

MEDICAL IMAGE INTERPRETATION BY FUZZY NEURAL

NETWORKS and EXPERT SYSTEM

N.BENAMRANE, R.ABDERAHIM and L.NEMMICHE,

VISION and MEDICAL IMAGERY Laboratory, Department of Computer Science, Faculty of science, Mohamed Boudiaf U.S.T.O.

BP.1505.EL M'Naouar ORAN.31000. ALGERIA

TEL/FAX 00 213 41 34 85 43/ 00 213 41 42 53 22

E-Mail: nabenamrane@yahoo.com

Abstract :

The object of this paper is to elaborate an automatic system in order to detect suspect zones or tumors in medical image especially brain ones. The purpose is to define with precision the existence of different kinds of lesions using a hybrid system which combines Fuzzy Neural Networks and Expert System. After getting regions features by regions growing or mathematical morphology, the fuzzy neural networks detects the suspect regions which are validated by an expert system to determine the nature of lesions.

Key Words : Fuzzy Neural Network, Expert System, Medical Images, Tumors, Diagnostic, Interpretation.

1. Introduction

Artificial vision aims to replace the human vision in various area such as aerial, robotics, a nuclear plants as well as in medical imagery. Image interpretation represents an essential phase in the chain of the vision process by computer. Several methods have been proposed based on neural networks, genetic algorithm and expert systems[1][2]. Hybrid systems combining the fuzzy logic and artificial neural networks (Fuzzy-Neural Networks) have been proposed. There exists different approach for this combination. Nauck and Kruse[3] have proposed competitors Fuzzy-Neural networks model that are the form it less used of Fuzzy-Neural Networks ; the two techniques are used of competitive manner for the same mark. The Neural network is used as meadow/post processing for the fuzzy system, but the neural system does not change anything (parameters) to the fuzzy system.

The second proposed model is *The Cooperative Fuzzy-Neural networks model* [3] a learning process is used, to learn some parameters (intervals , fuzzy rules, or weights of rules) of the fuzzy system.. Neural networks and fuzzy systems are no longer separated. Recent approaches of

Fuzzy-neural networks are formed of this type. Nauck and Kruse have proposed two hybrids fuzzy-neural approach using fuzzy intervals : NEFCLASS[3] and NEFCON[3] [4] [5].

They are derived of a model of fuzzy perceptron that defines basic properties of this type of model of Fuzzy-Neural networks. The fuzzy perceptron has the same architecture of a generic neuron system, but weights, and in this case values of membership, are modelled in fuzzy area, and outputs, and functions of propagation are changed in agreement with weights.

NEFCON is used in applications of control with learning by strengthening, while NEFCLASS is used for the analysis and the classification of data by supervised learning.

2. The Proposed Method

2.1 Image Segmentation

A major problem in image analysis is to describe more compactly the visual information that they contain. This problem can be solved either by either by finding local discontinuities of the grey level function : edge, detection, either by searching

areas of the image which present some homogenous properties : region segmentation.

So as to segment our images, two techniques have been used : the segmentation by growing region and the segmentation by mathematical morphology.

The segmentation by growing region [7][8][9] consists in using the proceeding SPILT proposed by Pavlidis and the hierarchical sequence of merging criterion. The idea is to minimise the cost function by merging neighboring regions which verify a predicate and whose union gives the best local quality. The properties that the regions which verify a predicate and a local quality function. The mathematical morphology is based on transformations of the collection to analyse that is compared to a collection called element structuring. The target is to extract morphological and structural characteristics.

Characteristics of images segmented by growing region are presented as follows :

- Number of regions of the image
- Surface of each region
- Maximal gray level
- Minimal gray level
- Coordinate of the rectangle
- Summons intensity
- Summons squares
- Number from point frontier
- Number of neighbours of each
- Edge point
- Coordinate and level gray of
- each neighbours

Attributes that we have chosen : The surface of the region, the compactness that represents the factor of circularity, the mean gray level of the region, the variance and the elongation that, in our case, has been calculated by using axes of parallel inertia so as to marry at best the form of the region concerned.

These attributes extracted from regions of the image are presented to entries of the Fuzzy-Neural Networks for the detection.

ATTRIBUTES	PREDICATES		
	Small	Middle	Large
Surface	Small	Middle	Large
Mean Gray level	Somber	Gray	Clear
Variance	Not Homogeneous	Homogeneous	Very homogeneous
Elongation	Not Elongated	Elongated	Very Elongated
Compacity	Not Compact	Compact	Very compact

Table 1

2.2 Detection of anomalies by Fuzzy Neural Networks.

After the stage segmentation[6][9], the regions and photometric and geometric features such as

compacity, gray value average, gray value variance, surface and the elongation are extracted. These extracted features are presented to entries of the Fuzzy-Neural Networks for the detection.

To each of these features are associated three predicates (table 1) making call to fixed thresholds after having examined characteristics of regions of several medical images representing the cranium.

For this stage, we have used a Fuzzy-Neural Networks that is a prototype of the NEFCLASS model quoted if over, and having an Input layer counting the morphological attributes, a first hidden layer where are calculated degrees of membership, a second hidden layer for the blurred rule evaluation and an output layer counting the result(Figure 1).

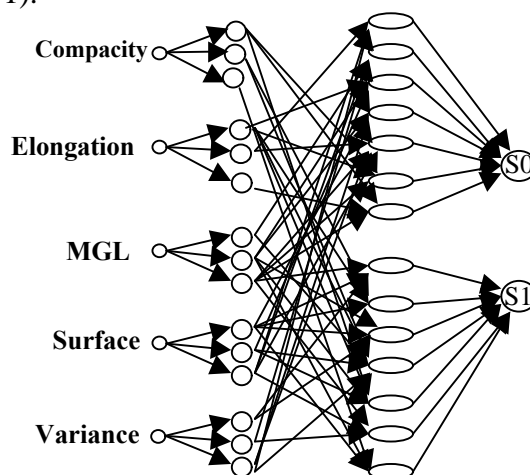


Figure 1 Fuzzy-Neural Networks Architecture

The input layer contains five neurons representing the characteristics choose of each region of the image. For each entry neuron , we allocate three membership areas (fuzzy set), that represent predicate intervals quoted previously. For example :

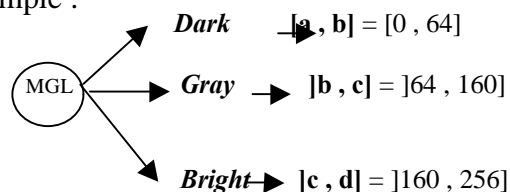


Figure 2 Neurons associated to « average gray value

2.3 Learning Phasis

The first hidden layer contains fifteen neurons representing membership degrees of each neuron of entry to the three fuzzy collection admitted (the three predicates), such that each neuron of the input layer is connected with three neurons of the first hidden layer.

$$m_{ij}(x) = \begin{cases} x-a / b-a & ; \text{ If } a < x < b \\ x-b / c-b & ; \text{ If } b < x < c \\ d-x / d-c & ; \text{ If } c < x < d \\ 0 & ; \text{ Otherwise.} \end{cases}$$

For $i=1,2,3$
For $j=1,\dots,5$

The second hidden Layer (Layer of Rules) is represented by collection of rules evaluated by a function of aggregation (in our case the function is MIN -MAX), these last are an estimation of truth rate of each rules. These rules are used so as to detected the presence of an or several anomalies in each region of the image.

The calculation of rules will be undertaken as continuation :

For the rule : If X1 is μ_1 and X2 is μ_2 and X3 is μ_3 Then C1

Us will have $R = \text{MIN}(\mu_1, \mu_2, \mu_3)$, where X1, X2, X3 represent entries of the system.

We have used fourteen rules for the detection as presented in table 2. The output layer contains two neurons, these last cost initially 0 , and take values 1 or 0 according to whether the region presents an anomaly or no anomaly.

This values are calculated as continuation :

For all rules connected to the output1 and to the output2, the neuron of exit takes:

$$\text{Output} = \text{MAX}(R_0, \dots, R_n) ;$$

for n : the number of rule connected to the same output.

If the region is suspicious then :

$$\text{Output} = (1,0) ;$$

If the region is suspicious not then :

$$\text{Output} = (0,1) ;$$

Any other labeling returns a region not classified.

We have used a supervised learning by gradient retropropagation .

This last has for target to adjust fuzzy intervals, that will be used in phase of detection.

The algorithm of the learning is :

I. For each region of the image to make the processing following :

-To propagate its characteristics through the system, and to determine outputs.

-For each output, to determine Delta values , such that :

$$d_{\text{output } i} = \text{Output_Desired}_i - \text{Output_calculated}_i$$

-For each neuron of the layer of rules a_R such that $a_R > 0$:

a)- Determined Delta values :

$$d_{\text{rule}} = a_R (1 - a_R) \sum W(\text{R}, \text{Output}_i) \delta_{\text{Output } i} .$$

b)- to Find μ_k that causes the minimum in the totality of μ connected to the even rules :

$$W(\mu_k, R) (\mu_k) = \text{MIN}\{ W(\mu_{ij}, R), (\mu_{ij}) \}$$

such that $\mu_{ij} \in$ first hidden layer.

- To determine the input X connected with this minimum.

c)- to Adjust areas of this input by determining Delta values for each parameter of areas(a, b, c, d) such that :

$$d_b = \delta_{\text{rule}} (d-a) \text{Sign} (X-b)$$

$$d_a = -\delta_{\text{rule}} (d-a) + \delta_b$$

$$d_c = \delta_{\text{rule}} (d-a) \text{Sign} (X-c)$$

$$d_d = \delta_{\text{rule}} (d-a) + \delta_c$$

2.4 Specification of the nature of anomalies

Expert systems know equally to manipulate vague data and uncertain knowledge. During this phase, we have used next criteria : Limit (regularity or irregularity (well limited, pain limited or blurred), density(homogeneity of region) and size (more the tumor is great, more the crafty potential is raised).

-knowledge Base: Represents the different features of region to define (compacity, MGL, surface, elongation and variance).

- Rule Base : Rules defined in this basis are :

Rules of malignancy prescription : In order that an anomaly is considered as a crafty tumor, it presents generally next signs : single, great, irregular, pain limited, heterogeneous, hypodense.

benign if it presents next signs : It can be multiple, generally small and well limited, regular.

- **Engine of inference** : Nucleus of the expert system that combines and exploits the basis of rules and the basis of data. The conceived expert system during this phase is an expert system that determine the nature of anomalies detected by the fuzzy-neural networks, where one takes in consideration that tumors, any other anomaly is labelled not recognized.

We will calculate this manner the rate of recognition **TR** that is equal to :

$$TR = (\text{Nbr crafty tumors} + \text{Nbr benign tumors}) / \text{Nbr anomalies.}$$

3 Testing and Results

This method has been tested on medical images representing MRI of human images representing the cranium. showing anomalies (tumors)(see Figure 3 and Figure 8) . These images were segmented by the growing region or mathematical mophology (see Figure 5 and Figure 10) . The extracted region features are fed to the Fuzzy neural network to detect suspect regions. The network interpreted image is shown on Figure 6 and Figure 7.

The suspect regions which detected by fuzzy neuronal network are validated by an expert system to determine the nature of lesions. The results are show in figure 7 and figure

3.1 Conclusion

We have proposed in this paper an approach of medical image interpretation based on regions primitives by fuzzy-neural networks and expert system. We have made tests on brain images, the obtained results are satisfying and our system is able to make reliable predictions with a discriminating performance comparable to that of experienced pathologists. This method can be generalized to other medical images in order to detect and identify various kinds of anomalies. It can also be used to analyze other types of images such as: satellite images and aerial .

Acknowledgments

The autor would like to thank Dr R. NEKKACHE of the surgical clinic NEKKACHE for the help on data base image and for their co-supervision for this work.

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	N° Rule	Compacity	Elongation	MGL	Surface	Variance
<i>A N O M A L I E</i>	0	\	Elongated	\	Great	Not Homogeneous
	1	\	\	Dark	Great	Homogeneous
	2	\	Not Elongated	Bright	Middle	\
	3	\	\	Bright	Small	Not Homogeneous
	4	\	Elongated	Bright	Great	Not Homogeneous
	5	Not compact	Not Elongated	Bright	\	\
<i>P A S S A N O M A L I E</i>	6	Bit compact	Very Elongated	Bright	\	\
	7	\	\	Bright	Small	Very Homogeneous
	8	Compact	Not Elongated	\	Small	\
	9	\	\	Gray	Small	Very Homogeneous
	10	Compact	Not Elongated	Dark	Middle	Not Homogeneous
	11	Not compact	Not Elongated	Gray	Middle	\
	12	\	\	Bright	Great	Homogeneous
	13	Very compact	\	Gray	Small	\

Table 2 : Rules used for the detection of anomalies

With : Rule 0 \longrightarrow presence of anomaly.
 Rule 10 \longrightarrow absence of anomaly