Guided Tone Mapping

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(a) (b) (c) (d)

Figure 1: *(a) the input high dynamic range (HDR) image. (b) the guided image constructed by our approach. Mathematically, the guided image can be regarded as a scalar matrix which map the HDR luminance channel* $\mathbf{I^h}$ *into low dynamic range (LDR) luminance channel* $\mathbf{I^l}$ *simply by* $\mathbf{I^l} = \mathbf{P} \cdot \mathbf{I^h}$. *The scalar matrix* $\mathbf{P}$ *is calculated per pixel with local mean and variance in the luminance channel of the input HDR image. Bright regions in the guided image indicate that the same areas of the input HDR image should be enhanced, otherwise should be compressed. (c) our enhanced result in details(*$\lambda_1 = 0.6, \lambda_2 = 0.3$*). (d) our natural result(*$\lambda_1 = 0.6, \lambda_2 = 0.1$*).*

Abstract

In this paper, we propose a simple but effective tone mapping operator, which can achieve impressive results with low complexity in both the formulation and computation. The key point of our operator is to calculate a scalar matrix by which the input HDR image can be mapped into a displayable LDR image. From the graphical perspective, we can regard the scalar matrix as a guided image, as shown in Figure 1(b). Experimental results show that our algorithm can achieve real-time perceptually pleasing result.

Keywords: tone mapping, high dynamic range, guided image

1 Introduction

The last three decades have witnessed the prosperity in tone mapping algorithm. Mathematically, given a HDR luminance channel $\mathbf{I^h}$, the target of tone mapping is to find a mapping function $f(\cdot)$ so that we can get the LDR luminance channel $\mathbf{I^l}$ by $\mathbf{I^l} = f(\mathbf{I^h})$. In literature, the tone mapping operators can be roughly classified into two categories: global operators and local operators. The mapping functions $f(\cdot)$ in global techniques, such as linear function, gamma function, histogram based function and so on, have different formulations but share one similarity that it is spatially invariant in the whole image. Global operators are usually simple and fast, but they always fail in balancing unveiling visual contents and preserving details. Therefore, the recent literature focus on local operators in which the mapping function $f(\cdot)$ is locally invariant. For local operators, the key point is transformed to how to define a local measurement rather than find a suitable mapping function because, in each local patch, linear mapping function is usually good enough to obtain a satisfactory result. As a result, different local measurements based on neighborhoods, layers after decomposition, areas after segmentation have enjoyed a boom in different local operators in the last ten years. Local operators can effectively compress the high dynamic range while maintain or enhance the details. However, most of them have a high complexity in formulation or computation. Typically, Paris [Paris et al. 2011] decompose the input HDR image into different parts and layers by standard Laplacian pyramids and then the same function is used in each layer or part to achieve edge-aware tone mapping. The local Laplacian methods can produce impressive high-quality results, especially in details enhancement. Unfortunately, their algorithm suffers from high complexity.

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2 Our Approach

As analyzed above, if we still focus on how to find an explicit mapping function or a new local measurement, it is not easy to avoid the problem of balancing the complexity and the effect. Actually, if the mapping function $f(\cdot)$ can be expressed as a formulation of dot product, namely $f(\mathbf{I^h}) = \mathbf{P} \cdot \mathbf{I^h}$, this problem might be solved. Under this circumstance, the fundamental task of tone mapping is to find a suitable scalar matrix. Fortunately, inspired by the observation of Stockham [Stockham 1972], we find such a proper scalar matrix which can be calculated as:

$$\mathbf{P}_i = \frac{1}{max(u_i^{\lambda_1} \sigma_i^{\lambda_2}, k_0)}. \qquad (1)$$

Where u_i and σ_i denote the mean and variance of the local patch centering in pixel i, while $k_0 = 0.001$ is a constant value to keep the denominator from zero. Note that our operator has not only a simple formulation but also a low computation complexity because there are only local mean and variance computation and dot product involved in our algorithm. Besides, our results can be adapted to specific requirements by toning up the two parameters. To be more specific, parameter λ_1 controls the total brightness of the output LDR image while parameter λ_2 influences the details manipulation, as shown in Figure 1(c), (d). More experimental results are illustrated in the supplementary.

References

PARIS, S., HASINOFF, S. W., AND KAUTZ, J. 2011. Local laplacian filters: edge-aware image processing with a laplacian pyramid. *ACM Trans. Graph. 30*, 68:1–68:12.

STOCKHAM, T.G., J. 1972. Image processing in the context of a visual model. *Proceedings of the IEEE. 60*, 7, 828–842.

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