A Comparison of Iteration-free Bi-dimensional Mode Decomposition and Empirical Monocomponent Image Decomposition

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***Abstract*—This article describes the difference between iteration-free bi-dimensional mode decomposition and empirical monocomponent image decomposition, which are two recently published and very interesting papers, in terms of concept and their applications.**

I. Introduction

Image decomposition plays an important role in image analysis such as image denoising, image filtering, and related applications. The trend of recently proposed decomposition techniques has been focused on data-driven methods; i.e., these techniques do not need any prior functions for decomposition. Two recently published and very interesting papers were iteration-free bi-dimensional empirical mode decomposition (iBEMD) [1] and empirical monocomponent image decomposition (EMID) [2]. The iBEMD was originated from the classical empirical mode decomposition (EMD) introduced by Huang et al. [3]. It was strongly improved performance in terms of the computation time and decomposed image quality, thus making it practical for real applications. On the other hand, the EMID was originated from the empirical wavelet transform (EWT) proposed by Gilles [4] in 2013. It mainly improves quality of decomposed images or monocomponent images. Although both iBEMD and EMID are image decomposition techniques, they are rooted from the different concepts. Therefore, they always produce the different decomposed images and perhaps lead to different solutions for problem-solving. The following section describes the concept of both methods.

II. Analysis of iBEMD and EMID

This section briefly describes the evolutions of EMD and EWT, and analyze their extensions to the newest improved algorithms.

A. Iteration-free Bi-dimensional Mode Decomposition

An empirical mode decomposition (EMD) was first introduced by Huang et al. [3] in 1996 for non-linear and non-stationary signal analysis. Since then its extensions has been proposed for both 1D and 2D EMDs. The 2D EMD is also known as bi-dimensional empirical mode decomposition (BEMD). The most improvement of modified BEMDs: BEMD-RBF [5], FBEMD [6], FaBEMD [7], and MEMD [8] were proposed for different purposes. However, the computational cost of those BEMDs is very high [1]. Recently, iBEMD has been proposed by Titijaroonroj et al. for speeding up the computing time and for enhancing the decomposed image quality. The iBEMD was based on locally partial correlation for principal component analysis (LPC-PCA) to directly estimate mean surface from bi-dimensional signals without using iteration technique for extracting bi-dimensional intrinsic mode functions (BIMFs), which are decomposed images, from an original image. Fig.1 shows an original image and a set of BIMFs decomposed by BEMD-RBF, FBEMD, FaBEMD, MEMD, and iBEMF, respectively. The iBEMD method achieves in fast computation of algorithm and high quality of decomposed image.

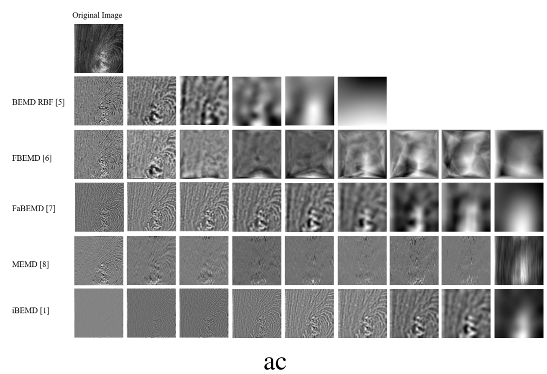

Fig. 1. A set of BIMFs decomposed by various approaches with wood texture image.

B. Empirical Monocomponent Image Decomposition

2D empirical wavelet transform (2D EWT) proposed by Gilles et al. [9] was the first adaptive image decomposition in frequency domain extended from the empirical wavelet transform [4] for signal analysis. The 2D EWT method adaptively decomposes an image by segmenting its spectrum in

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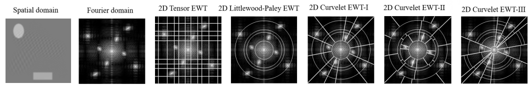

Fig. 2. Various segmentation methods lead to inaccurate spectrum segmentation.

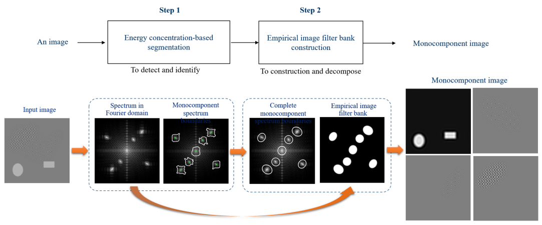

Fig. 3. Framework of empirical monocomponent image decomposition.

Fourier support. In Gilles's method, the spectrum segmentation is very important for monocomponent image decomposition. However, a variety of spectrum segmentations as shown in Fig. 2 presented by Gilles et al. still does not achieve the high quality of monocomponents. Newly, an EMID method was proposed by Suttapakti et al. [2]. The EMID method was based on (i) energy concentration-based segmentation and (ii) empirical image filter bank construction as shown in Fig. 3. In energy-based segmentation, 2D local maximum point detection is performed on an empirical mean plane that is created by principal component analysis (PCA) to detect the central frequencies of candidate mono-component spectra. Then a 2D local minimum boundary detection algorithm is used to detect a component boundary from each detected central frequency. After that, an actual monocomponent identification algorithm is used to identify actual monocomponent spectrum boundaries. In empirical image filter bank construction, all filter banks are constructed in accordance with monocomponent spectrum boundaries by means of ellipse and Gaussian functions, and is used to decompose an image into monocomponent images with fewer ringing artifacts. Like this, the proposed EMID method is able to achieve a high quality of monocomponent images.

C. Comparison

As mentioned in subsections II-A and II-B, we can summarize the difference between the iBEMD and EMID methods as follows. In iBEMD method, a decomposed image is a BIMF which can be represented more than one frequencies. Meanwhile, a decomposed image extracted by the EMID method is a monocomponent image which can be represented a single frequency. The different decomposed images of those methods are the different number of frequencies in each decomposed image. This leads to the different solutions for solving the same application. For example, in Thai text localization, the EMID can identify the text region on the image, since text-texture components in Fourier support are located in the same position, thus making it easy to segment text region from the background. However, it cannot eliminate the illumination effect on the input image, due to the fact that illumination component is one of non-linear and non-stationary signals which can be located in other positions of Fourier support. On the other hand, the iBEMD method can eliminate the illumination component from the input image easily, because it is designed for non-linear and non-stationary signal analysis. It can extract the BIMF which contains more than one frequencies and is also nearly similar oscillation, whereas the iBEMD method cannot directly segment the text region from the background, since more than one frequencies are there. Therefore, we can conclude that the EMID method is a powerful image decomposition for a linear signal, whereas the iBEMD method is effective in signal analysis for non-linear and non-stationary data.

D. Conclusion

This article has addressed two recently published papers in image decomposition techniques. Both techniques were rooted from different concepts. Therefore, they always produce the different decomposed images and perhaps lead to different solutions for problem-solving.

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