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2D Fr-An: A Friendly Interactive Matlab® Based Software for 2D Fractal Analysis of Closed Domain Clusters

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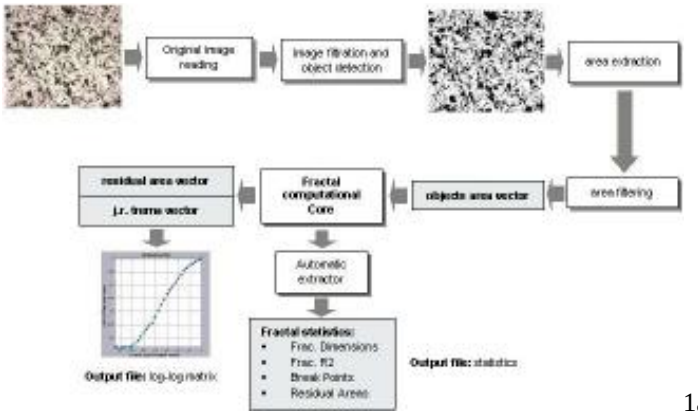
2D-FrAn is a tool developed to study the fractal characteristics [1] of two-dimensional objects (closed domains) distribution in a limited available 2D-space (analysed image field) [2]. It can provide: i) single (interactive) sessions of analysis for any binarized image (BMP, TIFF, JPG) or ii) continuous (batch) processing of a set of images supplied to the analyser through retrieving actions from an image data base previously built. To perform the extraction of the different fractal parameters, several information must be supplied to the algorithm, that is: i) in-out data files name and extension; ii) image tuning parameters (thresholding value, gamma, brightness and contrast levels); iii) data for the computation of the 2D-fractal core algorithm (total image area, background connectivity, etc.) and iv) regression method selection to perform the analysis starting from the fractal plot. This latter aspect is one of the most critical of the entire procedure, being addressed to define the algorithmic architecture to process the data in order to identify the correct fractal parameters. It this perspective an automatic extraction procedure of the fractal parameters, able to avoid a "subjective interpretation" of the Richardson plot, was designed. An "extractor" was developed to find: i) whether, or not, in the log-log plots are present straight lines (fractal); ii) the maximum number of detectable fractal ranges and, finally, iii) the precision of the computed parameters (expressed with their standard deviation). Two regression methods have been implemented and tested during the study, that is : i) maximization of the Pearson determination coefficient (R^2) method and ii) Hough Transform method. The regression method that allowed to reach results closer to the manual regression, that is the interpretation performed by the expert, was the that based on Pearson approach.

The *2D-FrAn* architecture (Figure1) was developed inside Matlab® 6.0 through the definition of a suitable Matlab® script and can be executed from the Matlab® prompt window. *2D-FrAn* uses some functions included in the Matlab® Image Processing Toolbox that must be installed along with Matlab® 6.0. It provides also a simple user-interface window (Figure 1), that allows the user to furnish the whole set of operative parameters and to visualise on-line results in terms of 2D-fractal dimensions, their precision and the log-log plot (Richardson plot). *2D-FrAn* tool was specifically and successfully developed to perform the analysis of microscopic images of fine and ultra-fine particles (Figure 3), where at the most only two fractal dimensions are usually detectable. It was aimed to detect the extension of the medium fractal range and then, the upper one, as complementary to the lower one.

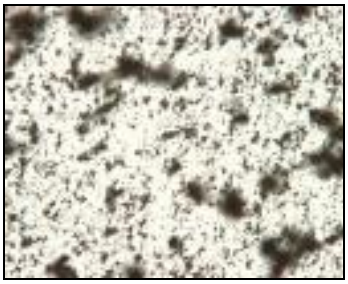
[1] B.B. Mandelbrot, The Fractal Geometry of Nature, W.H. Freeman &Co., San Francisco, (1983).
[2] B.H. Kaye: "A random walk through fractal dimensions" - VCH Publishers, Weinhein, 1989.
[3] G.Bonifazi, A.D' Addetta, 2D-Fractal Analysis of Respirable Dust Fraction: Theoretical Aspects and Applications. Third International Conference on Intelligent Processing and Manufacturing of Materials: IPMM 2001, Richmond, British Columbia, Canada (2001).



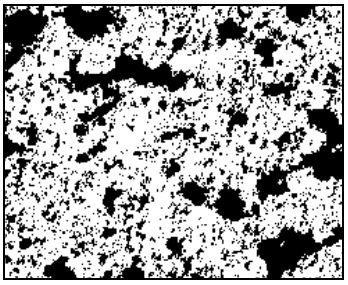
1a

1b

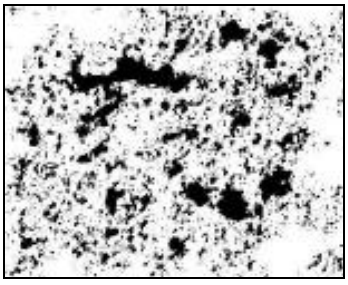
Figure 1 – 1a: Flow-sheet of *2D-FrAn* (2D-Fractal Analyzer) extractor algorithm. 1b: Matlab® 6.0 user-interface of *2D-FrAn* (2D-Fractal Analyzer) extractor algorithm. Different input ranges are expected for the different fractals in the image. Fractal dimension is calculated from the slope of the interpolating straight line.



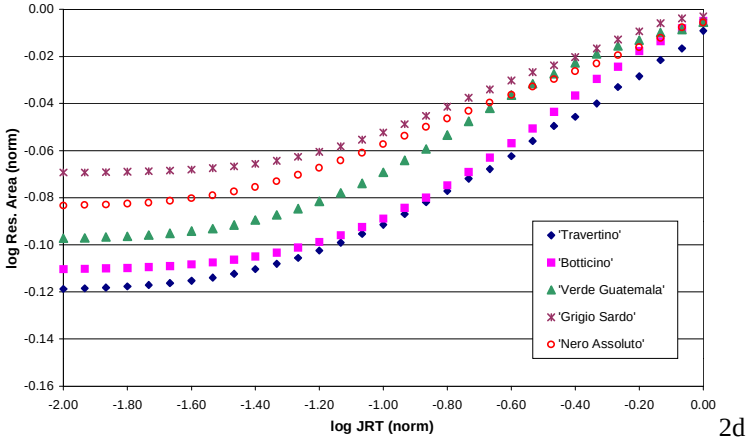
2a



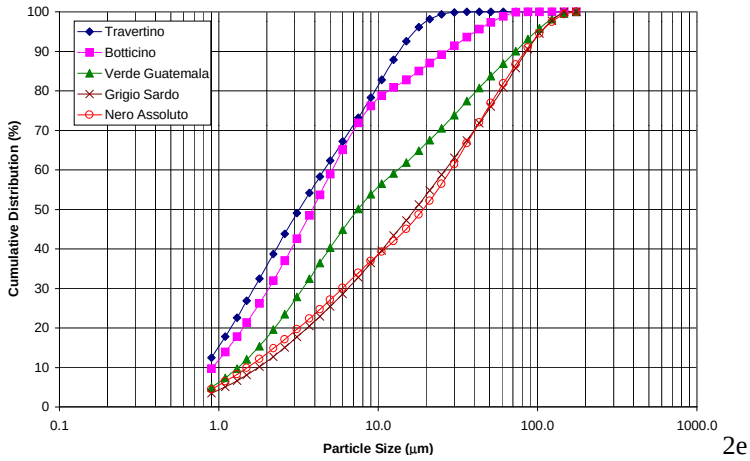
2b



2c



2d



2e

Figure 2 – Image sequence of Travertino stone fine particles population after milling. 2a: source image; 2b: binarized image; 2c: final resulting border-cleaned image, utilized to perform the fractal analysis; 2d: Richardson plot and 2e: corresponding size class distribution, laser diffraction based, of 5 the ultra-fine particles population of the 5 milled selected stones. The correlation factor driven out in the analysis, shows a good performance in the classification of the materials.

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