CURL: Neural Curve Layers for Global Image Enhancement

Sean Moran, Steven McDonagh, Gregory Slabaugh

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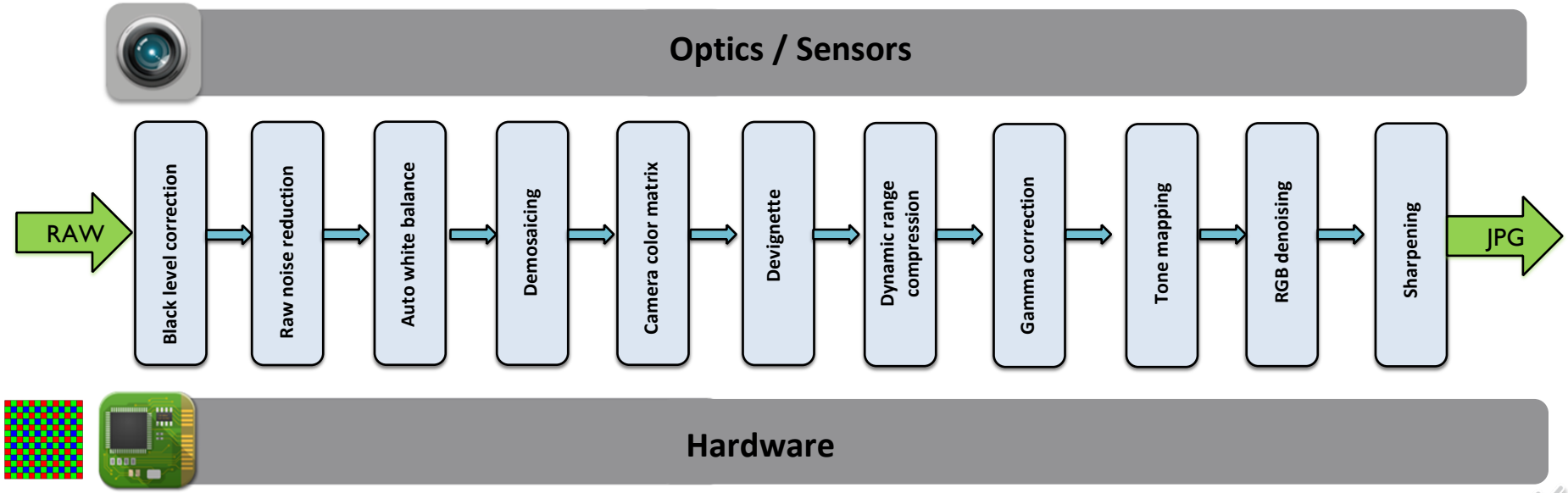
HUAWEI

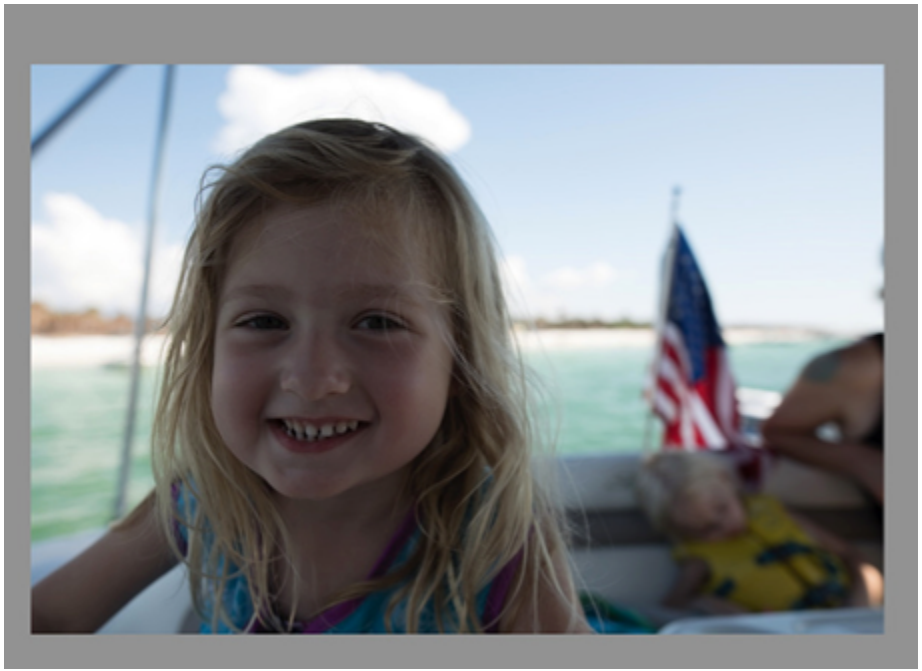
ICPR 20

Images and image quality

1.4 trillion photos will be taken in 2020



Manual image enhancement



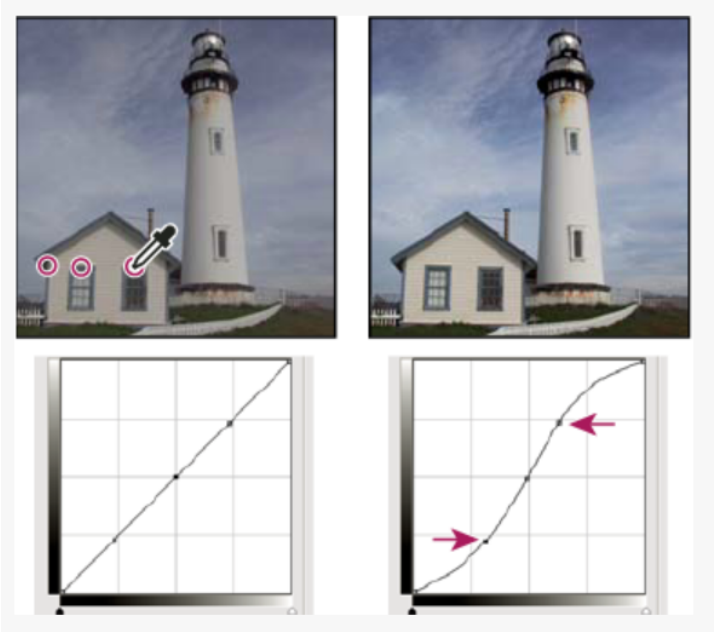
Photos courtesy of Jennifer Kielich, https://jenniferkielich.com/

Image enhancement using curve layers

Photoshop / Lightroom allows users to adjust global image properties through the *use of curves*

Research questions:

1. Can we automatically estimate, and apply, image adjustment curves to improve perceptual quality?
2. Which curves and colour spaces should be considered?
3. Does ordering matter?

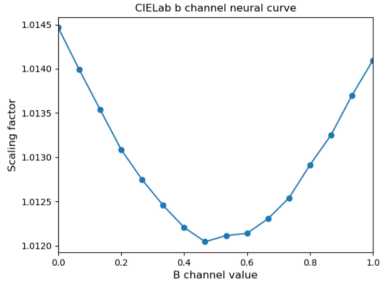


Example: adjusting brightness

CURL

Neural **CUR**ve **L**ayers (CURL) which learn and apply curve adjustments to an image. CURL has the following features:

- Curves are piecewise linear
- Curves can flexibly adjust different image attributes (brightness, saturation, colour)
- Different colour spaces (RGB, HSV, LAB) supported
- Fully differentiable and trained end-to-end
- Predicted curves are intuitive and can be user adjusted



Poor exposure input

Our approach

Professional artist (GT)

CURL contributions

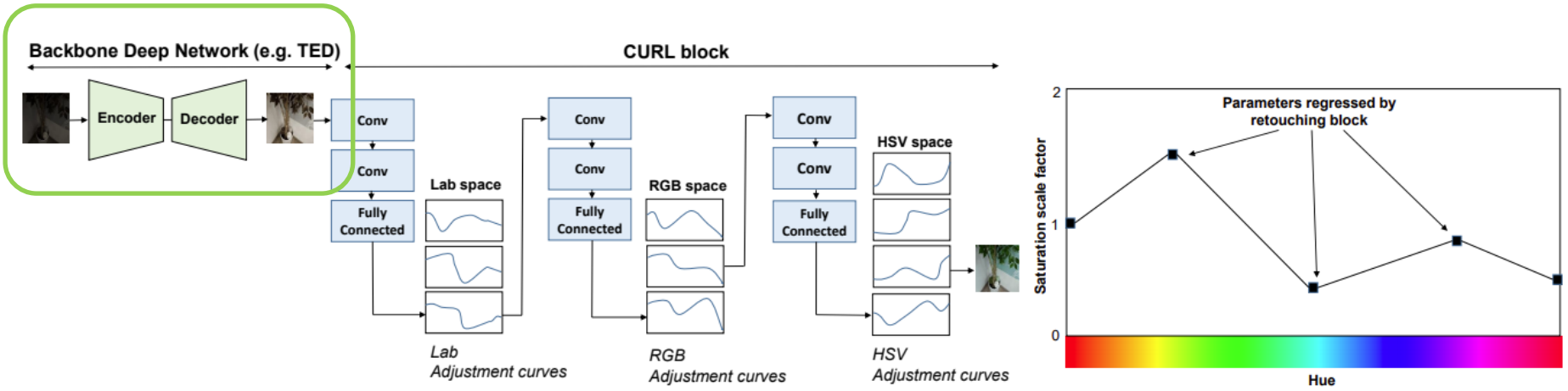
1. **Multi-colour-space neural retouching block**. We learn piecewise linear scaling curves for adjusting image properties in a human-interpretable manner

2. **Loss function** that guides sequential and differentiable image transforms in multiple colour spaces (HSV, Lab, RGB)

3. **Transformed Encoder-Decoder (TED) backbone**. We modify network backbone architectures by streamlining the use of skip connections towards improving decoder performance

4. **State-of-the-art performance** on three competitive benchmarks

Overview of the CURL architecture

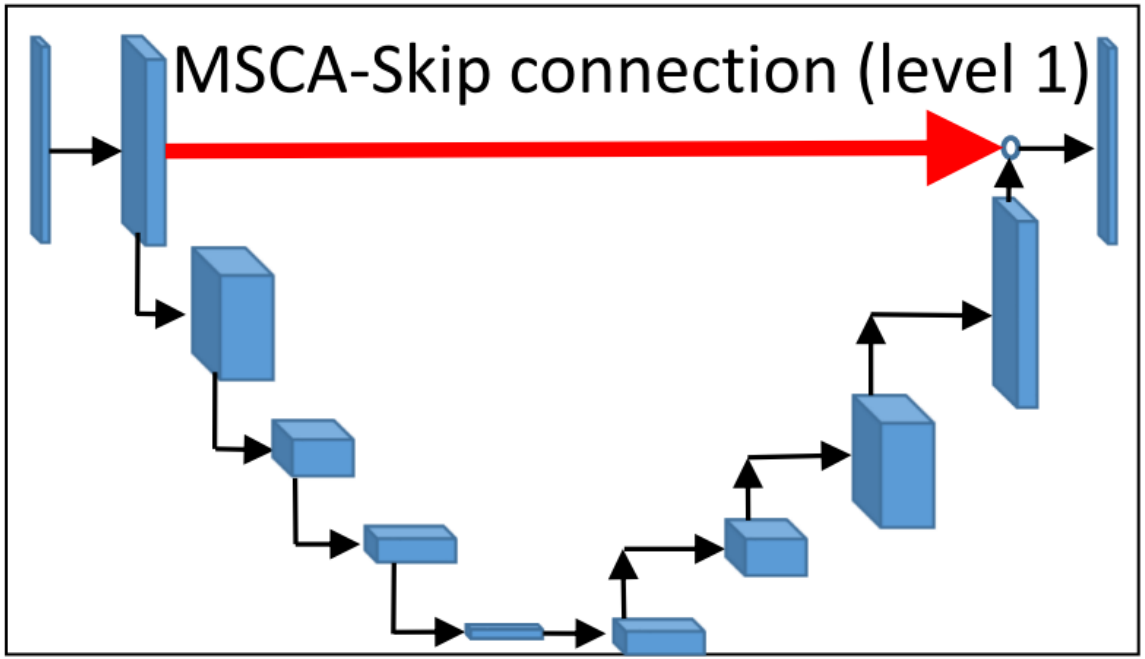


RAW to RGB (Image signal processor): RAW data is input to backbone network: denoising / demosaicing

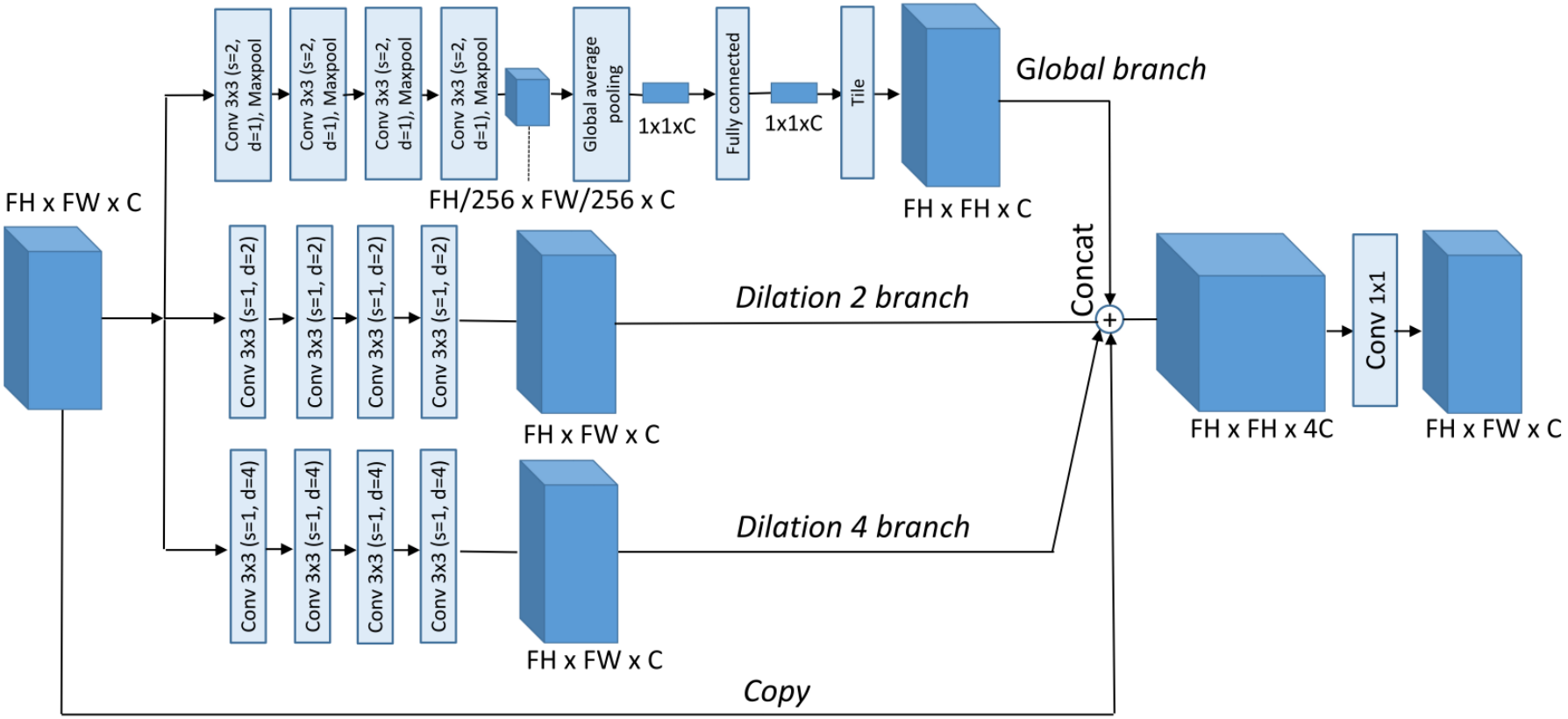
RGB to RGB (Image enhancement): RGB data is input instead

Transformed Encoder/Decoder (TED)

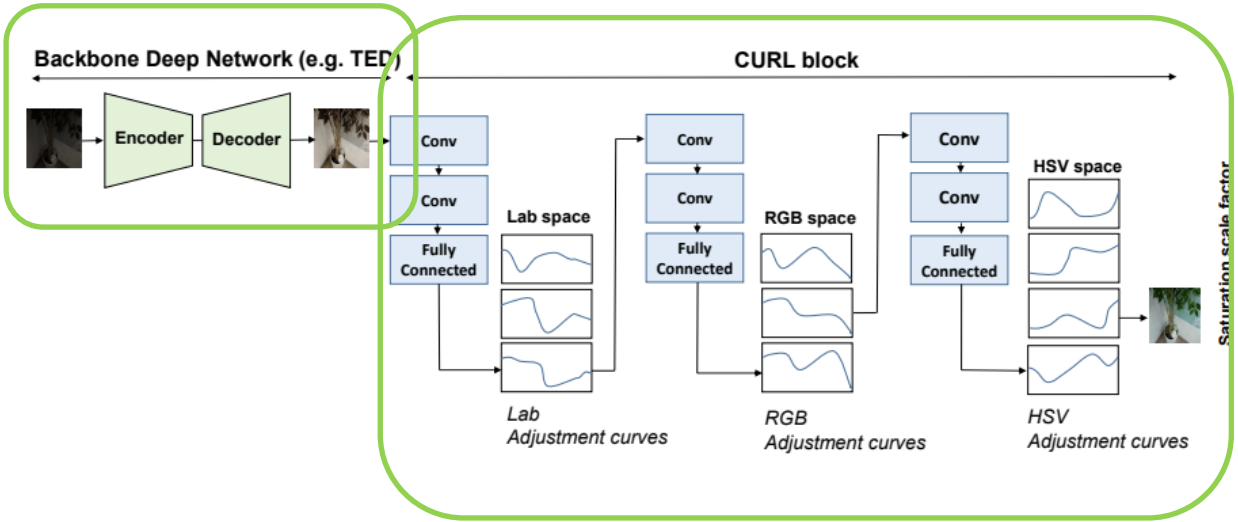
UNet style encoder/decoder but uses a multi-scale contextual awareness (MSCA) connection on the first level

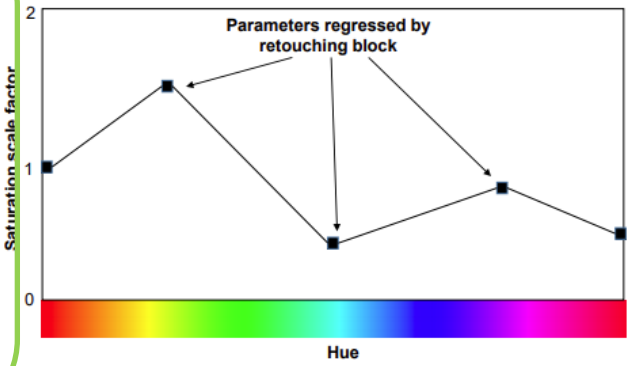


Multi-scale contextual awareness (MSCA) connection



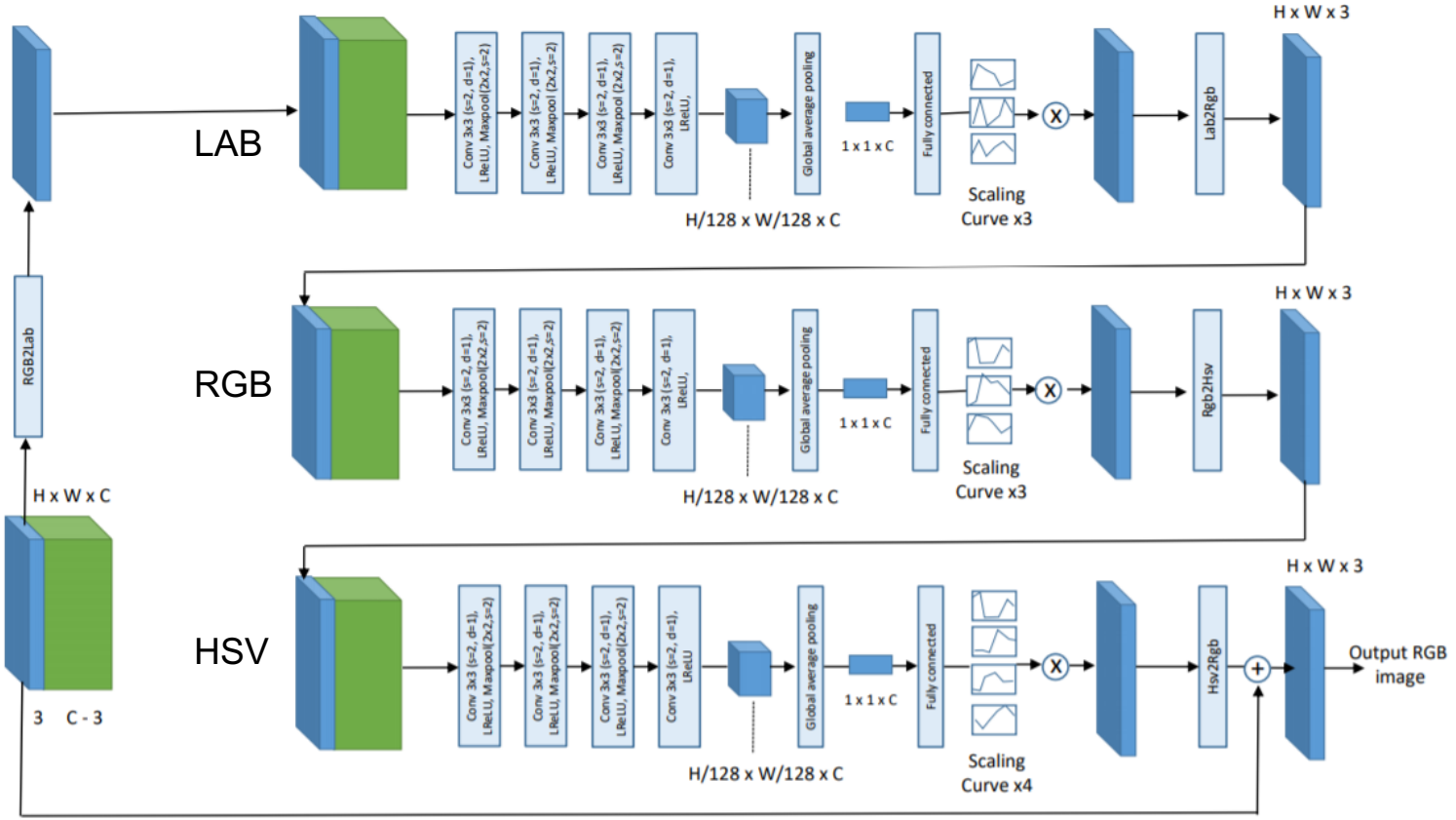
Overview of the CURL architecture





CURL block

A CURL block is a multi-colour space neural retouching block that estimates enhancement curves



Loss and ablation studies

$$\mathcal{L} = \sum_{i=1}^{N} \mathcal{L}^i_{hsv} + \mathcal{L}^i_{lab} + \mathcal{L}^i_{rgb} + \mathcal{L}^i_{reg}$$

Loss is designed to control each of the colour-space specific transformations in CURL

Results

DeepISP (28.19 dB)

TED+CURL (29.37 dB)

Groundtruth

DeepUPE (16.85 dB)

TED+CURL (23.55 dB)

Groundtruth

Tables

Ordering	PSNR (test)↑
HSV→RGB→LAB	26.20
RGB→HSV→LAB	26.83
LAB→RGB→HSV	**27.09**
LAB→HSV→RGB	26.37
RGB→LAB→HSV	25.32
HSV→LAB→RGB	26.53

Ordering through colour spaces

Architecture	PSNR↑
TED+ CURL	**27.04**
TED	26.56
U-Net [13]	25.90
DeepISP [8]	26.51

RAW to RGB

Architecture	PSNR↑
TED+CURL	**24.20**
HDRNet [15]	21.96
DPE [3]	22.15
White-Box [2]	18.57
Distort-and-Recover [24]	20.97
DeepUPE [1]	23.04

RGB to RGB

Thank you

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