Computer Modeling in Engineering & Sciences

Tech Science Press

DOI: 10.32604/cmes.2023.024755

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Prediction System for Diagnosis and Detection of Coronavirus Disease-2019 (COVID-19): A Fuzzy-Soft Expert System

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Received: 07 June 2022 Accepted: 08 August 2022

ABSTRACT

In early December 2019, a new virus named "2019 novel coronavirus (2019-nCoV)" appeared in Wuhan, China. The disease quickly spread worldwide, resulting in the COVID-19 pandemic. In the current work, we will propose a novel fuzzy soft modal (i.e., fuzzy-soft expert system) for early detection of COVID-19. The main construction of the fuzzy-soft expert system consists of five portions. The exploratory study includes sixty patients (i.e., forty males and twenty females) with symptoms similar to COVID-19 in (Nanjing Chest Hospital, Department of Respiratory, China). The proposed fuzzy-soft expert system depended on five symptoms of COVID-19 (i.e., shortness of breath, sore throat, cough, fever, and age). We will use the algorithm proposed by Kong et al. to detect these patients who may suffer from COVID-19. In this way, the present system is beneficial to help the physician decide if there is any patient who has COVID-19 or not. Finally, we present the comparison between the present system and the fuzzy expert system.

KEYWORDS

Coronavirus disease-2019 (COVID-19); fuzzy-soft expert system; fuzzy expert system; diagnosed results

1 Introduction

In early December 2019, a new virus named "2019 novel coronavirus (2019-nCoV)" appeared in Wuhan, China. A novel epidemic disease (named "coronavirus disease-2019 (COVID-19)") was announced by the World Health Organization (WHO) on February 11, 2020 [1]. Also, the WHO described that COVID-19 is of origin. It is transmitted between animals and humans [1,2]. Moreover, WHO showed that COVID-19 is the source of the disease as a severe acute respiratory syndrome in the Middle East [1]. The latest statistics showed that the number of cases of the disease reached 3,152,556 cases, 964,840 of which were recovered and 218,491 deaths, while the number of patients currently infected is 1,969,225, of whom 1,912,345 are in stable condition and 56,880 are in critical condition [3].

Newly, research works on COVID-19 are very active and developing rapidly: The relationship between the severe acute respiratory syndrome coronavirus 2 (for short, SARS-CoV-2) and COVID-19 was discussed [4]. Characteristics of human coronaviruses (COVID-19 infection) were presented [5]. COVID-19 was discussed as belonging to other coronaviruses and it was from the platoon Bedside [6,7]. Further, it was published that there are diseases that increase the weakening of the body's immunity and the speed of the infection with COVID-19 (for example, diabetes, hypertension cases, and cancers) [8]. The relationship between COVID-19 and rheumatoid disease was shown and studied [9]. The effect of COVID-19 on several diseases, such as dialysis renal histopathological and hemodialysis patients was studied [10,11]. The relationship between epilepsy and fever COVID-19 and neurological convulsions in the human body were studied [12]. COVID-19 is an unusual virus because it reduces the percentage of white cells in the human body, especially of the type lymphopenia. As for the rapid spread of the disease, there was a study that shows that infection with COVID-19 is possible not only through respiratory droplets, but also possible through urine or stools, and the fecal-oral route [13,14]. On the other side, about COVID-19 and its relationship to climate, there was a study examining four climatic factors related to high and low infections: Temperature, Humidity, Wind Speed, and UV rays [15]. On the other hand, a final review was undergone for the COVID-19 prediction models that identified and evaluated twenty-seven studies, that statistically described thirty-one models [16].

Recently, COVID-19 has become one of the most dangerous viruses spread in the world and is an inspiration of the first death. To reduce the prevalence of COVID-19, we must find some appropriate solutions to keep people safe, which is to inform people about the dangers of COVID-19. Therefore, early detection of this virus (COVID-19) should be done through the medical expert systems or the design of a matching medical diagnostic system for expert physicians. There are several expert medical systems developed in medical diagnosis to detect the seriousness of the diseases (see [17–38]).

The present paper is arranged as follows: The basic notions of this paper are introduced in Section 2. The structure of the fuzzy-soft expert system is explained in Section 3. Experimental results are discussed in Section 4. A comparison between the present system and the fuzzy expert system is presented in Section 5. Finally, the conclusion is given in Section 6.

2 Preliminaries

2.1 Fuzzy Set, Soft Set, and Fuzzy Soft Set

Definition 2.1 (cf. [39–42]) For given set X, let 2^X be the set of all subsets of X, $[0,1]^X$ (resp., $[0,1]^{XI} = ([0,1]^X)^I$) be the set of all mappings from X (resp., I) to $[0,1]$ (resp., $[0,1]^X$). Then each element $\mathcal{A} \in [0,1]^X$ will be called a fuzzy set on X, and each element $\mathcal{A} \in 2^{X\times I} = (2^X)^I$ (resp., $\mathcal{A} \in [0,1]^{XI}$) will be called a soft set (resp., a fuzzy soft set) on X indexed by I.

The trapezoidal fuzzy numbers $[\hat{x}, \hat{x}, \hat{y}\rangle, \langle\hat{x}, \hat{y}, \hat{y}] \in [0,1]^{\widetilde{\mathcal{R}}}$ (called fuzzy sets, $\widetilde{\mathcal{R}}$ is the set of all real numbers), where $\hat{x} \leq \hat{y}$ and also $\langle\hat{x}, \hat{y}, \hat{z}\rangle \in [0,1]^{\widetilde{\mathcal{R}}}$ (called fuzzy set), where $\hat{x} \leq \hat{y} \leq \hat{z}$ are used repeatedly in the present paper, are defined by

$$[\hat{x},\hat{x},\hat{y}\rangle(u)=\begin{cases}1, & u\le \hat{x},\\ \dfrac{\hat{y}-u}{\hat{y}-\hat{x}}, & \hat{x}<u<\hat{y},\\ 0, & u\ge \hat{y};\end{cases}\quad \langle\hat{x},\hat{y},\hat{y}](u)=\begin{cases}0, & u\le \hat{x},\\ \dfrac{u-\hat{x}}{\hat{y}-\hat{x}}, & \hat{x}<u<\hat{y},\\ 1, & u\ge \hat{y};\end{cases}$$

$$\langle\hat{x},\hat{y},\hat{z}\rangle(u)=\begin{cases}\dfrac{u-\hat{x}}{\hat{y}-\hat{x}}, & \hat{x}\le u<\hat{y},\\ \dfrac{\hat{z}-u}{\hat{z}-\hat{y}}, & \hat{y}\le u<\hat{z},\\ 0, & \text{otherwise.}\end{cases} \tag{1}$$

Example 2.2 Suppose that $X=\{u_1,u_2,u_3\}$ be a set of three types of houses and $I=\{i_1,i_2\}$ a set of two parameters, where i_1 is 'price', and i_3 is 'size'. This situation can be described by the following soft set:

$$\mathcal{A}=\left\{\frac{\{u_1,u_3\}}{i_1},\frac{\{u_2\}}{i_2}\right\}.$$

It can also be described more precisely by the following fuzzy soft set:

$$\mathcal{A}=\left\{\frac{\left\{\frac{1}{u_1},\frac{0}{u_2},\frac{1}{u_3}\right\}}{i_1},\frac{\left\{\frac{0.1}{u_1},\frac{0}{u_2},\frac{1}{u_3}\right\}}{i_2}\right\}.$$

Definition 2.3 (cf. [41,42]) For two fuzzy soft sets $\mathcal{A}\in[0,1]^{XI}$ and $\mathcal{B}\in[0,1]^{XJ}$, define the fuzzy soft set $\mathcal{A}\overline{\vee}\mathcal{B}\in([0,1]^X)^{I\times J}$ (called "OR " operation) by $(\mathcal{A}\overline{\vee}\mathcal{B})(i,j)=\mathcal{A}(i)\vee\mathcal{B}(j)$ $(\forall(i,j)\in I\times J)$ (also can be written $(\mathcal{A}\overline{\vee}\mathcal{B})_{(i,j)}=\mathcal{A}_i\vee\mathcal{B}_j$).

Example 2.4 (Continued from Example 2.2). Consider $\{\mathcal{A},\mathcal{B}\}\subseteq[0,1]^{XI}$, defined by

$$\mathcal{A}=\left\{\frac{\left\{\frac{0.5}{u_1},\frac{0.4}{u_2},\frac{0.3}{u_3}\right\}}{i_1},\frac{\left\{\frac{0.7}{u_1},\frac{0.1}{u_2},\frac{0.9}{u_3}\right\}}{i_2}\right\},\ \mathcal{B}=\left\{\frac{\left\{\frac{0.2}{u_1},\frac{0.8}{u_2},\frac{0.7}{u_3}\right\}}{i_1},\frac{\left\{\frac{0.4}{u_1},\frac{0.5}{u_2},\frac{0.1}{u_3}\right\}}{i_2}\right\}.$$

then

$$\mathcal{A}\overline{\vee}\mathcal{B}=\left\{\frac{\left\{\frac{0.5}{u_1},\frac{0.8}{u_2},\frac{0.7}{u_3}\right\}}{(i_1,i_1)},\frac{\left\{\frac{0.5}{u_1},\frac{0.5}{u_2},\frac{0.3}{u_3}\right\}}{(i_1,i_2)}\ \frac{\left\{\frac{0.7}{u_1},\frac{0.8}{u_2},\frac{0.9}{u_3}\right\}}{(i_2,i_1)},\frac{\left\{\frac{0.7}{u_1},\frac{0.5}{u_2},\frac{0.9}{u_3}\right\}}{(i_2,i_2)}\right\}.$$

2.2 Five Symptoms of COVID-19

COVID-19 signs and symptoms may appear between 2 to 14 days after exposure to the virus. The data for our work in this paper is obtained from (Department of Respiratory, Nanjing Chest Hospital, China). We used the five important symptoms [43] (**Shortness of Breath** (**ShB**), **Sore Throat** (**STh**), **Cough**, **Fever**, **Age**). The symptoms of COVID-19 can range from very mild to severe. Some people may never have symptoms. Older people or those with medical conditions, such as diabetes, heart and lung disease, or a weakened immune system, may be more likely to develop severe disease. This is similar to other respiratory diseases, such as influenza. So, we have considered the five symptoms in designing our system.

3 Methodology of Proposed Fuzzy-Soft Expert System

The fuzzy-soft expert system gives diagnostic assistance related to COVID-19 where the final results of the sixty patients will be discussed by specialist doctors. The basic construction of our system has five steps illustrated in Fig. 1. As Fig. 1, these five steps are explained in detail as shown below.

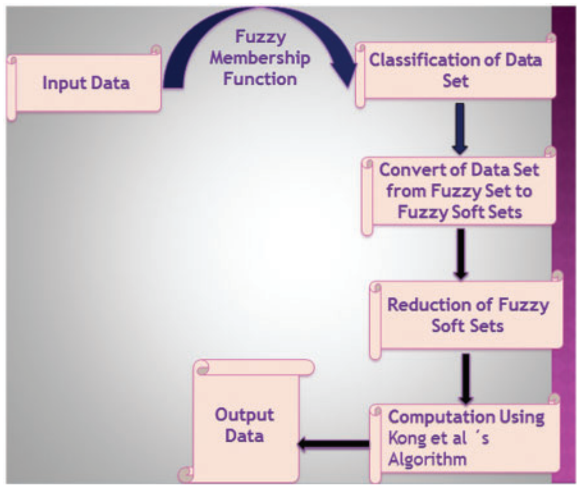

Figure 1: Main construction of fuzzy-soft expert system

3.1 Classification of Data Set

We will explain the classification of data set according to membership functions as follows:

(1) **ShB:** have four membership functions (**Low (L), Medium (M), High (H), Very High (VH)**), where the range of **L** is less than 25, **M** is in between 23 to 49, **H** is in between 37 to 60, and **VH** is greater than 49. Trapezoidal represents '**L**' and ' **VH**', also triangular represents '**M**' and ' **H**'.

(2) **STh:** have four membership functions (**Low (L), Medium (M), High (H), Very High (VH)**), where the range of **L** is less than 35, **M** is in between 35 to 60, **H** is in between 47 to 75, and **VH** is greater than 60. Trapezoidal represents '**L**' and '**VH**', also triangular represents '**M**' and '**H**'.

(3) **Cough:** have four membership functions (**Low (L), Medium (M), High (H), Very High (VH)**), where the range of **L** is less than 14, **M** is in between 11 to 48, **H** is in between 33 to 65, and **VH** is greater than 59. Trapezoidal represents '**L**' and '**VH**', also triangular represents '**M**' and '**H**'.

(4) **Fever:** have four membership functions (**Low (L), Normal (N), Moderate (M), High (H)**), where the range of **L** is less than 36.4, **N** is in between 36.5 to 37.5, **M** is in between 37.6 to 38.3, and **H** is greater than 38.4. Trapezoidal represents '**L**' and '**H**', also triangular represents '**N**' and '**M**'.

(5) **Age:** have four membership functions (**Young (Y), Mild (M), Old (O), Very Old (VO)**) where the range of **Y** is less than 38, **M** is in between 33 to 45, **O** is in between 40 to 58, and **VO** is greater than 52. Trapezoidal represents '**Y**' and '**VO**', also triangular represents '**M**' and '**O**'.

4 Experimental Results and Analysis

In the present work, we will give an exploratory study that includes sixty patients (i.e., forty males and twenty females) with symptoms similar to COVID-19 in (Department of Respiratory, Nanjing

Chest Hospital, China), where forty males: $p_1, p_3, p_4, p_6 - p_{12}, p_{14} - p_{20}, p_{23}, p_{25}, p_{30}, p_{32} - p_{37}, p_{45} - p_{50}, p_{52} - p_{59}$ and twenty females: $p_2, p_5, p_{13}, p_{21}, p_{22}, p_{24}, p_{26} - p_{29}, p_{31}, p_{38} - p_{44}, p_{51}, p_{60}$. The data of sixty patients are illustrated in Table 1.

Table 1: Data of sixty patients

P	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
ShB	39	41	52	45	39	55	60	61	62	50	37	68	37	37	41
STh	48	51	48	53	62	55	57	60	47	51	52	51	47	50	52
Cough	18	41	32	44	49	36	37	28	43	56	51	59	16	20	31
Fever	37.8	38	38.5	37.8	40	38	38.5	37.9	38.6	39	40	38.5	38.2	38.5	37.9
Age	67	41	44	68	70	50	54	67	70	53	62	71	43	60	55
P	p_{16}	p_{17}	p_{18}	p_{19}	p_{20}	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}	p_{27}	p_{28}	p_{29}	p_{30}
ShB	42	45	52	56	51	52	38	40	61	59	42	41	39	38	46
STh	48	47	56	56	52	60	51	48	49	56	52	51	57	46	47
Cough	33	41	42	16	21	22	24	28	29	38	49	41	43	53	52
Fever	38	37.9	37.8	40	39.5	38.2	38.8	40	37.9	39.2	40	39	39	38.8	37.9
Age	45	48	49	60	45	66	55	60	45	64	45	46	57	59	74
P	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}	p_{37}	p_{38}	p_{39}	p_{40}	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}
ShB	42	43	55	53	56	63	62	41	48	50	44	41	45	57	63
STh	47	60	51	48	48	55	52	54	52	51	60	50	49	56	59
Cough	25	30	42	53	51	20	24	26	19	36	35	40	51	50	45
Fever	38.5	38.7	39.1	41	37.7	40	39.4	39.7	37.8	38	38.1	37.8	39	40	39.8
Age	70	47	52	57	58	61	60	39	39	40	44	50	65	44	39
P	p_{46}	p_{47}	p_{48}	p_{49}	p_{50}	p_{51}	p_{52}	p_{53}	p_{54}	p_{55}	p_{56}	p_{57}	p_{58}	p_{59}	p_{60}
ShB	42	45	54	51	52	60	64	42	45	49	45	41	40	56	62
STh	47	62	51	48	48	54	51	53	52	54	64	47	49	52	55
Cough	29	49	42	56	57	19	23	26	36	16	23	39	52	52	15
Fever	40	38.1	38.2	39	38.6	38.5	39.4	40	37.6	37.9	39	40	41	40	39.5
Age	55	46	53	51	52	44	39	47	43	49	56	61	49	62	63

Next, we will get the membership functions of every patient (i.e., forty males and twenty females) are illustrated in Tables 2–5.

Table 2: Membership functions of patients $p_1 - p_{15}$

P	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
ShB															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.8	0.66	0	0.33	0.8	0	0	0	0	0	1	0	1	1	0.66
H	0.16	0.33	0.72	0.66	0.16	0.45	0	0	0	0.9	0	0	0	0	0.33
VH	0	0	0.27	0	0	0.54	1	1	1	0.09	0	1	0	0	0
STh															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.9	0.69	0.9	0.53	0	0.38	0.2	0	1	0.69	0.6	0.69	1	0.76	0.6
H	0.7	0.3	0.07	0.46	0.8	0.61	0.76	1	0	0.3	0.38	0.3	0	0.23	0.38
VH	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0
Cough															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.4	0.35	0.8	0.2	0	0.6	0.6	1	0.25	0	0	0	0.29	0.5	0.85
H	0	0.47	0	0.6	0.94	0.17	0.2	0	0.58	0.6	0.9	0.4	0	0	0
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fever															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	1	0	0	0	1	0	0.75	0	0	0	0	0.33	0	0.75
H	0.12	0	0.62	0.5	1	0	0.62	0	0.125	0.37	1	0.62	0	0.06	0
Age															
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0.57	0.14	0	0	0	0	0	0	0	0	0	0.28	0	0
O	0	0.2	0.5	0	0	0.8	0.4	0	0	0.5	0	0	0.37	0	0.3
VO	1	0	0	1	1	0	0.25	1	1	0.12	1	1	0	1	0.37

Table 3: Membership functions of patients $p_{16} - p_{30}$

P	p_{16}	p_{17}	p_{18}	p_{19}	p_{20}	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}	p_{27}	p_{28}	p_{29}	p_{30}
ShB															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.58	0.33	0	0	0	0	0.9	0.75	0	0	0.58	0.66	0.8	0.9	0.25
H	0.41	0.66	0.72	0.36	0.8	0.72	0.08	0.25	0	0.09	0.41	0.33	0.16	0.08	0.75
VH	0	0	0.27	0.63	0.18	0.27	0	0	1	0.9	0	0	0	0	0
STh															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.9	1	0.3	0.3	0.6	0	0.69	0.9	0.8	0.3	0.6	0.69	0.2	1	1

(Continued)

Table 3 (continued)

P	p_{16}	p_{17}	p_{18}	p_{19}	p_{20}	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}	p_{27}	p_{28}	p_{29}	p_{30}
H	0.07	0	0.69	0.69	0.38	1	0.3	0.07	0.15	0.69	0.36	0.3	0.76	0	0
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cough															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.75	0.35	0.29	0.58	0.64	0.76	1	0.95	0.5	0	0.35	0.25	0	0	0
H	0	0.47	0.5	0	0	0	0	0	0	0.29	0.9	0.47	0.58	0.8	0.86
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fever															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	1	0.75	0.5	0	0	0.33	0	0	0.75	0	0	0	0	0.33	0.75
H	0	0	0	1	0.68	0	0.25	1	0	0.8	1	0.37	0.37	0	0
Age															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O	0.62	1	0.9	0	0.62	0	0.3	0	0.62	0	0.62	0.75	0.1	0	0
VO	0	0	0	1	0	1	0.37	1	0	1	0	0	0.62	0.87	1

Table 4: Membership functions of patients $p_{31} - p_{45}$

P	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}	p_{37}	p_{38}	p_{39}	p_{40}	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}
ShB															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.58	0.5	0	0	0	0	0	0.66	0.08	0	0.41	0.66	0.33	0	0
H	0.41	0.5	0.45	0.6	0.36	0	0	0.33	0.91	0.9	0.58	0.33	0.66	0.27	0
VH	0	0	0.54	0.36	0.63	1	1	0	0	0.09	0	0	0	0.72	1
STh															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	1	0	0.69	0.9	0.9	0.38	0.6	0.46	0.6	0.69	0	0.76	0.8	0.3	0.07
H	0	1	0.3	0.07	0.07	0.61	0.36	0.53	0.36	0.3	1	0.23	0.15	0.69	0.9
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cough															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.82	0.9	0.3	0	0	0.5	0.76	0.88	0.47	0.6	0.65	0.4	0	0	0.15
H	0	0	0.5	0.8	0.9	0	0	0	0	0.17	0.1	0.41	0.9	1	0.7
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fever															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0.25	0	0	0	0.75	1	0.66	0.66	0	0	0
H	0.06	0.18	0.4	1	0	1	0.62	0.81	0	0	0	0	0.37	1	0.87

(Continued)

Table 4 (continued)

P	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}	p_{37}	p_{38}	p_{39}	p_{40}	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}
Age															
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0	0.85	0.85	0.71	0.14	0	0	0.14	0.85
O	0	0.87	0.6	0.1	0	0	0	0	0	0	0.5	0.8	0	0.5	0
VO	0	0	0	0.62	0.75	1	1	0	0	0	0	0	1	0	0

Table 5: Membership functions of patients $p_{46} - p_{60}$

P	p_{46}	p_{47}	p_{48}	p_{49}	p_{50}	p_{51}	p_{52}	p_{53}	p_{54}	p_{55}	p_{56}	p_{57}	p_{58}	p_{59}	p_{60}
ShB															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.58	0.33	0	0	0	0	0	0.58	0.33	0	0.33	0.66	0.75	0	0
H	0.41	0.66	0.54	0.36	0.72	0	0	0.41	0.66	1	0.66	0.33	0.25	0.36	0
VH	0	0	0.45	0.63	0.27	1	1	0	0	0	0	0	0	0.63	1
STh															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	1	0	0.69	0.9	0.9	0.46	0.69	0.53	0.6	0.46	0	1	0.8	0.66	0.38
H	0	0.8	0.3	0.07	0.07	0.53	0.3	0.46	0.36	0.36	0.66	0	0.15	0.36	0.61
VH	0	0.1	0	0	0	0	0	0	0	0	0.3	0	0	0	0
Cough															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0.95	0	0.3	0	0	0.47	0.7	0.88	0.6	0.29	0.7	0.45	0	0	0.23
H	0	0.9	0.5	0.6	0.53	0	0	0	0.17	0	0	0.35	0.86	0.86	0
VH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fever															
L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0.66	0.33	0	0	0	0	0	0.75	0.5	0	0	0	0	0
H	1	0	0	0.37	0.12	0.06	0.62	1	0	0	0.12	1	1	1	0.68
Age															
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0.14	0.85	0	0.28	0	0	0	0	0	0
O	0.3	0.75	0.5	0.7	0.6	0.5	0	0.87	0.37	0.9	0.2	0	0.9	0	0
VO	0.37	0	0.13	0	0	0	0	0	0	0	0.5	1	0	1	1

4.1 Convert of Data Set and Reduction of Data Set

(1) Assume that $\mathcal{P} = \mathcal{P}_m \cup \mathcal{P}_f$, where $\mathcal{P}_m = \{p_1, p_3, p_4, p_6 - p_{12}, p_{14} - p_{20}, p_{23}, p_{25}, p_{30}, p_{32} - p_{37}, p_{45} - p_{50}, p_{52} - p_{59}\}$ represents the forty patients from males, $\mathcal{P}_f = \{p_2, p_5, p_{13}, p_{21}, p_{22}, p_{24}, p_{26} - p_{29}, p_{31}, p_{38} - p_{44}, p_{51}, p_{60}\}$ represents the twenty patients from females, and $\hat{\mathcal{I}}$ be the set consisting of 20 parameters as $\{$**ShB**(L), **ShB**(M), **ShB**(H), **ShB**(VH), **STh**(L), **STh**(M), **STh**(H), **STh**(VH), **Cough**(L), **Cough**(M),

Cough(H), **Cough**(VH), **Fever**(L), **Fever**(N), **Fever**(M), **Fever**(H), **Age**(Y), **Age**(M), **Age**(O), **Age**(VO)}. Further, assume that $\hat{\mathcal{A}}, \hat{\mathcal{B}}, \hat{\mathcal{C}}, \hat{\mathcal{D}}, \hat{\mathcal{E}} \subseteq \hat{\mathcal{I}}$ (i.e., have five fuzzy soft sets: $\mathcal{L}_{\hat{\mathcal{A}}}, \mathcal{M}_{\hat{\mathcal{B}}}, \mathcal{N}_{\hat{\mathcal{C}}}, \mathcal{Q}_{\hat{\mathcal{D}}}, \mathcal{R}_{\hat{\mathcal{E}}}$), where
$\hat{\mathcal{A}} = \{\mathbf{ShB}(L), \mathbf{ShB}(M), \mathbf{ShB}(H), \mathbf{ShB}(VH)\}$, $\hat{\mathcal{B}} = \{\mathbf{STh}(L), \mathbf{STh}(M), \mathbf{STh}(H), \mathbf{STh}(VH)\}$, $\hat{\mathcal{C}} = \{\mathbf{Cough}(L), \mathbf{Cough}(M), \mathbf{Cough}(H), \mathbf{Cough}(VH)\}$, $\hat{\mathcal{D}} = \{\mathbf{Fever}(L), \mathbf{Fever}(N), \mathbf{Fever}(M), \mathbf{Fever}(H)\}$, $\hat{\mathcal{E}} = \{\mathbf{Age}(Y), \mathbf{Age}(M), \mathbf{Age}(O), \mathbf{Age}(VO)\}$.

(2) Reduce the following parameters: {**ShB**(L), **ShB**(M), **ShB**(H), **ShB**(VH), **STh**(L), **STh**(M), **STh**(H), **STh**(VH), **Cough**(L), **Cough**(M), **Cough**(H), **Cough**(VH), **Fever**(L), **Fever**(N), **Fever**(M), **Fever**(H), **Age**(Y), **Age**(M), **Age**(O), **Age**(VO)} to {**ShB**(M), **ShB**(H), **ShB**(VH), **STh**(M), **STh**(H), .**STh**(VH), **Cough**(M), **Cough**(H), **Fever**(M), **Fever**(H), **Age**(M), **Age**(O), **Age**(VO)} according to the normal soft parameter reduction of fuzzy soft sets [44]. Therefore, we get on the five new fuzzy soft sets: $\mathcal{U}_{\hat{\mathcal{F}}}$, $\mathcal{V}_{\hat{\mathcal{G}}}$, $\mathcal{W}_{\hat{\mathcal{H}}}$, $\mathcal{X}_{\hat{\mathcal{J}}}$, and $\mathcal{Y}_{\hat{\mathcal{K}}}$, where

$\hat{\mathcal{F}}=\{\mathbf{ShB}(M), \mathbf{ShB}(H), \mathbf{ShB}(VH)\}$, $\hat{\mathcal{G}}=\{\mathbf{STh}(M), \mathbf{STh}(H), \mathbf{STh}(VH)\}$, $\hat{\mathcal{H}}=\{\mathbf{Cough}(M), \mathbf{Cough}(H)\}$,

$\hat{\mathcal{J}}=\{\mathbf{Fever}(M), \mathbf{Fever}(H)\}$, $\hat{\mathcal{K}}=\{\mathbf{Age}(M), \mathbf{Age}(O), \mathbf{Age}(VO)\}$.

4.2 Prediction Method for COVID-19

Through Kong et al.'s method [45] (i.e., as prediction method of COVID-19), we can predict which patient (forty male and twenty female) will suffer from COVID-19 as follows:

The first step: Input the following five new fuzzy soft sets (i.e., $\mathcal{U}_{\hat{\mathcal{F}}}$, $\mathcal{V}_{\hat{\mathcal{G}}}$, $\mathcal{W}_{\hat{\mathcal{H}}}$, $\mathcal{X}_{\hat{\mathcal{J}}}$, $\mathcal{Y}_{\hat{\mathcal{K}}}$).

The second step: Calculate the fuzzy soft set $\mathcal{T}_{\hat{\mathcal{P}}}$, for example, if we take "$\mathcal{U}_{\hat{\mathcal{F}}}$ OR $\mathcal{V}_{\hat{\mathcal{G}}}$" (i.e., $\mathcal{Z}_{\hat{\mathcal{O}}} = \mathcal{U}_{\hat{\mathcal{F}}} \underline{\vee} \mathcal{V}_{\hat{\mathcal{G}}}$, $\hat{\mathcal{O}} = \hat{\mathcal{F}} \times \hat{\mathcal{G}}$) (see Table 6), then we get on 9-element set of the form $\hat{\vartheta}_{ij}$, where $\hat{\vartheta}_{ij} = \pi_i \underline{\vee} \tau_j$, $(\forall\ i = j = 1,2,3)$ (i.e., $\hat{\vartheta}_{11} = \pi_1 \underline{\vee} \tau_1, \hat{\vartheta}_{12} = \pi_1 \underline{\vee} \tau_2, \hat{\vartheta}_{13} = \pi_1 \underline{\vee} \tau_3, \hat{\vartheta}_{21} = \pi_2 \underline{\vee} \tau_1, \hat{\vartheta}_{22} = \pi_2 \underline{\vee} \tau_2, \hat{\vartheta}_{23} = \pi_2 \underline{\vee} \tau_3, \hat{\vartheta}_{31} = \pi_3 \underline{\vee} \tau_1, \hat{\vartheta}_{32} = \pi_3 \underline{\vee} \tau_2, \hat{\vartheta}_{33} = \pi_3 \underline{\vee} \tau_3$) (where $\hat{\mathcal{O}} = \{\hat{\vartheta}_{11}, \hat{\vartheta}_{12}, \hat{\vartheta}_{13}, \hat{\vartheta}_{21}, \hat{\vartheta}_{22}, \hat{\vartheta}_{23}, \hat{\vartheta}_{31}, \hat{\vartheta}_{32}, \hat{\vartheta}_{33}\}$). Similarly, we can get on fuzzy soft sets $\mathcal{Z}_{\hat{\mathcal{O}}}$, $\mathcal{W}_{\hat{\mathcal{H}}}$, $\mathcal{X}_{\hat{\mathcal{J}}}$, and $\mathcal{Y}_{\hat{\mathcal{K}}}$ (i.e., $\mathcal{T}_{\hat{\mathcal{P}}} = \mathcal{Z}_{\hat{\mathcal{O}}} \underline{\vee} \mathcal{W}_{\hat{\mathcal{H}}} \underline{\vee} \mathcal{X}_{\hat{\mathcal{J}}} \underline{\vee} \mathcal{Y}_{\hat{\mathcal{K}}}$, $\hat{\mathcal{P}} = \hat{\mathcal{O}} \times \hat{\mathcal{H}} \times \hat{\mathcal{J}} \times \hat{\mathcal{K}}$). Then we can get on the 108-element set, where $\hat{\mathcal{P}} = \hat{\mathcal{O}} \times \hat{\mathcal{H}} \times \hat{\mathcal{J}} \times \hat{\mathcal{K}} = \{\zeta_1, \zeta_2, \zeta_3, \cdots, \zeta_{108}\}$.

The third step: Compute s_i, $(i = 1,2,3,...,60)$. by Kong et al.'s algorithm [45] as follows: $s_1 = -122.69$, $s_2 = 124.81$, $s_3 = -28.5$, $s_4 = -19.8$, $s_5 = 102.3$, $s_6 = 100.7$, $s_7 = 106.2$, $s_8 = -11.2$, $s_9 = 111.8$, $s_{10} = 123.2$, $s_{11} = 123.8$, $s_{12} = 125.3$, $s_{13} = -25$, $s_{14} = 132.4$, $s_{15} = -15.7$, $s_{16} = -24.8$, $s_{17} = -13.5$, $s_{18} = -22.5$, $s_{19} = 112.3$, $s_{20} = 110.2$, $s_{21} = -16.7$, $s_{22} = -14.9$, $s_{23} = 104.4$, $s_{24} = 125.8$, $s_{25} = 112.7$, $s_{26} = -50.3$, $s_{27} = 115.3$, $s_{28} = 107.4$, $s_{29} = 109.3$, $s_{30} = -31.2$, $s_{31} = 133.4$, $s_{32} = -21.2$, $s_{33} = 101.4$, $s_{34} = 125.8$, $s_{35} = -66.2$, $s_{36} = 123.7$, $s_{37} = 115.3$, $s_{38} = 113.2$, $s_{39} = -15.4$, $s_{40} = -30.4$, $s_{41} = -45.3$, $s_{42} = -61.2$, $s_{43} = 106.6$, $s_{44} = 123.9$, $s_{45} = -70.3$, $s_{46} = 105.3$, $s_{47} = -31.3$, $s_{48} = -36.5$, $s_{49} = 120.8$, $s_{50} = 119.5$, $s_{51} = -75.5$, $s_{52} = -46.8$, $s_{53} = 135.9$, $s_{54} = -44.6$, $s_{55} = -20.2$, $s_{56} = 126.8$, $s_{57} = 130.5$, $s_{58} = 133.2$, $s_{59} = 129.7$, and $s_{60} = 127.2$.

Table 6: $\mathcal{U}_{\hat{\mathcal{F}}}$ or $\mathcal{V}_{\hat{\mathcal{G}}}$

P	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
$\hat{\vartheta}_{11}$	0.9	0.69	0.9	0.53	0	0.38	0.2	0	1	0.69	1	0.69	1	1	0.66
$\hat{\vartheta}_{12}$	0.8	0.66	0.07	0.46	0.8	0.61	0.76	1	0	0.3	1	0.3	1	1	0.66
$\hat{\vartheta}_{13}$	0.8	0.66	0	0.33	0.8	0	0	0	0	0	1	0	1	1	0.66
$\hat{\vartheta}_{21}$	0.9	0.69	0.72	0.66	0.16	0.45	0.2	0	1	0.9	0.6	0.69	1	0.76	0.76
$\hat{\vartheta}_{22}$	0.7	0.33	0.72	0.66	0.8	0.61	0.76	1	0	0.9	0.38	0.3	0	0.23	0.38
$\hat{\vartheta}_{23}$	0.16	0.33	0.72	0.66	0.16	0.45	0	0	0	0.9	0	0	0	0	0.33
$\hat{\vartheta}_{31}$	0.9	0.69	0.9	0.53	0	0.54	1	1	1	0.69	0.6	1	1	0.76	0.6
$\hat{\vartheta}_{32}$	0.7	0.3	0.27	0.46	0.8	0.61	1	1	1	0.3	0.38	1	0	0.23	0.38
$\hat{\vartheta}_{33}$	0	0	0.27	0.1	0	0.54	1	1	1	0.09	0	1	0	0	0

P	p_{16}	p_{17}	p_{18}	p_{19}	p_{20}	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}	p_{27}	p_{28}	p_{29}	p_{30}
$\hat{\vartheta}_{11}$	0.58	0.33	0	0	0	0	0.9	0.75	0	0	0.58	0.69	0.8	0.9	0.25
$\hat{\vartheta}_{12}$	0.9	1	0.3	0.3	0.6	0	0.9	0.9	0.8	0.3	0.6	0.69	0.8	1	1
$\hat{\vartheta}_{13}$	0.58	0.33	0	0	0	0	0	0.9	0.75	0	0	0.58	0.66	0.8	0.9
$\hat{\vartheta}_{21}$	0.9	1	0.72	0.36	0.8	0.72	0.69	0.9	0.8	0.3	0.6	0.69	0.2	1	1
$\hat{\vartheta}_{22}$	0.41	0.66	0.72	0.69	0.8	0.75	0.3	0.25	0.15	0.69	0.41	0.33	0.76	0.08	0.75
$\hat{\vartheta}_{23}$	0.41	0.66	0.72	0.36	0.8	0.72	0.08	0.25	0	0.09	0.41	0.33	0.16	0.08	0.75
$\hat{\vartheta}_{31}$	0.9	1	0.3	0.63	0.6	0.27	0.69	0.9	1	0.9	0.6	0.69	0.2	1	1
$\hat{\vartheta}_{32}$	0	1	0.54	0.36	0.63	1	1	0.53	0.36	0.3	1	0.23	0.15	0.72	1
$\hat{\vartheta}_{33}$	0	0	0.27	0.63	0.18	0.27	0	0	1	0.9	0	0	0	0	0

P	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}	p_{37}	p_{38}	p_{39}	p_{40}	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}
$\hat{\vartheta}_{11}$	1	0.5	0.69	0.9	0.9	0.38	0.6	0.66	0.6	0.69	0.4	0.76	0.8	0.3	0.07
$\hat{\vartheta}_{12}$	0.58	1	0.3	0.07	0.07	0.61	0.36	0.66	0.36	0.3	1	0.66	0.33	0.69	0.9
$\hat{\vartheta}_{13}$	0.58	0.5	0	0	0	0	0	0.66	0.08	0	0.41	0.66	0.33	0	0
$\hat{\vartheta}_{21}$	1	0.5	0.69	0.9	0.9	0.38	0.6	0.46	0.91	0.9	0.58	0.76	0.8	0.3	0.07
$\hat{\vartheta}_{22}$	0.41	1	0.45	0.6	0.36	0.61	0.36	0.53	0.91	0.9	1	0.33	0.66	0.69	0.9
$\hat{\vartheta}_{23}$	0.41	0.5	0.45	0.6	0.36	0	0	0.33	0.91	0.9	0.58	0.33	0.66	0.27	0
$\hat{\vartheta}_{31}$	1	0	0.69	0.9	0.9	1	1	0.46	0.6	0.69	0	0.76	0.8	0.3	0.07
$\hat{\vartheta}_{32}$	0	1	0.54	0.36	0.63	1	1	0.53	0.36	0.3	1	0.23	0.15	0.72	1
$\hat{\vartheta}_{33}$	0	0	0.54	0.36	0.63	1	1	0	0	0.09	0	0	0	0.72	1

P	p_{46}	p_{47}	p_{48}	p_{49}	p_{50}	p_{51}	p_{52}	p_{53}	p_{54}	p_{55}	p_{56}	p_{57}	p_{58}	p_{59}	p_{60}
$\hat{\vartheta}_{11}$	1	0.33	0.69	0.9	0.9	0.46	0.69	0.58	0.6	0.46	0.33	1	0.8	0.6	0.38
$\hat{\vartheta}_{12}$	0.58	0.8	0.3	0.07	0.07	0.53	0.3	0.58	0.36	0.36	0.66	0.66	0.75	0.36	0.61
$\hat{\vartheta}_{13}$	0.58	0.33	0	0	0	0	0	0.58	0.33	0	0.33	0.66	0.75	0	0
$\hat{\vartheta}_{21}$	1	0.66	0.69	0.9	0.9	0.46	0.69	0.53	0.66	1	0.66	1	0.8	0.6	0.38
$\hat{\vartheta}_{22}$	0.41	0.8	0.54	0.36	0.72	0.53	0.3	0.46	0.66	1	0.66	0.33	0.25	0.36	0.61
$\hat{\vartheta}_{23}$	0.41	0.5	0.45	0.6	0.36	0	0	0.33	0.91	0.9	0.58	0.33	0.66	0.27	0

(Continued)

Table 6 (continued)

P	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}
$\hat{\vartheta}_{31}$	1	0	0.69	0.9	0.9	1	1	0	0.6	0.46	0	1	0.8	0.63	1
$\hat{\vartheta}_{32}$	0	0.8	0.45	0.63	0.27	1	1	0.64	0.36	0.36	0.66	0	0.15	0.63	1
$\hat{\vartheta}_{33}$	0	0.16	0.45	0.63	0.27	1	1	0	0	0	0.3	0	0	0.63	0

The fourth step: From the third step we can conclude that thirty four patients $p_2, p_5 - p_7$, $p_9 - p_{12}, p_{14}, p_{19}, p_{20}, p_{23} - p_{25}, p_{27} - p_{29}, p_{31}, p_{33}, p_{34}, p_{36} - p_{38}, p_{43}, p_{44}, p_{46}, p_{49}, p_{50}, p_{53}$, and $p_{56} - p_{60}$ have high values of s_i. Therefore, these patients potentially suffer from COVID-19. All values of s_i $(i = 1, 2, 3, \ldots, 60)$ and its relationship to sixty patients $(p_1 - p_{60})$ are shown in Fig. 2 and the diagnosis results are illustrated in Table 7.

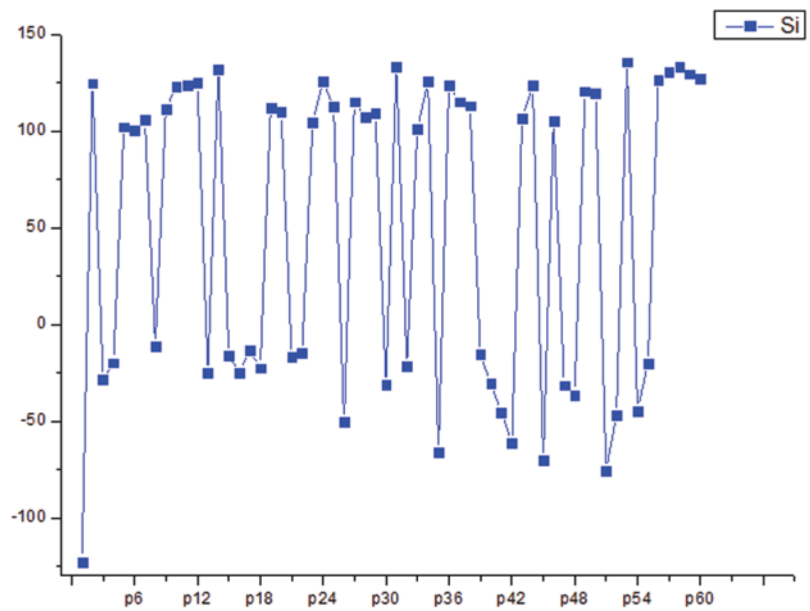

Figure 2: The relationship between $p_1 - p_{60}$ and s_i

Table 7: Diagnosis results from expert physician

P	ShB	STh	Cough	Fever	Age	Diagnosis
p_1	39	48	18	37.8	67	No virus
p_2	41	51	41	38	41	Coronavirus
p_3	52	48	32	38.5	44	No virus
p_4	45	53	44	37.8	68	No virus
p_5	39	62	49	40	70	Coronavirus
p_6	55	55	36	38	50	Coronavirus

(Continued)

Table 7 (continued)

P	**ShB**	**STh**	**Cough**	**Fever**	**Age**	Diagnosis
p_7	60	57	37	38.5	54	Coronavirus
p_8	61	60	28	37.9	67	No virus
p_9	62	47	43	38.6	70	Coronavirus
p_{10}	50	51	56	39	53	Coronavirus
p_{11}	37	52	51	40	62	Coronavirus
p_{12}	68	51	59	38.5	71	Coronavirus
p_{13}	37	47	16	38.2	43	No virus
p_{14}	37	50	20	38.5	60	Coronavirus
p_{15}	41	52	31	37.9	55	No virus
p_{16}	42	48	33	38	45	No virus
p_{17}	45	47	41	37.9	48	No virus
p_{18}	52	56	42	37.8	49	No virus
p_{19}	56	56	16	40	60	Coronavirus
p_{20}	51	52	21	39.5	45	Coronavirus
p_{21}	52	60	22	38.2	66	No virus
p_{22}	38	51	24	38.8	55	No virus
p_{23}	40	48	28	40	60	Coronavirus
p_{24}	61	56	38	39.2	64	Coronavirus
p_{25}	59	52	49	40	45	Coronavirus
p_{26}	42	51	41	39	46	No virus
p_{27}	41	57	43	39	57	Coronavirus
p_{28}	39	46	53	38.8	59	Coronavirus
p_{29}	38	47	52	37.9	74	Coronavirus
p_{30}	46	48	18	37.9	55	No virus
p_{31}	42	47	25	38.5	70	Coronavirus
p_{32}	43	60	30	38.7	47	No virus
p_{33}	55	51	42	39.1	52	Coronavirus
p_{34}	53	48	53	41	57	Coronavirus
p_{35}	56	48	51	37.7	58	No virus
p_{36}	63	55	20	40	61	Coronavirus
p_{37}	62	52	24	39.4	60	Coronavirus
p_{38}	41	54	26	39.7	39	Coronavirus
p_{39}	48	52	19	37.8	39	No virus
p_{40}	50	51	36	38	40	No virus
p_{41}	44	60	35	38.1	44	No virus
p_{42}	41	50	40	37.8	50	No virus
p_{43}	45	49	51	39	65	Coronavirus
p_{44}	57	56	50	40	44	Coronavirus
p_{45}	63	59	45	39.8	39	No virus
p_{46}	42	47	29	40	55	Coronavirus
p_{47}	45	62	49	38.1	46	No virus

(Continued)

Table 7 (continued)

P	ShB	STh	Cough	Fever	Age	Diagnosis
p_{48}	54	51	42	38.2	53	No virus
p_{49}	51	48	56	39	51	Coronavirus
p_{50}	52	48	57	38.6	52	Coronavirus
p_{51}	60	54	19	38.5	44	No virus
p_{52}	64	51	23	39.4	39	No virus
p_{53}	42	53	26	40	47	Coronavirus
p_{54}	45	52	36	37.6	43	No virus
p_{55}	49	54	16	37.9	49	No virus
p_{56}	45	64	23	39	56	Coronavirus
p_{57}	41	47	39	40	61	Coronavirus
p_{58}	40	49	52	41	49	Coronavirus
p_{59}	56	52	52	40	62	Coronavirus
p_{60}	62	55	15	39.5	63	Coronavirus

5 Comparison Among the Fuzzy-Soft Expert System and the Fuzzy Expert System

5.1 Fuzzy Expert System

A fuzzy expert system is one of the known systems used for medical diagnosis. The main structure of the fuzzy expert system is illustrated in Fig. 3.

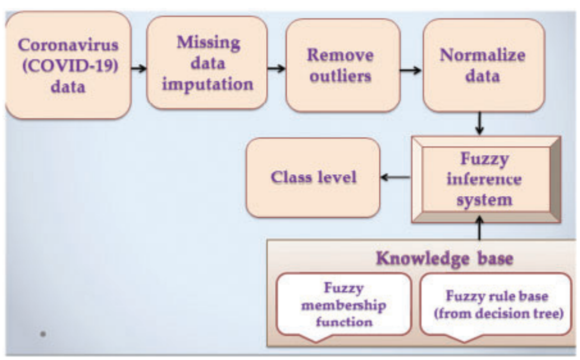

Figure 3: Main structure of the fuzzy expert system

The basic rules of COVID-19 data are inside the fuzzy expert system, though there are several insufficiencies in the above fuzzy expert system of COVID-19. Therefore,

(1) The fuzzy expert system depends on fuzzy rules (i.e., the input data of **ShB** have 4 membership functions (**L, M, H, VH**), the input data of **STh** have 4 membership functions (**L, M, H, VH**), the input data of **Cough** have 4 membership functions (**L, M, H, VH**), the input data of **Fever** have 4 membership functions (**L, N, M, H**), and the input data of **Age** have 4 membership functions (**Y, M, O, VO**)) which mean $4 \times 4 \times 4 \times 4 \times 4 = 1024$ fuzzy rules; so the diagnosis results by a fuzzy expert system of COVID-19 according to several groups of fuzzy rules are contrary. For example,

(i) If the patient (*p*) has **ShB (H)** and **STh (VH)** and **Cough (H)** and **Fever (H)** and **Age (O)**, then *p* have Coronavirus (COVID-19).

(ii) If the same patient (*p*) has **ShB (M)** and **STh (M)** and **Cough (L)** and **Fever (N)** and **Age (Y)**, then *p* don't have Coronavirus (COVID-19).

(2) The diagnosis results by a fuzzy expert system of COVID-19 are contrary to that of an expert physician.

If we apply a fuzzy expert system (according to 1024 fuzzy rules) by using the data from Table 1, then we can note that all the patients have Coronavirus (COVID-19).

According to the above discussion, our proposed system's diagnosis results (which is the same as the diagnosis results from expert physicians) are better than the diagnosis results from the fuzzy expert system. Therefore, our proposed system (which depends on the approach by Kong et al. [45] for the prediction of COVID-19) is evidence to present a remarkable improvement in the fuzzy expert system.

6 Conclusions

In this work, the fuzzy-soft expert system is better than the fuzzy expert system for the accuracy of diagnosis results. This method of our work is simple because it does not depend on programming software, as well as, unconventional medical analysis methods where the patient suffers from fatigue and the diagnosis appears after a long period of time. This proposed fuzzy-soft expert system will assist physicians and senior researchers who are interested in this emerging virus (COVID-19) in the rapid prediction of this virus diagnosis. Further, there is a study presented that some medical tests such as PCR to detect COVID-19 give inaccurate results [43,46]. In contrast, it is possible to use our system for accuracy and ease of implementation. In cooperation with the computer sciences department, the subsequent work will be the establishment of a program in hospitals, centers of diseases, and also at airports to limit the rapid spread of COVID-19 using this system.

Acknowledgement: The authors wish to express their appreciation to the reviewers for their helpful suggestions which greatly improved the presentation of this paper.

Funding Statement: The authors received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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