Pattern Recognition in Medical Images using Neural Networks

Lic. Laura Lanzarini[1], Ing. A. De Giusti[2]

Laboratorio de Investigación y Desarrollo en Informática[3]
Departamento de Informática - Facultad de Ciencias Exactas
Universidad Nacional de La Plata

Summary

The proposal of this research line is the search for alternatives to the resolution of complex problems where human knowledge should be apprehended in a general fashion.

In particular, the activities developed so far can be included in the area of Medical Diagnosis, even though similar applications in other fields are not discarded.

In general, one of the greatest problems of medical diagnosis is the subjectivity of the specialist. The experience of the professional greatly affects the final diagnosis. This is due to the fact that the result does not depend on a systematized solution, but on the interpretation of the patient's answer.

The solution to this kind of problems can be found in the area of Adaptive Pattern Recognition, where the solution rests on the easiness with which the systems adapts to the information available, in this case coming from the patient.

In this sense, *neural networks* are extremely useful, since they are not only capable of learning with the aid of an expert, but they can also make generalizations based on the information from the input data, thus showing relations that are a priori of a complex nature.

Key Words: Neural Networks, Adaptive Pattern Recognition, Medical Diagnosis.

1. Pattern Recognition and Neural Networks

Human beings do not analyze the different situations of the real world as isolated facts, but they try and describe them in terms of *patterns* of related facts. Sometimes these relations are implicit because they all refer to the same object. Some other times, however, it is necessary to explicitly connect these characteristics in order to find a relation.

It is interesting to observe the power of perception of human beings. We are very well adapted to carrying out pattern processing activities. Examples of this can be found in the recognition of hand-written characters or in image recognition. In both cases, interpretations would be correct even if there were distortions or lack of information.

---

[1] Profesor Adjunto Dedicación Exclusiva. Dpto. de Informática, Facultad de Ciencias Exactas. Universidad Nacional de La Plata. E-mail: laural@info.unlp.edu.ar
[2] Investigador Principal del CONICET. Profesor Titular Dedicación Exclusiva. Dpto. de Informática, Facultad de Ciencias Exactas. Universidad Nacional de La Plata. E-mail: degiusti@info.unlp.edu.ar
[3] Calle 50 y 115 1er Piso, (1900) La Plata, Argentina, TE/Fax +(54)(221)422-7707. http://lidi.info.unlp.edu.ar

Since this skill is not only used for the perception of facts but also for knowledge, ways of providing computers with this same pattern processing skill of human beings has been sought for.

This could lead not only to a simpler way of using computers, but also to more efficient applications in real world tasks. This possibility has increased the interest to understand how to handle information expressed as patterns.

Within the pattern recognition area, one of the most important concepts is that of *discriminant*.

In general, a discriminant is a function or operator that, when applied to a pattern, allows to obtain an output corresponding to an estimation of the class to which it belongs, or an estimation of one or more of the attributes of the pattern.

The existence of discriminants constitutes the essence of pattern recognition.

When patterns are numeric, discriminants are based on one of the following concepts:

1. The discriminant is a surface dividing the space of input data from where patterns are classified according to the sector to which they belong.
2. The discriminant is a distance measurement, and patterns are classified according to the class to which their closest neighbor [Simp 92], [Simp 93], or the closest prototype [Torb 98], or the closest class center [Mega 98], [Shie 95] belong.

Solutions found by means of the use of neural networks allow to obtain discriminants of the first type.
The usual practice is to look for a pattern recognition system which is able to learn in an adaptive way from the experiences of several discriminants, each of them corresponding to a specific purpose. In an automatic pattern recognition system, learning and recognition stages are combined to achieve the objective desired [Cagn 93] [Valli 98]. In this sense, neural networks are a suitable tool for the implementation of adaptive solutions solved by the computer [Nigr 93].

Using neural networks, the concept of discriminant is based on a set of hyperplanes or hypersurfaces that map the input space into the output space.

On the other hand, the main characteristic of neural networks is their ability to generalize information, as well as their tolerance to noise. Therefore, one of the computer science areas that uses them the most is Pattern Recognition.

The research line of Neural Networks applied to Pattern Recognition has as its main objectives:

- The application of Neural Networks to specific problems of pattern recognition.
- The evaluation of efficiency metrics and reliability of the solutions proposed.
- The formation of human resources in the area

The tasks developed so far are part of the existing agreement between the Faculty of Medical Sciences of the UNLP and the LIDI.

2. Medical Diagnosis

One of the most important problems of medical diagnosis, in general, is the subjectivity of the specialist. It can be noted, in particular in pattern recognition activities, that the experience of the professional is closely related to the final diagnosis. This is due to the fact that the result does not depend on a systematized solution but on the interpretation of the patient's signal.

For example, in the case of the diagnosis of balance disorders, the signal corresponding to the ocular movement of the patient needs to be analyzed. This signal presents a pattern called nystagmus whose frequency in different tests determines the type of lesion. The pattern itself is closely related to the type of signal and is different for each patient. [Lanz 97]

Something similar happens with cell count. In general, every histologic sample has certain associated normality values that characterize the cell populations forming it. This allows the specialist, based on groupings of cells with the same characteristics, to perform a first classification of the tissue under examination as *normal* or *pathologic* [Lanz 98].

The methods allowing to determine the proportion of cells with similar characteristics are a routine, heavy task and subjected to errors on the part of the observer due to their mainly subjective character. Therefore, it would be extremely interesting to be able to establish this proportion with the highest objectivity possible, for more accurate diagnosis and prognosis.

Any method that allows to count cells with similar characteristics constitutes a very important tool to be able to distinguish a priori normal from pathologic samples, and, at a later stage, specific pathologies [Lanz 95] [Lanz 98].

Problems such as those mentioned here require tools that do not use an algorithm to find the solution, but that are able to behave according to the data of the problem. In this sense, *neural networks* are extremely useful, since not only are they capable of recognizing patterns with the aid of the expert, but also of generalizing the information contained in the input data, thus showing relations which are a priori complex.

Currently, the automatic recognition of the elements present in a histologic sample using neural networks is being studied; however, this type of solution can be applied to numerous diagnosis problems.

The system being used receives the image through a camera placed over the microscope. It should be noted that in order to calculate cell proportion of a preparation, it should be swept following a "Greek grill", which generates approximately 120 color images of 640x420 pixels. The magnitude of calculations to be carried out should be taken into account, as well as the need to speed up the classification process.

Here, processing of digital images and neural networks are combined to carry out the required recognition and classification. The solution to the problem can be divided in two parts: the segmentation of the different elements, and their subsequent classification.

As a solution for the first part, different clustering techniques have been studied, so as to achieve a suitable segmentation. The characteristic used has been color, in order for the solution proposed to be general. In this sense, good results have been obtained thanks to the definition of a new clustering algorithm based on e re-definition of the input image.

As for the classification stage, different solutions using neural networks have been compared, the results obtained being correct, with an error smaller than 10%.

3. Basic Bibliography

[Baxt 91] *Supervised Adaptive Resonance Networks*. Baxter. Center for Adaptive Systems. Boston University. 1991

[Cagn 93] *Neural Network Segmentation of Magnetic Resonance Spin Echo Images of the Brain*. Cagnoni, Coppini, Rucci, Caramella,Valli. Jounal of Biomedical Engineering, V 15, pp.355-362. 1993

[Gonz 92] *Digital Image Processing.* Gonzalez y Woods. Addison-Wesley. 1992

[Hecht 90] *Neurocomputing*. Robert Hecht-Nielsen. Addison-Wesley. 1990

[Jain 89] *Fundamentals of Digital Image Processing*. Anil Jain. Prentice Hall.1989

[Lanz 95] *Caracterizacion de los Elementos de una Muestra Histológica utilizando Khoros*. Lanzarini, Castañeda, Badrán, De Giusti. II International Congress on Information Engineering. Buenos Aires. 1995.

[Lanz 97] *Real Time Analysis of the Nystagmus and Movement Patterns in Balance Disturbances*. Lanzarini, Vargas, Estelrrich, De Giusti. 19th International Conference Information Technology Interfaces. Croatia. 1997

[Lanz 98] *Reconocimiento y Clasificación de los elementos de una muestra de sangre utilizando Redes Neuronales.* Lanzarini, Vargas, Badrán, De Giusti. 6º Congreso Internacional de Nuevas Tecnologías y Aplicaciones Informáticas. Cuba.1998

[Mega 98] *Fuzzy Neural Network for Classification and Detection of Anomalies.* Meneganti, Saviello y Tagliaferri. IEEE Transactions on Neural Networks, Vol.9, nº 5 Septiembre 1998

[Nigr 93] *Neural Networks for Pattern Recognition*. Albert Nigrin. MIT Press 1993

[Poli 96] *Optimun Segmentation of Medical Images with Hopfield Neural Networks*. Poli y Valli. CSRP-95-12. School of Computer Science. The University of Birmingham.

[Shie 95] *A method for fuzzy rules extraction directly from numerical data and its application to pattern recognition.* Shiego Abe and Ming-Shong Lan. IEEE Trans.on Fuzzy Systems, Vol.3,nº 1, Febrero 1995.

[Simp 92] *Fuzzy min-max neural networks - Part1 : Clasification*. P.Simpson. IEEE Trans.Neural Networks, Vol3, pp 776-786,1992

[Simp 93] *Fuzzy min-max neural networks – Part2 : Clasification*. P.Simpson. IEEE Trans.Neural Networks, Vol1, pp 32-45,1993

[Torb 98] *A new neural network for cluster-detection-and-labeling*. Torbjorn Eltoft. IEEE Transactions on Neural Networks, Vol. 9, nr. 5, pp 1021-1035. 1998

[Valli 98] *Neural Networks and Prior Knowledge Help the Segmentation of Medical Images*. Valli, Poli, Cagnoni and Coppini. Journal of Computing and Information Technology, Vol.6 Nº 2. 1998