Multi Modal Medical Image Fusion in the Stationary Wavelet Transform domain

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Abstract

We combine multiple images which are pre-registered. In case of Medical Image fusion the inputs for the algorithms come from different modalities, the randomness and redundancy in the images is reduced. Also clinical accuracy of the decisions which are based on images from different modalities is improved. This article provides a novel method for fusing multi-modal medical images. The quantity of samples of the output at each level is the same as the input.

1. INTRODUCTION

Fusion of medical images addresses issues based on the images of bodies, organs and cells. The use of multiple sensors [1] and multiple sources image fusion methods can provide a wider diversity of the features. The selection of a specific imaging modality depends on the organ under study. Fusion of images from different modalities has gained particular attention.

2. METHODS IN MEDICAL IMAGE FUSION

There are two phases of medical image fusion methods (a) Registration of images phase and (b) Fusion of relevant parameters. Registration corrects the misalignments in the spatial domain between the different data sets. It also involves affine compensations. Due to the presence of noise between different images and features or outliers may be missing; the problem of registration may become complicated. The fusion phase involves selection of relevant features depending on the clinical assessment purpose.

2.1. Methods based on Image Morphology

Morphology operators are used to extract relevant spatial information from medical images. Brain diagnosis [2] uses morphological filtering methods. Morphology operations depend heavily upon the structuring elements. Detection of features based on scale is done by a quantified sequence of actions. Noise and sensing errors are responsible for the inaccuracies in features. Data fusion is achieved by K-L transforms, Morphology and averaging operators.

2.2. Methods based on medical practitioner's knowledge

Registration, Labeling and Segmentation of images depend to a great extent on the medical practioners knowledge. Domain knowledge is needed in the following applications like tissue classification [3], brain diagnosis. Preprocessing techniques improves imaging quality and ground truth accuracy.

2.3. Methods based on Wavelet Transform

Detailed information is usually found in higher frequencies. Greater amount of decomposition levels is required by a higher resolution counterpart than a low resolution counterpart. Lot of methods in medical diagnosis [4] and color visualization [5] are included. Wavelets can be combined with other techniques.

2.4. Methods based on Neural Networks

The training set at the input determines the weights. The neural network predicts, analyzes and performs the inference. Variability nature amongst the images change as

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the modality changes, neural networks are best suited for medical image fusion tasks.

2.5. Fuzzy logic based methods

The disjunctive, conjunctive and compromise properties of Fuzzy logic are exploited in Image Fusion.

3. MODALITIES IN IMAGE FUSION

The following section lists and describes different modalities

3.1. MRI

There is an important role played by Magnetic Resonance Imaging (MRI) in the domain of non-invasive diagnosis of brain tumors. Trusted clinical settings use MRI as the most widely used imaging modality. Segmentation is the most commonly used imaging modality in MRI for extraction of various types of tissues and it is also helps in identifying reflective tumors. Several tumor segmentation method are proposed which vary in the accuracy of tumor detection and identification. Sensitivity to movement is the major disadvantage of MRI, it is therefore not a popular method for organs which involve movements such as detection of tumor in the mouths. Multi-modal image fusions overcome the limitation by enabling reconstruction and prediction. The MR images are fused with other modalities.

3.2. CT

Multi-modal medical image fusion [6] uses Computer Tomography (CT) prominently. Applications of CT images include tracked endoscopic images of CT data surface [7]. Scan time is shortened and higher resolution is obtained in CT images.

3.3. PET imaging

Radiology [8] uses Positron Emission Tomography (PET). Molecular imaging provides high sensitivity which is the advantage of a PET image. Fusion techniques using PET are on increase for improving the imaging quality.

3.4. SPECT Imaging

The flow of blood to tissues and organs is studied using Single photon emission computed tomography (SPECT). There is a tradeoff between sensitivity and the image resolution. Developments have been there up to sub millimeter range in pin-hole SPECT. Post processing techniques are needed for improving image quality.

3.5. Ultrasound Imaging

Low costs and lack of side effects make Ultrasound Imaging popular. Major deficiencies like avoiding air gaps and avoiding bony structures etc. necessitate the need to use other modalities as well in addition to ultrasound and imaging accuracy is ensured and better localization of regions for diagnostic use is achieved.

4. SWT

The Stationary wavelet transform (SWT) [9] is a specialized algorithm. Invariance in translation is achieved [10] [11] [12] [13]. SWT is an inherently redundant transform. This algorithm is called as *atrous* algorithm.

The following Fig. 1 illustrates the Stationary Wavelet Transform which depicts the SWT digital implementation.

The Fig. 2 illustrates the up-sampling operation

Applications of SWT include Pattern recognition, Signal De-noising, Pathological brain detection, Brain Image Classification.

5. THE MULTI-MODAL IMAGE FUSION ALGORITHM USING SWT

We perform here the fusion of two multi-modal images; the first image is a Magnetic Resonance (MR) image as shown in Figure 3 this is a black and white image. The second is a Single Photon Emission Computed Tomography (SPECT) image as shown in Figure 4 this is a colour image.

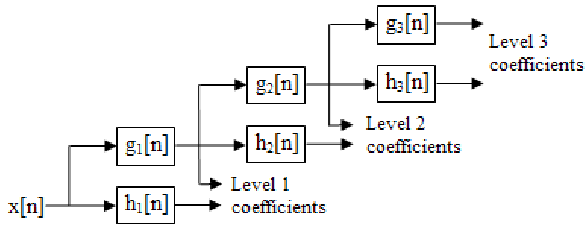

Figure 1: SWT Filter bank

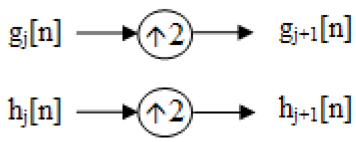

Figure 2: SWT filters up-Sampling operation

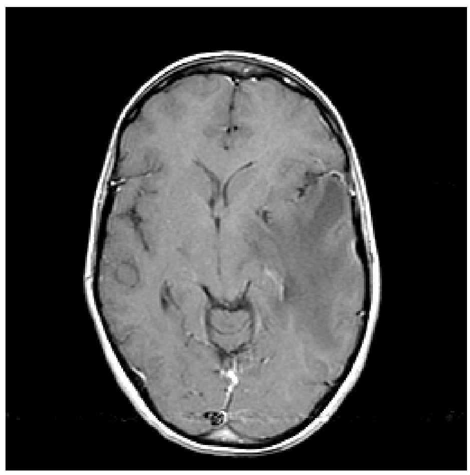

Figure 3: MR image of the brain

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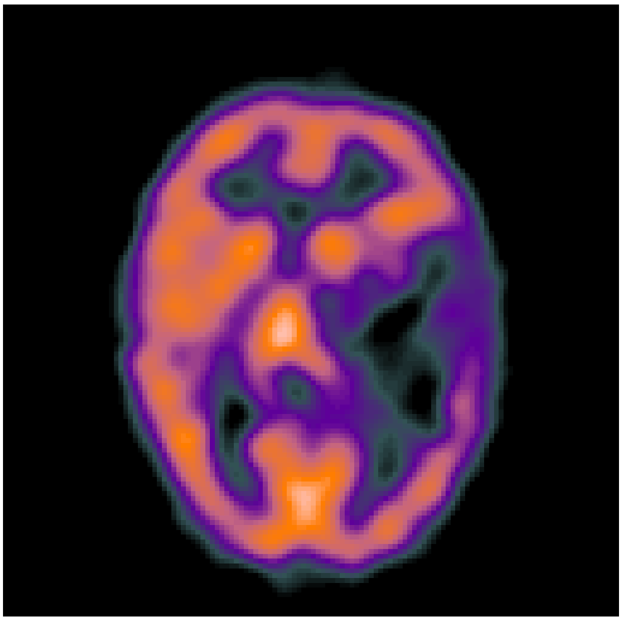

Figure 4: SPECT colour image of the brain

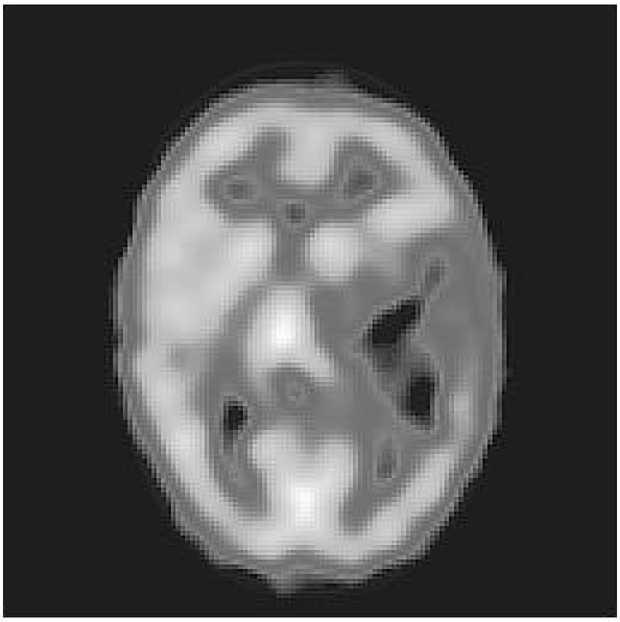

Figure 5: SWT Fused image of the brain using 2-levels

The following are the steps that are executed in the process of fusing the multi-modal images.

Step 1: Read both the images in an array.

Step 2: Perform the Stationary Wavelet Transform of both the images. The image gets decomposed into low-frequency bands A1L1 and A2L2. The remaining details are divided into the high-frequency bands as Vertical, Horizontal and Diagonal sub-bands.

Step 3: The low pass sub-bands are averaged out and the resultant for the fused image is calculated.

Step 4: From corresponding Horizontal, Vertical and Diagonal coefficients the greater coefficients are retained in the fused images.

Step 5: The fused sub-bands are aggregated and inverse stationary wavelet transform is performed.

6. DISCUSSIONS

Fusion can be carried at multiple levels, In the current scenario we go up to the level 2 decomposition. The fused images of the two multimodal images of Figure 1 and Figure 2 are shown in Figure 5.

7. CONCLUSIONS

Thus we have obtained a new fusion method in the SWT domain. The results are quite promising and the method is fairly simple and a fast approach.

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