## 2019-Multi-focus image fusion based on joint sparse representation and optimum theory-Signal Processing: Image Communication -IF 2.814-Q2

**目的：找到本文中心思想，找到稀疏表示切入点**

Tip1: Generally, image fusion can be divided into three categories: Pixel-level image fusion, feature-level image fusion, and decision-level image fusion [4]. The most widely used method for all kinds of image fusion is the pixel-level image fusion [5], and it can be classified into image fusion based on spatial domain, image fusion based on transform domain and image fusion based on deep learning. Methods based on spatial domain mainly process image pixels or regions directly, such as multi-focus image fusion based on probability filtering and region correction [6], multifocus image fusion using region segmentation and spatial frequency [7] and a general framework for multi-resolution image fusion: from pixels to regions [8].

[5] S. Li, X. Kang, L. Fang, J. Hu, H. Yin, Pixel-level image fusion: A survey of the state of the Art, Inf. Fusion 33 (2017) 100–112, http://dx.doi.org/10.1016/ j.inffus.2016.05.004.

Tip2: Liu proposed a multi-focus image fusion with a deep convolutional neural network [15]

这个代码已经有了，他还写了个综述make a summary about deep learning for pixel-level image fusion in [16]

L. Yu, C. Xun, W. Zengfu, W. Jane, R.K. Ward, W. Xuesong, Deep learning for pixel-level image fusion: Recent advances and future prospects, Inf.Fusion42(2018)158173,http://dx.doi.org/10.1016/j.inffus.2017.10.007

但是在他的个人主页上没有找到相关代码，估计是将卷积神经网络三个应用都柔和到了一起。

Tip3:论文中关于压缩感知引入介绍，具体压缩感知有个介绍，放在09 INTRODUCTION COMPRESSED SENSING里面，是2006年写的，可以看看

[18] Z. Zhu, H. Yin, Y. Chai, Y. Li, G. Qi, A novel multi-modality image fusion method based on image decomposition and sparse representation,Inf.Sci.432(2018)516529,http://dx.doi.org/10.1016/j.ins.2017.09.010.这篇文章层次较高 一区 影响因子5.524 值得看看

[19] Z. Gao, C. Zhang, Texture clear multi-modal image fusion with joint sparsity model, Optik 130 (2017) 255–265, http://dx.doi.org/10.1016/j.ijleo.2016.09. 126.三区，影响因子1.914

Tip4：字典表步骤为When conducting image fusion,

01 authors firstly block an image and rearrange each image block into a column vector.

02 Then, initialize a fixed dictionary such as contourlet dictionary [20],

[20] M. Do, M. Vetterli, The contourlet transform: an efficient directional multiresolu- tion image representation, IEEE Trans. Image Process.14(12)(2005)20912106,<http://dx.doi.org/10.1109/TIP.2005.859376>.

这篇论文发表在图像处理顶刊上，IEEE TRANSACTIONS ON IMAGE PROCESSING IF6.790 Q1

or learn the adaptive dictionary based on source images such as K-singular value decomposition (K-SVD) [21].

M. Elad, M. Aharon, Image denoising via sparse and redundant representations over learned dictionaries, IEEE Trans. Image Process. 15 (12) (2007) 3736–3745, http://dx.doi.org/10.1109/TIP.2006.881969

03 Next, sparse coefficients can be calculated by some iterative optimized methods such as orthogonal matching pur- suit (OMP) [22] and basis pursuit (BP) [23].

04 By adopting appropriate fusion rule, fused sparse coefficients can be obtained.

05 Finally, a fused image can be reconstructed by multiplying the dictionary with fused coefficients.

#### 可引-选择字典和融合规则的重要性

There are two important steps in the image fusion based on SR: One is the selection of the dictionary, and the other is the fusion rule of sparse coefficients.

Tip5：本文创新点在于以前融合方法没有考虑the complementarity and redundancy of information in source images

With the rise and development of JSR [24–26], Yao [27] proposed an image fusion method based on joint sparse representation, which tried to calculate the sparse coefficients by BP.

[24] D. Baron, M.B. Wakin, M.F. Duarte, S. Sarvotham, R.G. Baraniuk, Distributed compressed sensing, IEEE Trans. Inform. Theory 52 (12) (2006) 5406–5425.

[25] Q. Zhang, Y. Liu, R. S.Blum, J. Han, D. Tao, Sparse representation based multi- sensor image fusion for multi-focus and multi-modality images: A review, Inf. Fusion 40 (2018) 57–75, <http://dx.doi.org/10.1016/j.inffus.2017.05.006>.

[26] Q. Zhang, Y. Fu, H. Li, J. Zou, Dictionary learning method for joint sparse representation-based image fusion, Opt. Eng. 52 (5) (2013) 057006, http://dx. doi.org/10.1117/1.OE.52.5.057006.

[27] Y. Yao, X. Xin, P. Guo, OMP or BP? a comparison study of image fusion based on joint sparse representation, Neural Inf. Process. 7667 (2012) 75–82.

A novel fusion rule based on optimum theory for sparse coefficients was proposed, and an optimal solution could be obtained by OMP.

A fused image can be reconstructed by multiplying the final dictionary with fused sparse coefficients.

Tip6: SR has been widely used in image processing, such as image de-noising [28], super-resolution reconstruction [29], and image re- trieval [30]. As is well known, for image fusion, there are redundant and complementary information in source images. It would be better if we use different dictionaries to represent different components. In JSR model, we suppose that all images have common and individual com- ponents which are unique form others [25,27]. Let ?? denotes a source image, ?? denotes the dictionary and ?? denotes sparse coefficients. Then, JSR model can be expressed as follows [18].

**直接看论文去了，看能不能找到关于JSR的描述**

### [18] 2018-A novel multi-modality image fusion method based on image decomposition and sparse representation- INFORMATION SCIENCES-IF 5.5 Q1

Tip1：主要就是将原图像分解成两种成分，

To preserve the structure information and perform the detailed information of source images, a novel image fusion scheme based on image cartoon-texture decomposition and sparse representation is proposed. In proposed image fusion method, source multi-modality images are decomposed into cartoon and texture components. For cartoon components a proper spatial-based method is presented for morphological structure preservation. An energy based fusion rule is used to preserve structure information of each source image. For texture components, a sparse-representation based method is proposed. A dictionary with strong representation ability is trained for the proposed sparse- representation based fusion method. Finally, according to the texture enhancement fusion rule, the fused cartoon and texture components are integrated.

Tip2: 空间域方法的缺点

spatial-domain methods may lead to blurring edges, contrast decrease, and reduction of sharpness [25] . Some methods, as block-based and region-based algorithms [13] , are proposed to improve the quality of fused image. Although lock-based algorithms improve the detailed expression of fused image, the sharpness of fused image may still be undesirable. Block-based algorithms may cause block effect, when they are applied to spatial-domain based methods.

变换域方法的缺点

Transform-domain based methods use a transform tool to decompose source images into coefficients and transform bases first. Then the coefficients are fused by diverse fusion rules in different applications. Finally, the fused image can be obtained by inversely transforming fused coefficients and transform bases. Multi-scale transform(MST) is one of the most popular fu- sion techniques in multi-modal image fusion. Starting with Discrete Wavelet Transform (DWT) [28] , a variety of transforms including Dual-Tree Complex Wavelet Transform (DT-CWT) [11] , Curvelet Transform (CVT) [27] , Shearlet Transform [37] and Non-Subsampled Contourlet Transform (NSCT) [15] have been used in multi-modal image fusion. Although transform coef- ficients can reasonably represent important features of an image, each transform has its own merits and limitations corresponding to the context of input images [42] .

[42] B. Yang , S. Li , Pixel-level image fusion with simultaneous orthogonal matching pursuit, Inf. Fus. 13 (1) (2012) 10–19 . 在这篇文章中质量很高，发表在信息融合，此处关于（这篇文章提供的融合思想很好，值得品味）

#### 可引-变换域缺点的描述

可以放在论文中，文章中已经详细描述了几个变换域的缺点，只不过这里就是一笔带过，文章已经下载，放在REFERENCE

Thus, selecting an optimal transform basis is not an obvious and trivial problem as it relies on scene contexts and applications [17] .

In recent years, sparse representation(SR) has been successfully implemented to image classification [2,19] , image super-resolution [44] ,image recognition [21] , image feature extraction [20] , image deblurring [30] , image object recognition [18,20] and multi-modality information fusion [47] . As a transform-based method, SR was first applied to image fusion by Li and Yang [41] . They used DCT transform to build the dictionary for SR, and an SR-based fusion framework was proposed. A medical image fusion and de-noising method by group sparse-representation was introduced in [17] . However, this method is not tested on color medical images. Yang and Liu [42] proposed several kinds of mathematical models, that were utilized to construct hybrid dictionaries for image fusion. The hybrid dictionaries can well reflect several specific structures, but are still lack of the adaptability to represent different types of images. In that case, learning-based adaptive dictionaries were implemented for SR-based image fusion [36] . KSVD-based method is the most widely used adaptive dictionary construc- tion method for SR-based image fusion [26,45] . Multi-focus image fusion methods based on KSVD were proposed by Yin [45] and Nejati [26] , and showed good state-of-art performances. Yin [47] also proposed a multi-modality medical image fusion method by KSVD, which can enhance the performance of image details. Nonparametric Bayesian adaptive dictionary learning was proposed in [40] for remote-sensing image fusion.