EFFICIENT MEDICAL IMAGE FUSION BASED ON DENOISING AND FILTERING USING HYBRID FILTERS

Theres Paul[1] | T.B.Dharmaraj[2]
[1](UG Student, Christ the King Engineering College, thereslee533@gmail.com)
[2](Professor, Christ the King Engineering College, bellidharmaraj@gmail.com)

Abstract— *Image fusion is to automatically transfer the meaningful information contained in multiple source images to a single fused image without introducing information loss. Medical images are often corrupted by noise in acquisition or transmission, and the noise signal is easily mistaken for a useful characterization of the image, making the fusion effect drop significantly. The main aim of Medical Image fusion is in having better quality of fused image for the diagnostic purposes. Modified image fusion framework is the combination of Butterworth High pass filter and Cross Bilateral filter. Input source images are sharpened by using high order and low cut off frequency Butterworth filter. Sharpened source images are the inputs of cross bilateral filter. A multiscale alternating sequential filter is exploited to extract the useful characterizations (e.g., details and edges) from noisy input medical images by the process of feature extraction. Then, a bilateral filter - based filtering to guide the fusion of main features of input images. The modified image fusion framework is effective in preserving brightness, fine details, information content, texture and contrast of image.*

Keywords— Feature Extraction, Butterworth Filter, Cross Bilateral Filter, Multistate Alternating Sequential Filter, Medical Image Fusion

1. INTRODUCTION

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images without the introduction of distortion or loss of information. Image Fusion is the process of generating better quality image from two or more input images. The resultant image should retain all important features of all input images .Image fusion technology can be applied to many areas dealing with images such as medical image analysis, remote sensing, military surveillance, etc.

The fusion of images is often required for images acquired from different instrument modalities or capture techniques of the same scene or objects. The objective of image fusion is to combine complementary as well as redundant information from multiple images to create a fused image output. Therefore, the new image generated should contain a more accurate description of the scene than any of the individual source image and or further image processing and analysis task. The fusion process should be shift and rotational invariant; it means that the fusion result should not depend on the location and orientation of an object the input image. The main principles of image fusion are the redundancy, the complementary, the time-limit and low cost.

Image fusion is an essential subject in vision processing. Picture fusion means the combining of two in to a single picture that has the maximum information content without producing details which are nonexistent in a given picture. Caused by vision fusion is a new vision that retains the most desirable information and characteristics of input vision. Several situations in vision processing require high spatial and high spectral resolve in a single vision. Most of the existing equipment is not capable of providing such records convincingly. In remote sensing and in astronomy, multi sensor merging can be used to reach high spatial and spectral resolution by merging visions from two sensors among that has high spatial resolution and the other one high spectral resolution. The key utilization of vision fusion is merging the grey level high resolution panchromatic vision and the coloured low resolution.

The vision fusion techniques enable the mixture of different information sources. The merged vision may have complementary spatial and spectral resolution features. When using the vision merging technique, some general requirements should be considered. The fusion procedure shouldn't discard any information within the source pictures. The fusion procedure shouldn't introduce any artifacts or inconsistencies that may distract or mislead a human observer or any subsequent vision processing steps. The fusion procedure should be consistent, strong and have, as much as possible, the capacity to tolerate imperfections such as noise or miss registrations.

2.RELATED WORKS

2.1. Medical Image fusion

Medical image fusion attracts much attention in the recent years due to being a vital component of machine vision. It is a significant technology for diagnostics and treatments in the field of medical instrumentation and measurement. It is based on the fact that each imaging modality reports on a restricted domain and provides information in limited domains that some are common and some are unique. For instance, Computed Tomography (CT) image provides the best information on dense structures with less distortion like bones and implants, but it cannot detect physiological changes. Magnetic Resonance (MR) image provides better information on soft tissue.

Medical image fusion aims at integrating information from multimodality medical images to obtain a more complete and accurate description of the same object. It provides an easy access for radiologists to quickly and effectively report CT/MR studies. In fact, in many applications, the medical images obtained from medical instruments are noisy due to imperfection of image capturing devices. Unfortunately, noise is easily mistaken for the useful feature of the image, making the traditional image fusion algorithms invalid, although they can efficiently fuse noise-free images. Thus, it is necessary and challenging to investigate joint fusion and denoising for multimodality medical images. Fusion of images is more suitable for human/machine perception for object detection in the field of remote sensing and diagnosis in case of medical imaging.

2.2.Basic Levels of Image Fusion

Image fusion can be divided into three levels such as Pixellevel fusion, Feature-level fusion and Decision-level fusion. This categorization is based according to merging stage.

2.2.1. Pixel Level Fusion

Pixel level fusion generates a fused image in which information content associated with each pixel is determined from a set of pixels in source images. Fusion at this level can be performed either in spatial or in frequency domain. However, pixel level fusion may conduct to contrast reduction. In Pixel based image fusion, the fusion process is performed on a pixel-by-pixel basis. It generates a fused image in which information associated with each pixel is determined from a set of pixels in source images to improve the performance of image processing tasks such as segmentation. Pixel level image fusion is the process which contains detailed information. Most of the medical image fusion process employs Pixel level image fusion due to the advantage of easy implementation, original measured quantity and efficient computation.

2.2.2.Feature Level Fusion

Feature level fusion requires the extraction of salient features which are depending on their environment such as pixel intensities, edges or textures. These similar features from the input images are fused. This fusion level can be used as a means of creating additional composite features. The fused image can also be used for classification or detection. Feature level image fusion is extracting the feature from different images that are to be fused in order to form a new image.

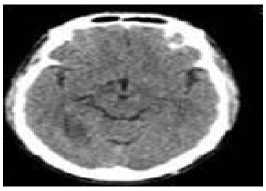
2.2.3. Decision Level Fusion

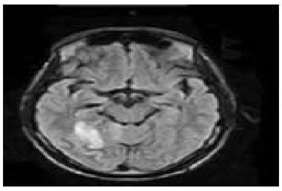
Decision level is a higher level of fusion. Input images are processed individually for information extraction. The obtained information is then combined applying decision rules to reinforce common interpretation.

Decision level image fusion contains compact data. It requires the extraction of important features which are depending on their environment such as pixel intensities, edges or textures. These similar features from input images are fused. Decision level image fusion is effective for complicated system which is not suitable for general applications. Decision level fusion consists of merging information at a higher level of abstraction it combines the results from multiple algorithms to yield a final fused decision.

2.3. Different Types of Medical Images

The medical imaging field demands more complementary information for disease diagnosis purpose. However, this is not possible using single modality medical images as X-ray computed tomography (CT) is suited only for recognizing bones structure, MRI giving clear information about the soft tissues and so on. In this regard, medical image fusion is the only emerging technique which has attracted researchers to assist the doctors in fusing images and retrieving relevant information from multiple modalities such as CT, MRI, FMRI, SPECT, PET. Each image has its own limitation, which can be solved by creating the fused image from two different image modalities. In Medical field there are different types of medical scan are available in order to diagnosis a tumor of a patient in absolute manner.

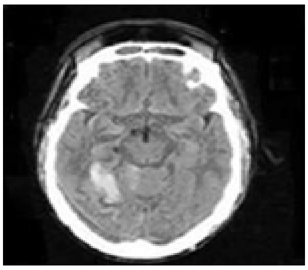




CT Image MRI Image

A CT Image used to determine information of hard bone and it provides the structure of the body, including internal organs, blood vessels, bones and tumors. CT image is a type of X-ray technology used for broken bones, blood clots, tumors, blockages and heart disease. CT image provides better information about structure of tissue and it is better visualized in CT image.

MRI image is a type of medical diagnostic imaging used to look at the blood vessels, brain, heart, spinal cord and other internal organs. MRI image provides better information on soft tissue. Normal and Pathological soft tissues are better visualized. The composite image not only provides salient information from both image but also reveal the position of soft tissue with respect to the bone structure. Normally MRI images are typically used to visualize soft tissue information.



Fused Image

This would lead to improved diagnosis, better surgical planning, more accurate radiation therapy and countless other medical benefits. The main advantage of Image fusion (IF) is integrating complementary, as well as redundant information from multiple images to create a fused image for providing more complete and accurate information. Another advantage of image fusion is that it reduces the storage cost by storing only the single fused image, instead of the multisource images. Some of the examples of medical scan are CT image, MRI image, PET image and SPECT image.

2.4.Conventional Methods of Image Fusion

In the Image Fusion method the required data from the given supply photographs is merged together to make a composite image whose quality is more advanced than the given feedback images. Picture combination methods could be categorized in to two groups as Spatial domain fusion method and Transform domain fusion. Spatial image fusion methods work by combining the pixel values of the two or more images to be fused in a linear or nonlinear way. This simplistic approach often has serious side effects. Pixel level image fusion methods are affected by blurring effect which directly affect on the contrast of the image. The limitations of Spatial Domain are resolved by Transform Domain.

2.4.1.Spatial Domain Method

Spatial do main methods operate directly on pixels. Pixels of the image will be represented in a matrix format. In spatial domain practices, the pixel price of a picture is immediately dealt with. The pixel values are altered to obtain preferred result. Fusion is required in every area where images are required to be examined. For example, medical image analysis, microscopic imaging, analysis of photographs from satellite, remote sensing request, pc vision and battlefield monitoring. An analysis of remote sensing photographs is being performed utilizing the adjustable quality analysis tool. Spatial domain processes can be denoted by the expression as given by equation

$$g(x, y) = T[f(x,y)]$$

where f (x, y) is the input image, g (x, y) is the processed image and T is an operator on f, defined over some neighborhood of (x, y). One of the principle approaches in this formulation is based on the use of so-called masks (also referred to as kernels, templates, windows or filters). A mask is a s mall 2-D array in which the values of the mask coefficients determine the nature of the process, such as image sharpening.

2.4.2.ransform Domain Method

The Countourlet Transform method has advantage of Contourlet transform and images blocking fusion algorithms, First in this the new image fusion method combined Contourlet transform and fusion-blocking. Contourlet transform fusion algorithm with a new designed fusion rule was used for the border part between the clear area and blurring one. The source image blocks, which were more similar to the corresponding initial fused image blocks, were chosen as the final fused image blocks. Used of new algorithm effectively overcome the translation invariance of Contourlet Transform and obtains a better visual effect. It is a new Method for Multi-Focus Image Fusion.

2.8.Pixel Based And Wavelet Based Image Fusion Methods

In this method, two methods used for image fusion one is pixel based image fusion and another technique is wavelet based image Fusion, it uses weighted average for pixel base image fusion in this paper authors have used select maximum approach for image fusion. In this approach two input images A and B are compared with the help of pixel coordinate of images and takes only maximum value. Second approach uses wavelet based approach. This approach reduces the blurring effect cause by pixel based method. The wavelet provides way of representing signals in time and frequency domain. This Discrete wavelet uses two types of filter high pass and low pass filter.

Transform domain processing techniques are based on modifying the Fourier transform of image. They are Pyramid Method, Wavelet Transform, Multiwavelet transform, Curvelet Transform. In Transform Domain, Image is first transferred into frequency domain. All the Fusion operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image.

2.5.Medical Image Fusion using combined wavelet and ripplet transform

Medical Image Fusion using combined wavelet and ripplet transform method using the combined effect of DWT and DRT. The DWT could detect local features of images. DRT had provide better advantage of directionality and localization, then PCCN was applied to low pass coefficients and maximum fusion rule was applied to fuse the approximation image. Proposed method had better clarity compared to DWT and PCNN methods.

2.6. Medical Image Fusion Based On Ripplet Transform Type-I

In this method, the concept of Medical Image Fusion is introduced using DRT method. As a novel MGA-tool, ripplet offers better advantage of directionality, localization, multi-scale and anisotropy, which cannot be perfectly achieved by traditional MRAtool like wavelet transform. Even though, here only used simple fusion rules in this paper, the experimental results show that RT is very effective in MIF. The proposed MIF method based on RT, is analyzed both visually and quantitatively. The proposed method is compared with CNT, and the superiority of the proposed method is established. Experimental results show that the RT based MIF, can preserve more useful information in the fused medical image with higher spatial resolution and less difference to the source images. The one disadvantage of this method is it does not provide MultiResolution.

2.7. Medical Image Fusion Using Countourlet Transform
This technique decomposes image into four images which contains different detail value based on horizontal, vertical and diagonal component. Based on this coefficient value it compares two input images and apply inverse transformation for fused image. Wavelet based fusion method offer several advantage over pixel based. It removes blurred part in output image and provide clear object then wavelet based method.

2.9. Butterworth High Pass Filter and Cross Bilateral filter
Input source images are sharpened by using high order and low cut off frequency Butterworth filter. Sharpened source images are the inputs of cross bilateral filter. Modified image fusion framework is the combination of Butterworth High pass filter and Cross Bilateral filter. A multiscale alternating sequential filter is exploited to extract the useful characterizations (e.g., details and edges) from noisy input medical images. Then, a bilateral filter based filtering to guide the fusion of main features of input images. The modified image fusion framework is effective in preserving brightness, fine details, information content, texture and contrast of image.
It provides an easy access for radiologists to quickly and effectively report CT/MR studies. In fact, in many applications, the medical images obtained from medical instruments are noisy due to imperfection of image capturing devices. Unfortunately, noise is easily mistaken for the useful feature of the image, making the traditional image fusion algorithms invalid, although they can efficiently fuse noise-free images. Thus, it is necessary and challenging to investigate joint fusion and denoising for multimodality medical images.

2.10. Multiscale Alternating Sequential Filter
Multiscale alternating sequential filter is exploited to extract the useful characterizations from noisy input medical images. The image feature extraction of the source input image is obtained using morphological multi-scale alternating sequence filter. Mathematical morphology, dilation can merge the points of the

background image into the surrounding objects. Erosion can eliminate the boundary points of the object. Other two important operations, which are opening and closing. The closing can remove the small holes and fill the gaps on the contour, while opening can eliminate the “glitches” and scatters of the object edge.

3.FEATURE EXTRACTION
Noise and features of the medical image have similar characteristics in the spatial and frequency domains, making it difficult to image feature extraction. An image feature extraction method based on a morphological multi-scale alternating sequence filter is proposed. The basic operations of mathematical morphology are dilation, erosion, opening and closing. Dilation and erosion, denoted by f ⊕ B and f _ B, which are defined as follows:

$$f \oplus B = \max_{u,v}(f(x-u, y-v) + B(u,v))$$
$$f \ominus B = \min_{u,v}(f(x+u, y+v) - B(u,v)).$$

Mathematical morphology, dilation can merge the points of the background image into the surrounding objects. Erosion can eliminate the boundary points of the object. Other two important operations, which are opening and closing and denoted by f ◦ B and f • B, are defined as follows:

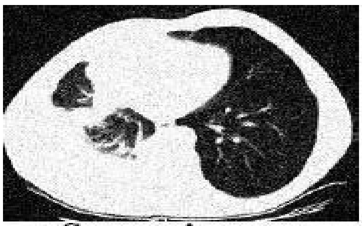
$$f \circ B = (f \ominus B) \oplus B$$
$$f \bullet B = (f \oplus B) \ominus B.$$

Closing can remove the small holes and fill the gaps on the contour, while opening can eliminate the “glitches” and scatters of the object edge. We use the structuring element of 3×3 for closing operation to reduce noise and the structuring and the structuring element of 5 × 5 for opening operation to fill the holes generated by closing operations. The image feature extraction method as follows:
where F(ui) is the image feature of the input image ui, and B3×3 and B5×5 are defined as

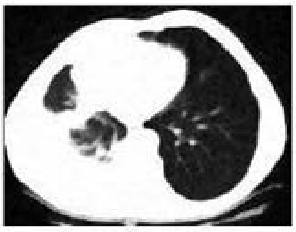
$$F(u_i) = (u_i \oplus B_{3\times3}) \oplus B_{5\times5} - A(u_i)$$

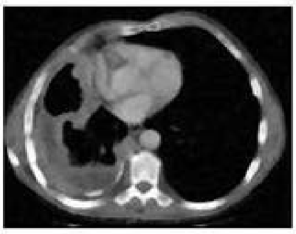
$$B_{3\times3} = \frac{1}{4}\sum_{j=0^\circ}^{135^\circ} B^j_{3\times3},\quad B_{5\times5} = \frac{1}{4}\sum_{j=0^\circ}^{135^\circ} B^j_{5\times5}$$
$$\{j \mid j = 0^\circ, 45^\circ, 90^\circ \text{ and } 135^\circ\}.$$

The proposed image feature extraction method can effectively extract the main features from the noisy source image.



Source image u_1





4.AVERAGE WEIGHT PIXEL

A multi-scale alternating sequential filter is first innovatively integrated into the multimodal medical image fusion framework by recursive filtering-based weight map technique.It can effectively extract the main characteristics from noisy input medical images, preventing noise interference.The weight should highlight the main feature from the source images, so the feature maps are compared to determine the weight map as follows:

$$w'_n(x,y)=\begin{cases}1 & F_n(x,y)=\underbrace{F_1(x,y),F_2(x,y),\ldots,F_N(x,y)}_{\max}\\ 0 & \text{otherwise}\end{cases}$$

where N is the number of source images, Fn(x, y) is the feature value of the pixel (x, y) in the nth image. The weights estimated above are noisy and hard (0 or 1), which may produce artifacts to the fused image. Thus, we use the recursive filter to smooth the weight map. Pixels with similar gray values tend to have similar smoothed weight. Here, The cross bilateral filter is performed on the weight map.

$$\widetilde{w}_n = \mathrm{RF}_{\sigma_s,\sigma_r}\left(w'_n\right)$$

where RF denotes the recursive filter operation, and σs and σr the parameters and they, respectively, control the space and range support of the recursive filter

$$w_n = \left(\sum_{i=1}^{n}\widetilde{w}_i\right)^{-1}\widetilde{w}_n.$$

where RF denotes the recursive filter operation, and σs and σr the parameters and they, respectively, control the space and range support of the recursive filter. The redefined weight maps can transform the hard and noise weight maps into smooth weight maps and can well highlight the main features in each source medical image.

5.IMAGE ENHANCEMENT

The main notion behind filtering is to get the filtered image and the results obtained from these filtered images are more useful for medical applications. Image filtering is useful for the removal of noise and the enhancement of image details such as edges or lines. Low pass filter (LPF) leads to the smoothing of image by removing the high frequency components, and High pass filter (HPF) used for the sharpening purposes. For sharpening purposes, Ideal

HPF has the sharp discontinuity which produces the unwanted ringing effect. BHPF does not have sharp discontinuity, thus not having much ringing artifacts. It has maximal flat phase delay. Gaussian HPF is smoother than both BHPF and IHPF. BHPF is the transition between the IHPF and GHPF. BHPF has the gradual attenuation profile, in which the cut off and slope are to be adjusted independently. The transfer function of BHPF is given as

$$H(f) = \frac{1}{(1+f_0/f)^{2n}}$$

where fo is a certain cut off frequency, n is the order of the filter. It passes the frequency above fo and rejects the lower frequencies. In BHPF, both cut off frequency and order can be changed to yield variety of results. As the cut off frequency increases, the filter becomes smoother, and the resultant filtered images are milder. The effect is not much pronounced due to the order, which can be controlled independently to get the sharper images. But in GHPF, order cannot be changed, and thus increase in cut off frequency results in more smoothness. Hence, images filtered from BHPF are superior in quality.

6. DENOISING AND FUSION FRAMEWORK

Bilateral filter is a smoothing filter, which nonlinearly combines the image values while maintaining the edges. It filters the images by taking the weighted average of pixels, which is same as the Gaussian convolution. But Gaussian filter (GF) depends only on domain filtering and BF depend upon both the range filtering and domain filtering. The up gradation of weights also depends on intensity of image. BF thus used for both color and gray scale images. Edges do not have much difference in intensity, so they remain preserved and not get impaired. For filtered images P and Q, the bilateral filter outputs are given as

$$P_{CBF}(m)=\frac{1}{W}\sum_{n\in S}G_{\sigma_d}(\|m-n\|)G_{\sigma_r}(|P(m)-P(n)|)P(n) \quad (1)$$

$$Q_{CBF}(m)=\frac{1}{W}\sum_{n\in S}G_{\sigma_d}(\|m-n\|)G_{\sigma_r}(|P(m)-P(n)|)Q(n) \quad (2)$$

Where

$W=\sum_{n\in S}G_{\sigma_d}(\|m-n\|)G_{\sigma_r}(|P(m)-P(n)|)$ is a normalization constant.

$G_{\sigma_d}(\|m-n\|)=e^{-\frac{\|m-n\|^2}{2\sigma_d^2}}$ is a domain filtering function

$G_{\sigma_r}(|P(m)-P(n)|)=e^{-\frac{|P(m)-P(n)|^2}{2\sigma_r^2}}$ is a range filtering function

σ_d and σ_r parameters, which control the filtering of bilateral filter.

Increasing the value of leads to the smoothing of features and also decreases the Mean square error (MSE). Increasing the filter becomes closer to the Gaussian blur. The sum of these detail strengths gives the weights of detailed images. And the fused image is obtained from the weighted average of source images given as:

$$F(i,j)=\frac{P(i,j)wt_p(i,j)+Q(i,j)wt_q(i,j)}{wt_p(i,j)+wt_q(i,j)}$$

7.CONCLUSION

A novel and effective variation-model-based method for multimodal medical image fusion and denoising has been presented. The multiscale alternating sequential filter is first innovatively integrated into the multimodal medical image fusion framework by recursive filtering-based weight map technique. It can effectively extract the main characteristics from noisy input medical images, preventing noise interference. Furthermore, the local AFOTV constraint is constructed to further suppress noise, overcoming the shortcoming of the TV. The experiments demonstrate that the proposed method provides a more general solution and is successfully applied to the fusion of noisy and noise-free multimodal medical images. Encouragingly, the proposed method can greatly suppress noise while well preserving the complementary information and main features of noisy input medical images. Future research will be done for the adaptability of the parameters.

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