J Sci Comput (2016) 67:103–129
DOI 10.1007/s10915-015-0073-9

Removing Mixture of Gaussian and Impulse Noise by Patch-Based Weighted Means

Haijuan Hu[1,2,3] · **Bing Li**[4] · **Quansheng Liu**[3]

Received: 7 March 2014 / Revised: 5 June 2015 / Accepted: 11 July 2015 / Published online: 21 July 2015

Abstract We first establish a law of large numbers and a convergence theorem in distribution to show the rate of convergence of the non-local means filter for removing Gaussian noise. Based on the convergence theorems, we propose a patch-based weighted means filter for removing an impulse noise and its mixture with a Gaussian noise by combining the essential idea of the trilateral filter and that of the non-local means filter. Experiments show that our filter is competitive compared to recently proposed methods. We also introduce the notion of degree of similarity to measure the impact of the similarity among patches on the non-local means filter for removing a Gaussian noise, as well as on our new filter for removing an impulse noise or a mixed noise. Using again the convergence theorem in distribution, together with the notion of degree of similarity, we obtain an estimation for the PSNR value of the denoised image by the non-local means filter or by the new proposed filter, which is close to the real PSNR value.

Keywords Gaussian noise · Impulse noise · Mixed noise · Trilateral filter · Non-local means filter · Convergence theorems · Degree of similarity · Estimation of PSNR

✉ Quansheng Liu
Quansheng.Liu@univ-ubs.fr

Haijuan Hu
huhaijuan61@126.com

Bing Li
libcs@263.net

1 School of Mathematics and Statistics, Northeastern University at Qinhuangdao, Qinhuangdao 066004, China

2 College of Information Science and Engineering, Northeastern University, Shenyang 110819, China

3 CNRS UMR 6205, LMBA, Université de Bretagne-Sud, Campus de Tohannic, 56000 Vannes, France

4 Department of Mathematics, Zhongshan Polytechnic, Zhongshan 528404, China