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NEURAL NETWORKS SKIN TUMOR DIAGNOSTIC SYSTEM

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ABSTRACT

In this study, a malignant melanoma diagnostic system is designed using a straightforward neural network with the back-propagation learning algorithm. Eleven features are automatically extracted from skin tumor images. The correct diagnostic rate of this system is better than the average rate of 16 dermatologists who based their diagnosis with only the slide images.

1. INTRODUCTION

The mortality from melanoma has increased in recent years, especially in white males [1], possibly as a result of increased recreational exposure to sunlight. In 1991, about 32,000 new cases of malignant melanoma were diagnosed with approximately 80% of patients surviving five years [2]. Even malignant melanoma is curable if treated prior to the onset of the vertical growth phase with its metastatic potential [3]. Therefore, there has been a rising interest in the automated detection and diagnosis of skin cancer in recent years, particularly malignant melanoma [4].

Melanoma cells usually continuously produce melanin, which cause the cancers to appear in mixed shades of tan, brown and black (in variegated coloring). It has a tendency to spread, therefore early detection and treatment are important

2. SUGGESTED FEATURES FOR THE NEURALNETWORK DIAGNOSTIC SYSTEM

Eleven features are extracted from skin tumor images. They are

- Irregularity
- Asymmetry index
- Average red, green, and blue inside the tumor
- Colorbin
- Variance of Local Average Color for RGB.
- Area and Elevation (manually estimated).

These features form a feature vector with eleven variables. The features were calculated or manually estimated from each of the skin tumor images, and they are the inputs to the neural network diagnostic system discussed in the next section.

2.1. Irregularity

In this study, the irregularity is defined as:

$$I=P^2/(4\pi A)$$

Where P is the perimeter of the tumor in pixels and A is the area of the tumor in pixels. For an ideal circle, the index is one, which indicates a perfectly regular shape. Most melanomas have a high irregularity index. However, there is a significant portion of benign tumors, which also have high irregularity indices. Therefore, irregularity index alone is not considered to be sufficient for discriminating melanoma from other tumor categories.

2.2. Asymmetry Index

The asymmetry index is computed by first finding the principal axis of inertia of the tumor shape in the tumor image. It is obtained by overlapping the two halves of the tumor along the principal axis of inertia and dividing the non-overlapping area differences of the two halves by the total area of the tumor.

2.3. Area and Elevation

Unlike all the other shape and color features, these two features are not calculated by computer. They are provided by a dermatologist. The area index equals one if the area of the tumor is estimated as greater than or equal to 6mm, otherwise it is zero. The elevation index equals one if the elevation of the tumor is estimated to be greater than or equal to 2mm, otherwise it is zero.

2.4. Colorbin

McLean [5] presented the idea of colorbin, which is defined as the percentage of the malignant melanoma colored foreground pixels. The object (like hair, nose, eye etc.) contamination can be removed if all the objects are segmented automatically or manually. The colorbin feature, however, provides a solution to reduce the object contamination without further segmentation of all the foreground and background objects.

2.5. Variance of Local Average Color

Three features based on first-order statistics of local properties are suggested. Local average colors are chosen to represent the local properties of tumor regions. The features are called variance of local average colors. To calculate these features, first, the area inside the tumor border was split into small blocks. The average red, green, and blue were calculated for each block, and then the variance of the average color is calculated. These three features represent the uniformness of the tumor colors. If the variance is low, then the colors are more consistent throughout the tumor.

3. RESULTS OF NEURAL NETWORK DIAGNOSTIC SYSTEM

The results of three experiments are reported in this paper. The investigation uses a straightforward neural network with a back-propagation learning algorithm and a hyperbolic tangent transfer function for each perceptron. The network has 11 nodes in the input layer, 22 nodes in the first hidden layer, 8 nodes in the second hidden layer, and 1 node in the output layer. The experiment is done using the neural network simulation package "NWORKS".

First, a set of 66 slides are given to a group of 16 dermatologists, and their average diagnosis accuracy rate is compared to the performance of the neural network. Second, the system is tested using a larger 300-image set. For each test, 50% of the images are selected randomly as the training set, with the other 50% used as the testing set.

Table 1 shows the diagnostic result of the neural network based on the automatically detected border [6]. Table 2 shows the diagnostic result of the neural network based on the manual border, which are drawn under the supervision of a dermatologist. Table 3 shows the diagnostic result of the neural network based on the automatic border.

Table 1. Diagnostic Results

Total image	Correct diagnosis	Correct percentage
66	61	92

Table 2. Diagnostic Result Using Manual Border

Total image	Malignant melanoma		Benign	
	Correct	Wrong	Correct	Wrong
277	115	30	126	6

Table 3. Diagnostic Result Using Automatic Border

Total image	Malignant melanoma		Benign	
	Correct	Wrong	Correct	Wrong
226	92	27	98	9

For the smaller 66 skin tumor image set, the neural network has a better performance than the average correct rate of the 16 dermatologists, who also based their diagnosis with only the slides. The average correct diagnostic rate for the 16 dermatologists is 81%.

For the larger images set, although using manual borders has slightly better result than using automatic borders, the result from automatic borders is close to the result from manual borders. It also demonstrates the usefulness of the automatic border detector.

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