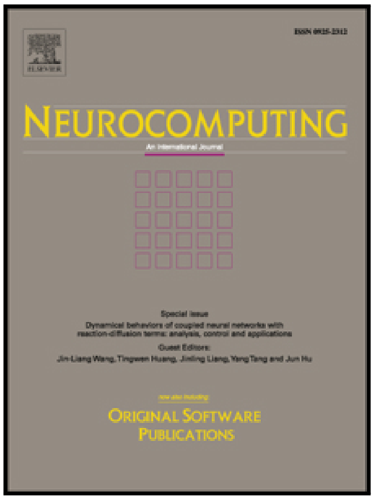
Communicated by Prof. Zidong Wang

Accepted Manuscript



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PII: S0925-2312(17)31477-7
DOI: 10.1016/j.neucom.2017.09.006
Reference: NEUCOM 18848

To appear in: *Neurocomputing*

Received date: 1 February 2017
Revised date: 20 August 2017
Accepted date: 3 September 2017

Please cite this article as: Beijia Chen, Huaijiang Sun, Lei Feng, Guiyu Xia, Guoqing Zhang, Robust Image Compressive Sensing based on M-estimator and Nonlocal Low-rank Regularization, *Neurocomputing* (2017), doi: 10.1016/j.neucom.2017.09.006

Robust Image Compressive Sensing based on M-estimator and Nonlocal Low-rank Regularization

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Abstract

The current compressive sensing (CS) methods based on nonlocal low-rank regularization have shown the state-of-art recovery performance. However, these methods exploiting l_2-norm as the cost function depends heavily on the Gaussianity assumption of noise. The recovery performance will degrade when impulsive noise occurs in acquisition process. In this paper, we propose a robust image CS recovery framework combining m-estimator with nonlocal low-rank regularization, to investigate the situation where measurements are corrupted by impulsive noise. Since l_2-norm is mainly responsible for the performance degradation under impulsive noise, we substitute it with the robust Welsch m-estimator which has shown great ability of managing impulsive noise in a wide range of applications. As for low-rank regularization, we utilize the truncated schatten-p norm which has been verified to be the best surrogate function in the open literature. Furthermore, we have developed a framework based on alternating direction multiplier method (ADMM) and half-quadratic (HQ) theory to solve the resulting nonconvex problem. Extensive experiments have demonstrated that the proposed method significantly outperforms the existing state-of-art methods in terms of both PSNR index and visual quality under impulsive noise.

Keywords: compressive sensing, image recovery, impulsive noise, m-estimator, half-quadratic theory

1. Introduction

Compressive sensing [1, 2] is a newly built framework for information acquisition and processing. It elucidates that one can obtain the exact reconstruction of signals from far fewer measurements than the traditional Nyquist sampling theorem uses. By conducting compression and sampling at the same stage, CS theory offers new opportunities to solve the remained problems (such as high acquisition cost and data redundancy) in traditional sampling methods. In Recent years, CS theory has achieved great feedbacks in various fields. For instance, single-pixel camera [3] has been built successfully based on CS theory. By applying CS theory to Magnetic Resonance Imaging (MRI), the scanning time is remarkably shortened [4].

In the standard CS problem, we study the recovery of a signal $x \in \mathbb{R}^n$ from its measurements $y \in \mathbb{R}^m$ generated with sensing matrix $\Phi \in \mathbb{R}^{m\times n}(m \ll n)$ which meets the restricted isometry property (RIP) [1, 2], and they satisfy $y = \Phi x$. Since $m \ll n$, the recovery problem is ill-posed and may yield plenty of different solutions mathematically. In order to obtain accurate reconstruction results, useful prior knowledge must be introduced to the recovery problem. One commonly employed assumption is that many natural images can be sparsely represented in some domain, such as DCT [5] or wavelets [6]. By adding a l_0-norm sparse constraint to the primal problem, the recovery of images from its few measurements is possible. However, the l_0-norm minimization is NP-hard. Based on the l_0-l_1 equivalence theory [1, 7], numerous CS methods [8, 9, 10] are developed on the l_1-norm sparsity and the resulting convex problem can be efficiently solved

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