Chapter 16
DEPSO With DTCWT Algorithm for Multimodal Medical Image Fusion

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ABSTRACT

In this paper, the authors propose an algorithm of hybrid particle swarm with differential evolution (DE) operator, termed DEPSO, with the help of a multi-resolution transform named dual tree complex wavelet transform (DTCWT) to solve the problem of multimodal medical image fusion. This hybridizing approach aims to combine algorithms in a judicious manner, where the resulting algorithm will contain the positive features of these different algorithms. This new algorithm decomposes the source images into high-frequency and low-frequency coefficients by the DTCWT, then adopts the absolute maximum method to fuse high-frequency coefficients; the low-frequency coefficients are fused by a weighted average method while the weights are estimated and enhanced by an optimization method to gain optimal results. The authors demonstrate by the experiments that this algorithm, besides its simplicity, provides a robust and efficient way to fuse multimodal medical images compared to existing wavelet transform-based image fusion algorithms.

1. INTRODUCTION

Computer assisted diagnosis and therapy strongly depend on image processing methods as they are of increasing importance in modern medicine and health care. Over the past decade, research in processing and analysis of medical data has begun to flourish. In order to support more accurate clinical information for physicians to deal with medical diagnosis and evaluation, multimodality medical images are needed

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such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), positron emission tomography (PET) images, and many others. These sensors provide complementary information about patient's pathology, anatomy, and physiology.

For example, the CT image is widely used for tumor and anatomical detection, it can provide dense structures like bones and implants with less distortion, but it cannot detect physiological changes; the MRI image on the other hand can provide normal and pathological soft tissues information, but it cannot support the bones information. Similarly, other medical imaging techniques like fMRI (functional magnetic resonance imaging), PET (positron emission tomography), SPECT (single positron emission computed tomography) provide functional and metabolic information. Furthermore, T1-MRI image provides details about anatomical structure of tissues, whereas T2-MRI image gives information about normal and abnormal tissues.

Hence, one can easily conclude that none of these modalities is able to carry all relevant information in a single image. In this case, only one kind of image may not be sufficient to provide accurate clinical requirements for the physicians. Therefore, multimodal medical image fusion is required to obtain all possible relevant information in a single composite image for better diagnosis and treatment. It has become a promising and very challenging research area these recent years (Yang, 2010).

Image fusion is the process that aims to produce a more representative image through merging the input images with each other. Various methods were proposed to perform the required fusion goal. The work by Shih-gu Huang (Huang) demonstrates classification of various algorithms available in literature to perform image fusion. The different image fusion algorithms existing in literature are Intensity-hue-saturation (IHS) transform, PCA, Arithmetic combinations such as Brovey transform and Ratio enhancement technique, Multi-scale transform based fusion such as HPF method, Pyramid method, DWT, SWT, Dual tree discrete wavelet transform and Lifting wavelet transform, Neural network, fuzzy logic method, and sparse technique (Nandeesh, 2015).

In fact, existing algorithms generally use Discrete Wavelet Transform (DWT) (Li, 2003) for the fusion of multimodal medical images because the DWT keeps the different frequency information in a stable state and allows a good localization in time as well as in the domain of the spatial frequencies. However, one of the major disadvantages of the DWT is that the transformation does not provide an offset invariance. This causes a major change in the wavelet coefficients of the image, even for minor shifts (changes) in the input image. In medical imaging, it is important to know and preserve the exact location of this information, but the offset variance can lead to inaccuracies. As an alternative (Kingsbury, 1998), proposed dual-tree complex wavelet transform (DTCWT), which is able to conserve subtle texture regions of brain images in which ringing effects are reduced and edge details are retained in a clear way. To conclude, DTCWT is better than DWT because of its directional selectivity and shift variant nature (it provides an approximate shift invariance).

The integration of image fusion algorithms offers immense potential for new research as each rule emphasizes on different characteristics of the source image. This is why we propose, in this paper, a novel hybrid architecture for wavelet based image fusion combining the Dual-Tree Complex Wavelet Transform with the Particle Swarm Optimization and Differential Evolution method.

The organization of the rest of this paper is as follows: In the second section, an overview of the medical image fusion methods is given. Next in section 3, works related to the proposed medical image fusion algorithm are presented. In section 4, we describe the use of the DTCWT for image fusion. The methodology for the proposed method and the implementation scheme are explained in section 5.