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Implementation of Image Fusion Algorithm using 2G Curvelet Transform

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Abstract:
Image fusion is an important research topic in many related areas such as computer vision, robotics, and medical imaging, etc. Multi-sensor image fusion is the process of combining relevant information from several images into one image. The final output image can provide more information than any of the single images. Image fusion, as opposed to strict data fusion, requires data representing every point on a surface or in space to be fused, rather than selected points of interest. There are numerous medical examples presented of image fusion for registering and combining Magnetic Resonance (MR) and Computer Tomography (CT) into composites to aid surgery. In each of these examples, there are numerous opportunities for image fusion success to help in decision-making and diagnostics. It also contains various potential applications for medical data collection and diagnosis. It assists physicians in extracting features that may not be normally visible in images produced by different modalities. There are surveillance examples of image fusion for combining polariometric Synthetic Aperture Radar (SAR) and Hyper Spectral (HSI) data. Finally, a third field is industrial applications that include Non Destructive Evaluation (NDE) techniques to inspect parts. A variety of techniques have been developed for fuse the images, broadly classified into the spatial and spectral methods. Image fusion algorithms can be categorized into different levels: low, middle, and high; or pixel, feature, and symbolic levels.

Key words*: Curvelet transform, Image fusion Ridgelet transform, Wavelet transform, Wrapping*

1. Introduction

The use of image fusion techniques has gained significant popularity over the past decade. It is improved with development of digital image processing and image analysis technology, and gradually demonstrates. It's wide range of applications in the automatic target recognition, remote sensing, medical image processing and other fields. Image fusion is an important research topic in many related areas such as computer vision, Satellite imaging, remote sensing, image processing, robotics, and medical imaging. Multi-sensor image fusion is the process of combining relevant information from several images into one image. More information can be obtained from the final output image. Image fusion, as opposed to strict data fusion, requiresdata representing every point on a surface or in space tobefused, rather than selected points of interest. It also contains various potential applications for medical data collection and diagnosis. It assists physicians in extracting features that may not be normally visible in images produced by different modalities. There are numerous medical examples presented of image fusion for registering and combining magnetic resonance (MR) and computer tomography (CT) into composites to aid surgery. Likewise, there are surveillance examples of image fusion for combining polariometric synthetic aperture radar (SAR) and hyper spectral (HSI) data. Another example is fusion of high-altitude images from Electro-optical/infrared (EO/IR), HSI, and SAR.

Finally, a third field is industrial applications that include non destructive (NDE) evaluation techniques to inspect parts. In each of these examples, there are numerous opportunities for image fusion success in bringing together images from different sensors to help in decision making and diagnostics. For many applications, image fusion provides a pleasing perceptual display for a user to make better decisions which drives research in medical applications, geo-spatial displays and military situational awareness. The exploration of image fusion techniques relies on interplay between the user and the system to augment the feature and content of the image. To enhance the user validation of the image fusion techniques, metrics are being designed to facilitate the image fusion quality. Image fusion algorithms can be categorized into different levels: low, middle, and high; or pixel, feature, and symbolic levels. The Pixel Level image fusion is to take the average of the two images pixel by pixel. However, this method usually leads to undesirable side effect such as reduced contrast. The feature-level algorithms typically segment the image into contiguous regions and fuse the regions together using their properties. The features used may be calculated separately from each image or they may be obtained by the simultaneous processing of all the images. Decision-level Fusion algorithms combine image descriptions to the fused image, such as in the form of a relational graph. So the main objective of image fusion is to obtain a better visual understanding of certain phenomena, and to introduce or enhance intelligence and system control functions.

2. Image Fusion

Image fusion is a data fusion technology which keeps images as main research contents. It refers to the techniques that integrate multi-images of the same scene from multiple image sensor data or integrate multi-images of the same scene at different times from one image sensor. Image fusion combines perfectly registered images from multiple sources to produce a high quality fused image with spatial and spectral information. It integrates complementary information from various modalities based on specific rules to give a better visual picture of a scenario, suitable for processing. This Complementary Fusion is useful in many Medical Applications. Image Fusion can be done in different levels such as pixel Level Fusion, Region Based Fusion, Feature Level Fusion, Entropy Based Fusion, Decision Level Fusion, and Contrast Based Fusion.

Image Fusion also contains various potential applications for medical data collection and diagnosis. It assists physicians in extracting features that may not be normally visible in images produced by different modalities. For example, a MRI-T1 provides greater detail about anatomical structure, whereas a MRI-T2 provides a greater contrast between the normal and abnormal tissues. Other medical image analyses, an image showing functional and metabolic activity such as a single photon emission computed tomography (SPECT), positron emission tomography (PET), and magnetic resonance spectroscopy (MRS), are often registered to an Image which shows anatomical structures such as a magnetic resonance image (MRI), computed tomography (CT), and an ultrasound. Thus to extract more information, medical image fusion is performed in such a manner as to combine these contrasting and complimentary features into one image. Advantages of these applications are to reduce the difficulty in diagnosing disease and reducing storage cost. The goal of image fusion is to obtain useful complementary information from multimodality images as much as possible. The simplest way to obtain a fused image from two or more medical images is to average them. Although mostly preserving the original meaning of the images, it is prone to reduce the contrast of the fused image. Most of present image fusion methods aim at obtaining as many as information from the different modality images. The fusion criterion is to minimize different error between the fused image and the input images. With respect to the medical diagnosis, the edges and outlines of the interested objects is more important than other information. Therefore, how to preserve the edge-like features is worthy of investigating for medical image fusion. The Image Quality of Fused Image can be evaluated by PSNR, RMSE and Entropy.

2.1. Discrete Curvelet Based Fusion

Curvelet transform is anisotropy, which can represent the contour of image more sparsely and provide more information for image processing. In this curvelet approach, input image is first decomposed into a set of sub bands each of which is then partitioned into several blocks for ridge let analysis. The ridgelet transform is implemented using the Radon transform and the 1-D wavelet transform. During the ridge let transform, one of the processes is the spatial partitioning which involves overlapping of windows to avoid blocking effects. It results in a large amount of redundancy. The Curvelet Co-efficient has taken and depending upon the maximum value the fusion between the images takes place. It is used to extract the edge information, the ridge let transform is complicated so the process is very time Consuming. In Medical applications the edge information plays a major role since we need all the data to recognize the disease. The blocking artifacts can be reduced in the Curvelet Transform

3. Proposed Image Fusion

Image Fusion is defined as the process of combining information in two or more images of a scene to enhance viewing or understanding of the scene. Image fusion is opposed to strict data fusion, requires data representing every point on a surface or in space so to be fused, rather than selected points of interest. Image fusion can be based on Pixel, Features, Region, Entropy and Contrast based Fusion. In this project we deal with Pixel Level Fusion, Region based Fusion and Feature Level Fusion. It’s used to fuse Medical images using Complementary analysis where the CT image and MRI Images are fused together to get all the visual information about the image. To fuse these images there are many fusion algorithms based on Wavelet. Now we have proposed a new fusion algorithm based on both wavelet and Second generation Curvelet Transform. Since using Wavelet Transform edge information can’t be extracted clearly. In Medical Image Fusion the edge information is most important so we are going to use a new algorithm to fuse the images. It is a combination of Wavelet and Curvelet based algorithm which extracts edge information and the process is simple to analyze the fusion of images. Images are fused in Pixel level fusion; Region based fusion and Feature level Fusion. It’s mainly used in medical applications and it can be taken on pixel directly, and then fused image could be obtained. We can keep as more information as possible from source images. Using Complementary Fusion, the image of CT and MRI has been fused. Fig 2.1 shows the steps to fuse two images as follows Using Wavelet Transform to decompose original images into proper levels. One low-frequency approximate component and three high-frequency detail components will be acquired in each level. Curvelet Transform of individual acquired low frequency approximate component and high frequency detail components from both of images, neighborhood interpolation method is used and the details of gray can’t be changed. In Pixel level fusion depending on maximum value of pixels is chosen to measure definition for low frequency component. First, divide low-frequency as four sub square blocks and calculate the maximum value of the block. Taking Inverse transformation of coefficients after fusion, the reconstructed image will be a fused image. In Region based fusion the fusion depends upon the region which is segmented and depending on variance the image is fused**.** In the Feature Level Fusion, depending on the Entropy and Variance value based on Region based Fusion this fusion occurs. The Performance of the algorithm can be evaluated using Entropy, RMSE and PSNR.

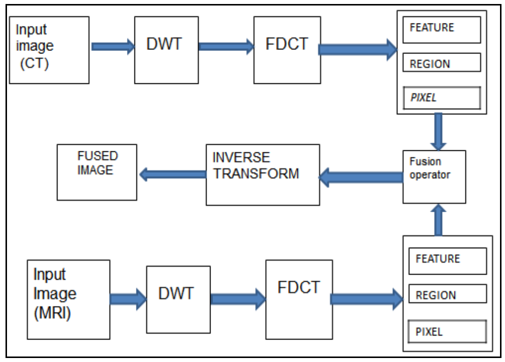

Figure 1: Block diagram of Image fusion algorithm

4. Simulation Result for Curvelet Transform

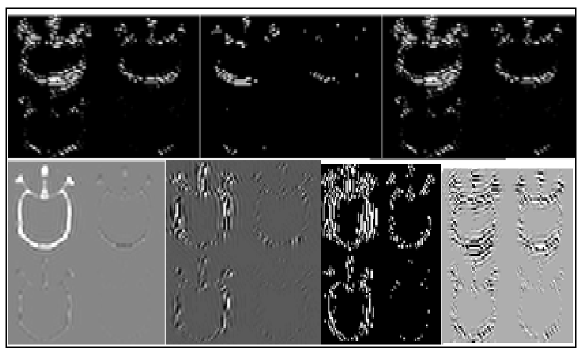

Figure 2: Simulated images of curvelet transform

Discrete curve let transform is implemented using the wrapping based fast discrete curvelet transform. Basically, multi resolution discrete curvelet transform in the spectral domain utilizes the advantages of Fast Fourier transform (FFT). During FFT, both the image and the curvelet at a given scale and orientation are transformed into the Fourier domain. The convolution of the curvelet with the image in the spatial domain then becomes their product in the Fourier domain. At the end of this computation process, we obtain a set of curvelet coefficients by applying inverse FFT to the spectral product. This set contains curve let coefficients in ascending order of the scales and orientations. There is a problem in applying inverse FFT on the obtained frequency spectrum. The frequency response of a curveletisa trapezoidal wedge which needs to be wrapped into a rectangular support to perform the inverse Fourier transforms.

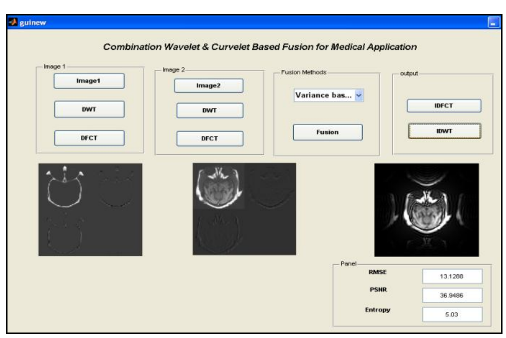

Figure 3: Screen shot of curvelet transform

The wrapping of this trapezoidal wedge is done by periodically tiling the spectrum inside the wedge and collecting the rectangular coefficient area in the origin. Through this periodic tiling, the rectangular region collects the wedge's corresponding fragmented portions from the surrounding parallelograms. For this wedge wrapping process, this approach of curvelet transform is known as the 'wrapping based curvelet transform'. The idea is to replicate the wedge on a 2-D grid, so a rectangle in the center captures all the components a, b, and c of the wedge. The Wedge wrapping is done for all the wedges at each scale in the frequency domain, so we obtain a set of sub bands or wedges at each curvelet decomposition level. These sub bands are the collection of discrete curvelet coefficients. To provide an illustration of curve let sub bands, we apply fast discrete curvelet transform to a 512×512 CT image with 6 decomposition levels using Curvelets. The sub bands generated from this image are shown in fig II. CT image has a rich collection of multidirectional edges. From all the subband images of CT image we find that the wrapping based discrete curvelet coefficients capture and represent the edge information more accurately than wavelet transform. When Curvelet transform is applied to the CT image which has been processed after wavelettransform has been applied to it. The screen shot fig III shows the format and procedure of the process of curvelet transform.

5. Conclusion

The Wavelet and Fast Discrete Curvelet Transform has been applied to the medical images. This fusion has been used to get all information clearly for diagnosis. This can be used to give the edge information clearly and speed of computation will be high compared to other methods. Experiments are conducted on multi-focus images by using different methods and the performances were evaluated with the indicators such as mean error, variance and information entropy. Experimental results show that the method is more suitable for multi-focus image fusion than some other ways, and the fusion image will have more information. The Feature Level Fusion depending upon the entropy and variance the images are fused. The Quantitative analysis will be processed comparing the Pixel, Region and Feature Level fusion.

6. Future Expansions

The image processed using curvelet transform can be further processed based on Pixel, Region and Feature level Fusion. Depending on the pixels and comparing each pixel the maximum value the image can fuse. Similarly based on the region the images can be used to extract all the visual information with reduced noise. The Feature Level Fusion depending upon the entropy and variance the images are fused. The Quantitative analysis will be processed comparing the Pixel, Region and Feature Level fusion. The Images can be fused depending upon the Decision Level Fusion.

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