Hyperspectral Image Super Resolution and Reconstruction

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Abstract: Hyperspectral (HS) imaging can capture the detailed spectral signature of each spatial location of a scene and greatly benefit for understanding of different materials' characteristics. However, existing HS sensors can only provide low spatial resolution images at a video rate in practice. To achieve the high resolution images in both spatial and spectral domains, two techniques: enhancing the resolution of the captured images by the common cameras or the conventional HS sensors and developing novel HS imaging methods using compressive sensing theory, have extensively been explored.

The first one aims to generating a high-resolution HS (HR-HS) image by merging the observed high-resolution RGB (HR-RGB) and the low-resolution HS (LR-HS) images, usually called as HS image super resolution (HSI SR), and is mainly implemented in two research paradigms: mathematical model based method and deep learning based method. Mathematical model based methods generally formulate the degradation procedure of the observed LR-HS and HR-RGB images with a mathematical model and employ an optimization strategy for solving. Due to the ill-posed essence of the fusion problem, most works leverage the hand-crafted prior to model the underlying structure of the latent HR-HS image to pursue a more robust solution of the HR-HS image. Recently, deep learning-based approaches have evolved for HSI SR, and current efforts mainly concentrated on designing more complicated and deeper network architectures for performance improvement. Although impressive super-resolving results can be achieved compared with the mathematical model based methods, the existing deep learning methods are usually implemented in a fully supervised manner, and require to collect large scale of external training dataset, which are widely synthesized by assuming that the spatial and spectral degradation procedures for capturing the LR-HS and HR-RGB images are fixed and known. Thus, the constructed models would produce very poor recovering performance for the observations with different degradation procedures in real tasks. To overcome the above limitations, our research focuses on proposing the unsupervised learning-based framework for HSI SR to learn the specific prior of an under-studying scene without any external dataset. To deal with the observed images captured under different degradation procedures, we further automatically learn the spatial blurring kernel and the camera spectral response function (CSF) related to the specific observations, and incorporate them with the above unsupervised framework to build a high-generalized blind unsupervised HSI SR paradigm.

The second one aims to explore an advanced computational spectral imaging technique to capture the spectral signatures of the dynamics world with sufficient spatial resolution. Within the coded aperture snapshot spectral imaging (CASSI), which jointly employs sensing device for measuring a 2D compressive snapshot of the 3D spectral data cubic and reconstruction paradigm for utilizing compressive sensing (CS) inversion algorithm to retrieve a 3D estimation of the underlying HS image, our research mainly focuses on exploring effective and robust computational reconstruction methods to enhance the recovering quality of the underlying HIS. Specifically, we introduce our recently proposed deep HS reconstruction models, and verify the effectiveness of the proposed models on several benchmark datasets.