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TWO-PHASE APPROACH FOR DEBLURRING IMAGES CORRUPTED BY IMPULSE PLUS GAUSSIAN NOISE

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Abstract. The restoration of blurred images corrupted with impulse noise is a difficult problem which has been considered in a series of recent papers. These papers tackle the problem by using variational methods involving an L1-shaped data-fidelity term. Because of this term, the relevant methods exhibit systematic errors at the corrupted pixel locations and require a cumbersome optimization stage. In this work we propose and justify a much simpler alternative approach which overcomes the above-mentioned systematic errors and leads to much better results. Following a theoretical derivation based on a simple model, we decouple the problem into two phases. First, we identify the outlier candidates—the pixels that are likely to be corrupted by the impulse noise, and we remove them from our data set. In a second phase, the image is deblurred and denoised simultaneously using essentially the outlier-free data. The resultant optimization stage is much simpler in comparison with the current full variational methods and the outlier contamination is more accurately corrected. The experiments show that we obtain a 2 to 6 dB improvement in PSNR. We emphasize that our method can be adapted to deblur images corrupted with mixed impulse plus Gaussian noise, and hence it can address a much wider class of practical problems.

1. Introduction.

Image deblurring [9] from noisy data is a fundamental problem in image processing. Let the true image x belong to a proper function space $\mathbb{S}(\Omega)$ on $\Omega = [0,1]^2$, and the observed digital image y be a matrix in $\mathbb{R}^{m\times m}$ indexed by $\mathcal{A} = \{1, 2, \cdots, m\}^2$. Image deblurring usually is modeled by $\tilde{y} = Hx + \sigma n$ where $H : \mathbb{S}(\Omega) \to \mathbb{R}^{m\times m}$ is a known linear operator that represents blurring and $\sigma n \in \mathbb{R}^{m\times m}$ is the additive zero-mean Gaussian noise with standard deviation $\sigma \geq 0$. In real applications, practical systems can sometimes suffer from few or more pixels, called outliers, which are much noisier than others. Such perturbations are typically caused by malfunctioning arrays in camera sensors, faulty memory locations in

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