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An extended DBC approach by using maximum Euclidian distance for fractal dimension of color images

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ABSTRACT

The Fractal Dimension (FD) of digital image represents the roughness in terms of real number with self similarity property in order to correlate with human perception of surface roughness. FD has broadly adopted in various kinds of applications in different field of computer graphics and image processing such as texture analysis, classification, segmentation and many more that establish in various literatures. For estimating FD there are several techniques were presented in gray scale domain, out of which differential box counting (DBC) is repeatedly used algorithm, but in case of color domain there are few and countable research has been done because the natural color images exhibits a non trivial and self-similar and scale invariance feature. This article presents a new color FD estimation algorithm by extending original DBC algorithm by implementing maximum color Euclidian distance from each non overlapping box block of RGB components. All the experimental work has been made on one set of standard brodatz color texture images and one set of known fractal dimension smooth color images used for showing feasibility of the proposed technique. The experimental result proved that the proposed algorithm efficiently captures the surface roughness of RGB color images. The computational time of this proposed method yields quit less than that of other existing algorithms. This is more reliable and precise method for color images.

1. Introduction

The natural objects surrounded to us are so complex and irregular pattern and that could be characterised by fractal geometry based on the property of self similarity. When each scaled part of an object are said to be self-similar if and only if, each scaled part is statistically alike to itself. The word fractal was initially derived by Mandelbrot [1] from the Greek word "fractus". The meaning of Factus called broken to create different models of fractal and model the different shapes using fractal geometry. Initially Mandelbrot describes mountains are not cone or sphers, similarly clouds are not cone or spheres, and coast lines are not circles, and skin is not treated as smooth surface. Hence the object like spheres, cones, and circle can be represented by Euclidian geometry whereas objects like cloud, mountain, coast line and any other natural features are very difficult to analysis by Euclidian geometry reported by [2–4]. Hence FD concept given its importance in order to represents these complex objects. Fractal based research has been extensively applied not only in image processing field like texture

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analysis [5–7], biometric [8,9], image segmentation and classification [10–13], but also in other field of applications such as stock market prediction, finance support analysis, other engineering applications [14]. Since the formulation of fractal concept, several estimating techniques have been suggested in response to box counting (BC) and its improved version techniques like DBC, relative DBC, improved DBC, improved BC [15]. Most of the researchers preferred these box counting techniques in numerous applications because it's quit easy for implementation and reliability [16–19]. In context to box counting and its improved version techniques in gray scale domain, Gangepain [20] suggested reticular cell counting method and Keller et al. [21] provided probabilistic box counting theories. Sarkar and Chaudhuri [22] suggested DBC approach for statistical similarity pattern by introducing reduction factor r. This DBC was considered an efficient method found in many literatures [16,17,23]. In line to DBC, Jain et al. [17] presented improve box counting techniques in order to flush out three major drawback related to DBC such as incorrect of choosing box height, box number calculation and partition of image intensity surface. In 2014 improved DBC was recommended [23] in order to remove another two problems related to DBC such as over-counting and under-counting problem. Nayak et al. [24] suggested more accurate estimation at each box scale by modifying appropriate height of DBC. Again Nayak et al. [25] suggested modified DBC and address three issues that persists with DBC, such as failed to capture minimum roughness variation, provides more computational error, and failed to give similar FD on same degree of fractal images. In response to DBC, Nayak et al. [26] suggested improved triangle BC by dividing the square grid into two triangle pattern for more accuracy in box count and shifted the grid in spatial plain in order to eliminate the two problems founds in [23]. After analysing the above literatures finding, we have observed that most of the techniques are presented on the basics of DBC approach in gray scale domain. However, our intention in this paper is to estimate FD of RGB color images. In this context very few and countable research has been made because the natural color images exhibits a non trivial and self-similar and scale invariance feature [27,28]. In color domain, Initially Ivanovic and Richard [29] has suggested color FD technique based on existing probability box counting technique in terms of 5D vector and recommended the FD range should varies between 2–5. In response to this same 5D vector, Nikolaidis et al. [30] suggested alternative color estimation technique based on the same box counting algorithm. Likewise, Nayak et al. [31] recommended color FD estimation by using DBC approach in terms of average (pixel) intensity value from individual RGB color channel. Similarly, Nayak and Mishra [32] suggested one more color estimation technique by implementing improved DBC [23] by means of same 5-D vector with addition of surface smoothness deduction technique. Zhao and Wang [33] recently suggested color estimation approach using modifying improved box counting technique [17] by employing maximum color distance in terms of hyper surface partition technique. Recently Nayak et al. [34] gave an interesting concept based on the ground truth experimental investigation on similar kinds of texture images, and finally produced the more impressive theory by using CIE based human perception model. In recent year, Nayak et al. [36] presented the prominent color FD estimation technique by imlemented box counting technique, and statistically proves that this proposed technique gives better performance as compared to state of the art technique. Moreover, the FD estimation of RGB color images is quiets a big challenges because the natural color images exhibit a nontrivial self-similar or scale-invariant feature. From the above literature analyses, we have observed that none of the existing techniques are used Euclidian distance measure in color domain. This article presents the new version of the color FD estimation by extended the original DBC approach by taking Euclidian distance from each RGB component, which was widely used in gray scale domain. For experimental analysis we have considered only two existing technique (USDBC, BM) but we have not considered the color probability box counting algorithm because previously original DBC has already reported the drawbacks of probability box counting which was discussed in earlier section. Our proposed method consider an image of size M × M and partitioning the image into non-overlapping block; from each block we will calculate Nr by taking Euclidian distance from each RGB component. The accuracy of the proposed method is verified and comparative results are given.

The reminder of this article are organised as follows. Firstly we briefly discuss about basic fractal dimension measurement and DBC related work. In subsequent sections we will discuss regarding our proposed methodology and experimental result discussion and in last section we have presented concluding remark, respectively.

2. Materials and methods

There are several dimensions are exists in order to represent fractal dimension in the area of computer graphics and image processing, which was termed as Hausdorff dimension, information dimension, packing dimension, box-counting (BC), differential box counting (DBC) and many more. Among which DBC was most popular and broadly used now a days in fractal geometry in order to represent self-similarity content. Generally this FD can be estimated by using the regression line of $log\ N_r(A)$ verses $\log(1/r)$ and mathematically this can be formulated as follows:

$$D = \log(N)/\log(1/r) \tag{1}$$

In this segment we have represented the detailed description of most well like DBC [19] approach, which was used in gray scale domain very frequently. In this case author took a square size image ($M \times M$) and scaled down into different size of grid ($L \times L$), and this L should be divisor of M and it must be varies between 2 to $M/2$. Then Each grid should holds the number of boxes ($L \times L \times H$), and this H specifies the height, this can be computed by means of: ($L \times G/M$). Here G represents