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Fractal Vision in Characterizing a Digitized Image

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Abstract

In non-destructive evaluation, it is often necessary to characterize a digitized image in identification of inserts, if any. Fractal theory can be successfully employed in quantitative assessment of digital images. The word *fractal* was first coined by Mandelbrot [1] and according to him, the fractal is a “shape made of parts similar to the whole in some way.” The defining parameter of a fractal is the fractal dimension. In respect of a two-dimensional (2-D) digitized surface, the fractal dimension corresponds quite closely to our intuitive notion of roughness. An N by N two-dimensional digitized image contains N^2 pixels, each of which has an individual intensity value attached to it. A 3-D representation of this 2-D image may be conceived by incorporating the third dimension as the intensity of each pixel. Therefore, a 2-D image with different intensity values on its pixels may be thought as an imperfect cube (i.e., a cube with dents) whose fractal dimension should lie between 2 and 3. A digitally rough surface will have a smaller fractal dimension while an image with constant intensity is similar to a cube with no dents and the corresponding fractal dimension will be 3 as per definition.

In the present investigation, fractal theory has been employed to characterize 2-D digitized images in detection of inserts. Following the algorithm proposed by Bhatt et. al. [2], fractal dimensions are computed from the slope of the best line fit (in a least square sense) of the fractal graphs of the images. To demonstrate the utility of the fractal concepts, a 30 by 30 pixel (in all 900 pixels) domain having an insert spread over a region of 8 by 8 pixels is considered. The average intensities of the parent domain are in the range of 32-38 while the same for the pixels representing the insert are in the range of 168-180 in the 0-255 grey scale. The grey intensity values were obtained after taking image of the part of a strip containing square pills by a CCD camera, and digitizing the image by a Matrox board. Once the intensities of the pixels pertaining to the parent domain and the insert are obtained, several other domains with different positions of the insert are simulated.

The fractal analysis shows that it can clearly distinguish between the domains with and without insert. Interestingly, the fractal dimension is not only dependent on the relative size and intensities in the insert region, but it is also sensitive to the relative position of the insert. Different domains are considered in which the insert is shifted along the diagonal and any edge of the domain. Curves depicting variations of the fractal dimensions for different positions of the insert are obtained and they may be used as guidelines in identifying inserts in a digitized domain.

References

1 Mandelbrot B.B., 1982, The Fractal Geometry of Nature, Freeman, San Francisco.
2 Bhatt V., Munshi P. and Bhattacharjee J.K., 1991, Application of fractal dimension for non-destructive testing, Materials Evaluation, Vol., 49, pp. 1414-1418.

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