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Multifocal Image Fusion Based on NSCT

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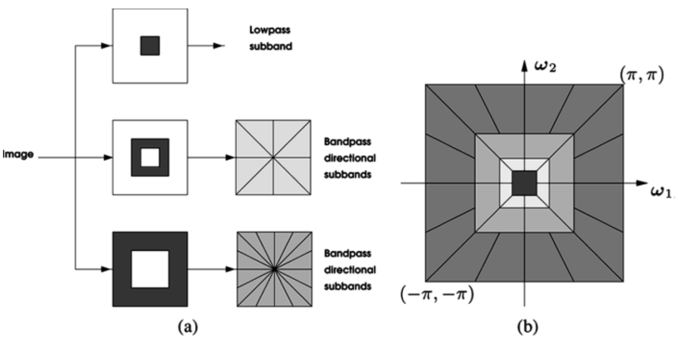
ABSTRACT

To overcome the difficulties of sub-band coefficients selection in multiscale transform domain-based image fusion and solve the problem of block effects suffered by spatial domain-based image fusion, this paper presents a novel hybrid multifocus image fusion method. First, the source multifocus 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, 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. Experimental results demonstrate that the proposed method is better than various existing transform-based fusion methods, including gradient pyramid transform, discrete wavelet transform, NSCT, and a spatial-based method, in terms of both subjective and objective evaluations.
Keywords : Multi-focus image fusion, non-sub sampled contourlet transform, Log-Gabor energy, focused area detection, mathematical morphology.

I. INTRODUCTION

THE importance of image fusion in current image processing systems is increasing, primarily because of the increased number and variety of image acquisition techniques. The purpose of image fusion is to combine different images from several sensors or the same sensor at different Manuscript received July 15, 2014; revised December 7, 2014; accepted December 7, 2014.Date of publication December 12, 2014; date of current version March 27, 2015. This work was supported in part by the National Natural Science Foundation of China under Grant 61262034, Grant 61462031, and Grant 61473221, in part by the Key Project through the Ministry of Education, China, under Grant 211087, in part by the Natural Science Foundation of Jiangxi Province under Grant 20114BAB211020 and under Grant 20132BAB201025, in part by the Young Scientist Foundation of Jiangxi Province under Grant 20122BCB23017, and in part by the Project of the Education Department of Jiangxi Province under Grant GJJ14334 and Grant KJLD14031. The associate editor coordinating the review of this paper and approving it for publication was Dr. D. Hecht. Y. Yang and S. Tong are with the School of Information Technology, Jiangxi University of Finance and Economics, Nanchang 330013, China. S. Huang is with the School of Software and Communication Engineering, Jiangxi University of Finance and Economics, Nanchang 330013, China. Lin is with the Institute of Biomedical Engineering, Xi'an Jiaotong University, Xi'an 710049, China (e-mail: tiger.lin9906@gmail.com). Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org. Digital Object Identifier 10.1109/JSEN.2014.2380153 times to create a new image that will be more accurate and comprehensive and, thus, more suitable for a human operator or other image processing tasks. Currently, image fusion technology has been widely used in digital imaging, remote sensing, biomedical imaging, computer vision, and so on. Image fusion methods are usually divided into spatial domain and transform domain fusion techniques [9]. Fusion methods in the spatial domain are directly on pixel gray level or color space from the source images for fusion operation, so the spatial domain fusion methods are also known as single-scale fusion method. For transform domainbased methods, each source image is first decomposed into a sequence of images through a particular mathematical transformation. Then, the fused coefficients are obtained through some fusion rules for combination. Finally, the fusion image is obtained by means of a mathematical inverse transform. Thus, the transform domain fusion methods are also known as Multi-scale fusion methods. Here we use NSCT to improve the performance of the image.



In this paper, we propose an overcomplete transform that we call the nonsubsampled contourlet transform (NSCT). Our main motivation is to construct a flexible and efficient transform targeting applications where redundancy is not a major issue (e.g., denoising). The NSCT is a fully shift-invariant, multiscale, and multidirection expansion that has a fast implementation. The proposed construction leads to a filter-design problem that to the best of our knowledge has not been addressed elsewhere. The design problem is much less constrained than that of contourlets. This enables us to design filters with better frequency selectivity thereby achieving better subband decomposition. Using the mapping approach we provide a framework for filter design that ensures good frequency localization in addition to having a fast implementation through ladders steps. The NSCT has proven to be very efficient in image denoising and image enhancement as we show in this paper.

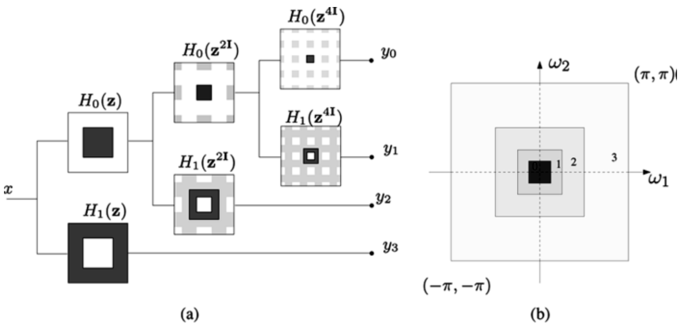
II. METHODS AND MATERIAL

Related Work

The paper is structured as follows, we describe the NSCT and its building blocks. We introduce a pyramid structure that ensures the multiscale feature of the NSCT and the directional filtering structure based on the DFB. The basic unit in our construction is the non-sub sampled filter bank (NSFB) which is discussed, we study the issues associated with the NSFB design and implementation problems. Applications of the NSCT in image denoising and enhancement are discussed.

If the building block 2-channel NSFBs in the NSP and NSDFB are invertible, then clearly the NSCT is invertible. It also underlies a frame expansion (see Section II-C). The frame elements are localized in space and oriented along a discrete set of directions. The NSCT is flexible in that it allows any number of directions in each scale. In particular, it can satisfy the anisotropic scaling law—a key property in establishing the expansion nonlinear approximation behavior. This property is ensured by doubling the number of directions in the NSDFB expansion at every other scale. The NSCT has redundancy given by , where denotes the number of levels in the NSDFB at the th scale.

In this proposed system the describes about how the out of focus image is focused by using NSCT (Non Sub sampled Contour Transform). By using this system we can view the non-cleared image will be cleared manner. This model is very useful to see the blur portion of the image in a cleared manner.



Fi.. Proposed nonsubsampled pyramid is a 2-D multiresolution expansion similar to the 1-D NSWT. (a) Three-stage pyramid decomposition. The lighter gray regions denote the aliasing caused by upsampling. (b) Subbands on the frequency plane.

Multifocal Image Fusion

The multifocal image fusion technique is a advance method used in the medical application such as scanning in to the minute parts of the inner particles, Film industries, CCTV monitoring to find the thefts, etc.

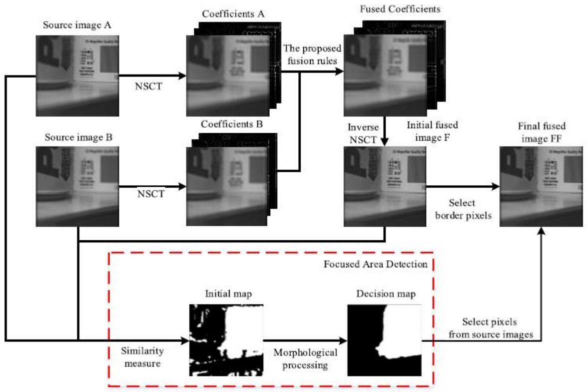


Figure 1. Block Diagram

This paper proposes a novel image fusion framework for multi-focus images, which relies on the NSCT domain and focused area detection. The process of fusion is divided into two stages: initial fusion and final fusion. In the process of initial fusion, the SML based local visual contrast rule and local Log-Gabor energy rule are selected as the fusion scheme for low- and highfrequency coefficients of the NSCT domain, respectively. For fusing the low-frequency coefficients, the model of the SML based local visual contrast is used. Using this model, the contrast representation are selected from low frequency coefficients and combined into the fused one. The Log-Gabor Energy in NSCT domain is proposed and used to combine high-frequency coefficients. The main benefit of Log-Gabor Energy is that it selects and combines the most prominent edge and texture information contained in the high frequency coefficients. Based on the result of initial fused image, morphological opening and closing are employed for post-processing to generate a fusion decision diagram. According to the fusion decision diagram, pixels of the source image and the initial fusion image are selected to obtain the final fusion image.

Further, the proposed method can provide a better performance than the current fusion methods whatever the source images are clean or noisy.

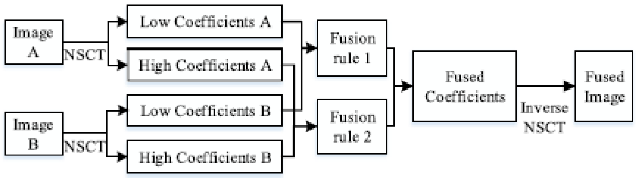


Figure 2. Schematic diagram of NSCT-based fusion algorithm.

In this section, the NSCT-based image fusion scheme, which is used in this paper, will be discussed. Considering a pair of input images, A and B, the NSCT-based image fusion can be described by the following steps:

Step 1: Perform θ-level NSCT on images A and B to obtain one low frequency sub band and a series of high frequency sub bands at each level and direction l, i.e., A:_L A, H A kl _ and B:_LB, H B kl _, where L A, LB are the low frequency sub images and H A k, l , H A k, l represent the high frequency sub-images at level k ∈ [1, θ] in the orientation l.

Step 2: Fuse low frequency sub bands and high frequency Sub bands through certain fusion rules to obtain fused low frequency (LF) and high frequency (H F kl) sub bands.

Step 3: Perform θ-level inverse NSCT on the fused low frequency sub band and high frequency sub bands to obtain the fused image. The framework of NSCT-based image fusion methods is shown in Fig.

III. RESULTS AND DISCUSSION

The major difficult occurred in the film industries and camera professions are to get the cleared image from the blurred out of focused image. By using this proposal we can get the cleared image of the original image using Non Sub sampled Contour Transform

Figure 3. Non cleared image

Then we are using this NSCT to the above image we can get the cleared view of the blurred portion of the original image.

Figure 4. Cleared image

IV. CONCLUSION

In this paper, a novel image fusion scheme that is based on NSCT and focused area detection is proposed for multi focus image fusion. The potential advantages of the proposed method include: NSCT is more suitable for image fusion because of superiorities such as multi-resolution, multi direction, and shift-invariance; using the detected focused areas as a fusion decision map to guide the fusion process not only reduces the complexity of the procedure but also increases the reliability and robustness of the fusion results; and the proposed fusion scheme can prevent artifacts and erroneous results at the boundary of the focused areas that may be introduced by detection focused area based methods during the fusion process. The experimental results on several groups of multi-focus images, regardless of whether there is noise or not, have shown the superior performance of the proposed fusion schem. The NSCT algorithm is time-consuming and of high complexity, so the next step that will be studied is how to improve the speech of the algorithm.

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