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Fuzzy Analysis of CT-scan Images of Hepatic Parasitosis

Bouharati Imene[1, 3, *], Bounechada Mustapha[2], Babouche Farid[1], Bouharati Khaoula[4], Bouharati Saddek[3]

[1]Radiology Department, UFAS Ferhat Abbas Sétif1 University, Setif, Algeria
[2]Department of Biology and Animal Physiology, UFAS Ferhat Abbas Sétif1 University, Setif, Algeria
[3]Laboratory of Intelligent Systems, UFAS Ferhat Abbas Sétif1 University, Setif, Algeria
[4]Laboratory of Health and Environment, UFAS Ferhat Abbas Sétif1 University, Setif, Algeria

Email address:

imene.bouharati@univ-setif.dz (B. Imene)
[*]Corresponding author

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Abstract

Background: Hepatobiliary parasites are often the cause of a granulomatous reaction, they are responsible of radiological confusion mimicking tumor lesions. In imaging radiology, this is characterized by the absence of lesional contrast, the presence of calcification and the presence of hepatic granulomas. The example of toxocariasis that is caused by the toxocaracani or Taticati parasite manifested in ultrasound and CT-scan (computerized tomography), by multiple small intrahepatic lesions, oval or elongated and poorly defined. This result is hypo or isoechogenic. Objectif: If the confirmation of the diagnosis passes by a liver biopsy on specific eosinophilic granulomas we propose in this study the identification of the granulomas of origin toxocarose and to differentiate them from the tumoral forms. Methods: Given the complexity of the system, the factors taken into account are the volume distribution of the density, the size, and the shape of the contour, the location and the living conditions of the patient. These variables are considered input variables to a fuzzy system. The output variable expresses the nature of the granuloma. As the fuzzy logic that is a subfield of artificial intelligence deals with the uncertain and imprecise, its application in this area proves adequate. A database is established from the real cases in the form (If... Then). Conclusion: Once the fuzzy algorithm is done, it allows identifying the nature of the tumoral granulomas or toxocariasis before biological techniques confirmation.

Keywords

Hepatobiliary, Parasites, Toxocariasis, CT-Scan, Granulomas, Tumor, Fuzzy Logic

1. Introduction

Toxocariasis is a parasitic disease in the form of an infection whose cause is Toxocaracanis or Toxocaracati and the liver is the organ most affected by this infection [1]. Sometimes this infection can progress to an abscess although this is rare. The larvae of this one propagate after hatching in the intestines to reach the liver [2]. If the main cause of this infection is due to the larvae or eggs of Toxocaracani, that caused by Toxocaracati remains rare [3]. Routes of contamination are soil ingestions containing eggs or larvae or through ingestion of the liver of infected animals [4]. Raw meat from birds or other animals can also induce this contamination [5]. The cycle involves the release of larvae through the intestinal wall to reach the liver via the venous system. Propagation may include other organs [6, 7]. Symptoms usually appear within six months of infection [8]. Lesions caused inside the liver take ill-defined forms of granulomas and often of varying sizes. As contours are generally poorly limited, radiographic detection is confusing. In this study, different radiographic and imaging techniques are used in this detection. For an efficient analysis, a system based on artificial intelligence techniques is proposed. This fuzzy inference system is adequate. Because, the fuzzy logic deals with the uncertain and the imprecise and where there is confusion. The size, shape, granuloma density, location, environmental conditions of the patient are considered as input variables to the system. The nature of the granuloma represents the output variable. A rule base is established and once the system is done, it will define precisely the toxocariasis or tumoral nature of the granuloma and thus decide on the diagnosis.

2. Clinical Aspect

The diseases caused by Toxocara are often asymptomatic. This makes it difficult to detect especially since the symptoms are various. The evolution of these infections is a function of the patient's immune response. When the parasite is absent in the sample, it makes it even more difficult to detect abscesses caused by taxocara [9]. Clinically, it is based on the size of the inoculums as well as on the recurrence of the infection and the position of the larvae. Subjects exposed in their larval environments are thought to be the most vulnerable and therefore the most exposed at high frequencies. Medical imaging is often used as a diagnostic tool [10].

3. Radiology Imaging

There is often confusion between imaging visceral hepatic migrating larvae and benign lesions in the liver. In magnetic resonance imaging (MRI), eosinophilic infiltrates are differentiated. With diffusion imaging, no restriction is shown for benign lesions in the liver [11]. It is also very difficult to differentiate the attenuations because the results are nonspecific [12]. In order to improve MRI images, hepatocyte-specific agents are sometimes used. This has some advantages in detecting larvae [13]. The difficulty lies in the fact that sometimes lesions show no wash either in equilibrium or delayed phase. This can be confusing with the nodules of hepatocellular carcinomas [14, 15]. Be that as it may, based on the forms, the small intrahepatic lesions have oval or elongated and often poorly defined forms forming granulomas in ultrasound imaging. In contrast CT, the lesions appear hypodense, multiple, indefinite, of variable size and fuzzy boundaries [15-17]. In conclusion, despite various radiographic imaging techniques, difficulties remain to be solved in this area.

4. Material and Methods

4.1. Fuzzy Inference

In our study, fuzzy logic system is applied for resolving such confusion. The basic principles of fuzzy logic are introduced by Zadeh in 1965 [18]. These notions come as an extension to binary logic. The limits of the sets are not clear, but considered fuzzy. This gives the possibility to introduce the notion of partial membership to a set. The transition from one set to another is not abrupt, but gradual. Numeric values can then be translated into linguistic variables. In this, it imitates human reasoning. This confers on this technique an intelligent reasoning and therefore belongs to the techniques of artificial intelligence. The general principle of the rules of a fuzzy system is of the form: If X1 IS X1 (1) and X2 IS X2 (2) and… XnISXn (n) THAN Y1 is Y1 (1).

Fuzzy logic Fuzzy logical inference has been used in several areas. When the system to be analyzed is characterized by complexity, uncertainty or imprecision, its application becomes necessary. It turns out that in the medical field; virtually all systems have these characteristics [19]. Roughly speaking, where the effects of the factors involved in a process are complex or even sometimes completely ignored, the principles of fuzzy inference are perfectly adequate [20].

4.2. Fuzzy Variables

In classical logic, binary variables only admit two states (1 or 0). Fuzzy variables admit values between (1) and (0). In the case study for example, the distribution of the density in the form recorded on the image cannot be quantified numerically. On the other hand, the evolution of the density through the volume is gradual, and admits in this sense levels between 1 and 0. By considering it as a fuzzy variable, its expression becomes easy and close to reality. The variable "density" is then easily expressed in linguistic terms (low density, medium density and high density). Thus, this transposition is called "fuzzyfication". All input and output variables are therefore fuzzyfied.

4.3. Fuzzy Logic Modeling

In our case, the analyzed input factors involved in the identification of the granuloma recorded in the liver are (the volume distribution of the density, the size, and the shape of the contour, the living conditions of the patient). The output variable expresses the nature of the granuloma. The system built is with four inputs and one output (Figure 1).

4.4. FuzzyFicationof Input and Output Variables

Each variable is fuzzyfied. This operation consists of converting numerical values into linguistic variables. This is an imitation of human reasoning. The uncertainties and inaccuracies related to the phenomenon are compensated. Each input or output variable is fuzzyfied in three fuzzy intervals as follows:

[System]
Name='Hepatic Parasitosis'
Type='mamdani'
Version=2.0
NumInputs=4
NumOutputs=1
NumRules=30
AndMethod='min'
OrMethod='max'
ImpMethod='min'

AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='Density'
Range=[0 4]
NumMFs=3
MF1='Low':'trimf', [0 1 2]
MF2='Medium':'trimf', [1 2 3]
MF3='High':'trimf', [2 3 4]

[Input2]
Name='Size'
Range=[0 4]
NumMFs=3
MF1='Small':'trimf', [0 1 2]
MF2='Medium':'trimf', [1 2 3]
MF3='Large':'trimf', [2 3 4]

[Input3]
Name='Shape'
Range=[0 4]
NumMFs=3
MF1='Spherical':'trimf', [0 1 2]
MF2='Oval':'trimf', [1 2 3]
MF3='Deformed':'trimf', [2 3 4]

[Input4]
Name='Conditions'
Range=[0 4]
NumMFs=3
MF1='No. Effect':'trimf', [0 1 2]
MF2='Medium. Effect':'trimf', [1 2 3]
MF3='Great. Effect':'trimf', [2 3 4]

[Output1]
Name='Granuloma. Nature'
Range=[0 3]
NumMFs=2
MF1='Parasitic. Granuloma':'trimf', [0 1 2]
MF2='Tumor. Granuloma':'trimf', [1 2 3]

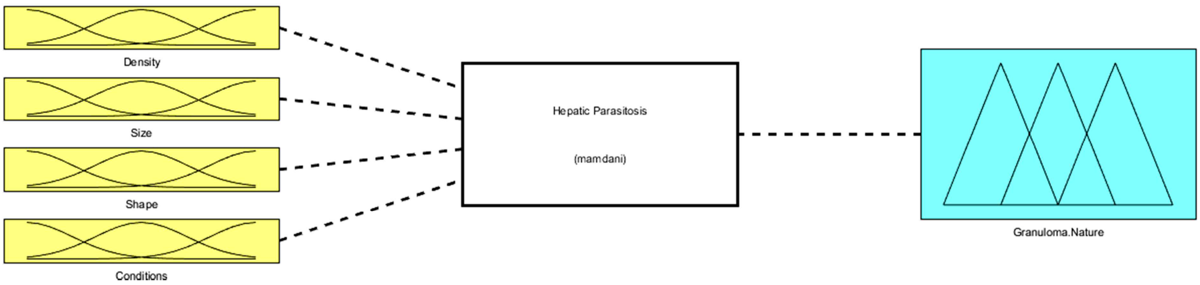

Figure 1. *Block diagram of the system.*

5. Result and Discussion

Each variable is represented by a triangular membership function over an interval ranging from 0 to 4 levels. Linguistic variables are assigned to intervals. Note that neighbouring intervals overlap in fuzzy intervals. By this, uncertainties are taken care of. The output variable is linked to the input variables to consider all possible combinations.

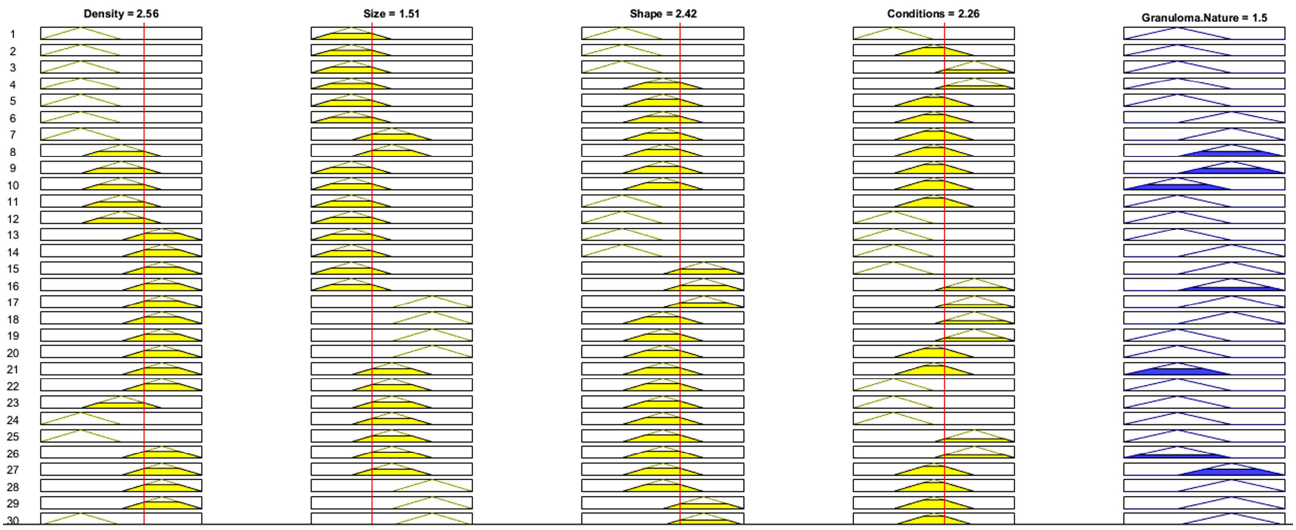

Figure 2. *Application example (input-output).*

Once the system is established, it gives the possibility to introduce random variables at the input to instantly read the result at the output. This result comes from the collaboration of all the rules that link the inputs to the output. An example of an application is illustrated in Figure 2. This same result can be illustrated by Figure 3 where it is possible to read the effect of each parameter on the nature of the granuloma recorded on the image.

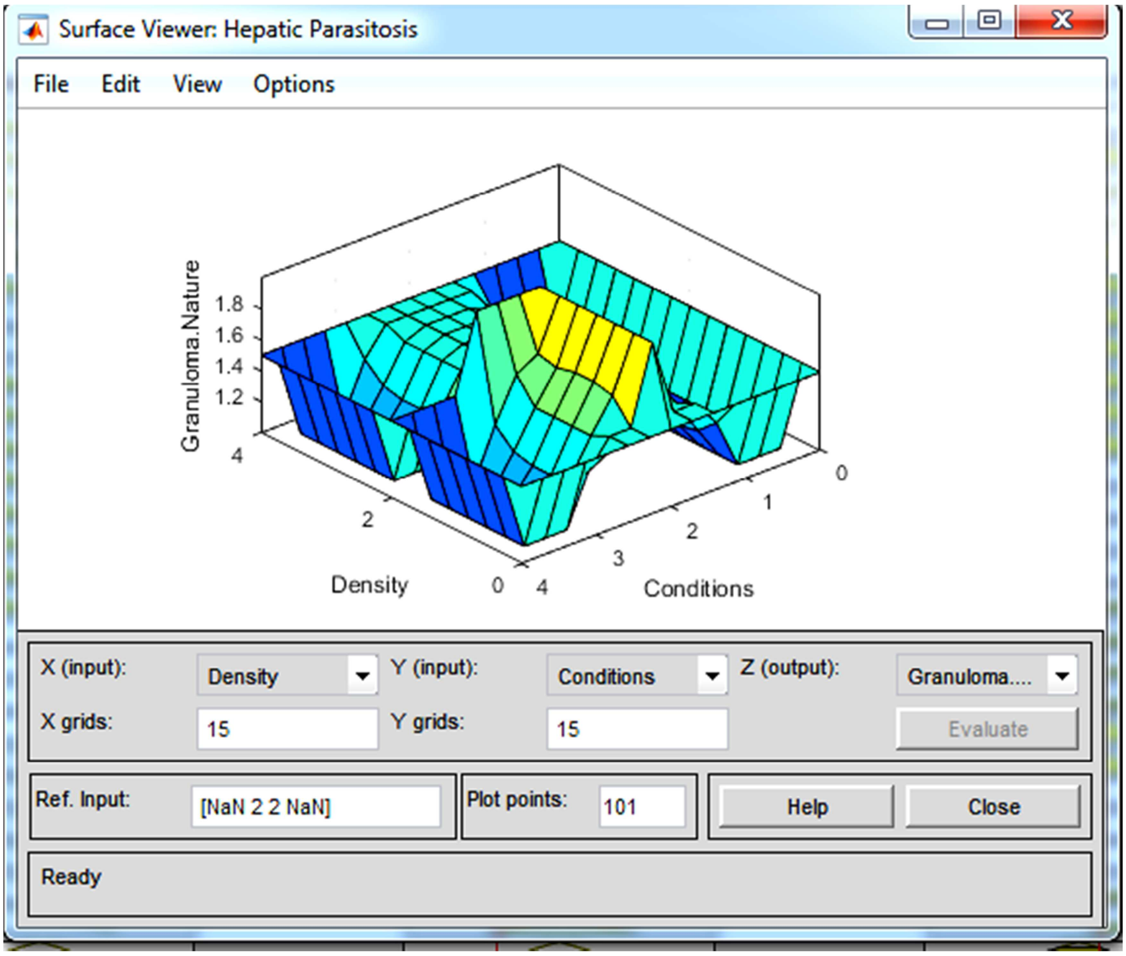

Figure 3. *View surfaces.*

6. Conclusion

The determination of the nature of the hepatic granuloma is confusing. Sometimes the parasitic nature merges with the tumor in imaging. The factors involved in the formation of these granulomas are very complex to analyze using conventional mathematical methods. The proposed system in this study is based on an intelligent approach. The principles of fuzzy inference used treat these factors as fuzzy variables. In this analysis mode, numerical values are translated into linguistic variables. This so-called artificial intelligence technique mimics human reasoning. By fuzzying input and output variables, uncertainties and inaccuracies are compensated. The basis of the rules established by a human expert takes in combination all the possible variants. The output of the system that expresses the nature of the granuloma combines all possibilities with the handling of uncertainties. The result will be as optimal as possible. The reading of the result at the output of the system is instantaneous from the random introduction of the values at the input. This tool does not have to replace the clinician or the radiologist, but rather it can be considered as a tool that supports diagnosis tool.

Competing Interests

All the authors do not have any possible conflicts of interest.

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