Learning to Enhance Low-Light Image via Zero-Reference Deep Curve Estimation

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摘要

This paper presents a novel method, Zero-Reference Deep Curve Estimation (Zero-DCE), which formulates light enhancement as a task of image-specific curve estimation with a deep network. Our method trains a lightweight deep network, DCE-Net, to estimate pixel-wise and high-order curves for dynamic range adjustment of a given image. The curve estimation is specially designed, considering pixel value range, monotonicity, and differentiability. Zero-DCE is appealing in its relaxed assumption on reference images, i.e., it does not require any paired or even unpaired data during training. This is achieved through a set of carefully formulated non-reference loss functions, which implicitly measure the enhancement quality and drive the learning of the network. Despite its simplicity, we show that it generalizes well to diverse lighting conditions. Our method is efficient as image enhancement can be achieved by an intuitive and simple nonlinear curve mapping. We further present an accelerated and light version of Zero-DCE, called Zero-DCE++, that takes advantage of a tiny network with just 10K parameters. Zero-DCE++ has a fast inference speed (1000/11 FPS on a single GPU/CPU for an image of size 1200x900x3) while keeping the enhancement performance of Zero-DCE. Extensive experiments on various benchmarks demonstrate the advantages of our method over state-of-the-art methods qualitatively and quantitatively. Furthermore, the potential benefits of our method to face detection in the dark are discussed. The source code is made publicly available at https://li-chongyi.github.io/Proj_Zero-DCE++.html.

关键词

作者关键词: Lighting; Estimation; Training; Image enhancement; Image color analysis; Dynamic range; Task analysis; Computational photography; low-light image enhancement; curve estimation; zero-reference learning

Keywords Plus: QUALITY ASSESSMENT

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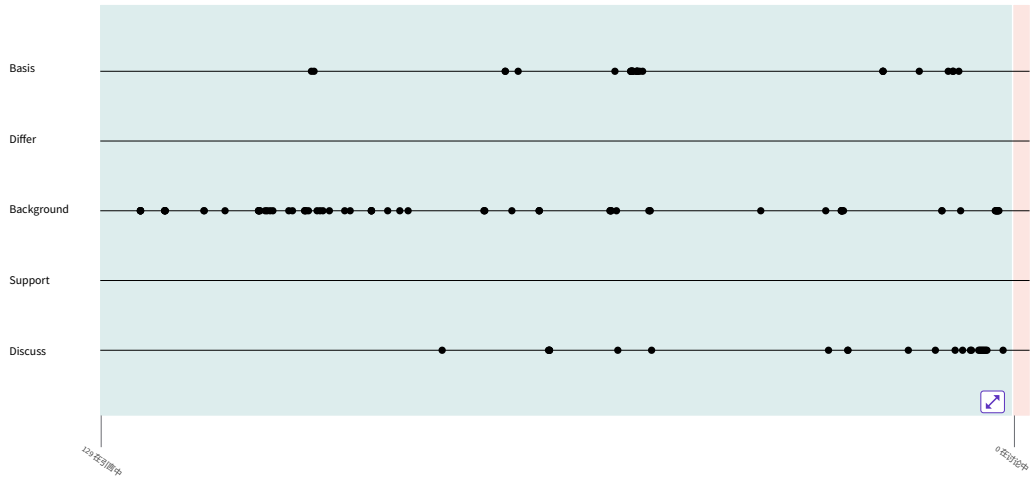

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