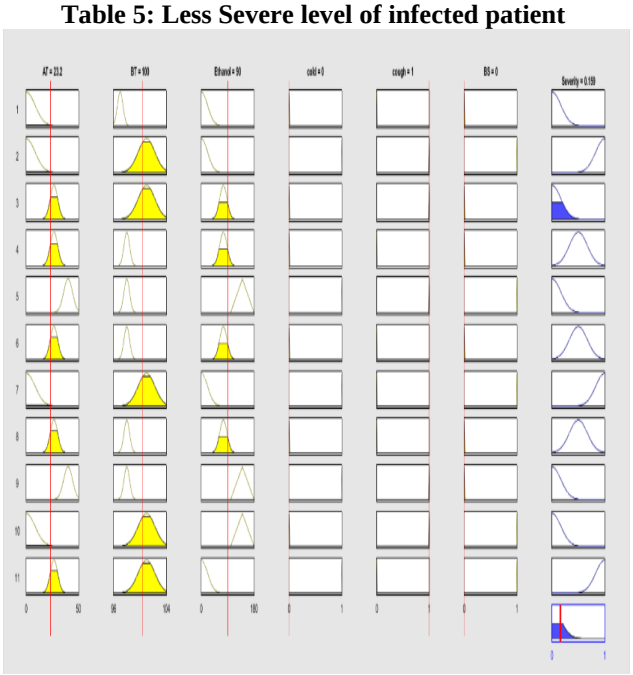
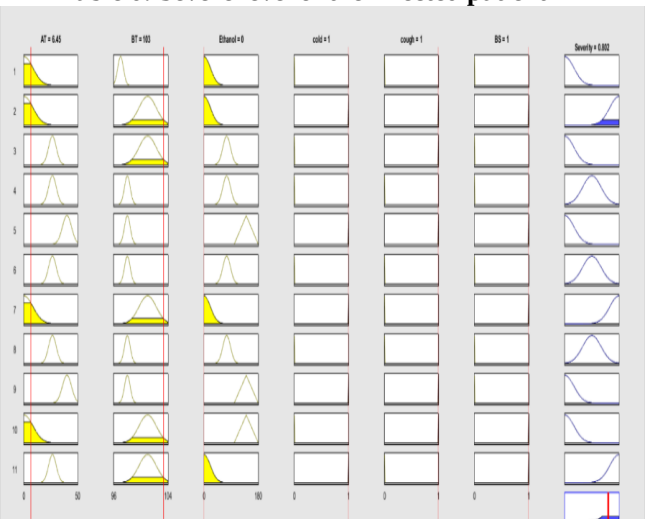


Table 6: Severe level of the infected patient



V. CONCLUSION

Coronaviruses abbreviated as CoV contains large family of viruses which causes basic symptoms like; cold, cough and fever. Out of these viruses COVID-19 is newly strained that introduced in 2019 which has not been identified before. The inference which we have developed in the research article, we may conclude the following observations;

1) From tab. 4 we may observe that if the atmospheric temperature is medium, more intake of ethanol and slightly higher body temperature then we will get Normal severity level of infected patient.
2) From tab. 5 if the atmospheric temperature is low, body temperature is medium, the intake ethanol quantity and patient suffering from cough then we may observe the severity level in the patient.
3) From tab. 6 we may observe that when the patient faces the difficulty in breathing difficulty, has sneezing problem with low intake of ethanol quantity then severity level will slightly higher be higher as compare to other cases.

So, our proposed inference system may be useful to the proper diagnostic of COVID-19 infected patients.

ACKNOWLEDGMENT

The first author is thankful to the University Grant Commission for financial assistance

REFERENCES

1. Vincent C. C. Cheng, Susanna K. P. La, Patrick C. Y. Woo, and Kwok Yung Yuen, "Severe Acute Respiratory Syndrome Coronavirus as an Agent of Emerging and Reemerging Infection", *CLINICAL MICROBIOLOGY REVIEWS*, 660–694, 2007.
2. Drosten C., Gunther S., Preiser W., van der Werf S., Brodt H.R., Becker S., Rabenau H., Panning M., Kolesnikova L., Fouchier R.A., Berger A., Burguiere A.M., Cinatl J., Eickmann M., Escriou N., Grywna K., Kramme S., Manuguerra J.C., Muller S., Rickerts V., Sturmer M., Vieth S., Klenk H.D., Osterhaus A.D., Schmitz H., and Doerr H.W.. "Identification of a novel coronavirus in patients with severe acute respiratory syndrome", *N. Engl. J. Med*., 348, 1967–1976, 2003
3. Ksiazek T. G., Erdman D., Goldsmith C.S., Zaki S.R., Peret T., Emery S., Tong S., Urbani C., Comer J.A., Lim W., Rollin P.E., Dowell S.F., Ling A.E., Humphrey C.D., Shieh W.J., Guarner J., Paddock C.D., Rota P., Fields B., DeRisi J., Yang J.Y., Cox N., Hughes J.M., LeDuc J.W., Bellini W.J., and Anderson L.J., "A novel coronavirus associated with severe acute respiratory syndrome*", N. Engl. J. Med*., 348, 1953–1966, 2003
4. Webster R. G., "Wet markets—a continuing source of severe acute respiratory syndrome and influenza?", *Lancet*, 363, 234–236, 2004
5. Woo P. C., Lau S.K., and Yuen K.Y., "Infectious diseases emerging from Chinese wet-markets: zoonotic origins of severe respiratory viral infections*", Curr. Opin. Infect. Dis.* 19, 401–407, 2006
6. Centers for Disease Control and Prevention (CDC), "*U.S. Department of Health & Human Services" 200 Independence Avenue, S.W. Washington, D.C.* 20201"
7. Kampf G., Todt D., Pfaender S. and Steinmann E., "Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents", *Journal of Hospital Infection*, 104, 246-251, 2020
8. Dhiman N and Sharma M.K., "Diabetes Diagnostic Model Based on Truth-Value Restriction method using inference of intuitionistic conditional and qualified fuzzy propositions", *International Journal of Engineering and Advance Technology (IJEAT*), 9(2), 2019
9. Dhiman N and Sharma M.K., "Mediative Sugeno's-TSK fuzzy logic-based screening analysis to diagnosis of heart disease", *Applied Mathematics*, 10, 448-467, 2019
10. Dhiman N and Sharma M.K., "Mediative multi-criteria decision support system for various alternatives based on fuzzy logic", *International Journal of Recent Technology and Engineering (IJRTE)*, 8(4), 2019
11. Our word in data, "*Global Change Data Lab", England and Wales* (Charity Number 1186433)
12. Novel Coronavirus (2019-nCoV), "Ministry of Health & Family Welfare" Situation Report 2020
13. COVID-19 IAF Med Services, *"Indian Air Force, New Delhi-India"*, 2020
14. List of private laboratories COVID-19 testing, "*Indian Council of Medical Research*", New Delhi

AUTHORS PROFILE

Nitesh Dhiman received the M.Sc. Degree in Mathematics from GKV, Hardwar in 2013, UGC-CSIR-JRF in Mathematics (June-2016 &June-2017) and pursuing Ph.D. in Mathematics from C.C.S. Uni., Meerut, India. His research interest includes Fuzzy Logic in Medical Sciences.

M. K. Sharma received a Ph.D. Degree in Fuzzy Reliability Theory from C.C.S. Uni., Meerut India in 2007. He is currently an Associate Professor in the Department of Mathematics, C.C.S. Uni., Meerut India. He has contributed more than 60 research articles to professional Journals. He has participated and presented more than 40 research articles in National and International conferences. His research interest includes Reliability Theory, Fuzzy logic, Intuitionistic fuzzy logic, vague logic and their applications in Engineering and Healthcare.