# Artificial Intelligence in Computer-Aided Diagnosis



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## INTRODUCTION

Professionals of the medical radiology area depend directly on the process of decision making in their daily activities. This process is mainly based on the analysis of a great amount of information obtained for the evaluation of radiographic images.

Some studies demonstrate the great capacity of Artificial Neural Networks (ANN) in support systems for diagnosis, mainly in applications as pattern classification.

The objective of this article is to present the development of an ANN-based system, verifying its behavior as a feature extraction and dimensionality reduction tool, for recognition and characterization of patterns, for posterior classification in normal and abnormal patterns.

## BACKGROUND

The computer-aided diagnosis (CAD) is considered one of the main areas of research of the medical images and radiological diagnosis (Doi, 2005).

According to Giger (2002) "In the future, is probable that all the medical images have some form of executed CAD to benefit to the results and the patient cares".

The diagnosis of the radiologist is normally based on qualitative interpretation of the analyzed data, that can be influenced and be harmed by many factors, as low quality of the image, visual fatigue, distraction, overlapping of structures, amongst others (Azevedo-Marques, 2001). Moreover, the human beings possess limitations in its visual ability, which can harm the analysis of a medical image, mainly in the detection of determined presented patterns (Giger, 2002).

Research demonstrates that when the analysis is carried out by two radiologists, the diagnosis sensitivity is significantly increases (Thurfjell *et al.*, 1994). In this direction, the CAD can be used as a second specialist, when providing the computer reply as a second opinion (Doi, 2005).

Many works analyze the radiologist performance front the use of a CAD systems, of which we detach the research of Jiang *et al.* (2001) and Fenton *et al.* (2007).

In the development of CAD systems, techniques from two computational areas are normally used: Computer Vision and Artificial Intelligence.

From the area of Computer Vision, techniques of image processing for enhancement, segmentation and feature extraction are used (Azevedo-Marques, 2001).

The enhancement objectives to improve an image to make it more appropriate for a specific application (Gonzalez & Woods, 2001). In applications with digital medical images, the enhancement is important to facilitate the visual analysis on the part of the specialist.

The segmentation is the stage where the image is subdivided in parts or constituent objects (Gonzalez & Woods, 2001). The result of the segmentation is a set of objects that can be analyzed and quantified individually, representing determined characteristic of the original image.

The final stage involved in image processing is the feature extraction, that it basically involves the quantification of elements that compose segmented objects of the original image, such as size, contrast and form.

After concluded this first part, the quantified attributes are used for the classification of the structures identified in the image, normally using methods of Artificial Intelligence. According to Kononenko (2001), the use of Artificial Intelligence in the support to the diagnosis is efficient, for allowing a complex data analysis of simple and direct form.

Many methods and techniques of Artificial Intelligence can be applied in this stage, normally with the objective to identify and to separate the patterns in distinct groups (Theodorides & Koutroumbas, 2003), for example, normal and abnormal patterns. According to Kahn Jr (1994), among the main techniques, can be

cited: rule-based reasoning, artificial neural networks, bayesian networks, case-based reasoning. To these, the statistical methods, the genetic algorithms and the decision trees can be added.

A problem that reaches most of the applications of pattern recognition is the data dimensionality. The dimensionality is associated with the number of attributes that represent a pattern, that is, the dimension of the search space. When this space contains only the most relevant attributes, the classification process is faster and consumes little processing resources (Jain *et al.*, 2000), and also allows for greater precision of the classifier.

In the problems of medical image processing, the importance of the dimensionality reduction is accentuated; therefore normally the images to be processed are composed of a very great number of pixels, used as basic attributes in the classification.

The feature extraction is a common boarding to effect the dimensionality reduction. Of general form, an extraction algorithm creates a new set of attributes from transformations or combinations of the original set.

Some methods are studied with the intention to promote the feature extraction and, consequently, the dimensionality reduction, such as statistical methods, methods based on the signal theory, and artificial neural networks (Verikas & Bacauskiene, 2002).

As example of the use of artificial neural networks in the support to the medical diagnosis, we can cite the research of Papadopoulos *et al.* (2005) and André & Rangayan (2006).

## MAIN FOCUS OF THE ARTICLE

In this paper, we also present a proposal of use of Artificial Intelligence in the stage of feature extraction, substituting the traditional techniques of image processing.

Traditionally, the feature extraction is carried out on the basis of statistical or spectral techniques, which result in, for example, texture or geometric attributes.

After these attributes are obtained, techniques of Artificial Intelligence are applied in the pattern classification.

Our proposal is the use of ANN also for feature extraction.

## Feature Extraction with ANNs

The feature extraction with the use of Artificial Neural Networks functions basically as a selection of characteristics that represent the original data set.

This selection of characteristics is related to a process in which a data set is transformed into a space of characteristics that, in theory, accurately describes the same information as the original space of the data. However, the transformation is projected in such a way that the data set is represented by a reduced effective characteristic, keeping most of the intrinsic information to the data, that is, the original data set suffers a significant dimensionality reduction (Haykin, 1999).

The dimensionality reduction is extremely useful in applications that involve digital image processing, which normally depend on a very high number of data points to be manipulated.

In summary, the feature extraction with ANNs transforms the original set of pixels into a map, of reduced dimensions, that represents the original image without a significant loss of information.

For this function, self-organizing neural networks are normally used, as for example, the Kohonen's Self-Organizing Map (SOM).

The self-organizing map searches ways to transform one determined pattern into a bi-dimensional map, following a certain topological order (Haykin, 1999). The elements that compose the map are distributed in an only layer, having formed a grid (Figure 1).

*Figure 1. Illustrative representation of a Kohonen's self-organizing map*