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**Classification of cancer and pre-cancer skin images using 1D texture signatures**

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This work presents a methodology for the classification of images of five skin lesions: actinic keratosis, melanoma, basal cell carcinoma, squamous cell carcinoma and intraepithelial carcinoma. 1D texture signatures are used in the classification space. The classification space is generated with the vector support machine technique. The methodology obtained 98% accuracy, 98.04% sensitivity, 99.51% specificity and 98.133% precision in the classification of 5000 grayscale images (1000 images per type of skin lesion). The problem-images present scale, rotation, translation, perspective transformations and elastic deformations.

Keywords: 1D signatures; texture analysis; pattern recognition; grayscale images; skin lesions.

Topic Code: Image processing, vision and artificial intelligence

## Introduction

According to Theodoridis [1] pattern recognition is a scientific discipline whose objective is the classification of objects in many categories or classes. However, one of the challenges present in this area is the extraction of the relevant characteristics of the objects to be classified. The feature extraction in carcinogenic images of the skin is a great challenge given the nature of these, like texture, diffuse edges, and low contrast of tonalities [2].

In this work, we present an image classifier of carcinogenic lesions of the skin: actinic keratosis, melanoma, squamous cell carcinoma, basal cell carcinoma, and intraepithelial carcinoma. The United States had 85 million cases of some skin lesion in 2013. It generated 75 billions of dollars in treatments [3]. In Australia, the incidence of carcinogenic skin diseases were 2000 cases per 100,000 inhabitants [4]. In Mexico, skin cancer is the second most common type of cancer [5]. Therefore, these methodologies are useful tools to dermatologists in decision-making for prevention.

## Methodology

### The 1D Haralick signature

In this work, 10 out of 28 textural features proposed by Haralick et al. are used [6]. Also, it is utilized the four main gray-tone spatial-dependence matrices: 0, 45, 90 and 135 degrees, named $P_0, P_{45}, P_{90}, P_{135}$, respectively. The textural features employed are: autocorrelation, contrast, correlation, energy, entropy, homogeneity, maximal probability, sum average, variance and sum variance, called $c_1, c_2, \dots, c_{10}$, respectively. For each matrix, the 1D Haralick signature is constructed like $H_j = [c_{j1}, c_{j2}, \dots, c_{j10}]$, $j = 0, 45, 90, 135$. The signature of the image is the cumulative sum $S_H(k) = \sum_{p=1}^{k} f(p)$, $k = 1,2, \dots 40$, where $f = [H_0, H_{45}, H_{90}, H_{135}]$ ; hence $S_H$ is a 40-length vector.

### The 1D fractal signature

Florindo et al. [7] built 1D fractal signatures using triangular prisms. They employed square windows of odd size and length $\epsilon$ departures from the coordinate $(i,j)$ of the grayscale image (in our case the images are $256 \times 256$ pixels). So, the triangular prism has coordinates: $(i,j,I(i,j))$, $(i+\epsilon,j,I(i+\epsilon,j))$,$(i,j+\epsilon,I(i,j+\epsilon))$,$(i+\epsilon,j+\epsilon,I(i+\epsilon,j+\epsilon))$,$\left(i+\frac{\epsilon}{2},j+\frac{\epsilon}{2},\gamma\right)$, $\gamma = \frac{I(i,j)+I(i+\epsilon,j)+I(i,j+\epsilon)+I(i+\epsilon,j+\epsilon)}{4}$. Next, the area $A_q$ of the four triangular faces of the prism are calculated to obtain $s_{i,j} = \sum_{q=1}^{4} A_q$. The 1D fractal signature is given by $s^{\alpha}(\delta) = \sum_{i=1}^{M-\epsilon}\sum_{j=1}^{M-\epsilon} s_{i,j}^{\alpha}(\delta)$, $\epsilon = \lfloor 2^{\delta} \rfloor$, $\delta = 1,2, \dots, log_2(256)$, $\alpha \in \mathbb{R}^+$. In this proposal $\alpha = 1.3$ and the 1D fractal signature of the image is the cumulative sum of $s^{\alpha}(\delta)$, that is $S_F(\delta)$=$\sum_{p=1}^{\delta} s^{\alpha}(p)$, $\delta = 1,2, \dots 8$; hence $S_F$ is an 8-length vector.