Knowledge-Based Smart System for the Identification of Coronavirus (COVID-19): Battling the Pandemic with Scientific Perspectives

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Abstract
The acute respiratory infection known as a coronavirus (COVID-19) may present with a wide range of clinical manifestations, ranging from no symptoms at all to severe pneumonia and even death. Expert medical systems, particularly those used in the diagnostic and monitoring phases of treatment, have the potential to provide beneficial results in the fight against COVID-19. The significance of healthcare mobile technologies, as well as the advantages they provide, are quickly growing, particularly when such applications are linked to the internet of things. This research work presents a knowledge-based smart system for the primary diagnosis of COVID-19. The system uses symptoms that manifest in the patient to make an educated guess about the severity of the COVID-19 infection. The proposed inference system can assist individuals in self-diagnosing their conditions and can also assist medical professionals in identifying the ailment. The system is designed to be user-friendly and easy to use, with the goal of increasing the speed and accuracy of COVID-19 diagnosis. With the current global pandemic, early identification of COVID-19 is essential to regulate and break the cycle of transmission of the disease. The results of this research demonstrate the feasibility and effectiveness of using a knowledge-based smart system for COVID-19 diagnosis, and the system has the potential to improve the overall response to the COVID-19 pandemic. In conclusion, these sorts of knowledge-based smart technologies have the potential to be useful in preventing the deaths caused by the COVID-19 pandemic.

Keywords:
Coronavirus; COVID-19; Knowledge based; pandemic; Diagnosis; Fuzzy system

1. Introduction

The severe acute respiratory syndrome coronavirus 2 (SARSCoV-2) is the new coronavirus responsible for COVID-19 [1]. This new virus originally arose in December 2019 in Wuhan, China, and has since spread over the entire planet in a relatively short length of time. The World Health Organization (WHO) declared the illness a global epidemic on March 11, 2020, due to serious worries about increasing rates of disease transmission and severity, as well as alarming rates of inertia. World Health Organization (WHO) estimates place the total number of confirmed cases at over 241 million, with 4.9 million fatalities. According to the World Health Organization (WHO), the most common COVID-19 symptoms reported in confirmed cases are fever, dry cough, and exhaustion. Other prominent COVID-19 symptoms include confusion, chest pain or pressure, difficulty breathing, or shortness of breath. Other COVID-19 symptoms include weakness of taste, runny nose, conjunctivitis, sore throat, headache, muscle pain, various types of skin rash, nausea, and more. Age, chronic illness, the immune system, and genetics have all been proven to affect the severity of symptoms and the likelihood of recovery from the disease [2, 3]. The several features and conditions of COVID-19 are explored in the systematic reviews, comprehensive reviews, and meta-analysis articles [4-9]. Recently, many unique COVID-19 variants have been found in the UK, South Africa, India, and Brazil. Research to date [10, 11] shows that these changes make the virus more contagious. COVID-19 strains originating from the United Kingdom, South Africa, India, and Brazil have all been confirmed to harbor these mutations. According to [12], the Delta mutation was first identified in India and has since spread to the vast majority of countries around the world. New COVID-19 mutations and variants are being discovered all the time, therefore studies on the numerous forms of this virus are far from complete.

The intensity of the symptoms associated with COVID-19 can range from being extremely minor to being severe. Some people could only experience a few symptoms, while others might be completely symptom-free, a condition known as being asymptomatic. There is a possibility that some individuals will experience a

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worsening of their symptoms, including a worsening of their shortness of breath and pneumonia. It may be difficult to differentiate between COVID-19 and the flu based on verbal, ambiguous, or intuitive responses because some of the symptoms of both conditions are comparable. On the other hand, an increased risk of serious illness caused by COVID-19 is associated with advanced age, and this risk rises with increasing age. . People who already have one or more medical disorders may be at a greater risk of developing a serious illness. The signs and symptoms of COVID-19 infection were investigated in [13], which included 46,248 individuals. 17% of infected individuals had hypertension, 8% had diabetes, 5% had cardiovascular disease, and 2% had respiratory disease. All of these chronic conditions were commonly related with one another. There were 76,993 patients infected with COVID-19, and out of those, 16.37% had hypertension, 12.11% had cardiovascular disease, 7.63% had a history of smoking, and 7.82% had diabetes, according to research published in [14]. The spread of an infection can be slowed or stopped if people with mild or no symptoms would just get medical help. At the same time, it is vital to take steps such as rapid detection, isolation, and contact tracing of community COVID-19 patients in order to limit the spread of COVID-19 within the community [15].

It might be difficult to represent and accurately evaluate medical sector concepts due to their inherent abstractness. Moreover, medical diagnosis is challenging since symptoms can be convoluted, and it's tough to make sense of and work with linkages that are indirect or unknown [16]. The inability to accurately detect illnesses is a direct result of this. Computer-linked approaches based on human cognitive are being used in the medical diagnostic procedure nowadays. These systems are built to not only establish a identification based on indications, but also to provide treatments based on what they learn from the symptoms. Most of these structures are founded on tenets of artificial intelligence. In order to model the uncertainty present in the healthcare industry, fuzzy modeling has been identified as a suitable approach [17]. For a citation, see [Citation needed] The medical diagnostic decision is therefore best modeled and supported by the fuzzy approach. However, this method's findings will help you become more knowledgeable, improve your ability to synthesize information and choose the best course of action. Thus, research on alternative intelligent methods that provide rapid answers concerning COVID-19 symptoms is critically important for facilitating early detection of infection.

Several research are summarized here that examine the intersection of the medical profession with the fuzzy approach. The current stage of chronic kidney disease can be evaluated with the use of a fuzzy rule-based expert system, as suggested in reference document [18]. With the goal of improving the quality and accuracy of medical diagnoses, [19] investigates the possibility of creating a diagnostic system based on fuzzy logic. Improving patients' care was the driving force behind the shift. In this study [20], the authors provide an unique Hybrid Diagnosis Strategy (HDS) for COVID-19 diagnosis, which is made up of two separate classifiers: a fuzzy inference engine and a Deep Neural Network (DNN). In the publication [21], it is recommended that COVID-19 be initially diagnosed with the help of a clever fuzzy inference system. This method determines the possibility that a patient has contracted COVID-19. The central rule for automatically detecting COVID-19 from chest X-ray pictures is described in [22] as an adaptive neuro-fuzzy inference system (ANFIS). Texture analysis features form the basis of this heuristic. Similar to the present work, another similar study [23] presents a fuzzy rule-based inference system designed to aid in medical diagnosis, reduce healthcare expenses, and maximize available resources. The actual information used to build this system was hand-picked by professionals in the medical sector. The article [24] uses fuzzy and neuro-fuzzy analysis techniques to create a smart medical diagnostic system for detecting kidney cancer. Fuzzy expert systems have seen rapid growth in the healthcare industry over the past two decades; this review of their progress and future applications in this sector can be found in [25]. These papers cite articles from a whopping 173 periodicals. In this work [26], we explore the use of fuzzy inference methods to enhance the quality of daily clinical care for patients with type-2 diabetes at the Anti-Diabetes Centre (CAD), which is part of the Local Health Authority ASL Naples 1. With the goal of reducing the spread of COVID-19 and improving demand management in the healthcare supply chain, Govindan et al. [27] created a physician-led, physician-informed, fuzzy inference system-based decision support system (FIS). This decision-making aid was developed specifically for use in deconstructing the COVID-19. Mangla et al. [28], using the Mamdani-based fuzzy expert system, discuss the three main types of factors that affect the COVID-19 mortality rate: risk factors, clinical factors, and other elements. Risk factors, clinical variables, and other considerations are all included here. In a previous study [29], a clinical decision support system in the form of a fuzzy expert system is developed for the purpose of detecting and prognosticating chronic renal illness.

As of this writing, numerous studies and inquiries are being undertaken on a wide variety of topics thought to be related to COVID-19. The number of confirmed cases of COVID-19 expected to be documented in China during the next ten days is predicted by a model developed by Al-Qaness et al. [30] using data from ANFIS. According to this hypothesis, there have been proven cases recorded in China in the past. Boucenna et al. [31] used fuzzy logic to investigate the spread of COVID-19 and the most likely people to be affected by it. Chowdhury et al. [32], using the fuzzy inference approach, analyzed the significance of several different environmental factors in the spread of

COVID-19. To help with the COVID-19 anti-epidemic standardization, Fu and Liang [33] employed fuzzy logic to undertake a study of common household medical supplies. Assessing a patient's present health and prognosis in order to determine the likelihood of death, Gemmar [34] examined and contrasted many alternative and sophisticated modeling approaches with models that had previously been suggested in the medical literature. Painuli et al. [35] attempted to provide a system that is built on fuzzy rules and may make predictions regarding whether or not an individual is experiencing symptoms of COVID-19. Fuzzy logic and a deep neural network were combined in a new Hybrid Diagnosis Strategy (HDS) reported by Shaban et al. [20] to detect COVID-19 patients. Foreseeing COVID-19 time series, Castillo and Melin [36] suggest a hybrid intelligent technique that combines fractal theory and fuzzy logic. The purpose of this method is to enhance precision. Ardabili et al. [37] evaluated the MLP and ANFIS models to predict the COVID-19 pandemic, while Sharma et al. [38] proposed a mediative fuzzy correlation mathematical technique that demonstrates a connection between the increase in patients testing positive for the virus and its spread over time.

In this article, we will use a knowledge-based smart system to calculate an individual's probability of contracting Coronavirus (COVID-19) and to quantify the symptoms of infection. The following is the structure of the paper: The approach and fuzzy logic inference system are broken down and explained in Section 2. The findings are provided in Section 3 of the report. In the fourth and last section, conclusions and prospects are discussed.

2. Methodology

In modern times, the fuzzy inference system, also known as FIS, has developed into a powerful tool for dealing with issues involving uncertainty and imprecision. This is made possible by Zadeh's fuzzy set theory, which has been successfully implemented [39]. As a direct consequence of this, the use of FIS makes it feasible to model the knowledge of a seasoned medical professional. The knowledge base of the system is critically important to the successful operation of the system, which is even more reliant on the system's rule base than it is on its database. One of the processes that go into fine-tuning the fuzzy inference system is determining the optimal distribution of the membership functions that are saved in the database.

When it comes to building a FIS, the phase that requires the most effort and the longest amount of time is the one in which you are tasked with the task of gathering new information. Because the knowledge of experts can provide solutions to a variety of problems involving uncertainty and imprecision in their particular domain, it is extremely important to communicate the knowledge of experts from a variety of domains in order to ensure that fuzzy inference systems are able to function successfully across a wide range of contexts. This is due to the fact that the knowledge of experts can solve various problems involving uncertainty and imprecision in the particular domain in which they specialize. This body of work develops a fuzzy inference system that uses a wide range of knowledge base rules from numerous experts to make an early diagnosis of COVID-19.

3. Designing of fuzzy inference system

The first phase is the collecting of data regarding COVID-19 disease, and for the design of the fuzzy inference system, data are selected based on their ability to determine COVID-19 sickness and its level of risk. Primarily, the data regarding COVID-19 disease consists of the symptoms and medical test results of patients. For early detection of COVID-19 infections, the most prevalent physical symptoms and blood test results are required, according to a study.

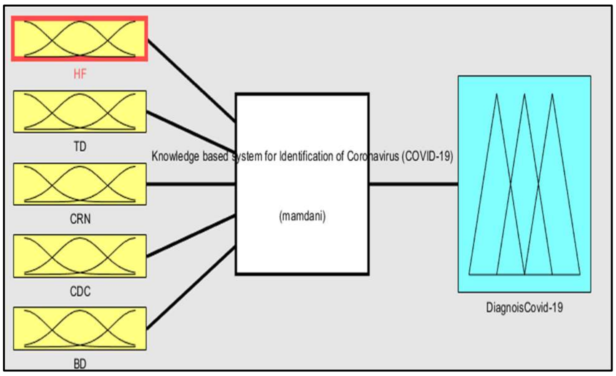

Figure 1. Input and output of knowledge-based system for Identification and Prevention of coronavirus (COVID-19)

Our proposed solution is based on the January to December 2020-2020 clinical dataset from Mayo Hospital Lahore, Pakistan. This dataset was compiled using the outcomes of numerous physical symptoms and medical tests conducted on COVID-19-positive and COVID-19-negative patients. We have selected five of the most prevalent signs and symptoms from this dataset as input variables. Clinical symptoms/signs:

a) High Fever
b) Tiredness
c) Cold
d) Running Noise
e) Continuous Dry Cough
f) Breathing Difficulties

Because these measures proved to be good predictors during a significant outbreak in Pakistan, they were selected for the early diagnosis of the COVID-19 disease.

A response is obtained by the expert system from the rules that are provided by the fuzzy logic system during the IF-THEN condition. The rule base contains a logical representation of the reasoning that is utilized by the system for making judgments. The process of fuzzification converts data that is supplied into the system, such as a discrete integer, into sets that are representative of fuzzy logic. The fuzzy input is analyzed by the inference engine, which then explains, on the basis of the rule, how many matching degree values there are. Defuzzification is the process of using inference engine methods to turn a set of fuzzy inputs into a set of clear values. The expert system lets you use these methods and can also reduce the number of mistakes it makes. Figure 1 shows what goes into and comes out of the knowledge-based system for detecting COVID-19.

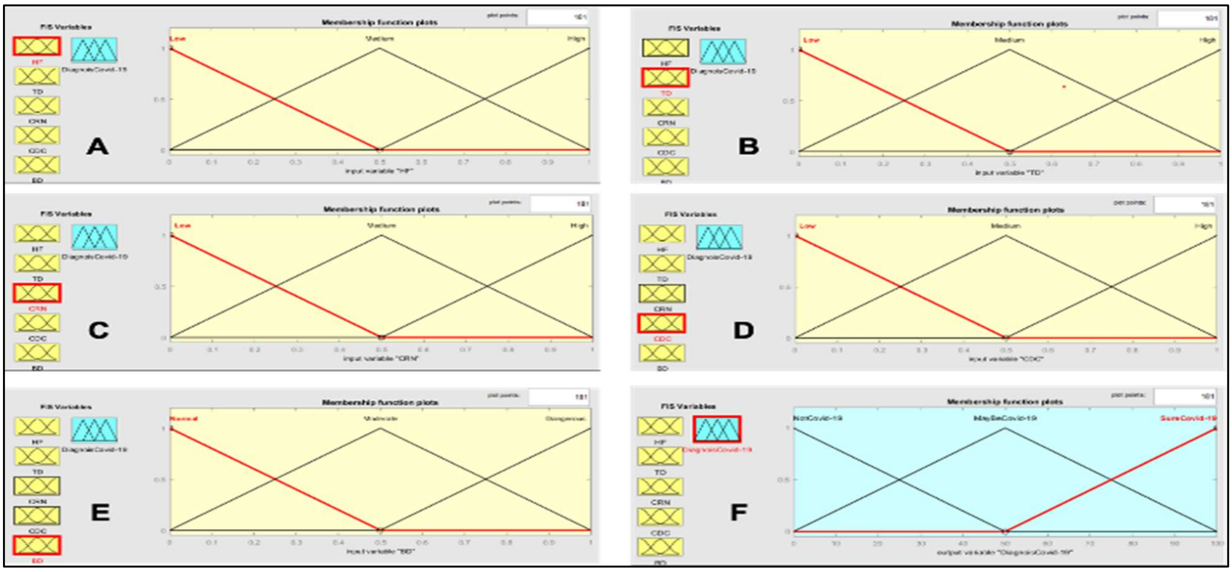

Figure 2: Graphical layout of a member function for an intelligent system to detect COVID-19.
A: High fever membership function plot.
B: Tiredness membership function plot.
C: Cold/Running Nose membership function plot.
D: Continuous Dry Cough membership function plot.
E: Breathing Difficulties membership function plot.
F: COVID-19 diagnosis membership function plot.

4. Knowledge base input and output fuzzy system

The suggested system has for variables that serve as inputs and one variable that serves as an output. These variables include a high temperature, exhaustion, a cold or running noise, a prolonged dry cough, and breathing difficulties. The factors of interest, both input and output, are broken down into finer points in Table 1.

5. Member Function

Membership functions are a type of Boolean logical operator that are used in fuzzy logic. These operators have predicates that indicate whether the conditional is true or false. Formulas in fuzzy logic are written in a language called predicate notation, which is similar to the notation used in Boolean logic. Performing mathematical calculations on a collection of data is often how membership functions are put to use. The graphical layout of a member function for an intelligent system to detect COVID-19 was shown in Figure 2 (A-F).

6. ules based

In modern times, the fuzzy inference system, also known as FIS, has developed into a powerful tool for dealing with issues involving uncertainty and imprecision. This is made possible by Zadeh's fuzzy set theory, which has been successfully implemented [39]. As a consequence of this, the knowledge of a seasoned medical professional can be modelled by utilizing FIS. The knowledge base of the system is critically important to the successful operation of the system, which is even more reliant on the system's rule base than it is on its database. One of the processes involved in the fine tuning of the fuzzy inference system is determining the optimal distribution of the membership functions that are saved in the database.

Decisions can be made in fuzzy rule-based systems based on a wide range of input and output forms and fuzzy logic varieties because of their flexibility and scalability. Fuzzy rules are implemented into knowledge base systems so that a large range of information can be accurately represented in a number of different contexts. All of the rules applied to this study were formulated with the help of the Mamdani fuzzy inference rule-making system, which was implemented in MATLAB. An illustration of the rules diagram can be seen in figure 3, which contains a depiction of the diagram

7. Defuzzification

Defuzzification is the process of transforming the membership degrees and sets of fuzzy logic into a formal, calculable form that may be used in crisp logic. This outcome can be achieved by the utilization of defuzzification, which can be thought of as both a tool and a structure. In addition to that, it is a method for selecting options using an algorithm (using a fuzzy set to select the best crisp input and output value). Figure 4 (A-D) is where you can find a graphical representation of the knowledge-based system that DeFuzzifier employs for the purpose of locating COVID-19.

8. Experimental Results

The MATLAB R2020a tool is used to produce the simulation results. MATLAB is a high-performance programming language that was designed specifically for use in computing applications related to scientific research and engineering. It makes it possible to program at a high level while consuming a small amount of memory, carrying out operations quickly, and making use of long-term memory in the background. In addition to its use for data visualization and scientific computing, the program known as MATLAB is also capable of performing numerical computations and processing images. Figure 5 describes the value of the parameter high fever = 0.741, tiredness = 0.161, Cold/running Nose = 0.161, Continuous Dry Cough = 0.065, and Breathing Difficulties = 0.0179 than Knowledge-based system diagnose COVID-19 level values is 32. It shows no COVID-19.

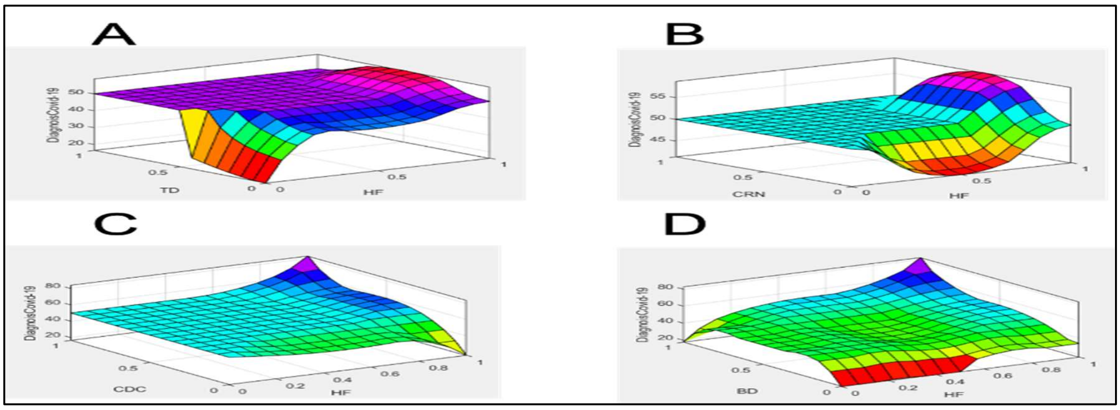

Figure 4: Detection of COVID-19 curved surface inputs output (diagnose COVID-19 level)
A: HF and TD
B: HF and CRN
C: HF and CDC
D: HF and BD

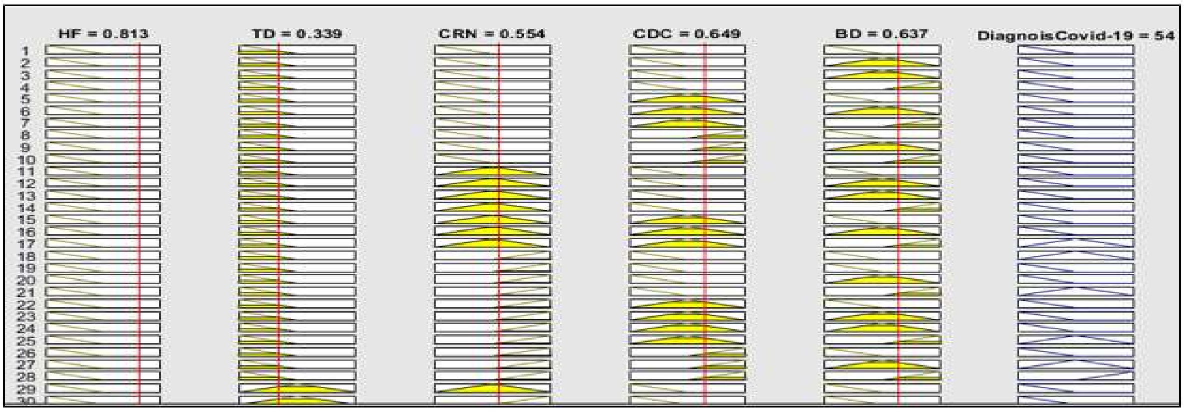

Figure 6. Rule viewer of Knowledge-based system for Identification COVID-19 that showed patient may be detected COVID-19

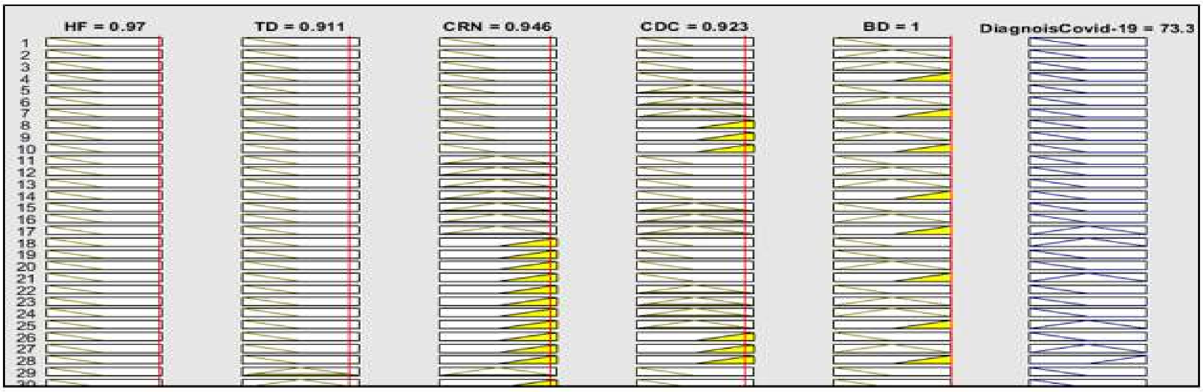

Figure 7. Rule viewer of Knowledge-based system that detects COVID-19

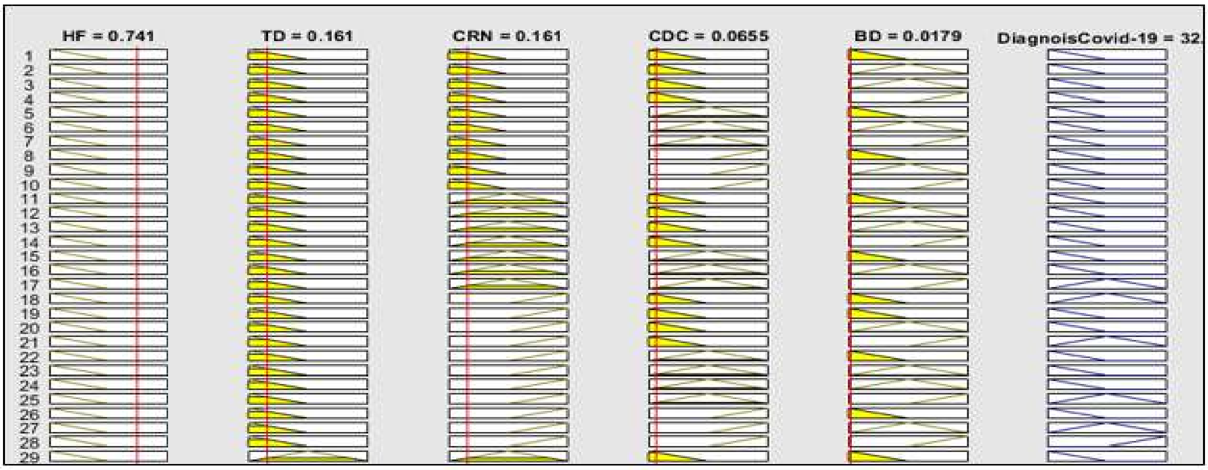

Figure 5. Rule viewer of Knowledge-based system for Identification COVID-19 that showed the patient was not detected COVID-19

Likewise, the Figure 6 describes the value of parameters high fever = 0.813, tiredness = 0.339, Cold/Running Nose = 0.554, Continuous Dry Cough = 0.649, and Breathing Difficulties = 0.637 than Knowledge-based system diagnose COVID-19 level values is 54. It shows may be COVID-19.

In a similar manner, the Figure 7 describes the value of the parameter high fever = 0.97, tiredness = 0.911, Cold/Running Nose = 0.946, Continuous Dry Cough = 0.923 and Breathing Difficulties = 1 than Knowledge-based system diagnose COVID-19 level values is 73.3. It shows high symptoms of COVID-19.

9. Conclusion and Future Work

In order to accomplish the initial identification of COVID-19, we suggested using a knowledge-based system that was both intelligent and sophisticated. The signs and symptoms that patients exhibit are used by the algorithm to derive an estimate of how likely it is that they are infected with the COVID-19 virus. The symptoms that are being taken into consideration are a high temperature, exhaustion, a cough that is dry and persistent, a cold or running noise, and breathing difficulties. The use of this inference method can be of use to medical professionals in the process of disease diagnosis. Even if the suggested approach is unable to provide a very accurate COVID-19 identification, it can be used with other methods of COVID-19 identification such as PCR tests and CT scans so that they can work together to confirm infected patients. Individuals will be able to undertake self-diagnostic on their own cases through the use of a web application that will be developed as part of our future work and will be based on the diagnosis system that we aim to implement. The scope of the study can be broadened to incorporate additional patient data, such as blood pressure, the peak-flow rate of breathing air, and the presence of a chronic ailment if the researchers so choose. One of the fascinating and potentially fruitful directions that the future may go is in the direction of applying data mining methods in order to derive fuzzy rules from patient data.

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