

Development of Multifocus Image Fusion in NSCT Domain and Focused Area Detection

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ABSTRACT: Image fusion is a process of combining multiple input images of the same scene into a single fused image, which preserves relevant information and also retains the important features from each of the original images and makes it more suitable for human and machine perception. Image fusion is the process extracting and synthesizing information from multiple sources, such as multi-sensor, multi-focus, multi-spectral or multi-frame images, in order to produce a more accurate, more reliable composite result than any single image from multiple different sources. The benefits of image fusion include improved spatial awareness, increased accuracy in target detection and recognition, reduced operator workload and increased system reliability. Multi-focus image fusion is an important branch of this field. Due to the limited depth-of-focus of optical lenses in camera, it is often not possible to obtain an image that contains all relevant focused objects. One way to overcome this problem is by using the multi-focus image fusion technique, through which several images with different focus points are combined to form a single image with all objects fully focused. Firstly, multi-scale decomposition is performed on source images using NSCT (Non-subsampled Contourlet Transform) to get high-frequency and low-frequency images. Secondly, the Sum-Modified-Laplacian and Log Gabor energy are respectively used to select the lowpass coefficient and highpass coefficients to combine fused image. Finally, the inverse Non-subsampled contourlet transform is applied to obtain fused image.

KEYWORDS: Multi-focus image fusion, non-subsampled contourlet transform, Log-Gabor energy, focused area detection, mathematical morphology.

I. INTRODUCTION

THE significance of picture combination in current picture handling frameworks is expanding, essentially as a result of the expanded number and assortment of picture securing methods [1]. The motivation behind picture combination is to consolidate distinctive pictures from a few sensors or the same sensor at various times to make another picture that will be more exact and exhaustive and, consequently, more suitable for a human administrator or other picture handling assignments [2]. At present, picture combination innovation has been broadly utilized as a part of advanced imaging, remote detecting, biomedical imaging, PC vision, thus on [3]–[5]. In utilizations of advanced cameras, optical magnifying lens or other hardware, as a result of the restricted profundity of-center of optical lens, it is frequently difficult to obtain a picture that contains all significant centered articles [6]. Hence, in the scene, a few items are in concentrate, however different articles at various separations from the imaging gear will be out of center and, therefore, obscured [7]. Be that as it may, as a general rule, individuals have a tendency to get a reasonable picture of all objectives. A conceivable approach to beat this issue is to use multi-center picture combination methods, in which one can get one picture with the majority of the articles in center by method for it containing the best data from various unique pictures [8]. Picture combination strategies are normally partitioned into spatial space and change area combination systems [9]. Combination techniques in the spatial area are specifically on pixel dark level or shading space from the source pictures for combination operation, so the spatial space combination strategies are otherwise called single-scale combination strategy. For change space based strategies, every source picture is initially deteriorated into a succession of pictures through a specific numerical change.

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At that point, the intertwined coefficients are acquired through some combination rules for mix. At long last, the combination picture is gotten by method for a numerical converse change. Along these lines, the change area combination techniques are otherwise called Multi-scale combination strategies. The least difficult spatial-based strategy is to take the normal of the info pictures pixel by pixel. Be that as it may, alongside its effortlessness, this technique prompts a few undesirable reactions, for example, diminished complexity. To enhance the nature of the melded picture, a few scientists have proposed to breaker information pictures by separating them into uniform-sized squares and having those pieces to assume the position of single pixels [10]. For the square based techniques, the pieces are consolidated by clarity record, which assesses whether the squares are clear or not. This sort of calculation may not just enhance the joining between every pixel in the intertwined picture however might likewise effortlessly deliver "piece impact" [11]. "Piece impact", which genuinely impacts the nature of the melded picture, is for the most part created by two issues [12]

1) The span of sub-squares is hard to decide. On the off chance that the size is too huge, it can without much of a stretch lead to circumstances where one square contains both clear regions and obscured territories; if the size is too little, it is difficult to judge the elements of the sub-piece, which is prone to bring about sub-piece determination blunder. 2) The centering properties of the sub-square are hard to decide. Particularly when the point of interest data of the square is not rich, it will effectively bring about sub-piece determination mistake. The fake neural system (ANN) technique and two-sided inclination strategy have been proposed individually by S. Li et al. [12] and J. Tian et al. [13] to enhance the exactness of the subblock choice. The combination execution of these techniques is enhanced contrasted and the conventional piece based strategies. In any case, "piece impact" can't be killed totally in these strategies, particularly when the same sub-square has both a reasonable region and an obscured range. Another imperative spatial-based technique called the engaged district based strategy can distinguish the reasonable locales of data pictures, and after that specifically duplicate the pixels from clear areas into the combined picture [14]–[16]. Be that as it may, these strategies might create fake data and broken marvels at the limits of centered districts in light of the fact that the limit can't be resolved precisely. These impacts will decrease the visual constancy of the intertwined picture. As of late, the more mainstream combination strategies utilizing Multi-scale Transform (MST) have been investigated, including the Laplacian Pyramid Transform [17], Gradient Pyramid Transform (GP) [18], Wavelet Transform [19]–[23], Log-Gabor Transform and other MST [24]–[27]. There is confirmation that MST with sign disintegration is like the human visual framework (HVS). Contrasted and spatial-based techniques, the strategies utilizing MST effectively beat the disservices that have been specified previously. The purpose behind this is the deterioration coefficients of MST consider the point of interest of the info pictures and chooses them out to create melded picture. As we probably am aware, the wavelet examination, with its upstanding limited characteristic in both the time and recurrence areas, has ended up a standout amongst the most ordinarily utilized as a part of the field of MST utilized for picture combination.

II. RELATED WORK

Any piece of information makes sense only when it is able to convey the content across. The clarity of information is important. Image Fusion is a mechanism to improve the quality of information from a set of images. By the process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images. This is achieved by applying a sequence of operators on the images that would make the good information in each of the image prominent. The resultant image is formed by combining such magnified information from the input images into a single image. Image fusion is the process that combines information in multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The object of the image fusion is to retain the most desirable characteristic of each image. With the availability of multi-sensor data in many fields, image fusion has been receiving increasing attention in these searches for a wide spectrum of applications. Here we use image fusion algorithm based on Wavelet Transform which faster developed was a multiresolution analysis image fusion. It has good time-frequency characteristics. To overcome the limitations of Wavelet Transform we put forward Curvelet Transform which consists of special filtering process and multi-scale Ridgelet Transform. This includes realization, sub-band division, smoothing block, normalization and so on. To improve the quality of the image at the edges by removing the noise we use

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Non-subsampled

Contourlet Transform. The construction proposed in this is based on pyramid and directional filters. The NSCT is fully shift-invariant, multiscale, and multidirectional

A new multifocus image fusion scheme based on fractional differential and NSCT is proposed. Firstly, in virtue of the properties of fractional differential, a novel focus measure in non-subsampled contourlet transform (NSCT) domain is presented and used to determine which coefficient is from the focused region. Then, based on the imaging principle of the multifocus image and the focus measure, a new selection principle for the lowpass subbands coefficients is developed. Meanwhile, focus measure maximum choosing scheme, namely select the coefficient with maximum focus measure value as the corresponding coefficient of the fused image, is applied to the high-frequency subbands. Finally, the inverse NSCT is employed to reconstruct the fused image and a pleasing fused result is generated. The experimental results show that the proposed method outperforms the conventional multifocus image fusion methods in both subjective and objective qualities.

The result of a non-subsampled pyramid structure and non-subsampled directional filter banks is a flexible multiscale, multidirection, and shiftinvariant image decomposition that can be efficiently implemented via the a trous algorithm. At the core of the proposed scheme is the non-separable two-channel non-subsampled filter bank (NSDFB). We exploit the less stringent design condition of the NSDFB to design filters that lead to a NSCT with better frequency selectivity and regularity when compared to the contourlet transform. We assess the performance of the NSCT in image denoising and enhancement applications. In both applications the NSCT compares favorably to other existing methods in the literature.

III. AIM AND OBJECTIVE

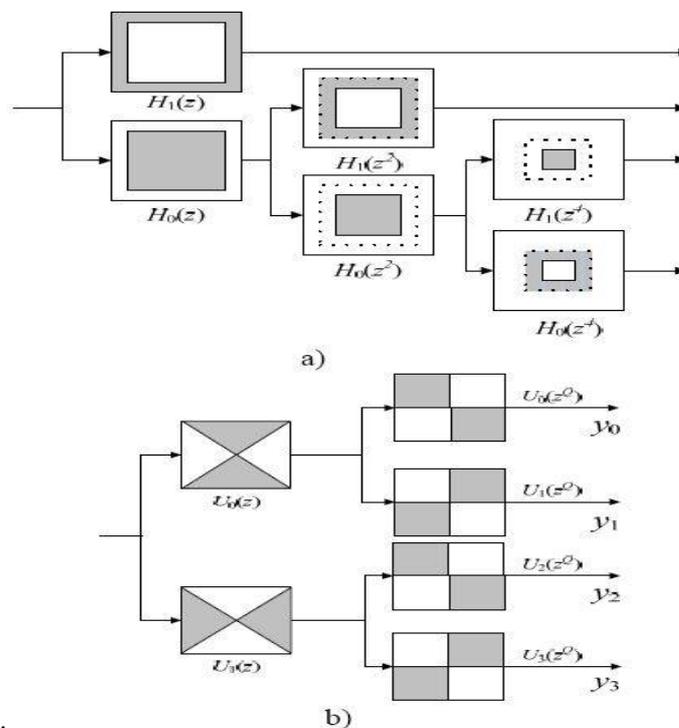


Fig.1. Diagram of NSP and NSDFB: a – three-levels NSP; b – decomposition of NSDFB

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- 1) This paper proposes a novel picture combination structure for multi-center pictures, which depends on the NSCT space and centered zone location. The procedure of combination is partitioned into two stages: introductory combination and last combination.
- 2) During the time spent introductory combination, the SML based nearby visual complexity principle and neighborhood Log-Gabor vitality tenet are chosen as the combination plan for low-and high recurrence coefficients of the NSCT area, individually. For combining the low-recurrence coefficients, the model of the SML based nearby visual complexity is utilized. Utilizing this model, the difference representation are chosen from low recurrence coefficients and joined into the intertwined one. The Log-Gabor Energy in NSCT area is proposed and used to join high recurrence coefficients. The principle advantage of Log-Gabor Energy is that it chooses and consolidates the most conspicuous edge and composition data contained in the high recurrence coefficients.
- 3) Based on the consequence of beginning intertwined picture, morphological opening and shutting are utilized for post-handling to produce a combination choice graph. By combination choice graph, pixels of the source picture and the beginning combination picture are chosen to get the last combination picture.
- 4) Further, the proposed technique can give a superior execution than the present combination strategies whatever the source pictures are spotless or boisterous

IV. ARCHITECTURE

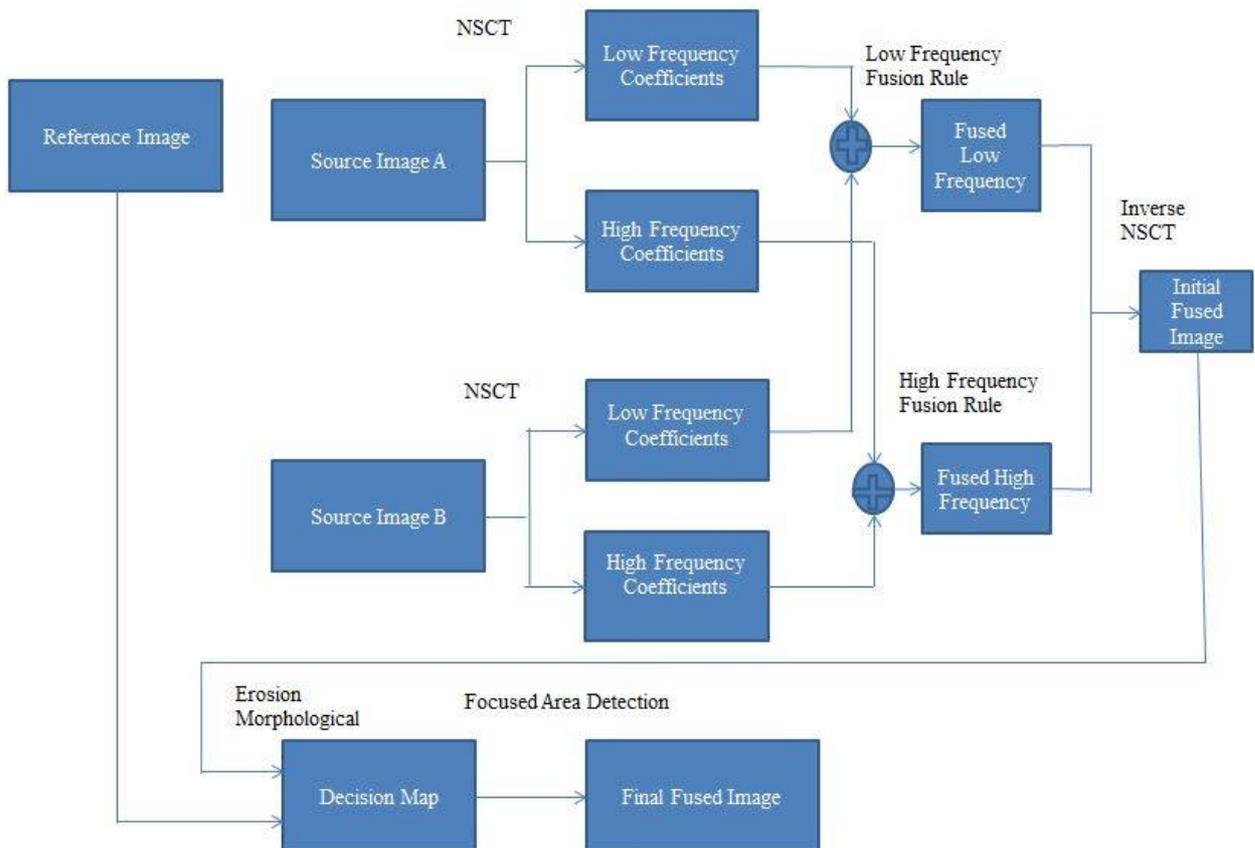


Figure 2. The fusion strategy for compressive imaging.

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Explanation-

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 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. The MST- based image fusion method can significantly enhance the visual effect, but in the focus area of the source image, clarity of the fused image will have different degrees of loss. That is because, in the process of multi-scale decomposition and reconstruction, improper selection of fusion rules often causes the loss of useful information in the source image.

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 high frequency 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.

Sum-modified Laplacian Based Visual Contrast

For spatial domain based multi-focus image fusion, there are many typical focus measurements such as energy of image gradient (EOG), spatial frequency (SF), tenengrad, Laplacian energy and SML. In , the authors compared these measurements through extensive experiments, and the results proved that SML is the best measurement. In the transform domain, SML is also very efficient and can produce the best fused results. The definition of SML is as follows:

$$ML^{lk}(i, j) = |2L^{lk}(i, j) - L^{lk}(i - step, j) - L^{lk}(i + step, j)| + |2L^{lk}(i, j) - L^{lk}(i, j - step) - L^{lk}(i, j + step)| \quad (1)$$

Where, *step* is a variable spacing between coefficients and always equal to 1.

$$SML^{lk}(i, j) = \sum_{m=M}^M \sum_{n=-N}^N [ML^{lk}(i + M, j + N)]^2$$

Log Gabor Energy

The high frequency coefficient sub bands represent the detailed components of the source images, such as the edges, textures, boundaries, and soon. Sharpness values and, therefore, affects the fusion performance. Thus, for the high frequency coefficients, the most common fusion rule is to select coefficient with larger absolute values. However, this does not take any consideration of the surrounding pixels. The value of a single pixel of high frequency coefficients is used to contrast the measurement of the high frequency component. This is especially true when the input contains noise, as the noise can be mistaken for fused coefficients and cause miscalculation of the sharpness value. Furthermore, humans are often sensitive to texture detail features, but are insensitive to the value of a single pixel. Gabor filters is a popular technique that has been extensively used to extract texture features. Log-Gabor filters are proposed based on Gabor filters. Compared with Gabor filters, Log-

Gabor filters, whose transfer function covers the shortage of the high frequency of Gabor filter component expression, are more in accord with HVS.

Therefore, Log-

Gabor filters can achieve optimal spatial orientation and wider spectrum information at the same time and thus more truly reflect the frequency response of the natural images and improve performance in terms of the accuracy.

Under polar coordinates, the Log-Gabor filter is defined as follows:

$$g(f, \theta) = \exp\left(\frac{-(\log(f/f_0))^2}{2(\log(\sigma/f_0))^2}\right) \exp\left(\frac{-(\theta-\theta_0)}{2\sigma_\theta^2}\right)$$

Where,

f_0 = Center Frequency of log gabor filter

θ_0 = Direction of the filter

σ = To determine bandwidth B_f of the radial filter

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σ_θ = To determine bandwidth B_θ of the orientation

$$B_f = 2\sqrt{2/\log 2} * |\log(\sigma/f_0)|$$

$$B_\theta = 2\sigma_\theta\sqrt{2/\log 2}$$

FOCUSED AREA DETECTION

In the process of MST, such as NSCT, decomposition and reconstruction will inevitably lose useful information contained in the focus area of reference image. In this project, the reference image, after NSCT-based initial fusion, are processed for increasing focus area detection. The next step, the detected focus areas will guide the image fusion, which would effectively guarantee that the focus area of the reference image does not suffer losses, and obtain the more accurate fusion results.

- 1) Decision map calculation using Morphological Operation.
- 2) Convert input images to intensity images.
- 3) Convert intensity image to binary using autothresholding concept.
- 4) Perform Erosion operation.
- 5) Use this Decision map to preserve the focus area.

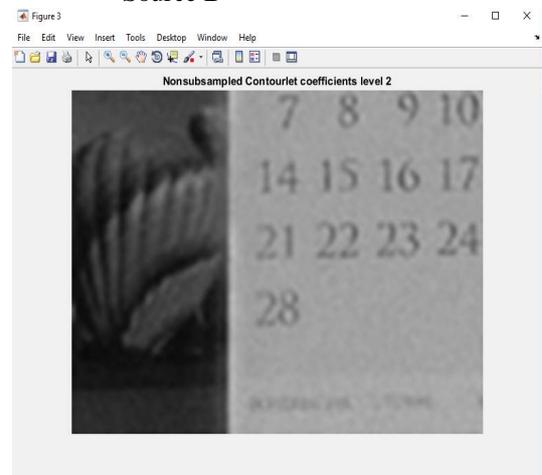
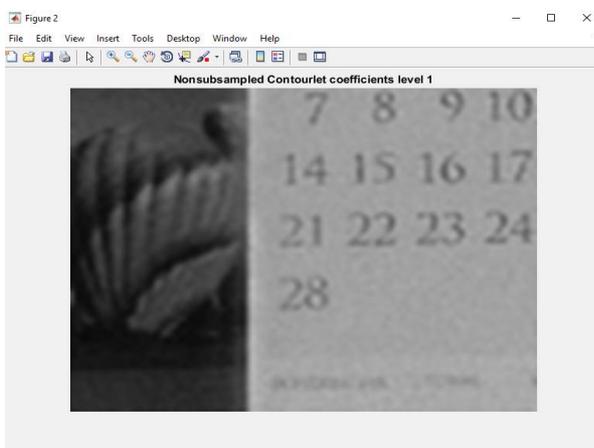
V. SIMULATION RESULT



Source A



Source B



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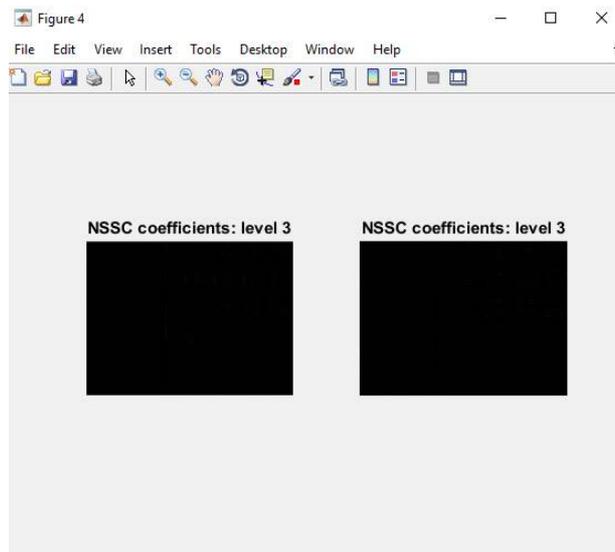


Figure 3 Nonsampled Contourlet Coefficients Levels of Source image A

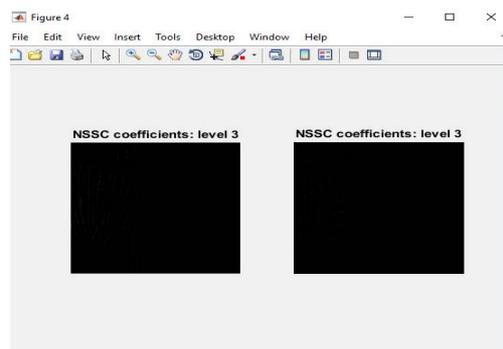
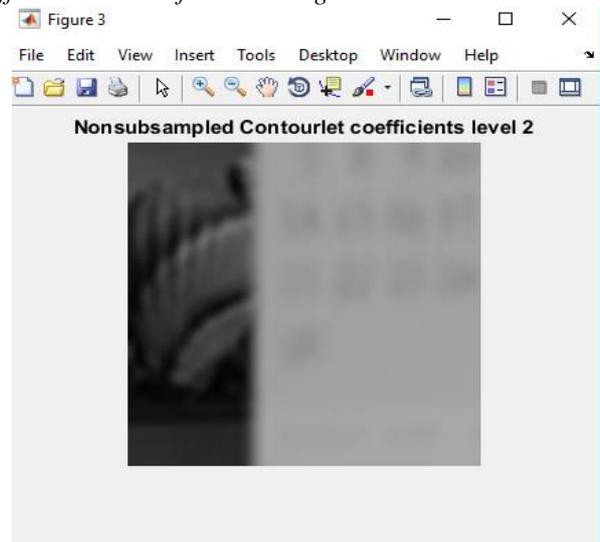
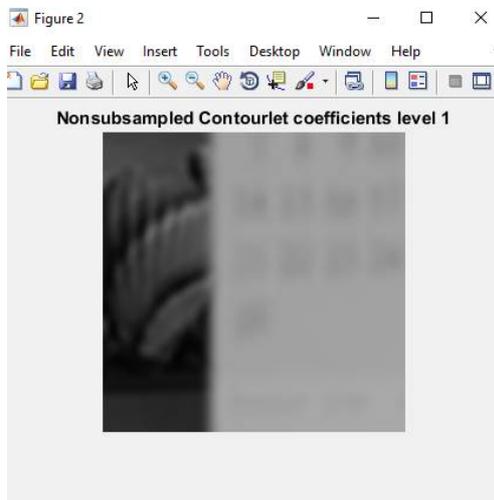


Figure 4 Nonsampled Contourlet Coefficients Levels of Source image B

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Figure 5 Initial Fused Images

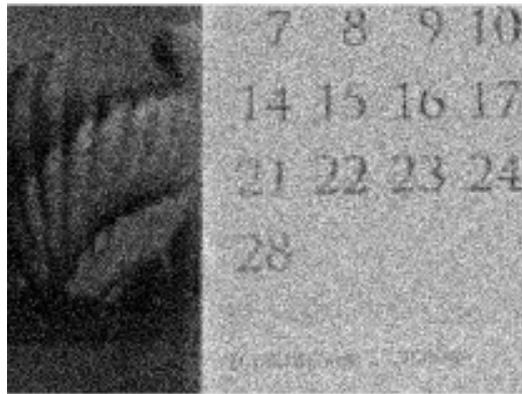


Figure 6 Decision map

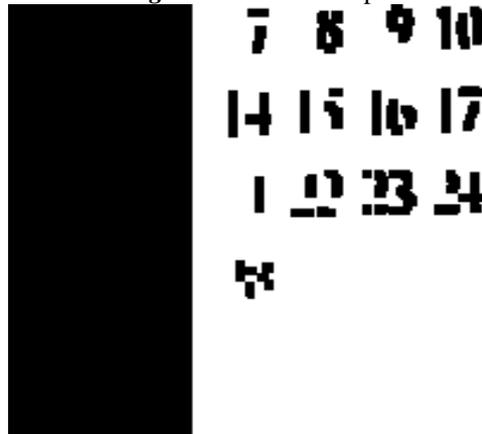
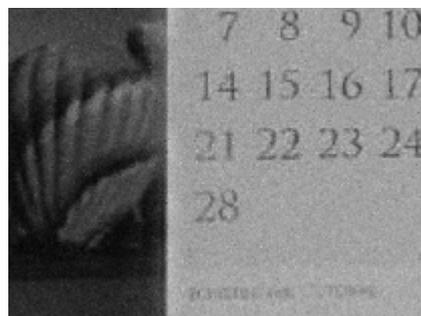


Figure 7 Final Fused Image



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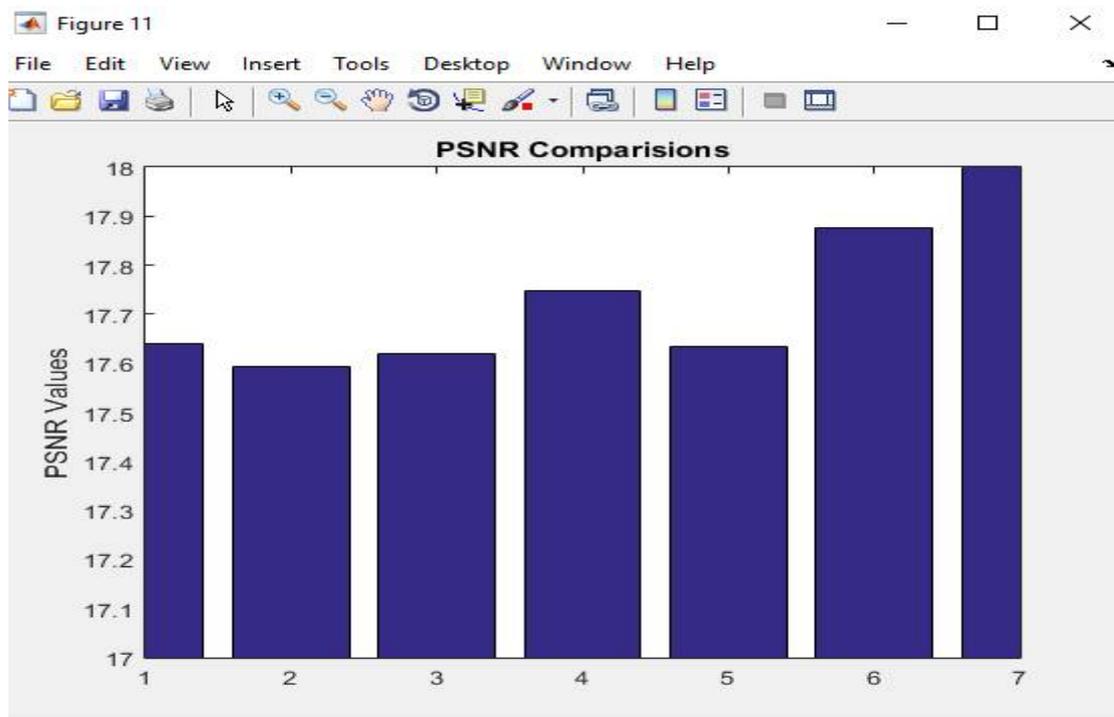


Figure 8 Comparison of PSNR with different methods

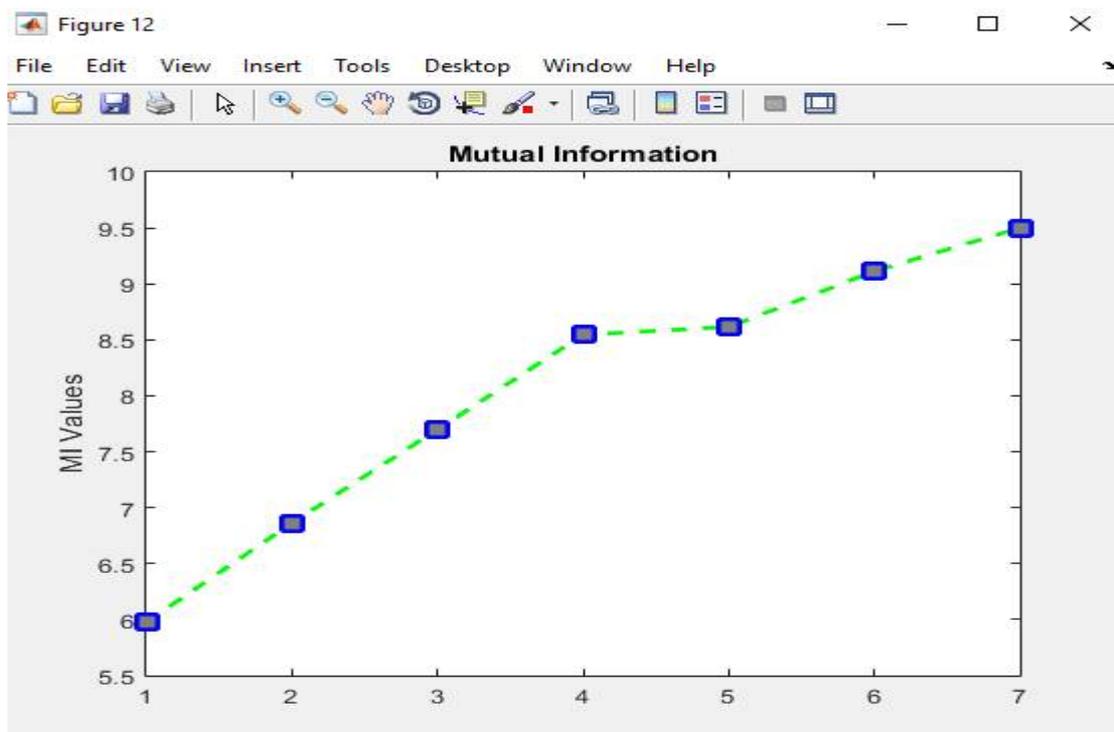


Figure 9 Comparison of MI with different methods

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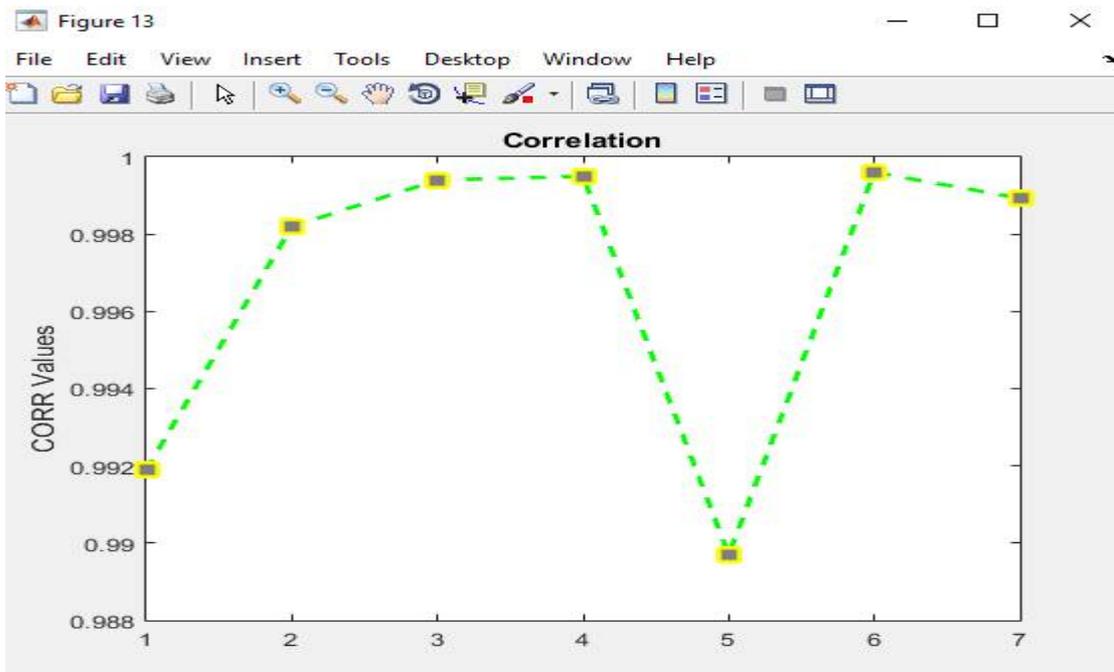


Figure Comparison of CORR with different methods

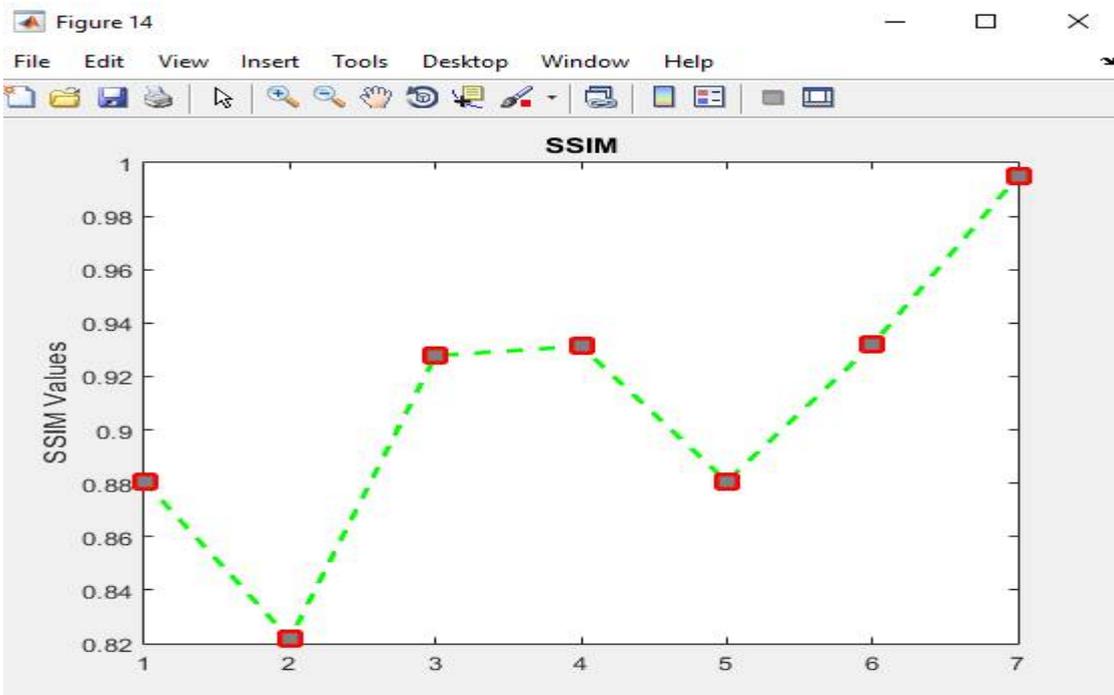


Figure 10 Comparison of SSIM with different methods

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Image	Evalution	GP	DWT	NSCT_1	NSCT_2	SCBG[13]	NSCT_3	Proposed Method
Calendar	PSNR	17.6398	17.5928	17.6198	17.7483	17.6333	17.8773	27.0346
	MI	5.9759	6.8624	7.6983	8.5456	8.6141	9.1123	9.5000
	SSIM	0.8807	0.9210	0.9278	0.9313	0.8807	0.9319	0.9304
	CORR	0.9919	0.9982	0.9982	0.9995	0.9897	0.9996	0.9966

Comparison on objective criteria of different methods

VI. CONCLUSION

In this paper, a novel picture combination conspire that depends on NSCT and centered territory identification is proposed for multifocus picture combination. The potential focal points of the proposed technique include: (1) NSCT is more suitable for picture combination on account of superiorities, for example, multi-determination, multidirectional, and shift-invariance; (2) utilizing the distinguished centered regions as a combination choice guide to direct the combination process diminishes the many-sided quality of the system as well as expansions the unwavering quality and vigor of the combination results; and (3) the proposed combination plan can anticipate antiques and mistaken results at the limit of the engaged regions that might be presented by identification centered territory based strategies amid the combination process. The test results on a few gatherings of multi-center pictures, paying little mind to whether there is commotion or not, have demonstrated the prevalent execution of the proposed combination plan. The NSCT calculation is tedious and of high unpredictability, so the following step that will be contemplated is the means by which to enhance the rate of the calculation.

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