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A Picture is worth a Billion Bits: Real-Time Image Reconstruction from Dense Binary Pixels

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Abstract : The pursuit of smaller pixel sizes at ever increasing resolution in digital image sensors is mainly driven by the stringent price and form-factor requirements of sensors and optics in the cellular phone market. Recently, Eric Fossum proposed a novel concept of an image sensor with dense sub-diffraction limit one-bit pixels (jots), which can be considered a digital emulation of silver halide photographic film. This idea has been recently embodied as the EPFL Gigavision camera. A major bottleneck in the design of such sensors is the image reconstruction process, producing a continuous high dynamic range image from oversampled binary measurements. The extreme quantization of the Poisson statistics is incompatible with the assumptions of most standard image processing and enhancement frameworks. The recently proposed maximum-likelihood (ML) approach addresses this difficulty, but suffers from image artifacts and has impractically high computational complexity. In this work, we study a variant of a sensor with binary threshold pixels and propose a reconstruction algorithm combining an ML data fitting term with a sparse synthesis prior. We also show an efficient hardware-friendly real-time approximation of this inverse operator. Promising results are shown on synthetic data as well as on HDR data emulated using multiple exposures of a regular CMOS sensor.

Keywords : binary pixels, maximum likelihood, neural networks, sparse coding
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