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RESEARCH ARTICLE

IMPLEMENTATION OF NON-SUBSAMPLED SHEARLET TRANSFORM FOR IMAGE FUSION

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ABSTRACT

Now a day an image fusion is an emerging field and powerful technology in the area of image processing. The process of integrating multiple input images into a new single composite image with more informative than any of input image. There are different image fusion transform techniques proposed by many researchers. Out of that transform techniques a Non-subsampled shearlet transform adds the property of shift-invariant, capture more directional information and represent the directions of edges more accurately as compared to other transform techniques such as discrete wavelet transform and Non-subsampled contourlet transform (NSCT) techniques. This paper presents concept of software simulation of Non-subsampled shearlet transform based decomposition algorithm for application of image fusion using MATLAB Simulink Library. Simulink library Blockset is used to implement a model which is able to do the pixel level averaging image fusion. Non-subsampled shearlet transform is implemented with the filter banks whose levels can be adjusted. The perfect reconstruction can be obtained with the down sampling of the images. NSST decomposition provides a simple hierarchical framework to fuse images with different spatial resolution. It is a powerful tool to separate the spectral content of an image from the spatial information.

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INTRODUCTION

The NSST is the shift-invariant version of shearlet transform, which can capture 2-D geometrical structure much more effectively than that traditional multi-scale transforms (Yong Yang *et al.*, 2015). When the NSST is introduced into the image fusion field, more information for fusion can be obtained and the impacts of miss-registration on the fused results can also be reduced effectively. Moreover, the computational complexity of NSST is lower than that of the NSCT. Therefore the NSST is suitable for image fusion (Xingbin Liu *et al.*, 2015). The frequency support of shearlet is a pair of trapezoidal region which is symmetric relatively for the origin along the direction of the slope s in different scales and the size of which is $2^{2j} \times 2^{j}$, and the frequency partition of NSST is shown in Fig.1 (Xingbin Liu *et al.*, 2015) An illustration of this frequency tiling is shown in Fig.1. (Xingbin Liu *et al.*, 2015). Shearlet are well localized and exhibit highly directional sensitivity, and the number of orientations doubles at each finer scale. The key idea of Shearlet transform is to filter signal in pseudo polar grid by one dimensional band-pass filter banks (Jingming Yang *et al.*, 2016). It is more important that frequency-domain implementation of Shearlet transform (Xingbin Liu *et al.*, 2015). Whose filtering is done in frequency domain directly without critical sampling operation, so the distortion in directional filtering is avoided and the translation-invariance is ensured. This transform can adaptively capture the geometrical characteristic of multidimensional data and is more efficient in representing images containing edges (Xingbin Liu *et al.*, 2015). So In more details, Non-sub-sampled Shearlet transform (NSST) with translation-invariant is designed to improve effectiveness algorithm (Yong Yang *et al.*, 2015).

Related work

In the last few years, there are different image fusion algorithms proposed by many researchers. Amira *et al.* (2001) has shown that fast Walsh-Hadamard transforms. These transforms are important in many signal-processing applications including speech compression, filtering and coding. Two novel architectures for the fast Hadamard transforms using both a systolic architecture and distributed arithmetic techniques are presented. Tianjiao Zeng *et al.* (2015) have discussed a Laplacian Pyramid Transform analysis and comparison of different algorithms; Laplacian pyramid transform focused on pixel level as our fusion methodology. Mobile computing is used, as the whole process is done on the mobile device without uploading to the cloud. The result of our project realizes the enhancement of reality, improves

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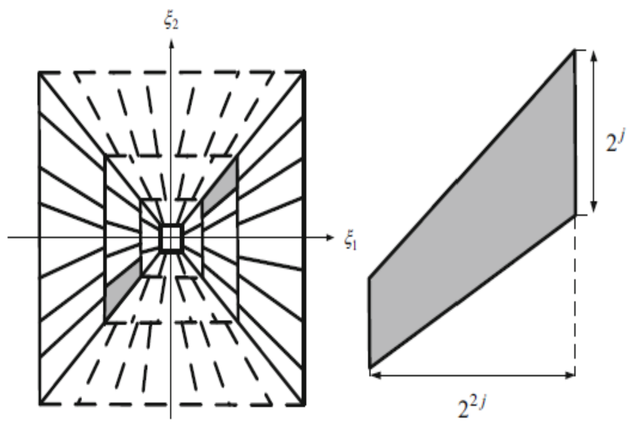
resolution and intelligibility. Ligia Chiorean and Mircea-Florin Vaida (2009) has presented a discrete wavelet transform, so the image fusion process allows combination of salient feature of these images. The dedicated application considers Java technology for using its facilities as a future development, regarding a remote access mechanism. Fitri Amia, Syiah Kuala, Banda Aceh (2009) improve perceptual quality of a robust Discrete Cosine Transform (DCT) domain watermarking scheme, a wavelet based image fusion has proposed instead of spatial masking techniques The robust watermarking is, achieved by inserting watermark sequences in the low frequency DCT coefficients of a host image. Then, the host and the watermarked image are decomposed using a two-level Discrete Wavelets transform (DWT). The image fusion is done by means of replacing the approximate and detail coefficients of the watermarked image with the new coefficients that obtained by applying a certain rule. Qiang Zhang, Bao-long Guo (2009) has discussed the Multi-focus image fusion using the non-subsampled contourlet transform. It significantly outperforms the traditional discrete wavelet transform-based and the discrete wavelet frame transform-based image fusion methods in terms of both visual quality and objective evaluation, especially when the source images are not perfectly registered. Siji Quan, Weiping Qian, Junhai Guo (2014) has shown that the Visible and infrared image fusion based on Curvelet transform. Curvelet transform decompose images to different resolutions, and standard fusion rules are built to integrate information from both images. This algorithm is carried out on a set of standard image set, and is compared to a traditional method. It proves that this fusion algorithm based on Curvelet transform is effective enough to accomplish visible and infrared image fusion.



(a) (b)

Fig.1. The structure of the frequency partition by NSST

Yong Yang, Song Tong, Shuying Huang and Pan Lin (2015) has shown that Multifocus Image Fusion Based on non-sub-sampled contourlet transform (NSCT) and Focused Area Detection. First, the source multi-focus images are decomposed using the non-subsampled contourlet transform (NSCT). The low-frequency sub-band coefficients are fused by the sum-modified Laplacian based local visual contrast, whereas the high-frequency sub-band coefficients are fused by the local Log-Gabor energy. The initial fused image is subsequently reconstructed based on the inverse NSCT with the fused coefficients. Second, after analyzing the similarity between the previous fused image and the source images, the initial focus area detection map is obtained; this is used for achieving the decision map obtained by employing a mathematical morphology post processing technique. Finally, based on the decision map, the final fused image is obtained by selecting the pixels in the focus areas and retaining the pixels in the focus region boundary as their corresponding pixels in the initial fused image. Xingbin Liu *et al*. (2015) has shown that the non-sub sampled shearlet transform algorithm for image fusion. In that algorithm the source images are decomposed into several sub-bands of different scales and directions by NSST and the low frequency sub-band and band-pass sub-band coefficients are obtained. Secondly, for the low frequency sub-band coefficients, the singular value decomposition method in the gradient domain is used to estimate the local structure information of image, and an adaptive 'weighted averaging' fusion rule based on the sigmoid function and the extracted features. And finally, the fused image is obtained by performing the inverse NSST on the combined coefficients. Hence the NSST has higher computational efficiency and stronger selectivity of anisotropic direction.

Proposed technique

Fusing of images using non-sub sampled shearlet transform has become as an important tool in many areas of image processing. Methodology as given below will be implemented in proposed work:

A new image fusion algorithm based on the non-subsampled shearlet transform (NSST) is presented. First, an initial fused image is acquired by using a conventional multi-resolution image fusion method (Xingbin Liu *et al*., 2015). The pixels of those source multi-focus images, which have smaller square error with the corresponding pixels of the initial fused image, are considered in the focused regions (Yong Yang *et al*., 2015). Based on this principle, the focused regions are determined, and the morphological opening and closing are employed for post-processing (Yong Yang *et al*., 2015). Then the focused regions and the focused border regions in each source image are identified and used to guide the fusion process in NSST domain. Finally, the fused image is obtained using the inverse NSST. Experimental results show that this proposed method can not only extract more important detailed information from source images, but also avoid the introduction of artificial information effectively (Jingming Yang *et al*., 2016).

The proposed image fusion method consists of the following four steps:

1. Perform a J-level NSST on source images A_K(k = 1, 2,…….,K), respectively, to obtain the corresponding low-pass sub-band coefficients and the band-pass directional sub-bands coefficients.
2. Detect the focused regions of the source images.
3. Employ the proposed fusion rules to construct the NSST coefficients of the fused image.
4. Reconstruct the fusion image based on the fused coefficients by taking an inverse NSST, and then the fusion image is obtained.

The block diagram of proposed technique is as shown in the Figure 2.

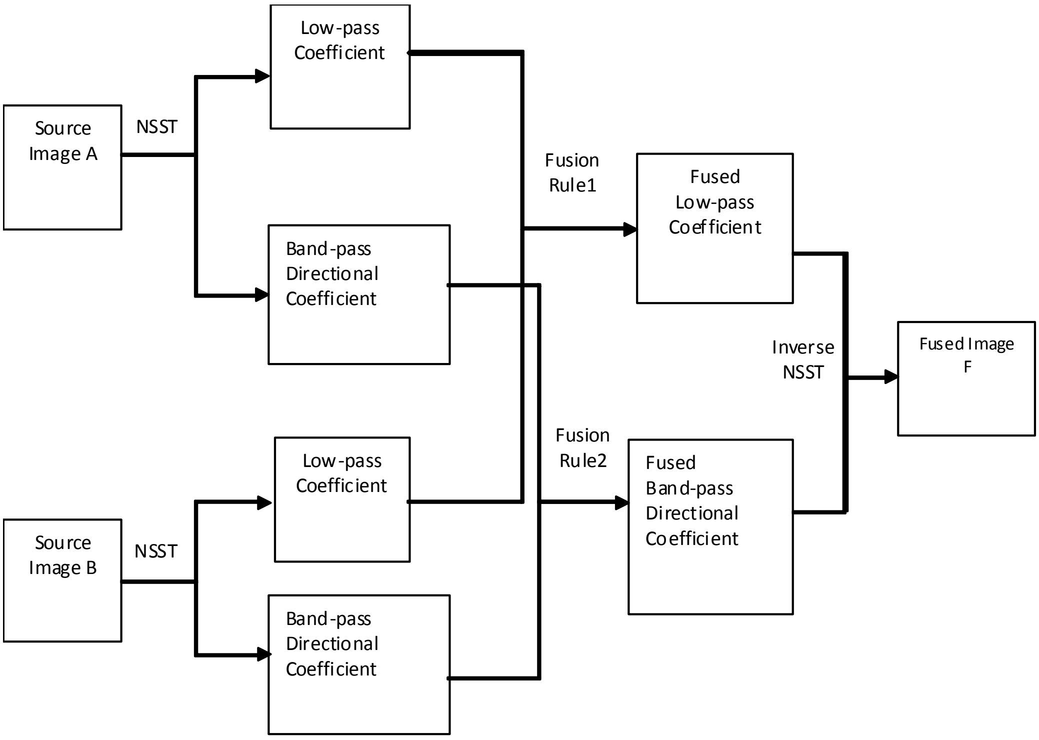


Fig.2. Block diagram of proposed technique

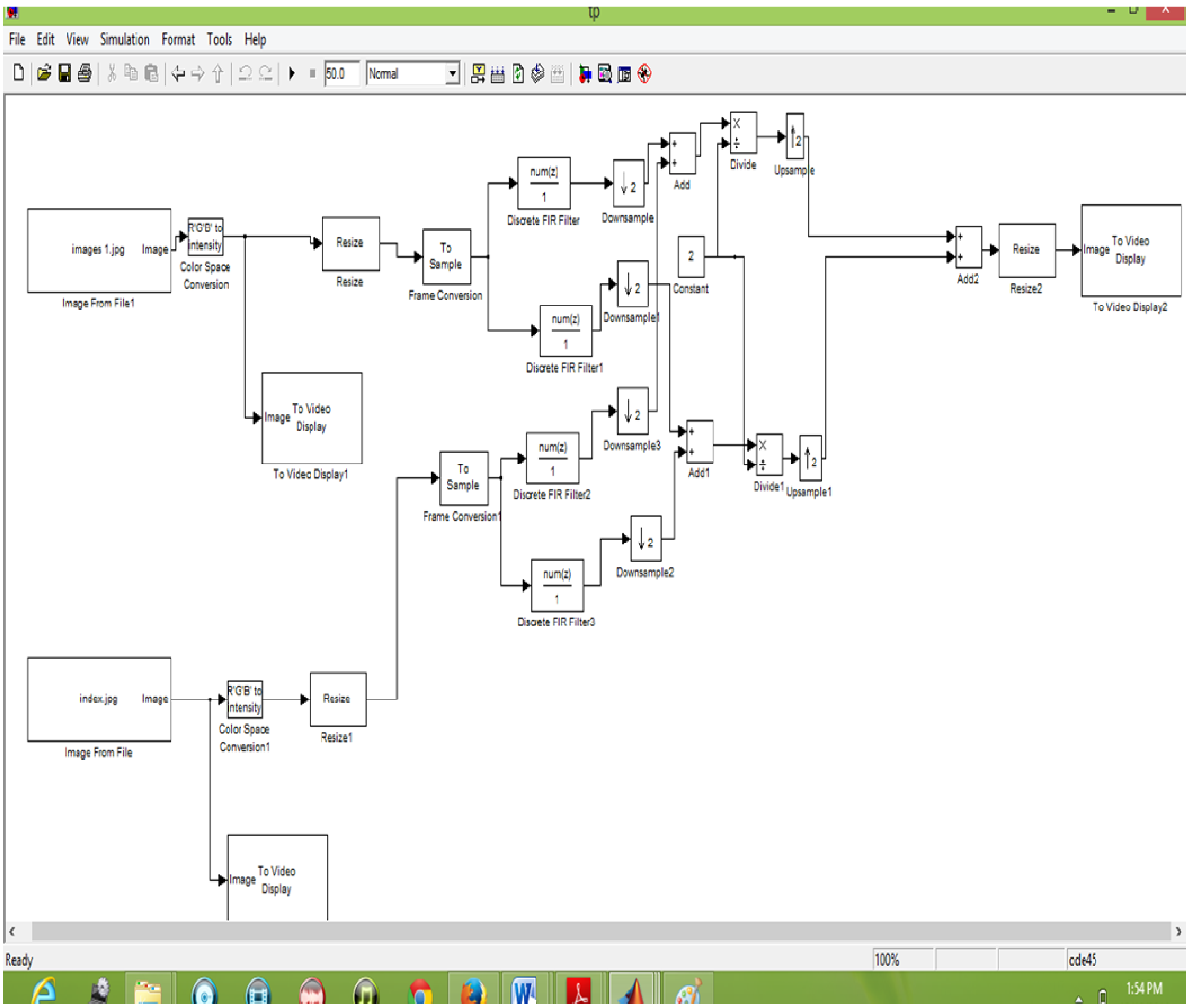


Fig.3. MATLAB Simulink model

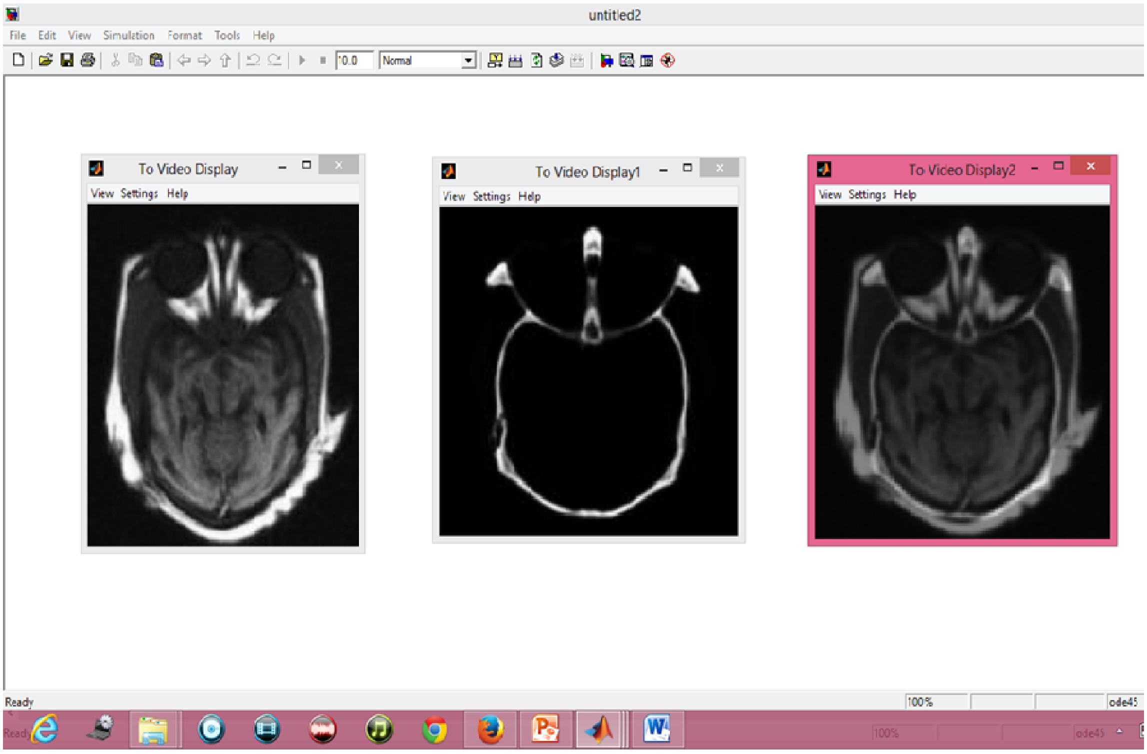


Fig.4. Fused image

Implementation

Simulink is an additional toolbox that runs on top of MATLAB. To start this, type "Simulink" in the Command Window or click on the Simulink icon. Simulink library provides various blocks that particularly for image processing applications. Image source and image viewer are Simulink block sets by using these blocks image can give as input and output image can be viewed on image viewer block set. Image pre-processing and image post-processing unite are common for all the image processing applications which are designed using Simulink block sets. Here in this model some of the image processing blocks are used such as image from file which is used to browse the required image. Along with this resize block is used to equalize the number of pixels before that R'G'B' to intensity block performs the gray conversion of image. Thus the two images are preprocessed using the preprocessing blocks in the Simulink library. These images are then given as input to the Discrete FIR filter which are designed as Low Pass Filter and High Pass filter respectively. Thus these images are filtered and up sampled to decompose the images with level of 2. Thus the low frequency components i.e. low pixel value and high frequency component i.e. high pixel values are separated and then added in the ADD block of the Simulink library. Low valued pixels as well as high valued pixels from individual images are added together to fuse the two different images but as when two pixels are added its value increases beyond limits. Therefore there is need to divide the pixel value by two so that Divide Block of Simulink library is used. These images are then up sampled to form a composite image. Simulink library provides two separate sampling blocks such as up sample and down sample along with this to display the images the block Video display is used. Thus the model is divided in the three sections such as 1) Image acquisition and preprocessing 2) decomposition 3) Image fusion.

Image fusion is obtained using the averaging method the mean value is calculated of two different images after the decomposition of images. The algorithms are developed and models are built for image fusion application using two level de-composition. These models are simulated in Matlab Simulink environment with suitable simulation time and simulation mode and tested. The reflected results can be seen on a video display.

RESULTS

The result of the image fusion based on the non-sub sampled shearlet transform technique which is implemented using MATLAB Simulink Library is as shown in the Fig.4. The composite fused image obtained is having the resolution as per the variable size which is designed using resize block. Thus the results obtained are shown above:

Conclusion

The non-sub-sampled shearlet transforms is the very good technique for the image fusion provide a high quality spectral content, Hence NSST has stronger selectivity of anisotropic direction, higher computational efficiency, and provides additional information about the geometry of the set of singularities such as edges and other discontinuities compared to NSCT. Therefore, NSST is more applicable in various applications of image fusion. And further it can be implemented on hardware platform in optimized manner. So non-sub-sampled shearlet transform (NSST) is found to be best algorithm for image fusion. The MATLAB tool Simulink library is a new application in image processing and offers a friendly environment design for the processing, because processing units are designed by blocks. This tool support software simulation, but the most important is that can be used synthesize in FPGAs hardware using system generator, with the parallelism, robust and speed, this features are essentials in image processing.

Future scope

In the Future discussion the main objectives are the Implementation and simulation of Simulink based model on XILINX System Generator using Xilinx Blockset and further it can be implemented on hardware platform in optimized manner. The hardware platform may be the VIRTEX or SPARTAN FPGA Board.

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