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Review Article

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Detection of COVID.19 Using CT Imaging: Intelligent Analysis

Bouharati Imene[1,2], Bouharati Khaoula[3] and Laouamri Slimane[4]

[1]Faculty of Medicine, Paris-Sorbonne University, France
[2]Laboratory of intelligent systems, UFAS Ferhat Abbas Setif University, Algeria
[3]Faculty of Medicine, Constantine University, Algeria
[4]Faculty of medicine, UFAS Ferhat Abbas Setif University, Algeria

Abstract: More and more, CT imaging is needed in the pre-diagnosis of COVID-19. The accumulation of data gives it more precision. However, in differential diagnosis, it is necessary to take into account peripheral pathologies such as pulmonary edema, infectious bronchiolitis or bacterial pneumonia. In the diagnosis susceptible to COVID-19, it is essential to identify its specificities in terms of location and characteristics. Signs of this show up on imaging as a moderate increase in lung parenchyma density secondary to edema. It is often bilateral and multifocal, is located on the periphery, inferior and posterior. Rarely, these signs are atypical. In order to properly interpret these images, it is necessary to take into account all thoracic pathologies for the elimination of differential diagnoses. It seems obvious that the system is much more complex to arrive at an exact reading and to pronounce. This study deals with the analysis of the specificities of CT images in relation to the patient's status in terms of thoracic co-morbidity. As the system is complex, analysis using artificial intelligence techniques is proposed. The principles of fuzzy inference are applied. Data relating to the patient's history and the nature of the recorded image are considered as input variables to the system. The degree to which COVID-19 has been confirmed or denied is the output variable of the system. The fuzzy analysis makes it possible to compensate for the uncertainties associated with the process and therefore the diagnosis will be as precise as possible. It can be seen as a diagnostic aid.

Keywords: Tomography CT, Covid-19, Data analysis, Fuzzy logic.

INTRODUCTION

To date, the detection of the positivity of COVID.19 is the confirmation by the microbiological tests in real time RT-PCR or sequencing (Yang, Y. *et al*., 2020; Ai, T. *et al*., 2020; Fang, Y. *et al*., 2020; Kanne, J. P. *et al*., 2020). As the thoracic computed tomography can constitute a more practical and faster technique in the diagnosis, it can be used as a complement to the microbiological analysis technique (Fang, Y. *et al*., 2020) although this is not systematically recommended (www.acr.org) and (https://thoracicrad.org).

A chest scanner is recommended for the preliminary detection of COVID-19 without injection (Revel, M. P. *et al*., 2020) and (Ojha, V. *et al*., 2020). This becomes necessary in particular when the patient presents signs of poor respiratory tolerances with a negative PCR (Ducray, V. *et al*., 2021) and (Oberlin, M. *et al*., 2020). When a suspicion presents itself without confirmation by PCR, the scanner can respond to false negative cases (Li, Y. *et al*., 2020) and (Ducray, V. *et al*., 2021). However, it is necessary to have an idea of the onset of signs because the onset of pulmonary embolism is not significant during the first days (Freund, Y. *et al*., 2020) and (Jalaber, C. *et al*., 2020). However, pulmonary pathologies are numerous and induce a differential diagnosis. In order to differentiate between the different origins of the condition, it is sometimes very difficult to accurately identify the disease. From there, it seems that the system is very complex to analyze. This study presents an analysis based on artificial intelligence techniques. The principles of fuzzy inference are applied. Interpretation of the recorded image must take into account other information related to the patient (PCR test result, age, history, onset of symptoms, etc.). These factors are considered fuzzy variables at the input of the system. The degree of confirmation of the positivity of the COVID.19 contamination is considered as an output variable of the system. A base of fuzzy rules is established connecting the inputs to the output. Once the system is complete, it becomes possible to enter the input data to automatically read the output result with maximum accuracy. This can be used as a diagnostic aid tool.

Image analysis

What characterizes the images linked to the diagnosis is the presence of ground-glass opacities (GGOs), consolidated with crazy paving pattern as well as reverse halo sign. Although the diagnosis follows the Radiological Society of North America consensus statement (Chung, M. *et al*., 2020), several specificities remain to be elucidated despite the specificity of the image and the degree of lung involvement in terms of percentage. As the lung undergoes several physiological changes over the course of life (Age, height, weight, oxygenation rate and muscular exercise), can be considered as determining factors of membrane diffusion and blood volume pulmonary capillary

***Corresponding Author:** Bouharati Imene

(Ben Saad, H. *et al.*, 2003). The knowledge of all these physiological modifications will allow a better interpretation of the pathological variations of the function of the deep lung (Rouatbi, S. *et al.*, 2006).

Fuzzy modeling

Like human reasoning which compensates for uncertainties and inaccuracies in deciding an exact result, a fuzzy inference system is an imitation of it. When the system to be analyzed is characterized by complexity, uncertainty and imprecision, its application becomes adequate. The constructed system includes an input space which groups together the variables that influence the output, and an output space. An established database allows input to output to be linked while encompassing all possible combinations (Khaoula, B. *et al.*, 2021).

MATERIALS AND METHODS

In our case, a fuzzy system is constructed with three fuzzy input variables (Reading the scanner image, PCR test, Patient history) and an output variable which expresses the degree of certainty of the attack by COVID.19 (Figure 1). All these variables are considered fuzzy and therefore uncertain. By this, it is necessary to fuzzyfy them (conversion to linguistic terms). A database is built from the actual recorded data. This database links the input variables to the output variable. It must contain all possible combinations. Mathematically, it is the function that links the input linguistic values to the input of the system:

Output = f (I,t,a)
Where : I (Scanner image)
t (PCR test)
h (patient history)

Figure 1. System schematic

Fuzzyfication of variables

Each input or output variable must be fuzzyfied. ie its conversion into the linguistic term of human language.

Fuzzyfication of input variables

The "Image scanner" variable expresses the reading made of the image received from the scanner according to the characteristics specific to COVID.19 in terms of degree of certainty (low, medium, high). This takes into consideration the nature of the image as well as the degree of lung involvement. This takes into consideration the nature of the image as well as the degree of lung involvement (Figure 2).

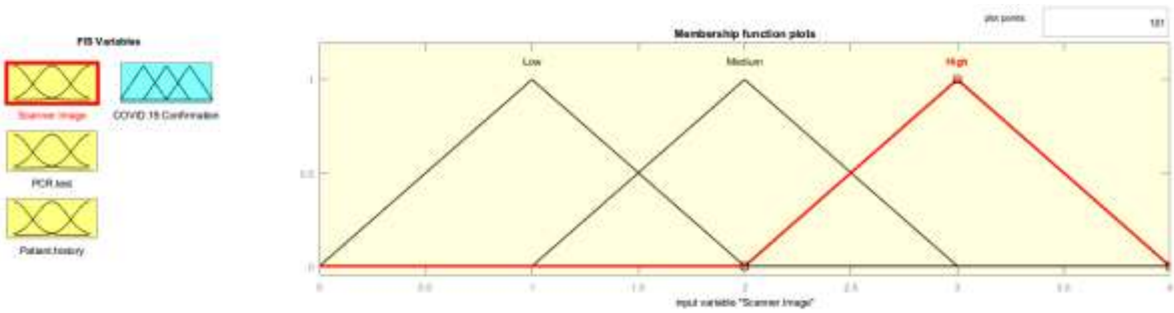

Figure 2. Fuzzyfication of the "Scanner image" variable

The "PCR test" variable is fuzzyfied into two fuzzy functions (confirmed, doubtful). The doubtful value expresses a false positive or false negative test (Figure 3).

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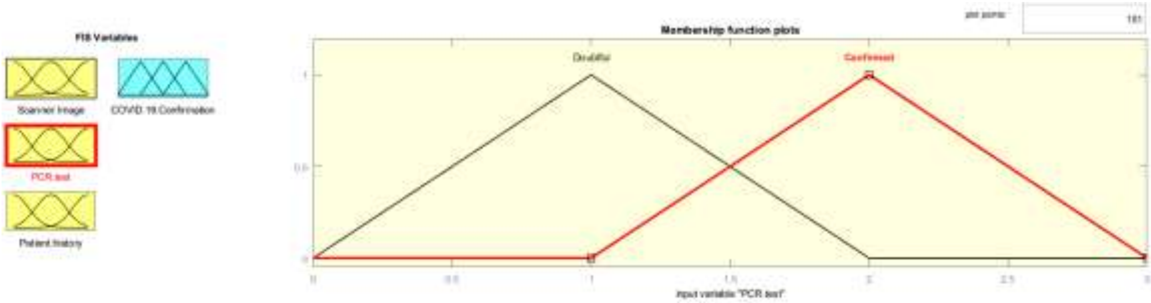

Figure 3. Fuzzyfication of the "PCR test" variable

The variable "patient history" is fuzzyfied in three functions expressed by (very susceptible, moderate susceptibility and not very susceptible) (Figure 4).

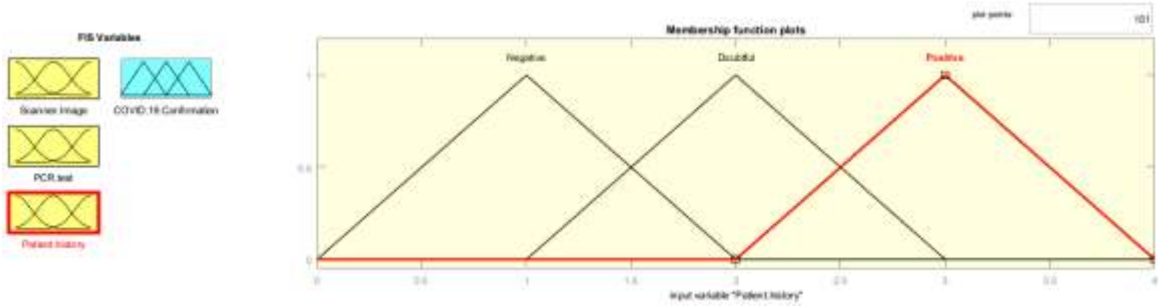

Figure 4. Fuzzyfication of the "Patient history" variable

Fuzzyfication of output variable

The output variable which expresses the degree of certainty of an attack by COVID.19 is fuzzyfied into three fuzzy functions (positive, doubtful, negative) (Figure 5).

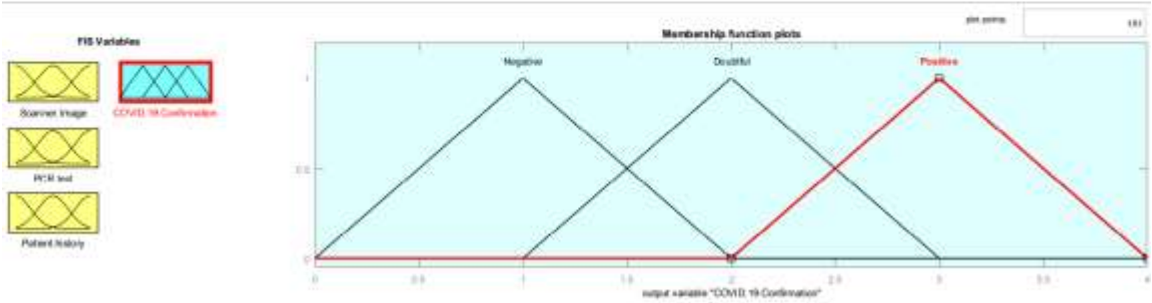

Figure 5. Fuzzyfication of the "COVID.19 confirmation" variable

Base of rules

This involves binding the input variables to the output variable. This is done from the actual values of the cases of the patients diagnosed. The higher the number of cases, the more accuracy is achieved. This base must contain all the possible combinations encountered.

The general form of a rule is:
IF (X_1 is X_{11} AND X_2 is X_{22} AND X_3 is X_{33}) THEN (Y is Y_1)

RESULT AND DISCUSSION

By referring to the cases diagnosed and by entering the values at the input of the system in linguistic terms, the system instantly and automatically displays the value at the output. Returning to the fuzzyfication function of this variable, we match this displayed value to the interval of the membership function to read the degree of certainty of the attack by COVID.19 Figure 6 illustrates an example of application.

The same illustration can be presented in figure 7. The reading of the degree of confirmation of attack by COVID-19 can be obtained by the variation of the other two factors.

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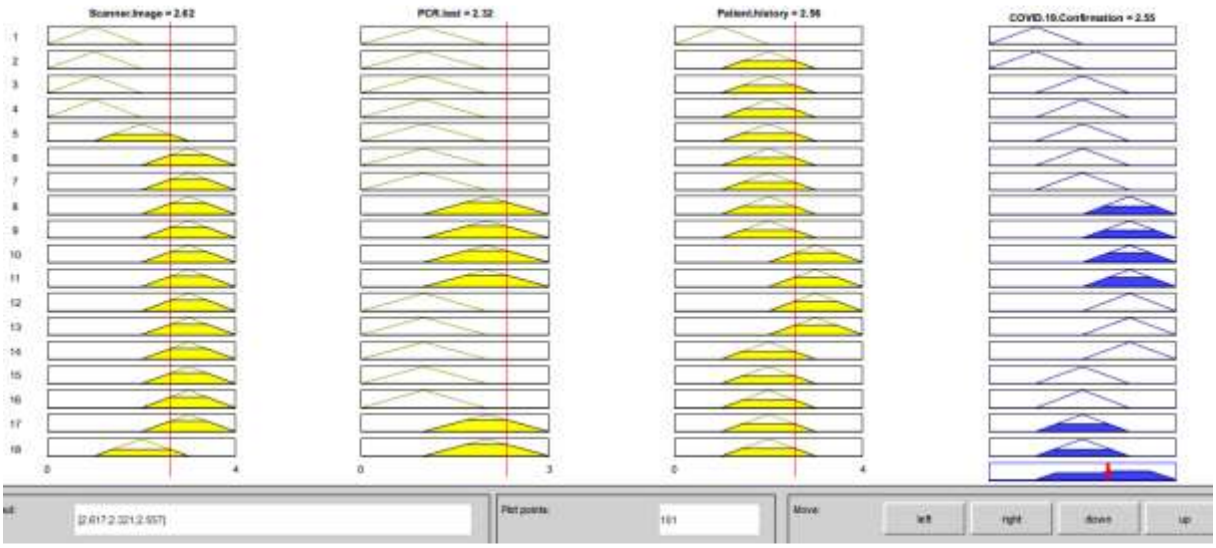

Figure 6. Example of application

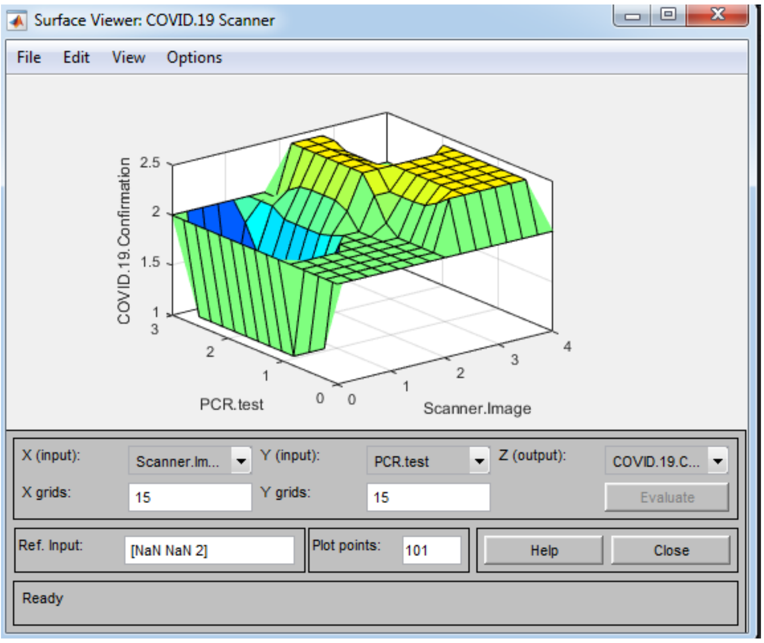

Figure 7. Confirmation degree variation according PCR test and Scanner image

CONCLUSION

Once the system is complete, this will allow random values to be entered at the input to read the result at the output with the minimum of errors. By this technique of fuzzyfication, uncertainties and imprecision are compensated. The system combines all the rules introduced from the base to calculate the value at the output. This tool can be used as an aid in the radiological diagnosis of COVID.19

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