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Optimum spectrum mask based medical image fusion using Gray Wolf Optimization

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ABSTRACT

Medical image fusion techniques have been extensively used in clinical diagnosis. Scaling based techniques are well known techniques in multimodal image fusion, the generalized scaling has static scale value selection which brims the quality of fusion. In this paper, we proposed an Optimum Spectrum Mask Fusion (OSMF) for medical image fusion using conventional Gray Wolves Optimization (GWO) algorithm. The GWO algorithm, indulges swiftest and dynamic scale selection. The spectrum masks technique, contrary to conventional spatial domain and transform domain fusion algorithms in terms of image contrast and edge quality. The optimum mask caters more information in the multi-modality fusion. The proposed OSMF is tested for MR-SPECT, MR-PET, MR-CT and MR: T1-T2 of brain images. Experimental results show, our technique pageantries the improved results than other conventional pixel based fusion techniques.

1. Introduction

Medical image fusion is a potent technology to combine multi modal clinical features in to a unique frame called fused image. The single modality does not contain bounteous medical features due to the complementary information requirement. The fusion algorithm succors to combine the twain features in to a nonpareil frame. For example, CT (Computerized Tomography) bestows the cogent hard tissues information, but the procured soft tissue information is paltriest. The MR (Magnetic Resonance) imaging is complement to the CT imaging [1,2]. The generalized medical image fusion algorithms consist of preprocessing techniques [3–8], transformation functions [9–13], optimization algorithms [14–17] and fusion rules [18]. Wang et al. [19] presented a multimodal registration technique for retinal image registration, in which they extracted the matched information and discarded the incorrect matches. Transformation function has a leonine role in medical image fusion and registration to map the different sensor outputs into a single mathematical domain. Cao et al. [20] introduced a Discrete Cosine Transformation (DCT) based image fusion based on entropy coding and quantization approach. Singh et al. [1] introduced a shearlet domain MR-CT image fusion technique, in which high frequency coefficients are fused using a biologically motivated Pulse Coupled Neural Network (PCNN). The wavelet domain coefficient based transform provides greater level of approximation and recently several modifications have been introduced in conventional wavelet transform. Xu et al. [21] presented a fractional wavelet transform based technique for MR-CT, MR-Positon Emission Tomography (PET), and MR-T1-MR-T2 multimodal medical image fusion. Wang et al. [12] presented a Shift Invariant Shearlet Transform (SIST) based technique for multimodal MR-PET and MR-Single Photon Emission Computed Tomography (SPECT) fusion applications. Recent trend of image fusion have given greater attention on Multi Scale Transform (MST) based fusion [22–24]. Liu et al. [25] introduced a Gradient Minimizing Smoothing Filter (GMSF) for multi scale edge preserving decomposition application and tested for MR-CT multimodal fusion. Optimization algorithms have a prominent stint in the selection of coefficient values. Genetic Algorithm (GA) [26] based techniques are well known population dependent optimization approaches controlled by genetic operators such as cross over and mutation. The conventional GA has the limitations in timing complexity, in last decades various biological inspired optimization algorithms have been developed by various researchers. Ant Colony Optimization (ACO) algorithm is provided an efficient edge enhancement for MR-SPECT and MR-PET image fusion [27]. Zhu et al. [28] presented a novel dictionary learning technique for medical image fusion, it preserved the edge

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quality but it required more computational time than other existing techniques. Fuzzy Transform (FT) [29] is presented in recent literature using maximization rule based coefficient fusion. The laplacian pyramid technique is used to obtain an accurate decomposition of input medical images [30]. The sparse representation technique has greater significance in image fusion applications and it performs multimodal fusion without any prior knowledge [31]. The visual quality and contrast improvement are real challenges in clinical diagnosis and computer guided surgery. Bhatnagar et al. [32] presented a contrast based medical image fusion technique using Non Subsampled Counterlet Transform (NSCT), in which the visual clarity is improved but the computational complexity is a limiting factor. In this paper, we proposed an optimum spectrum mask fusion to overcome the contrast limitations in conventional methods. The optimum scale values are selected using a recently introduced optimization algorithm called Gray Wolf Optimization (GWO).

The organization of this paper is as follows. Section 2 presents the need of optimum scale selection and proposed spectrum mask fusion. Section 3 describes the gray wolf optimization. Section 4 discusses the results and discussion. Lastly, Section 5 presents the conclusion and future scope.

2. Spectrum mask based medical image fusion

This section is divided into 2 subsections as follows

1. Need of optimum value in spectrum mask
2. Proposed optimum spectrum mask fusion

2.1. Need of optimum scale value in spectrum mask

In conventional mask based techniques, the static scale value is using irrespective of the varying input image cases. The scale value, which suit for one set of input images might be ineffective in other input images because of different acquisition devices. The mask based imaging techniques is controlled by the gain factor called scale value, the optimum scale value can dynamically adjust the scale value irrespective of input images.

2.2. Proposed optimum spectrum mask fusion

In this section, presented a new multi modal medical image fusion technique called, Optimum Spectrum Mask Fusion (OSMF). The objective of proposed technique is to obtain a contrast improved multimodal fusion using masking based techniques. The conventional GWO algorithm is used to select the optimum scale values (s_{1opt}, s_{2opt}) for masking formulation. The block diagram of proposed OSMF is given in Fig. 1. In which the input image modalities are transformed into Fourier space using Eq. (1). Let $F_{(u,v)}$ denotes the Fourier space of spatial domain image $I(x, y)$. The Fourier spectrum of the input images are optimum scaled using scale values $\left[s_{1opt}, s_{2opt}\right]$ obtained using GWO algorithm. In resultant masks, the mask 1 provides the anatomical features and mask 2 contains soft tissue details for MR-T2 input case and metabolic features in PET and SPECT input cases. The corresponding formulated masks is called spectrum mask 1 and spectrum mask 2. The resultant mask images are fused using pixel based averaging rule, the resultant fused image is obtained in the Fourier domain. Inverse Fourier transform is used for getting the spatial domain fused image, the mathematical expression is given in Eq. (2).

$$F_{(u,v)} = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} I(x, y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \quad (1)$$

$$I_{F(x,y)} = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u, v)\, e^{j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \quad (2)$$

Where M and N are represents the number of rows and columns of input medical image, here the considered images with size of $M = 256$ and $N = 256$. In Eq. (2), $I_{F(x,y)}$ is the resultant fused image in spatial domain.

3. Gray Wolfs Optimization

This section describes the application conventional GWO algorithm in medical image fusion. In our proposed technique, instead of conventional scaling, we have used optimum spectrum scaling. The GWO is a recently developed swarm intelligence based on the hunting mechanism of gray wolves family [33–36]. The pseudocode for GWO algorithm is given in Fig. 2. The various steps of GWO are described below:

3.1. Initialization of gray wolf positions

In our application, the range of scale values $[s_1, s_2]$ are considered in [0,1] for first and second modalities respectively. The number of iterations and population values are tested with various values using trial and error method and fixed the limits as 50 iteration and 50 scale values for multimodal fusion.

3.2. Fitness function

The GWO algorithm is applied for optimal selection of scale values in multi scaled medical image fusion. Mutual Information (MI) [37] is a quantitative measure for multi modal fusion, which

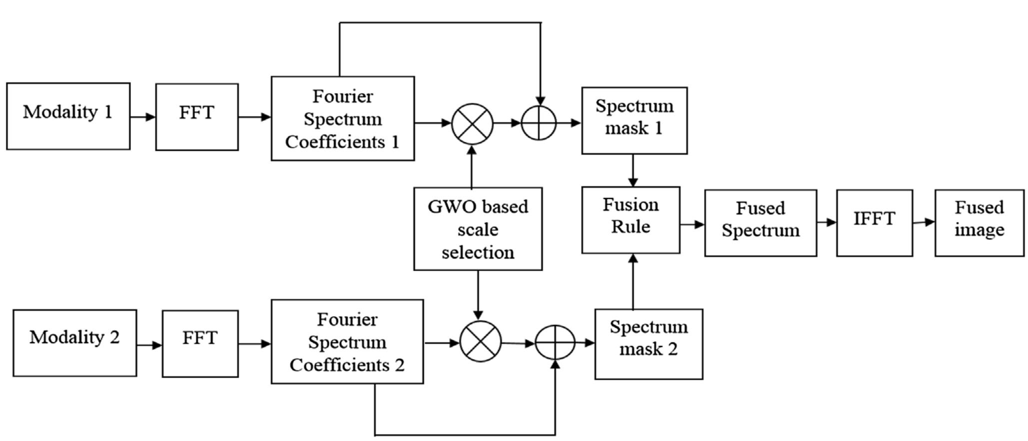

Fig. 1. Block diagram of Optimum Spectrum Mask Fusion.