A MULTI-FOCUS IMAGE FUSION METHOD
based on Fractal Dimension and Guided Filtering

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ABSTRACT

Fractal Dimension (FD) is widely used for image segmentation because of its successful approach toward quantifying texture information. In this paper, we present a FD-based multi-focus image fusion method that utilizes FD to identify focused regions, as the primary step for the multi-focus image fusion process. The algorithm aims to extract the local FD features of each multi-focus pair estimated using the differential box-counting method. A guided filter is employed to further specify the spatial information and increase the robustness of the FD features to noise. The outcome would be analyzed to achieve a focus map that identifies sharp regions in each partially focused image. Afterwards, the detected regions are combined into a single all-focused image. The experiments, along with the objective assessments, demonstrate the competitive performance of the proposed method compared to several state-of-the-art multi-focus image fusion methods.

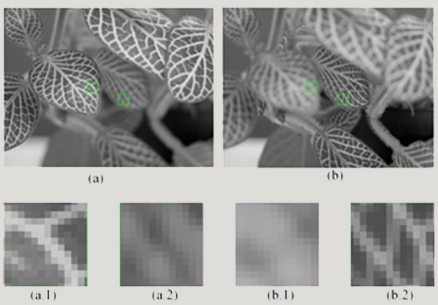
WHAT IS FRACTAL DIMENSION?

Fractal geometry, is able to describe self-similarity in irregular and complex objects in nature. Fractal Dimension (FD) is widely used to classify, analyze, and segment images due to its effective approach in representing surface roughness of digital images. Developments in estimating FD of an image led to the introduction of the Differential Box-counting (DBC) method by Sarkar et al. for estimating FD of gray-scale images, which is also employed in this paper [1]. First, a value is attributed to each pixel, representing the fractal dimension of its neighbouring pixels. Consequently, a matrix with the same dimension as the source image is formed, including local FD values of each corresponding area.

THE METHOD

A. Building FD Representing Matrix

Calculating the FD representing matrix for each of the partially focused images



B,C) Building and Refining the Focus Map

initial focus map (IFM) is built using the employment of a pixel-wise maximum rule on the corresponding FD matrices.

$$IFM(i,j) = \begin{cases} 1, & \text{if } FD_1(i,j) > FD_2(i,j) \\ 0, & \text{otherwise} \end{cases}$$

To further refine the segmentation and enhance the accuracy of the method, morphological opening and closing operators are applied to the initial focus map.

D) Obtaining Fused Images

using the obtained final map focused regions are extracted from each input image and integrated into the final fused image.

$$I_F(i,j) = FFM(i,j)\, I_1(i,j) + (1 - FFM(i,j))I_2(i,j)$$

SAMPLE RESULTS

PERFORMANCE OF FD BASED MULTI-FOCUS IMAGE FUSION ALGORITHM, APPLIED ON "FLOWER" IMAGE SET

(a) (b) (c) (d) (e)

(a),(b) Sample multi-focus images. (c) Initial Focus map. (d) Final focus map. (e) Fused fully focused image. Errors are specified (c) and their related regions in (a),(b).

References:

[1] N. Sarkar and B. B. Chaudhuri, "An Efficient Differential Box-Counting Approach to Compute Fractal Dimension of Image," IEEE Trans. Syst. Man Cybern., vol. 24(1), January 1994, pp. 115-120.