Chapter 18
An Improved Firefly Algorithm-Based 2-D Image Thresholding for Brain Image Fusion

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ABSTRACT

In this article, an attempt is made to diagnose brain diseases like neoplastic, cerebrovascular, Alzheimer's, and sarcomas by the effective fusion of two images. The two images are fused in three steps. Step 1. Segmentation: The images are segmented on the basis of optimal thresholding, the thresholds are optimized with an improved firefly algorithm (pFA) by assuming Renyi entropy as an objective function. Earlier, image thresholding was performed with a 1-D histogram, but it has been recently observed that a 2-D histogram-based thresholding is better. Step 2: the segmented features are extracted with the scale invariant feature transform (SIFT) algorithm. The SIFT algorithm is good in extracting the features even after image rotation and scaling. Step 3: The fusion rules are made on the basis of an interval type-2 fuzzy set (IT2FL), where uncertainty effects are minimized unlike type-1. The novelty of the proposed work is tested on different benchmark image fusion data sets and has proven better in all measuring parameters.

INTRODUCTION

Diagnosis of a disease is an important step to cure an illness. There are many diagnostic techniques and one of them is medical imaging. It is a technique to generate a visual representation of the desired part of the human body including tissues, bones and brain. Many multi-modal medical imaging techniques

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were introduced to achieve it. The main solution among them is Image fusion. Gathering required information from various images and fusing them together into a single image without any distortion and loss of information. Image fusion has many advantages, they include less ambiguity, improved reliability, image sharpening, feature enhancement, improved classification, diagnosing disease in early stages, easy to interpret, low in cost, reduces data transmission and fused image is true in color. Image fusion can be applied in medical diagnosis, satellite imaging, object detection and recognition, military, astronomy.

Many techniques and classifications have been originated in image fusion. The main techniques are spatial domain techniques (Ghassemian, 2016), transform domain techniques (Jin et al., 2017), contrast pyramid technique, ratio pyramid technique, morphological pyramid technique (Petrovic & Xydeas, 2004), Laplacian pyramid technique, PCNN (Yang et al., 2009), pixel level image fusion technique (Naidu & Rao, 2008), feature level image techniques (Nirmala & Vaidehi, 2015, March), decision level image fusion techniques (Al-Tayyan et al., 2017). The spatial domain image fusion technique directly deals with the pixels of the input images. This technique can be analyzed in four ways namely, principal component analysis (PCA) (Wan et al., 2013), Intensity hue and saturation (IHS), Simple averaging, Simple maxima. Although they are very important techniques, they have certain limitations. Simple maxima produces highly focused images but it causes blurring (Xu, 2014). Local contrast can be affected by blurring. Simple averaging cannot give clear images of the object, but it is the simplest method for image fusion. Spectral degradation is produced due to principal component analysis technique. Intensity hue saturation is only suitable for color image fusion so it cannot be applied in medical imaging (Haddadpour et al., 2017).

In transform domain techniques, initially the transform of the function is analyzed and the resultant coefficients of transforms are fused. Then, the inverse transform is estimated to get fused images. In this technique, images are converted into multi-resolution or multi-scale representations before fusion. This technique can be analyzed using discrete wavelet transform (DWT), DT-CWT, Curvelet transform (Choi et al., 2015), additive wavelet transforms, non-sub sampled Contourlet transform (NSCT). Contourlet transform is used for catching complex contours, edges and textures (Yang et al., 2008). Few methods in the transform domain are far better than spatial domain methods in many aspects. Discrete wavelet transform cannot handle curved edges. Therefore, it fails in fusing images of the brain in a required manner. It has poor directionality, shift sensitivity, destruction of phase information, less spatial resolution. It has Pseudo-Gibbs effect due to the down-sampling process. Curvelet transform is specially designed for curved edges and capturing curvilinear properties. Therefore, it is beneficial in fusing the images of brain easily and clearly this method is very complex and it takes very high processing time. DT-CWT technique has minor drawbacks as compared to spatial domain analysis and transforms domain analysis. DT-CWT technique has high directionality, better edge representation, approximate shift invariant property and takes less time for processing (El-Hoseny et al., 2018).

The Pyramid techniques in image fusion are suitable only for specific type of images. Therefore, only one bandpass image is generated by pyramid level image fusion techniques and they often cause blocking effects. Apart from this, Contrast pyramid technique will lose much information while Morphological pyramid technique has bad edges. The pulse coupled neural network (PCNN) technique is very useful for image segmentation, image enhancement and pattern recognition. It has an important biological background. PCNN is used to produce images with high contrast, clarity and information. M-PCNN is very useful when several images are fused at a time and depending upon the actual requirements, number of channels can be easily changed. Still it has drawbacks, it is very difficult and complex to set the design constraints, and they have to be adjusted manually or they can be estimated through large amount of