Simultaneous high dynamic range image reconstruction and denoising for non-static scenes

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The human eye has the ability to capture scenes of very high dynamic range, retaining details in both dark and bright regions. This is not the case for current standard digital cameras. The limited capacity of the sensor cells makes it impossible to record the irradiance from very bright regions for long exposures (saturated pixels) while very few photons will be captured in the dark regions for short exposures (noisy pixels).

Since the seminal work of Mann and Picard in 1994, the standard way to build high dynamic range (HDR) images from regular cameras has been to combine a reduced number of photographs captured with different exposure times. The algorithms proposed in the literature differ in the strategy used to combine these frames.

Under the hyphotesis of perfectly aligned images (fixed scene and static camera), a study of the different noise sources in the image acquisition process allows us to model the image fusion as a statistical estimation problem. We derive theoretical bounds for the performance of the HDR estimation problem and show that, even with a small number of photographs, the maximum likelihood estimator performs extremely close to these bounds.

In practice, scenes are dynamic and images are usually acquired with a hand-held camera. We propose a new HDR image generation approach that simultaneously copes with these problems and exploits image redundancy to produce a denoised result. A reference image is chosen and a patch-based approach is used to find similar pixels that are then combined for the irradiance estimation. This patch-based approach permits to obtain a denoised result and is robust to image misalignments and object motion. Results show significant improvements in terms of noise reduction over previous HDR image generation techniques, while being robust to motion and changes between the exposures.

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