Detection of Skin Neoplasia by Fractal Analysis of 2D Images and Microtopography Maps

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Abstract: Early detection of skin cancer is fundamental to its successful treatment. Changes in the shape, including the relief, of skin lesions are an indicator of a possible malignancy l and image processing optical microtopographic inspection of skin lesions can be used to identify diagnostic patterns of benign and malignant skin lesions. Statistical parameters like the mean roughness (Ra) may allow the discrimination between different types of lesions and degree of malignancy. Fractal analysis of bi-dimensional and 3D images of skin lesions can validate or complement this assessment by calculation of its fractal dimensions (FD). In the study reported herein, the microtopographic inspection of the skin lesions was performed by using the optical triangulation based microtopographer developed at the Physics Department of the University of Minho, MICROTOP.03.MFC. Images of the skin lesions were digitized and processed in order to calculate fractal parameters. The patients that participated in this research study were men and women older with the clinical and histopathology diagnoses of: melanoma, basocellular carcinoma, epidermoide carcinoma, actinic keratosis, keratoacantosis and benign nevus.

1. Introduction

The number of cases of skin cancer, in relation with other types of cancers, increases significantly every year [1]. In the period between 1992 and 1996 Mexico had the highest frequency rate in previous decades [2,3]. A 20% growth in number of cases between 1996 and 2006 was registered in Portugal with a rate of incidence of melanoma of 2.8 with respect to the other located neoplasms. In Mexico and Portugal the common types of cancer of the skin are: (BCC) Basal Cell Carcinoma, followed by the (SCC) Squamous Cell Carcinoma and the Malignant Melanoma (MM) [2,3].

In general the different types of skin cancers in early stages have a good prognosis if an early and reliable diagnose is made. A false diagnose of skin cancer in any of its varieties has serious repercussions in the patient's survival probabilities.

An early detection of the different forms or skin cancer is fundamental to a successful treatment. Several clinical diagnoses exist. Visual observation and follow up by trained specialists are the most common early evaluation procedure. This procedure can also be performed in automated ways. Changes in the color size and shape of skin mark are the typical sign of alert as are changes in skin texture and relief (topography). However, this is not as easily performed. Thus, we have proposed the use of optical microtopographical inspection [4] of skin lesions for the diagnosis of patterns of benign and malign skin' lesions [3]. On the other hand, it has been demonstrated that tissues of the human body show a fractal structure [5]. Therefore we suggest that both the fractal analysis [6-9] of histological slides and topographic maps will yield information meaningful to the characterization of the malignity of skin marks that could further improve the diagnosis by skin microtopographic inspection.

2. Method and Results

The microtopographical inspection of skin marks gives significant information about the degree of malignancy of skin cancer and type of lesion. The calculation of the fractal dimension both in 2D images of histological slides and relief maps, can be used to distinguish between healthy and malignant tissue in general, but not discriminate the different types of skin neoplasias. The combination of the rugometric evaluation and fractal geometry characterization provides valuable information about the malignity and type of skin lesions allowing an earlier diagnosis.

From the microtopographical inspection of cancerous skin, characteristic information could be obtained that enables differentiation among the types of lesion studied. For the melanoma it was observed that on average these tumors show a roughness increased by 67% when compared to the roughness of healthy skin. These measurements allow them to be distinguished clearly from other tumors as in the case of the basal cell carcinoma (49%) and benign lesions like the epidermoid cyst (37%) and the seborrhea keratosis (4%).We also observed that when the tumor is bigger and rougher it is more malignant.

The mean fractal dimension [8,9] of the histological slides was found to be 1.081±0.070 in healthy skin and 1.341±0.086 in malignant neoplasias. For the relief maps the mean fractal dimension was 2.221±0.070 for healthy skin and 2.961±0.040 for malignant neoplasia. The difference between the healthy skin and the malignant one was in both cases significant, $p \leq 0.001$ and $p \leq 0.007$, respectively.

Goldberger and co-workers9 demonstrated that the tissues of the human body show a fractal structure and revealed that as the human being goes older the fractal structure is lost. Naeim and co-workers [8] suggested a decrease in the FD of bone marrow hypocellularity. This means that if we have a bigger FD more complex the tissue will be and vice-versa. The FD of a malignant neoplasia was significantly greater than that of benign neoplasia when compared with their healthy control. This suggests that a cancerous process breaks with the cellular homeostasis, raising the FD of the tissue.

2. Conclusions

The microtopographical inspection of skin moulds and marks gives significant information about the degree of malignity of skin cancer and type of lesion. The calculation of the fractal dimension both in 2D images of histological slides and relief maps can be used to distinguish between healthy and malignant tissue in general but not discriminate the different types of skin neoplasias. The combination of the rugometric evaluation and fractal geometry characterization provides valuable information about the malignity and type of skin lesions allowing an earlier diagnosis.

The combination of the rugometric evaluation and fractal geometry characterization, both 2D and 3D, provides valuable information about the malignancy of skin lesions and type of lesion.

3. References

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