Multiframe Resolution-Enhancement using A Robust Iterative SRR based on Leclerc Stochastic Technique

Vorapoj Patanavijit†
Department of Computer and Network Engineering, Faculty of Engineering, Assumption University, Bangkok, Thailand 10240
Email: patanavijit@yahoo.com

Abstract

This paper proposes a multiframe resolution-enhancement using a robust iterative SRR (Super-Resolution Reconstruction) for applying on images that is corrupted by several noise models. Typically, the success of SRR algorithms is highly dependent on the model accuracy regarding the imaging process. The real noise models corrupting the measure sequence are unknown hence SRR algorithms using L1 or L2 norm may degrade the image sequence rather than enhance it. The proposed enhancement algorithm is based on the stochastic regularization SRR technique of Bayesian MAP estimation by minimizing a cost function. The Leclerc norm is used for removing outliers in the data and for measuring the difference between the projected estimate of the HR image and each LR image. Due to the ill-pose problem, Tikhonov regularization is used to remove artifacts from the final answer and improve the rate of convergence. The experimental results show the effectiveness of our methods and demonstrate its superiority to other SRR algorithm based on L1 and L2 norm for several noise models such as Noiseless, AWGN, Poisson Noise, Salt&Pepper Noise and Speckle Noise.

Keywords: Image reconstruction, Image enhancement, Video signal processing

1. Introduction

In most imaging applications, high spatial resolution images are desired and often required. The classical resolution enhancement from a single observation using image interpolation techniques is of limited application because of the aliasing present in the low-resolution (LR) image. SRR [2, 10, 12, 16, 20] refers to the process of producing a high spatial resolution image than what is afforded by the physical sensor through postprocessing, making use of one or more low resolution observations. It includes upsampling the image, thereby increasing the maximum spatial frequency, and removing degradations that arise during the image capture, namely, aliasing and blurring. The basic ideal behind SRR is the fusion of a sequence of low-resolution noisy blurred images to produce a higher-resolution image or sequence.

This section reviews some literatures [20] from the estimation point of view because the SRR estimation is one of the most importance parts of the SRR research areas and directly impact to the SRR performance. R. R. Schultz and R. L. Stevenson [14-15] proposed the SRR algorithm using ML estimator (L2 Norm) with HMRF Regularization in 1996. In 1997, M. Elad and A. Feuer [7] proposed the SRR algorithm using the ML estimator (L2 Norm) with nonellipsoid constraints. Next, M. Elad and A. Feuer [9] proposed the SRR algorithm using R-SD and R-LMS (L2 Norm) in 1999. M. Elad and A. Feuer [8] proposed the fast SRR algorithm ML estimator (L2 Norm) for restoration the warps are pure translations, the blur is space invariant and the same for all the images, and the noise is i.i.d. Gaussian in 2001. A. J. Patti and Y. Altunbasak proposed [1] a SRR algorithm using ML (L2 Norm) estimator with POCS-based regularization in 2001 and Y. Altunbasak, A. J. Patti, and R. M. Mersereau [21] proposed a SRR algorithm using ML (L2 Norm) estimator for the MPEG sequences in 2002. D. Rajan and S. Chaudhuri [2-3] proposed SRR using ML (L2 Norm) with MRF regularization to simultaneously estimate the depth map and the focused image of a scene in 2003. In 2003, E. S. Lee and M. G. Kang [4] proposed the regularized iterative SRR algorithm (L2 Norm) considering inaccurate subpixel registration. The regularization parameters are determined adaptively for each LR image because the registration error in each LR image has a difference pattern. S. Farsiu and M. D. Robinson [17-18] proposed SRR algorithm ML estimator (L1 Norm) with BTV Regularization in 2004. Next, they propose a fast SRR of color images [19] using ML estimator (L1 Norm) with BTV and Tikhonov Regularization in 2006. M. V. W. Zibetti and J. Mayer [13] proposed the regularized iterative SRR algorithm (L2 Norm) that estimates simultaneously all frames of a sequence. By employing the motion information only in the prior term of the cost function, the SRR algorithm achieves a better fidelity and more robust performance. Y. He et at. [22] proposed SRR algorithm to integrate image registration into SRR estimation (L2 Norm) in 2007. Consequently, the nonlinear least square technique is proposed for this simultaneous SRR algorithm.

For the data fidelity cost function, All the above SRR algorithms [1-22] are based on the simple estimation techniques such as L1 Norm or L2 Norm Minimization. For normally distributed data, the L1 norm produces estimates with higher variance than the optimal L2 (quadratic) norm but the L2 norm is very sensitive to outliers because the influence function increases linearly and without bound. From the robust statistical estimation [11], Leclerc Norm is more robust than L1 and L2. Leclerc Norm is designed to be robustness and reject outliers, the norm must be more forgiving about outliers; that is, it should increase less rapidly than L2. In this paper, we propose a robust iterative SRR algorithm using Leclerc Norm for the data fidelity cost function with Tikhonov Regularization. Whereas the former is responsible for robustness and edge preservation, the latter seeks

†This work has been supported by Research Grant for New Scholar from TRF (Thai Research Fund) and CHE (Commission on Higher Education) under Assumption University (Thailand).