Fusion of MRI and CT Images of Brain Tumor - Comprehensive Survey

G. P Hegde¹, Chethana R Shetty², Chinmaye K³, Roshani N Gaonkar⁴, Shambhavi R Belligatti⁵

¹,²,³,⁴,⁵Information Science, SDMIT Ujire

Abstract— Image fusion of MRI and CT images frames an integration of relevant information from a set of images into a single image, where the resultant fused image will be more informative and quantitative than any of the input images. In brain medical imaging, MRI image shows structural information of the brain without any functional data, whereas CT image describes functional information of the brain but with low spatial resolution and so on. These multi-modality images contain important information for the accurate and effective diagnosis of brain diseases. Thus, fusing various modalities of images in medical field into a distinct image with more detailed anatomical information and high spectral information is highly desired in clinical diagnosis. This work presents a detailed literature review done on image fusion and also the concepts and materials that helps for clear understanding of various fusion techniques.

Keywords— Magnetic resonance imaging (MRI), Computed Tomography (CT), fused image, brain medical imaging, spatial resolution, multi-modality, anatomical information.

I. INTRODUCTION

In medical field, both the qualities of spectral and spatial data in a solitary image is highly desired by the doctors (radiologists) for various purposes like researches, monitoring, accurate diseases diagnosing and also for treatment process [1]. Image fusion technique that integrates suitable information from various modalities of input images into a fused distinct image where the resultant image provides better inventive information in comparison with the input images which are used for fusion [2]. Image fusion of CT and MRI human brain images is presented in the Figure-1. Brain images showed a large mass with surrounding edema, and compression of adjacent midbrain structures.

Figure 1. Image fusion of CT and MRI of sample 1
II. LITERATURE REVIEW

Lewis et al. (2009) [3] presented a region based method and concluded that it has less noise and with high contrast, but there is loss of some data in this technique.

Mario Ciampi 2010 [4] has proposed fusion algorithm for a 3D multimodal images based on multi-resolution wavelet and he revealed that this method plays a significant role to divide an image into different frequency portions. Fused image is visualized using this method by the application of color to input images. When it is passed through rescaling and resampling filters, it should have both image slice number and spatial resolution almost equal. 3D images which are decomposed through the proper fusion rules are initiated and reconstructed using this method.

Lin et al. [5] proposed two fusion methods, IHS&LG+ and IHS&LG++ for fusion by choosing suitable decomposition scale and orientation for different regions of images based on IHS and log-Gabor wavelet. In the first method PET and MRI images are fused whereas in the second method, the intensity of the fused image is refined to further reduce color distortion and to put into effect the anatomical structure. This method uses the hue angle of each pixel in PET image to divide both PET and MRI pictures into districts of low and high movement. The fused intensity of each region is obtained by applying inverse log-Gabor transform. Experimental results based on this technique reveals that the final fused image is from three sets of brain disease images. Results illustrated that input images fused by IHS&LG+ are with less color distortion and with the same structural information as the images fused by IHS & RIM.

Chandra et al. [6] presented a procedure of forming a fused image which is mainly used for disease diagnosis from different images with good results including many performance metrics. Inputs taken are MR-T2 and CT scans to which fusion techniques like Mamdani sort least aggregate mean of maxima and Redundancy Discrete Wavelet Transform are connected and tested.

Haribabu et al. [7] developed a technique for fusing PET-MRI image using wavelet and spatial frequency method which removes the influence of image imbalance. This method reduced blur effect, improved the clarity which is useful for clinical diagnosis. The result analysis indicated that suggested system is comparatively better than the conventional algorithm based on principal component analysis in terms of good visual and quantitative fusion results.

Desale et al. (2013) [8] proposed DWT based two algorithms namely pixel averaging & maximum pixel replacement approach with very good fusion results which eliminates the drawbacks of PCA technique.
Huang et al [9] illustrated an approach regarding low and high activity regions of wavelet transform of brain which can generate proficient fusion result by slightly changing the gray matter (GM) anatomical structural information and then patching white matter (WM) spectral information, followed by wavelet decomposition and gray-level fusion. A novel adjustment for the pixel intensity in the non-white matter area of high-activity region in the gray-level fused image will bring more anatomical structural information into the final color fused image. Spectral information patching in the white matter area of high-activity region will preserve more color information from PET image for the white-matter area.

Swathi et al (2013) [10] proposed a new algorithm based on Daubechies transform coefficients for fusion and is compared using region segmentation and spatial frequency method. This work also covered the comparison of performance evaluation metrics such as entropy, standard deviation and fusion factor between input images and output images. Medical multimodal image fusion is an important method of medical imaging to obtain information from different multimodalities of medical images.

Singh et al [11] proposed an innovative multimodal medical image fusion method by means of Daubechies complex wavelet transform using mixed fusion scheme based on energy where image fusion is performed using spatial or transform domain methods. A scheme for image fusion which is helpful for determining average information of image is also described which gives better fusion results.

Sun and Guan [12] concluded that images that are obtained by combining magnetic resonance imaging and computed tomography images helps the doctor in analyzing more information and helps in clinical testing.

Shangli et al [13] have been addressed wavelet decomposition method for decomposing image happens in such a way that, low frequency components are achieved by performing maximum absolute values and it is verified using consistency. Maximum local variance rule helps in selecting the high frequency coefficients. Inverse wavelet transform added with combined wavelet coefficient is used to reconstruct the fused image.

Parmar et al [14] presented in his comparative analysis work about Fast Discrete curvelet Transform using Wrapper algorithm and he has concluded about soft tissues and denser tissues can also be obtained by this technique. To get more data regarding the image, the images are fused at different resolutions and intensities. The content of the image can be improved by using various imaging tools that helps in mixing useful information by removing the excessive information from registered source images.

Galande and Patil (2013) [15] addressed the combination of CT and MRI images, which is used for analysis purpose and the fused images obtained from fuzzy inference system helps in achieving the better result.

Pure et al. (2013) [16] proposed fast discrete curvelet transform that analyses the curved images, it is possible to fuse an MRI and CT image which helps in diagnosis of disease. Single Photon Emission Computed Tomography (SPECT) image does not contain anatomical information; hence it is difficult to use it for perception and diagnosis of disorders. MRI has high spatial resolution that shows brain tissue anatomy and SPECT has low spatial resolution and shows brain function. In order to remove the individual disadvantage, it is required to combine MRI and SPECT,
through which it is possible to obtain both functional, anatomical information, spatial and spectral features.

Nobariyan et al [17] proposed alternative methods such as IHS and Multi-resolution fusion methods for preserving spatial and spectral information respectively. The proposed method involved minimizing distortions of fused images compared to other methods.

Tamilselvan et al. [18] presented wavelet and watershed algorithm transforms used for image fusion. The detailed coefficients of the image are obtained by decomposing the source image and the achieved sub image are segmented using watershed algorithm to get the fused image. The images that are segmented are fused using Wavelet Transform-Fuzzy C-Means (WT-FCM) algorithm. The fused image should not contain any undesired feature and the fusion process should possess relevant information. Higher accuracy and reliability are provided by fused image.

Thomas et al [19] proposed new multilevel Daubechies complex wavelet transform (DCxWT) method works well on the principle of multimodal medical image fusion method which follows multi-resolution. In this method complex wavelet coefficients were fused using maximum selection.

Nobariyan et al (2014) [20] proposed a new technique in which YCbCr is performed on the multispectral image to get luminance, blue-difference and red-difference chromatic components and using DWT depending on PCNN (pulse coupled neural network) to combine luminance component(Y) and MRI image. Finally, by applying the inverse YCbCr transform to the new luminance and to the old blue and red difference chromatic components, the fused image is obtained. PCNN is used as it has pulse synchronization and global couple characteristics and is suitable for image processing and fusing images.

Vikrant et al [21] developed 2D-Discrete Wavelet Transform to preserve both spatial and spectral information based on merging of complementary diagnostic content using wavelets and Principal Component Analysis (PCA). To maximize the spatial resolution, PCA is applied to it. For better fusion results, Daubechies wavelet family has been selected, which improves the visual excellence of the fused image compared to other techniques.

Kavitha and Chellamuthu [22] introduced an Integer Wavelet Transform (IWT) that is used to decompose anatomical and functional images and Neuro-Fuzzy, which is used to fuse wavelet coefficients and is illustrated for a better fusion. Also, quantification of joint mutual information is analyzed using Fusion Factor (FF).

Das and Kundu [23] presented image fusion problem by analyzing image fusion with the help of contourlet transform and fuzzy and neural networks. Fuzzy membership values help in getting the linking strengths of neurons. Computational efficiency increases with usage of neural network having less complex structure and less number of parameters. The proposed scheme is with high contrast and lesser loss of detailed information of image.

Yang and Li [24] first apply SR theory to multi-focus image fusion, and they use orthogonal matching pursuit (OMP) to implement sparse coding. Liu et al. [25] presented that the geometric structure information in different scales of the image can be extracted effectively by these MGA tools. The tools above are widely studied to fuse general multimodal images.
III. CONCLUSION

Work mentioned in the literature indicated that most of the researchers have carried work on various fusion methods for medical images. Investigations from the comprehensive survey concluded that all these methods mentioned above have either a serious side effect of color distortion, visual clarity or missing some anatomical structural information in the gray matter area of the high-activity region of the fused image. Also from these reviews, it is identified that many techniques adopted earlier for fusion has spectral distortion and lacks spatial resolution. In future, the main objective is to investigate a new solution to overcome identified artifacts by designing an image fusion method which is different from the regular simple Discrete Wavelet Transform (DWT) fusion method and to generate promising results by varying the anatomical structural information in the GM area and then patching the spectral information in the WM area to have better color preservation after the wavelet decomposition and gray-level fusion.

REFERENCES


