CURL: Neural Curve Layers for Global Image Enhancement

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Introduction

Problem
- Final image quality is of pivotal importance in end-user imaging systems such as DSLR and smartphone cameras.
- Post-capture enhancement is an ill-posed problem that demands appropriate transformation of properties such as colour, saturation and luminance.
- Successful manual enhancement often requires digital artistic skill, time and professional software.

Observations
- Digital artists modify image properties through manual control of adjustment curves.
- Popular parameterized manual enhancement tools allow for smooth global image adjustments.
- Effective image enhancement requires both local and global adjustment.

Research questions
- Can we automatically estimate, and apply, image adjustment curves to improve perceptual quality?
- Which curves and colour spaces should be considered?
- Does adjustment application ordering matter?

Proposed approach and contributions
- CURL (our multi-colour-space neural retouching block) learns piece-wise linear scaling curves towards adjusting image properties in a human-interpretable manner.
- CURL is a multi-colour-space loss function: guides sequential and differentiable image transforms in multiple colour spaces (HSV, Lab, RGB).
- TED (Transformed Encoder Decoder backbone): modifies network backbone architectures by streamlining the use of skip connections towards improving decoder performance.
- State-of-the-art performance on three competitive benchmarks.

Method Overview

Transformed Encoder/Decoder (TED) backbone
- Our backbone architecture TED enables local pixel adjustment with a U-Net-like structure.
- We find global and mid-level contextual information to be important,Jon spatial inconsistencies.
- Content is accounted for by fusing global and mid-level features using a multi-scale contextual awareness (MSCA) connection.
- Our single skip connection trades-off parameter complexity and image quality.
- We highlight that embedding a skip connection with multi-scale processing reduces relative parameter counts while also improving image quality.
- Fusing multiple levels of image content delivers more contextually relevant features for the decoder path.

CURL: Neural Curve Layers for Global Image Adjustment
- CURL (our global image colour, saturation and luminance retouching block).
- The previous TED network outputs an $H \times W \times C$ tensor, that is fed to the CURL block.
- $H \times W \times C$ tensor represents the image to be globally enhanced, concatenated with additional feature maps serving as several curve input features.
- We perform a regression to acquire curve input points of piecewise-linear adjustment curves, for multiple colour spaces.
- Learned adjustment curves enhance image I by scaling pixels in three colour spaces (HSV, CELab, RGB).
- CURL therefore regresses expressive curves, used to scale rather than remap colours/already existing approaches.

Quantitative results
- Example experiment: prediction quality for photographs C
- State-of-the-art performance: PSNR, SSIM, LPIPS.
- Efficient architecture (usual weight parameter count).

Links
- [2] Qifeng Chen, Jia Xu, and Vladlen Koltun. Fast image processing with
- [4] Andrey Ignatov, Nikolay Kobyshev, Radu Timofte, Kenneth Vanhoey, and
- [8] Ruixing Wang, Qing Zhang, Chi-Wing Fu, Xiaoyong Shen, Wei-Shi Zheng,
- [6] 80 0
- [7] 66 0
- [8] 42 0
- [9] 76 0

References
- please see our paper for additional quantitative results.

Example: Samsung S7. Medium Exposure dataset

Example: MIT-Adobe-CPE dataset

Summary
- We introduce CURL: CURLow Layers for kable image enhancement
- Inspired by digital artists, we learn image retouching adjustment curves.
- Exploitation of image representation in three different colour spaces (CIELab, HSV, RGB).
- Extensive experimentation reports state-of-the-art quantitative, qualitative results across a suite of benchmarks.