International Journal Of Advance Research, Ideas And Innovations In Technology

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 1)
Available online at: www.ijariit.com

IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System

Syyada Abeer Fatima
abirbokhari.383038@gmail.com
Nishtar Institute of Dentistry, Multan, Pakistan

Naveed Hussain
naveedkhoja512@gmail.com
Nishtar Institute of Dentistry, Multan, Pakistan

Asma Balouch
hamdfatima63@gmail.com
Nishtar Institute of Dentistry, Multan, Pakistan

Iqra Rustam
iqra@ncbae.edu.pk
School of Computer Science NCBA and E, Lahore, Pakistan

Muhammad Saleem
msaleem@ncbae.edu.pk
School of Computer Science NCBA and E, Lahore, Pakistan

Muhammad Asif
muhammadasif@ncbae.edu.pk
School of Computer Science NCBA and E, Lahore, Pakistan

ABSTRACT

Almost 3,000 cases of respiratory disease due to a new coronavirus from Wuhan, China were registered between 1 December 2019 and 26 January 2020. The diagnosis of coronavirus in a human being on a wide scale was so hectic. This proposed research implements an Internet of Things (IoT) approach enabled by Fuzzy Inference System (FIS) to intelligently and efficiently predict the coronavirus known as 'IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System (IoTSMCFIS)' which smartly monitors and predicts either human is the victim of Coronavirus or not. For simulations, the IoTSMCFIS proposed system uses MATLAB 2019a and the proposed system indicates promising results regarding the simulations.

Keywords— IoT, IoTSMCFIS, FIS, SARS-CoV, MERS-CoV, WHO

1. INTRODUCTION

At the end of 2019, in Wuhan, China, a novel coronavirus named 2019-nCoV appeared. At least 830 cases were diagnosed in nine countries since January 24, 2020: China, Thailand, Japan, South Korea, Singapore, the United States, Vietnam, Taiwan, and Nepal. There have been 26 deaths, mostly in patients suffering from severe psychiatric disorders [1]. Although many aspects of the nature and ability of the virus to spread among humans remain unknown, a growing number of cases seem to have emerged from the transmission of the virus to humans. Despite the 2002 outbreak of Severe Acute Air Coronavirus (SARS-CoV) and the 2012 outbreak of Middle East Respire Syndrome (MERS-CoV), 2019-nCoV is the world's third most common coronavirus that has warned international health agency [2].

China has reacted swiftly by informing the World Health Organization (WHO), after the discovery of the potential cause, of the outbreak and sharing sequence data with the international community. The WHO quickly responded with the co-ordination of the production of the diagnostic; providing guidance on patient monitoring, collection of samples and care. Some countries in the region as well as in the USA are monitoring Wuhan travelers for a fever to detect cases of 2019-nCoV before the virus continues to spread. Chinese, Thailand, Korean and Japanese reports suggest that 2019-nCoV disease appears relatively mild compared to SARS and MERS [3].

In SARS and MERS, compounds play an important role. In SARS and MERS cases, many risk factors, particularly advanced age and male sex, are associated with progression into Acute Respiratory Disorder Syndrome (ARDS). With MERS, chronic conditions, including diabetes mellitus, hypertension cancer, renal and lung diseases, and co-infections, also include additional risk factors associated with severe illness. SARS-CoV and MERS-CoV are primarily spread from human to human in healthcare settings. Though well after the onset of symptoms, patients will only spill large amounts of the virus when patients will definitely still seek medical attention. 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 [4-5].

Experimental infections and field observations have shown that infected dromedaries release high amounts of viruses through nasa l secretions and that clinical disease signs are confined to rhinorrhoea and a mild increase in body temperature [6-8]. The first week of nasal Swab infection was diagnosed with the contagious virus, and 35 days after infections (dpi) RNA was detected [6,7]. However, successful infections from New World camelids, flames and alpacas following experimental MERS-CoV inoculation indicate a large host tropic of MERS-CoV for camelids.

2. LITERATURE REVIEW

Coronavirus (MERS-CoV) of the Middle East reported in 2012 [9]. More than 2300 incidents with an estimated fatality rate of 35 percent have been registered to date. Dromedary camels have been identified as the source of zoonotic MERS-CoV transmission in epidemiological studies, and evidence has been recorded of MERS-CoV distribution across the original range. Whether Bactrian camels are susceptible to infection is currently unknown. Throughout West and Central Asia, the range of Bactri an camels is partially concurrent with that of the dromedary camel. For the 14 residues that associate with the receptor MERS-CoV pulse, the receptor for MERS-CoV DPP4 of Bactrian camelia was 98.3% similar to the dromedary camel DPP4 and 100% equivalent. Animals developed a transient, primarily upper-respiratory system infection when intranasally inoculated with 107 plaque-forming MERS-CoV units. Clinical signs were benign for MERS-CoV infection, but large amounts of MERS-CoV were released from the URT. This data shows that Bactrians are susceptible to MERS-CoV and are at risk of the introduction and establishment of MERS-CoV in the Bactrian camel population due to their superimposed range. This evidence is close to infections in dromedary camel infections.

The causative agent of more than 2468 humans diagnosed and more than 851 fatalities in 27 countries since 2012, in the Middle East Respiratory Syndrome Coronavirus (MERS-CoV). Through a combination of lopinavir, ritonavir, and interferon-beta (LPV/RTV-IFNb) in humans in the Kingdom of Saudi Arabia is being investigated, there are no licensed therapies for MERS-CoV infection. It is demonstrated that remdesivir and IFNb have a superior antiviral activity to LPV and RTV in vitro. Prophylactic as well as therapeutic RDV improve lung function in mice and reduce lung viral loads and serious lung disease.

In contrast, prophylactic LPV/RTV-IFNb slightly reduces viral loads without impacting other disease parameters. Therapeutic LPV/RTV-IFNb improves pulmonary function but does not reduce virus replication or severe lung pathology. Thus, we provide in vivo evidence of the potential for RDV to treat MERS-CoV infections [10].

Since first identified, the epidemic scale of the recently emerged novel coronavirus (2019-nCoV) in Wuhan, China, has increased rapidly, with cases arising across China and other countries and regions. using a transmission model, we estimate a basic reproductive number of 3.11 (95%CI, 2.39-4.13); 58-76% of transmissions must be prevented to stop increasing; Wuhan case ascertainment of 5.0% (3.6-7.4); 21022 (11090-33490) total infections in Wuhan 1 to 22 January [11].

In response to the official announcement of a cluster of pneumonia of unknown etiology, which has an epidemiological link to a wet market in Wuhan, China on 31 December 2019, we present our proactive infection control measures for immediate prevention against hospital outbreaks due to such imported case into Hong Kong. Hong Kong is a cosmopolitan city in south China with a unique history in confirming the first case of human infection due to avian influenza A H5N1 in 1997 and severe acute respiratory syndrome-associated coronavirus (SARS-CoV) in 2003 [12].

In the existing era, diverse examination questions have been linked with formally existing evolutionary algorithms [13, 14], Swarm Intelligence [15, 16], Neural Network and fuzzy frameworks [17,18,19] that have just been adopted, yet also some new approaches. This unlocked various other times for the researchers.

3. PROPOSED IOT ENABLED SMART MONITORING OF CORONAVIRUS EMPOWERED WITH FUZZY INFERENCE SYSTEM

The proposed IoTSMCFIS system is used to resolve the need for smart FIS coronavirus monitoring. Figure 1, which consists of two cloud-connected phases, illustrates the proposed IoTSMCFIS model system. The first is a training phase and the second is a validation phase. The training phase comprises three levels: sensory layer, Preprocessing layer and application layer. Sensory Layer comprises of input parameters Flu Headache, Cough, Sore Throat and Fever that accumulate and transfer the input values through IoT in the database. Because of wireless communication, the data stored in the database may be noisy and incomplete, it is therefore called raw data. The preprocessing layer is the next and very critical layer. The missing values are controlled by moving average and normalization in order to reduce noisy results. The data is forwarded to the application layer after preprocessing. In addition, the application layer is divided into two layers: Prediction and Performance Layer.

FIS is used in the prediction layer to predict the output. The input has been grouped and altered to a fuzzy set with fuzzy linguistic variables, fuzzy semantic terms, and fuzzy membership functions. During the following point, fuzzy modifications will be made by the FIS. FIS the way to suppose a given source input by using fuzzy logic, after which fuzzy set possibilities are transformed into a fuzzy set in de-fuzzifier. It is usually necessary for a fuzzy control system.

FIS is used to predict the coronavirus in the prediction layer. If sensory layer input parameters are appropriate, it will move via fuzzification into the fuzzy crisp inputs. The crisp set of input data is obtained and transformed into a fuzzy set using fuzzy linguistic variables, fuzzy semantic terms and membership functions. The fuzzy technologies continue through the FIS in the next phase. FIS is the way to suppose an input that is given to the output using fuzzy logic, which is ultimately transformed into crisp in de-fuzzy set consistency. In fuzzy structures, it is usually needed.

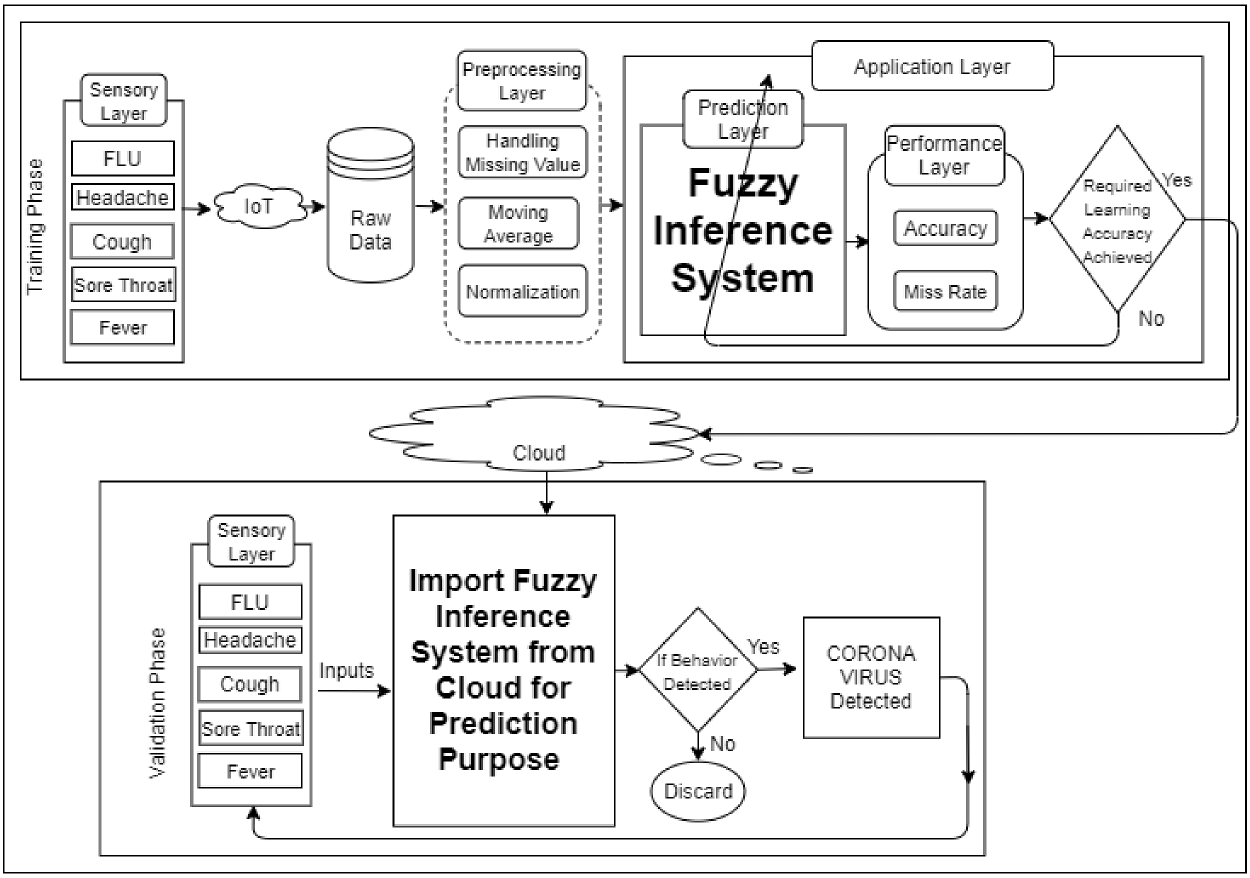
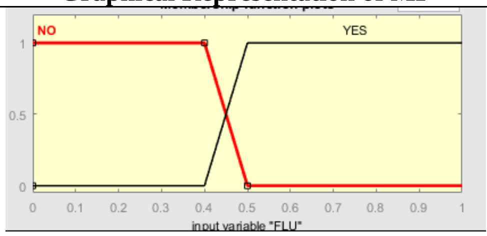
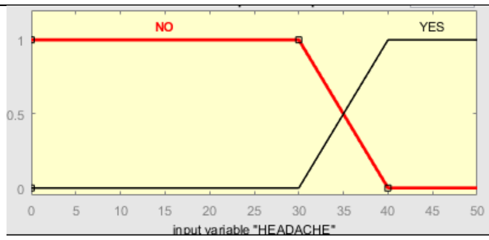
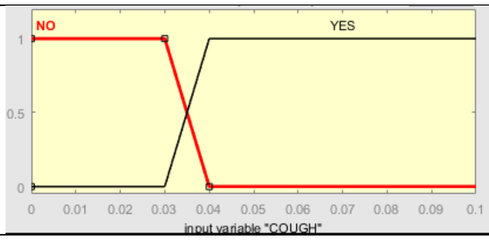


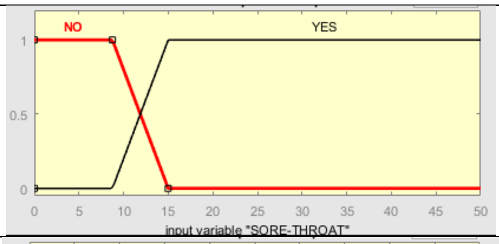
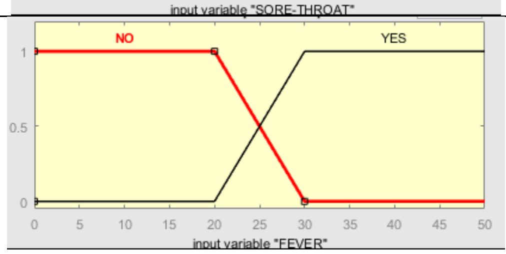
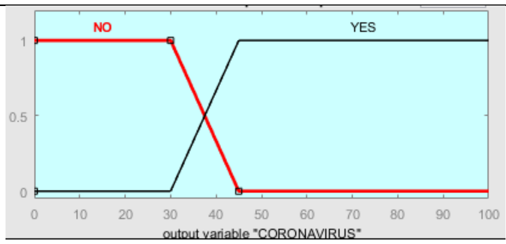
Fig. 1: IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System

3.1 Membership Function

A membership function is a statistical description of input and output variables, and it explains how the input variables are built for a membership value of between 0 and 1. FIS of proposed IoTSMCFIS Input / Output Variables are representing the graphical and mathematical form in Table 1. 2-6 rows represent the input member function while row 7 represents the output member function.

Table 1: Input/output Variables Membership Functions in Proposed IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System

Input/output	Membership Function	Graphical Representation of MF
$Flu = \mu_F(f)$	$\mu_{F_N}(f) = \left\{\max\left(\min\left(1, \frac{0.5-f}{0.1}\right), 0\right)\right\}$ $\mu_{F_Y}(f) = \{\max\left(\min\left(\frac{f-0.4}{0.1}, 1\right), 0\right)\}$	
$Headache = \mu_H(h)$	$\mu_{H_N}(h) = \left\{\max\left(\min\left(1, \frac{40-h}{10}\right), 0\right)\right\}$ $\mu_{H_Y}(h) = \{\max\left(\min\left(\frac{h-30}{10}, 1\right), 0\right)\}$	
$Cough = \mu_C(c)$	$\mu_{C_N}(c) = \left\{\max\left(\min\left(1, \frac{0.04-c}{0.01}\right), 0\right)\right\}$ $\mu_{H_Y}(c) = \{\max\left(\min\left(\frac{c-0.03}{0.01}, 1\right), 0\right)\}$	

<table>
<tr><td>$Sore\ Throat = \mu_{SR}(sr)$</td><td>$\mu_{SR_N}(sr) = \left\{\max\left(\min\left(1,\frac{15-sr}{5}\right),0\right)\right\}$
$\mu_{SR_Y}(sr) = \{\max\left(\min\left(\frac{sr-10}{5},1\right),0\right)\}$</td><td>
</td></tr>
<tr><td>$Fever = \mu_F(f)$</td><td>$\mu_{F_N}(f) = \left\{max\left(min\left(1,\frac{30-f}{10}\right),0\right)\right\}$
$\mu_{H_Y}(f) = \{max\ (min\left(\frac{f-20}{10},1\right),0)\}$</td><td>
</td></tr>
<tr><td>$Corona - Virus = \mu_{CV}(cv)$</td><td>$\mu_{CV_N}(cv) = \left\{\max\left(\min\left(1,\frac{45-cv}{15}\right),0\right)\right\}$
$\mu_{CV_Y}(cv) = \{\max\left(\min\left(\frac{cv-30}{15},1\right),0\right)\}$</td><td>
</td></tr>
</table>

3.2 Input Fuzzy Sets

The ambiguous input function is the statistical values used to predict the use of FIS for corona-virus. The article refers to the corona-virus diagnosis of five different types of fuzzy variables, Flu, Headache, Cough, Sore Throat, and Fever. Table 2 contains the descriptions of these input variables.

Table 2: Input/output Parameters of Proposed IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System

Parameters		
	No	**Yes**
Flu	0-0.5	0.4-1
Headache	0-40	30-50
Cough	0-0.04	0.03-0.1
Sore Throat	0-15	10-50
Fever	0-30	20-50
Corona-Virus	0-45	30-100

3.3 Rule-Based

Fuzzy sets and fuzzy logic are used as tools to describe various types of knowledge related to the issue as well as demonstrate connections and sources between their variables. II /O Rules are considered by the FIS as the fundamental part. Such rules are applied by the FIS. This model produces I / O rules that appear in table 1. Appeared above the suggested FIS-dependent I / O rule Inference Engine.

Inference Engine is one of the center parts of a FIS.

If (FLU is NO) and (HEADACHE is NO) and (COUGH is NO) and (SORE-THROAT is NO) and (FEVER is NO) then (CORONAVIRUS is NO)

If (FLU is NO) and (HEADACHE is NO) and (COUGH is NO) and (SORE-THROAT is NO) and (FEVER is NO) then (CORONAVIRUS is NO)

1. If (FLU is NO) and (HEADACHE is NO) and (COUGH is NO) and (SORE-THROAT is NO) and (FEVER is NO) then (CORONAVIRUS is NO)

.

.

.

If (FLU is YES) and (HEADACHE is YES) and (COUGH is YES) and (SORE-THROAT is YES) and (FEVER is YES) then (CORONAVIRUS is YES)

3.4 De-Fuzzifier

Defuzzification is the method of making a computable outcome in Crisp logic, accepted fuzzy sets and comparing membership degrees. The technique makes a fuzzy set to a fresh set. It is representative required in fuzzy control frameworks. There are various kinds of De-Fuzzifier. In the proposed model centroid kind of De-Fuzzifier is applied. Figure 2-4 shows the De-Fuzzifier graphical description of FIS.

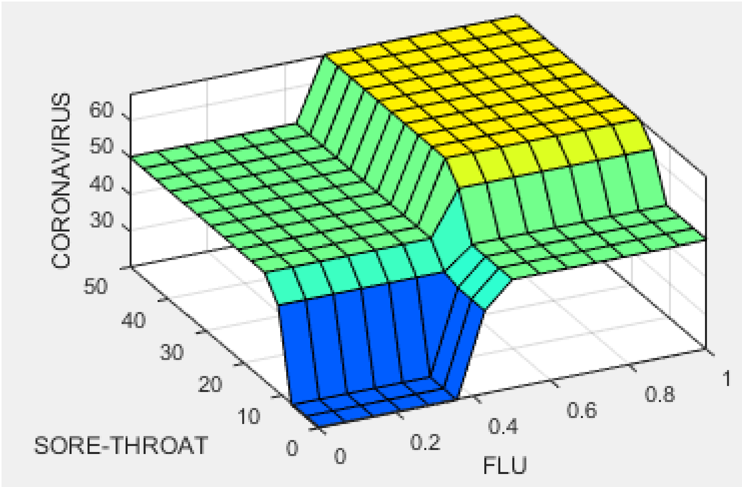


Fig. 2: Rule Surface of Proposed IoTSMCFIS based on Flu and Sore-Throat

Figure 2 represents the 3D view of the ruled surface of proposed IoTSMCFIS based on Flu and Sore-throat. It observed that the Proposed IoTSMCFIS system simulation results are Good (Yellow shade) and Satisfied (Greenish Shade), and Weak or Poor (Bluish Shade) respectively.

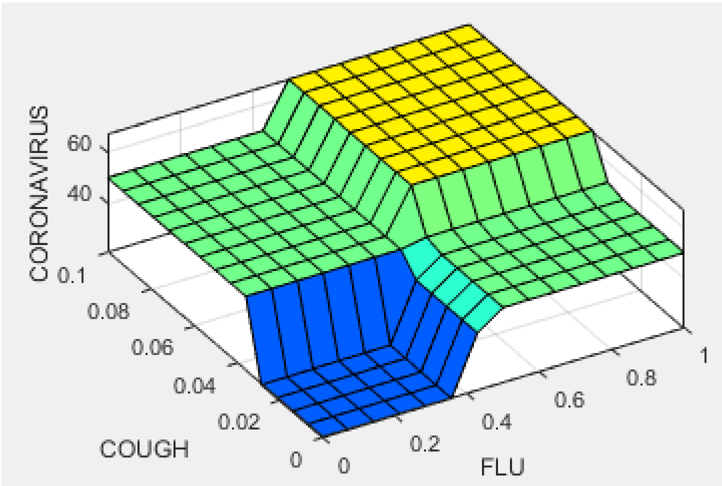


Fig. 3: Rule Surface of Proposed IoTSMCFIS based on Flu and Cough

Figure 3 represents the 3D view of the rule surface of proposed IoTSMCFIS based on Flu and Cough. It observed that the Proposed IoTSMCFIS system simulation results are Good (Yellow shade) and Satisfied (Greenish Shade), and Weak or Poor (Bluish Shade) respectively.

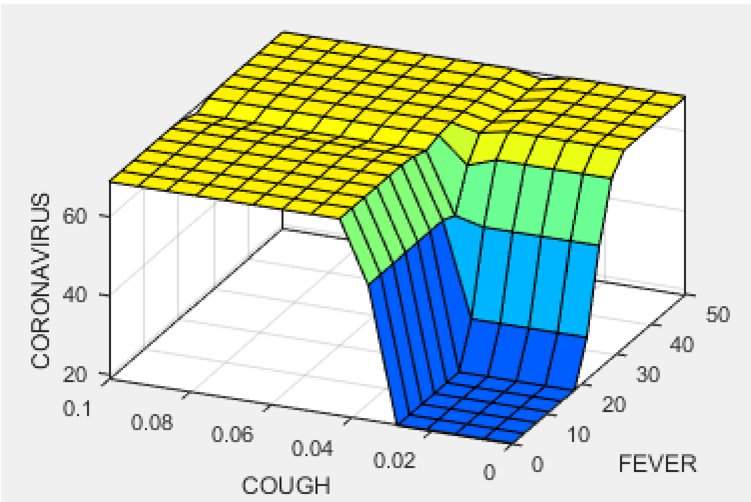


Fig. 4: Rule Surface of Proposed IoTSMCFIS based on Fever and Cough

Figure 4 represents the 3D view of the ruled surface of proposed IoTSMCFIS based on Fever and Cough. It observed that the Proposed IoTSMCFIS system simulation results are Good (Yellow shade) and Satisfied (Greenish Shade), and Weak or Poor (Bluish Shade) respectively.

After the prediction layer, the output of the prediction layer will be sent to the performance layer to predict the corona-virus smartly basis on accuracy and miss rate and decides that either required results are found or not. In the case of 'Yes,' a message will be shown that the corona-virus is detected and in the case of 'No' the prediction, a layer will be updated and so on. If learning criteria meet it move on a database that consists of a cloud and then it further moves on import Fuzzy Logic smart system from cloud prediction purpose.

3.5 Simulation Results of Proposed IoT enabled Smart Monitoring of Coronavirus empowered with Fuzzy Inference System

For simulation results, the MATLAB R2019a tool is utilized. MATLAB is likewise utilized for modeling, simulation, algorithm expansion, prototyping, and many other fields. For reproduction results, five data sources and one output factor are utilized. In this article, the proposed Fuzzy based system demonstrates the diverse types of output like IoTSMCFIS system prediction. Lookup rules diagram is generated by using Fuzzy Logic designer based upon the rules discussed in the lookup.

Fig 5 shows that if the values of Fuel are No, Headache is No, Cough is Yes, Sore-Throat is Yes and Fever is Yes then Corona-Virus prediction is Yes. Fig 6 shows that if the values of Fuel are No, Headache is No, Cough is No, Sore-Throat is No and Fever is No then Corona-Virus prediction is No. Fig 7 shows that if the values of Fuel are Yes, Headache is No, Cough is Yes, Sore-Throat is No and Fever is Yes then Corona-Virus prediction is Yes.

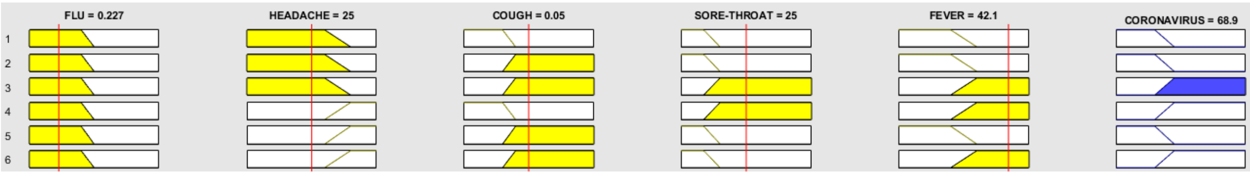


Fig. 5: Lookup diagram for proposed IoTSMCFIS (Yes)

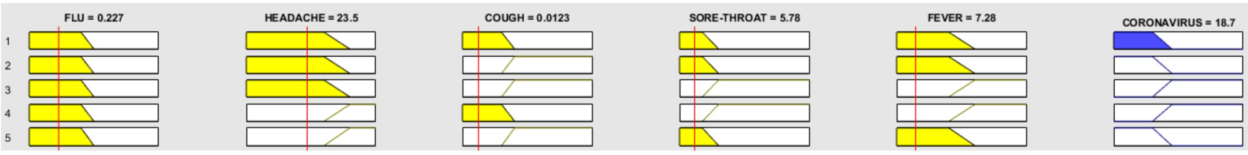


Fig. 6: Lookup diagram for proposed IoTSMCFIS (No)

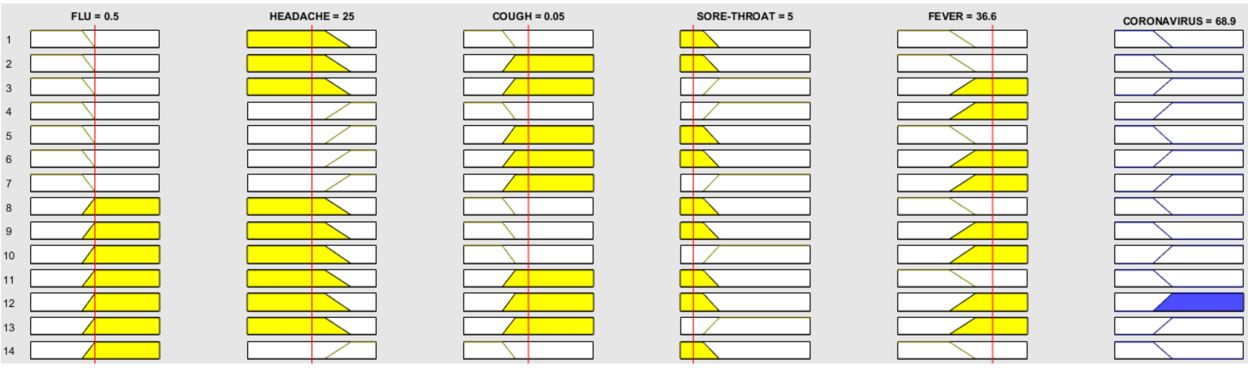


Fig. 7: Lookup diagram for proposed IoTSMCFIS (Yes)

4. CONCLUSION

It was so hectic task to monitor coronavirus detection in a human being on large cases of respiratory illness caused by a novel coronavirus originating in Wuhan, China has been reported. The proposed IoTSMCFIS system is introduced to monitor the corona-virus smartly and efficiently using FIS. The proposed IoTSMCFIS system monitors the patients smartly and detects that either the patient is a victim of Coronavirus or not. The proposed IoTSMCFIS system uses MATLAB 2019a for simulations and after the simulations, the proposed system results show attractive results.

5. REFERENCES

[1] Munster, V.J., Koopmans, M., van Doremalen, N., van Riel, D. and de Wit, E., 2020. A Novel Coronavirus Emerging in China—Key Questions for Impact Assessment. *New England Journal of Medicine*.

[2] de Wit, E., van Doremalen, N., Falzarano, D. and Munster, V.J., 2016. SARS and MERS: recent insights into emerging coronaviruses. *Nature Reviews Microbiology*, *14*(8), p.523.

[3] Conzade, R., Grant, R., Malik, M.R., Elkholy, A., Eliakim, M., Samhouri, D., Ben Embarek, P.K., and Van Kerkhove, M.D., 2018. Reported direct and indirect contact with dromedary camels among laboratory-confirmed MERS-CoV cases. *Viruses*, *10*(8), p.425.

[4] Memish, Z.A., Cotten, M., Meyer, B., Watson, S.J., Alsahafi, A.J., Al Rabeeah, A.A., Corman, V.M., Sieberg, A., Makhdoom, H.Q., Assiri, A. and Al Masri, M., 2014. Human infection with MERS coronavirus after exposure to infected camels, Saudi Arabia, 2013. *Emerging infectious diseases*, *20*(6), p.1012.

[5] Müller, M.A., Corman, V.M., Jores, J., Meyer, B., Younan, M., Liljander, A., Bosch, B.J., Lattwein, E., Hilali, M., Musa, B.E. and Bornstein, S., 2014. MERS coronavirus neutralizing antibodies in camels, Eastern Africa, 1983–1997. *Emerging infectious diseases*, *20*(12), p.2093.

[6] Adney, D.R., van Doremalen, N., Brown, V.R., Bushmaker, T., Scott, D., de Wit, E., Bowen, R.A. and Munster, V.J., 2014. Replication and shedding of MERS-CoV in the upper respiratory tract of inoculated dromedary camels. *Emerging infectious diseases*, *20*(12), p.1999.

[7] Khalafalla, A.I., Lu, X., Al-Mubarak, A.I., Dalab, A.H.S., Al-Busadah, K.A. and Erdman, D.D., 2015. MERS-CoV in the upper respiratory tract and lungs of dromedary camels, Saudi Arabia, 2013–2014. *Emerging infectious diseases*, *21*(7), p.1153.

[8] van Doremalen, N., Hijazeen, Z.S., Holloway, P., Al Omari, B., McDowell, C., Adney, D., Talafha, H.A., Guitian, J., Steel, J., Amarin, N. and Tibbo, M., 2017. High prevalence of Middle East respiratory coronavirus in young dromedary camels in Jordan. *Vector-borne and zoonotic diseases*, *17*(2), pp.155-159.

[9] Adney, D.R., Letko, M., Ragan, I.K., Scott, D., van Doremalen, N., Bowen, R.A. and Munster, V.J., 2019. Bactrian camels shed large quantities of Middle East respiratory syndrome coronavirus (MERS-CoV) after experimental infection. *Emerging microbes & infections*, *8*(1), pp.717-723.

[10] Sheahan, T.P., Sims, A.C., Leist, S.R., Schäfer, A., Won, J., Brown, A.J., Montgomery, S.A., Hogg, A., Babusis, D., Clarke, M.O. and Spahn, J.E., 2020. Comparative therapeutic efficacy of remdesivir and combination lopinavir, ritonavir, and interferon-beta against MERS-CoV. *Nature Communications*, *11*(1), pp.1-14.

[11] Read, J.M., Bridgen, J.R., Cummings, D.A., Ho, A. and Jewell, C.P., 2020. Novel coronavirus 2019-nCoV: early estimation of epidemiological parameters and epidemic predictions. *medRxiv*.

[12] Cheng, V.C., Wong, S.C., To, K.K., Ho, P.L. and Yuen, K.Y., 2020. Preparedness and proactive infection control measures against the emerging Wuhan coronavirus pneumonia in China. *Journal of Hospital Infection*.

[13] Khan MA, Umair M, Choudry MA. Island differential evolution based adaptive receiver for MC-CDMA system. In2015 International Conference on Information and Communication Technologies (ICICT) 2015 Dec 12 (pp. 1-6). IEEE.

[14] Zubair M, Choudhry MA, Qureshi IM. Multiuser detection using soft particle swarm optimization along with radial basis function. Turkish Journal of Electrical Engineering & Computer Sciences. 2014 Nov 13;22(6):1476-83.

[15] Zubair M, Saleem MA, Qureshi IM. Multi-user Detection using Soft Particle Swarm Optimization for Asynchronous MC-CDMA. International Information Institute (Tokyo). Information. 2013 Mar 1;16(3):2093.

[16] Asif M, Khan MA, Abbas S, Saleem M. Analysis of Space & Time Complexity with PSO Based Synchronous MC-CDMA System. In2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET) 2019 Jan 30 (pp. 1-5). IEEE.

[17] Saleem M, Khan MA, Abbas S, Asif M, Hassan M, Malik JA. Intelligent FSO Link for Communication in Natural Disasters empowered with Fuzzy Inference System. In2019 International Conference on Electrical, Communication, and Computer Engineering (ICECCE) 2019 Jul 24 (pp. 1-6). IEEE.

[18] Zubair M, Choudhry MA, Naveed A, Qureshi IM. Particle swarm with a soft decision for multiuser detection of synchronous multicarrier CDMA. IEICE transactions on communications. 2008 May 1;91(5):1640-3.

[19] Palanki R, inventor; Qualcomm Inc, assignee. Frequency hopping design for single-carrier FDMA systems. United States patent US 8,917,654. 2014 Dec 23.

