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"Assessing the Hallmarks of Psoriasis by using Visible and Thermal Imaging"

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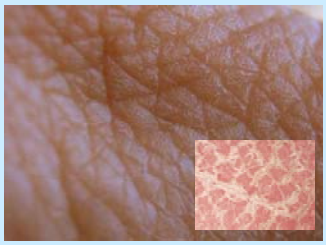
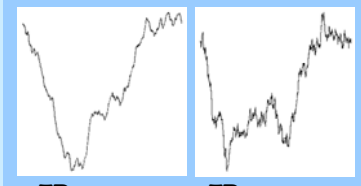
Human skin has a particular fractal-like pattern, both in colour and texture. This is due to thin ditches that intersect, the characteristic rhomboidal network, pores and hair of different size, thickness and density.



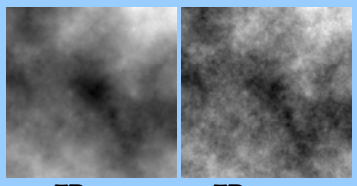
Fractal dimension (FD) is a real number that captures the complexity of a fractal object. We claim that this number is capable to characterize the hallmarks of the psoriatic lesions and implicitly their severity, and therefore it can be used to objectively assess the effectiveness of a dermatological treatment. Our goal is to create a system to be used in every day clinical practice, able to quantify the severity of lesions of psoriasis in a fast and meaningful way. In the next images, generated random fractals (1D, 2D and 5D) of different complexity are presented, in order to grasp the idea of increased complexity for grey-level and colour images.

1D random fractals



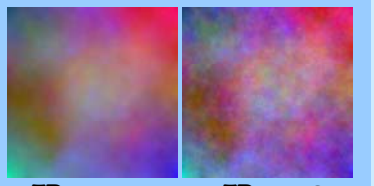
FD=1.05 FD=1.45

2D random fractals



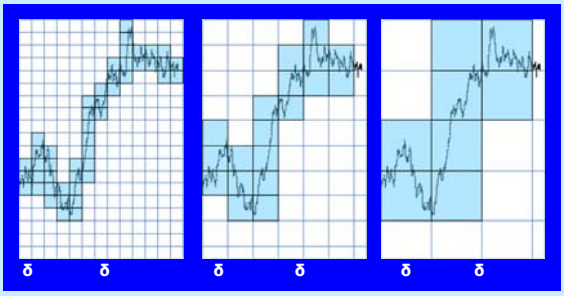
FD=2.1 FD=2.5

5D (colour) random fractals



FD=2.237 FD=3.258

The prototype system consists of a digital camera and a personal computer running a software application that implements the computation of the fractal dimension for colour fractal images. We briefly present the algorithm used to estimate the Box-Counting FD for a 1D fractal. For different box-sizes (δ), count how many boxes ($N(\delta)$) are needed to cover the object, then the FD is estimated as the slope of the regression line through the points $\langle \log(\delta), -\log(N(\delta)) \rangle$ (see the example from the right side).
Our approach is a colour extension of the Voss probabilistic (box-counting like) method. We consider the colour images of psoriatic lesions as 5D objects (pixel's spatial coordinates + colour: Red (R), Green (G) & Blue (B)) and, instead of boxes, we use hyper-cubes in the (x,y,R,G,B) space.



We present several images of psoriatic lesions of different severity, together with the erythema, the scaliness, the thickness and the overall severity subjectively estimated by the dermatologist, and the fractal dimension computed for each image by using our approach.

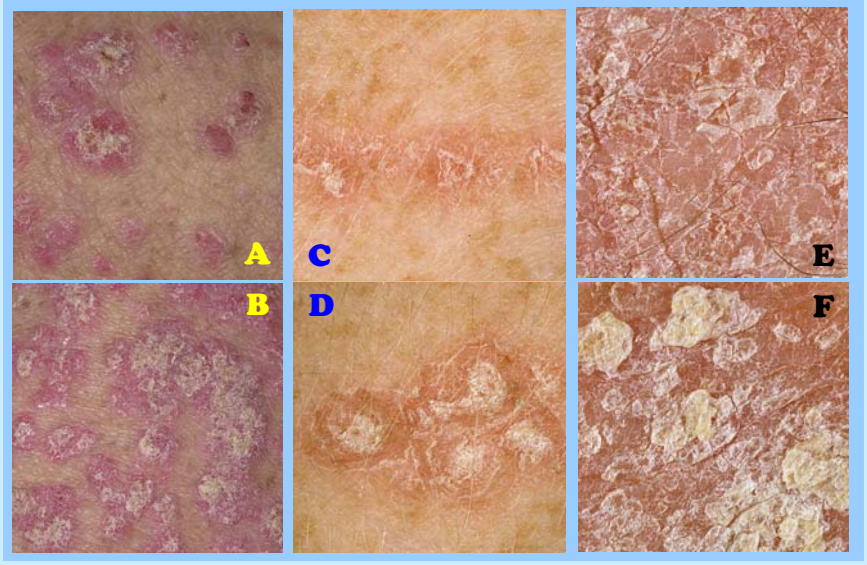


image	A	B	C	D	E	F
FD	3.16	3.33	3.64	3.78	3.88	3.99
erythema	3	3	1	2	2	3
scaliness	1	2	1	2	2	3
thickness	3	3	0	2	1	1
severity	2	3	1	2	1	2

Thermal imaging is an alternative approach able to reveal useful information for the characterization of the lesions and their severity, based on the assumption that the temperature at the surface of the psoriatic lesions is due to the accelerated keratinocyte turn-over, therefore directly linked to the severity. Currently, we investigate the correlation between the complexity of the image in the visible spectrum and the complexity of the temperature map.

We conclude that the fractal dimension is appropriate to objectively characterize the psoriatic lesions, and that it is capable to reflect the relative degree of severity. Our future plans include running extensive tests on a larger data-base of digital images representing psoriatic lesions, in parallel with a clinical study, in order to statistically prove the effectiveness of our approach. We also plan to develop a new approach for computing the fractal dimension regardless of the variations of illumination.