Image Dehazing with Boundary Constraint and Contextual Regularization: a ClearView Plus recreation attempt

Students:
Souhaiel BenSalem
Maxime Alvarez

07/04/2023

A challenging problem

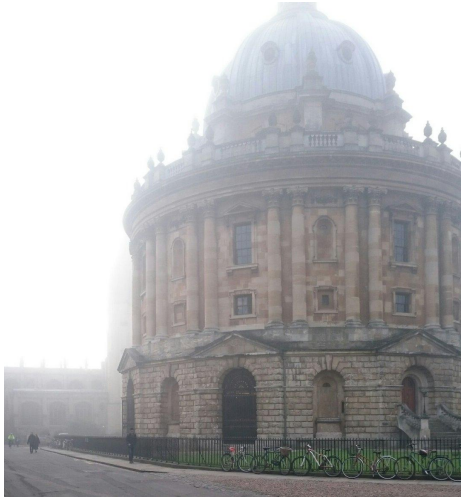
Haze affects every aspect of the photograph, for each category of photography

Hazy landscape

(pollution)

Hazy portrait

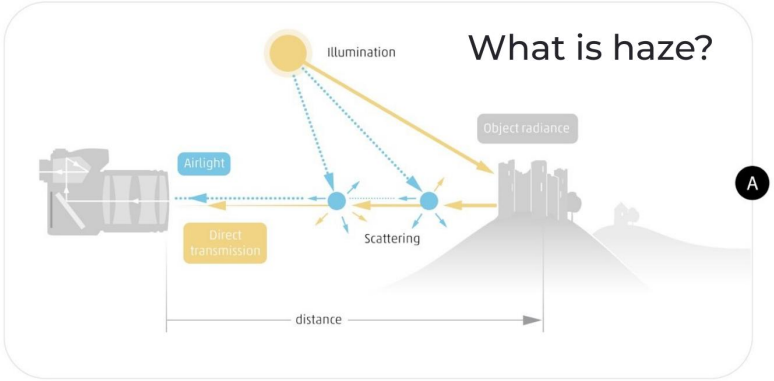
(lens haze)



Hazy still image

(fog)

What is haze ?

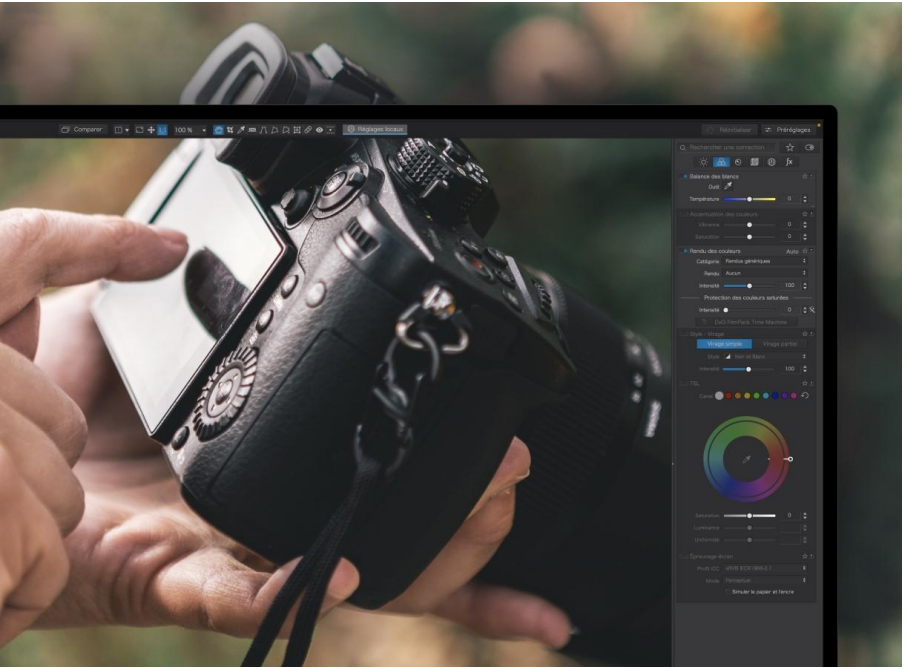


The formation of a hazy image

Haze: is a meteorological phenomenon that occurs when dust, smoke, and other dry particles obscure the clarity and color of the atmosphere.

- distorted colors and lower contrast
- less details and reduced visibility
- overall washed out image

Post processing software to the rescue!



DxO's PhotoLab 6

- A powerful photo editing software that specializes in image processing and correction.

- Offers a range of tools and features for enhancing image quality, such as noise reduction, sharpness,color correction and dehazing.

- Includes powerful tools for lens correction, which automatically corrects distortion, vignetting, and chromatic aberrations.

- Offers a customizable user interface with a range of editing and adjustment tools, including selective adjustments, local adjustments, and batch processing options.

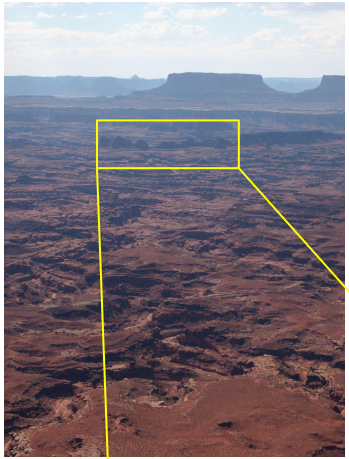
DxO's Clear View Plus

Misty image before correction

Dehazed image produced by Clear View +

Visual Inspection

Original image

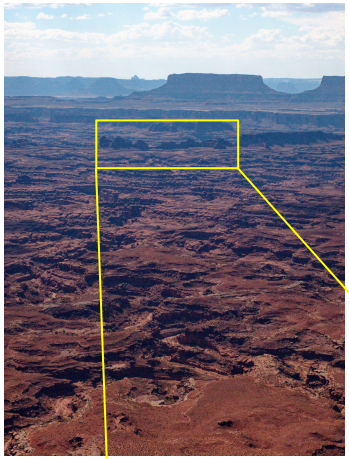


compact

flat image

little details

Clear View Plus applied at 50% capacity

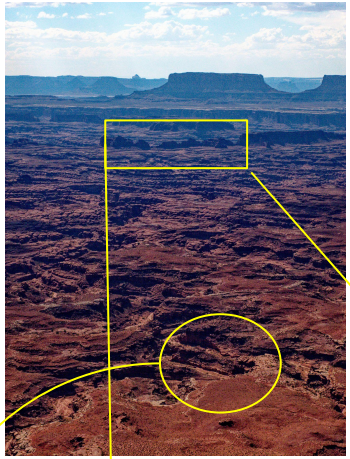


+ contrast

+ details

better colors

Clear View Plus applied at 100% capacity



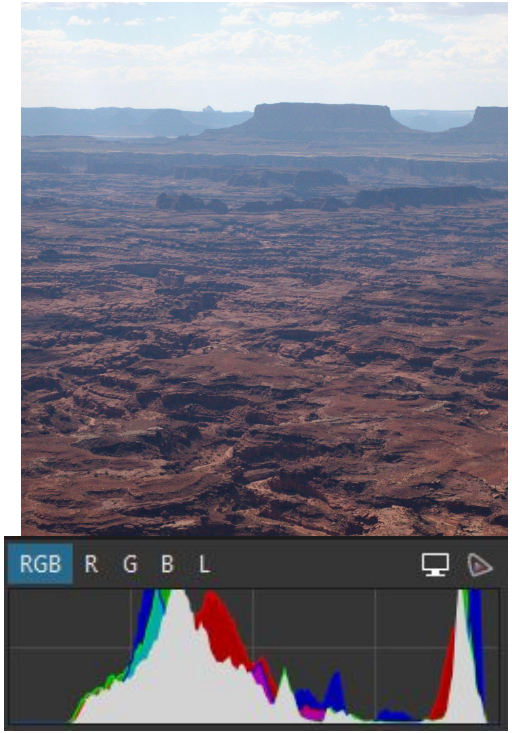
++ contrast

++ details

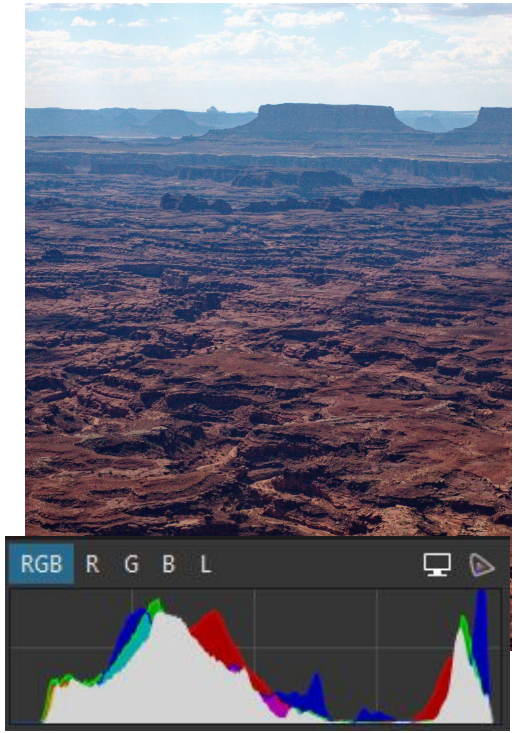
- oversaturation
- over-contrast

DxO's Clear View Plus

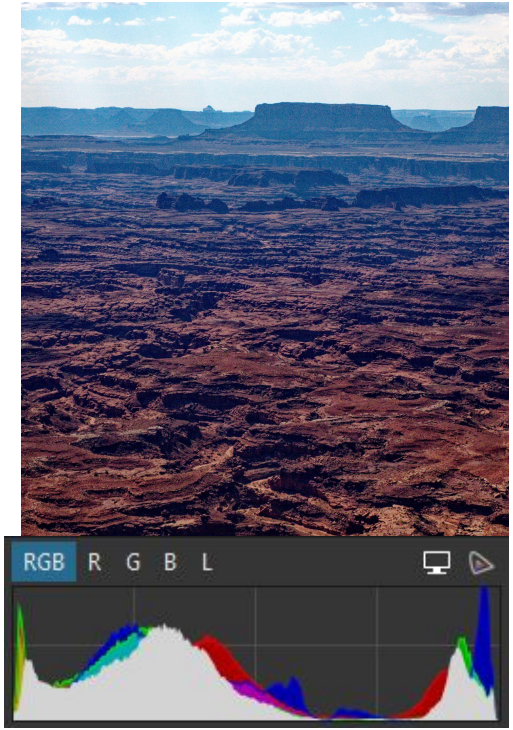
Original image



Clear View Plus applied at 50% capacity



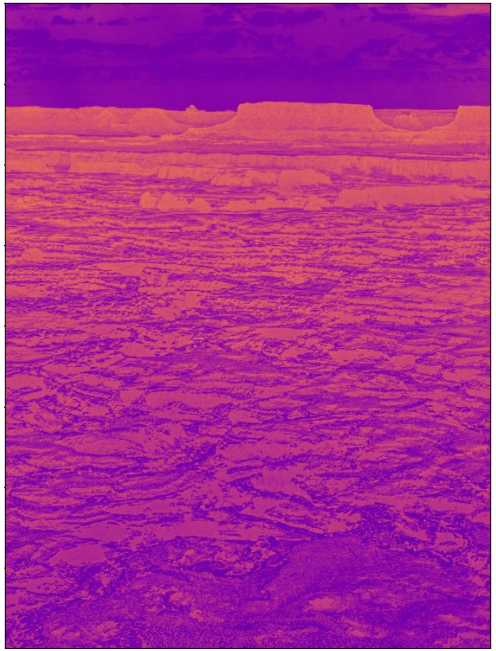
Clear View Plus applied at 100% capacity



DxO's Clear View Plus

Original image

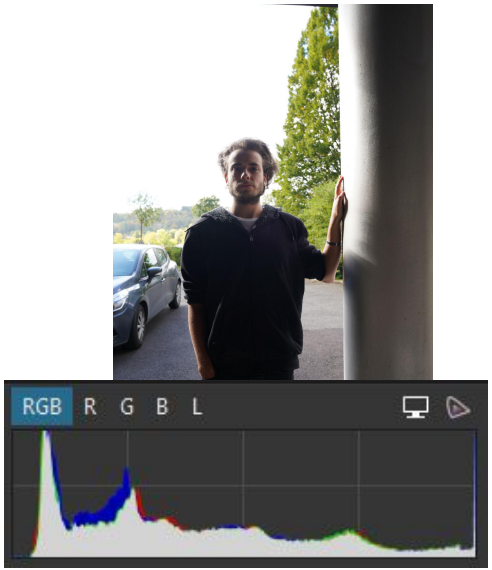
Difference between original and 100% ClearView



Clear View Plus applied at 100% capacity

Another Example of Visual Inspection

Original image



Clear View Plus applied at 50% capacity

Clear View Plus applied at 100% capacity

- wider distribution of pixel intensities, with fewer pixels concentrated around the hazy intensity values → Increased contrast
- a shift in the distribution of pixel intensities and a bit more distinct peaks and valleys → More details + better color balance

DxO's Clear View Plus

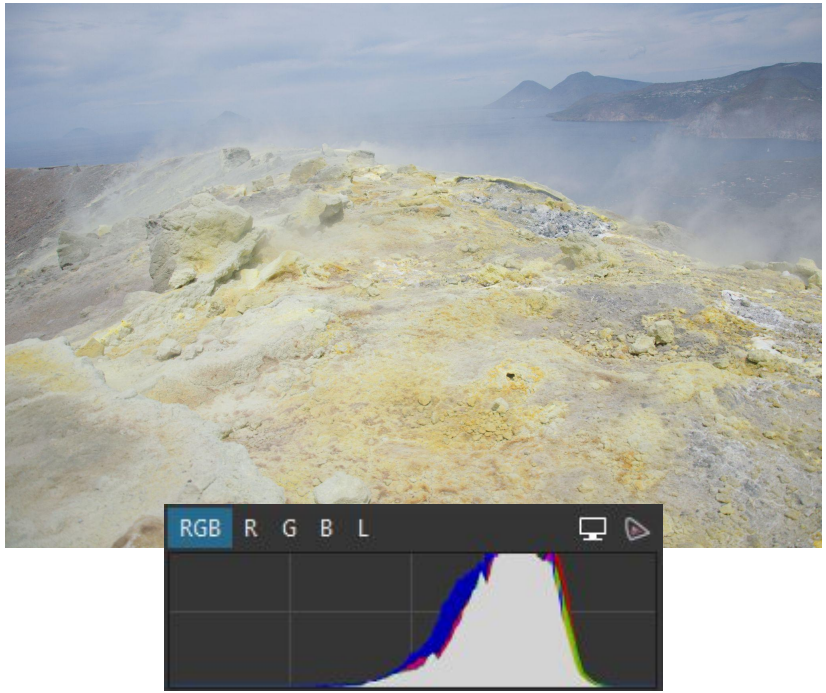
Original image

Difference between original and 100% ClearView

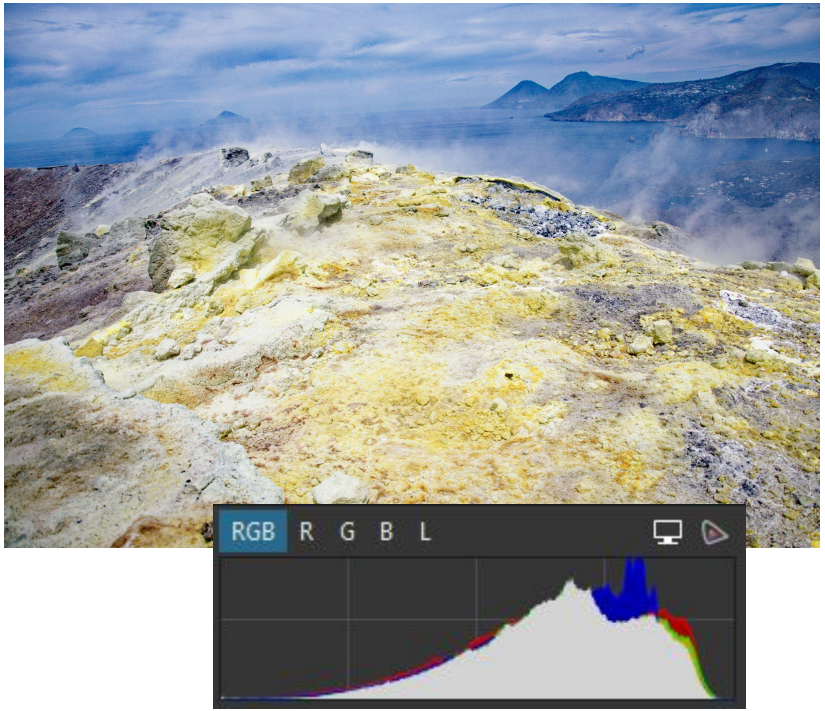
Clear View Plus applied at 100% capacity

Another Example of Visual Inspection

Original image

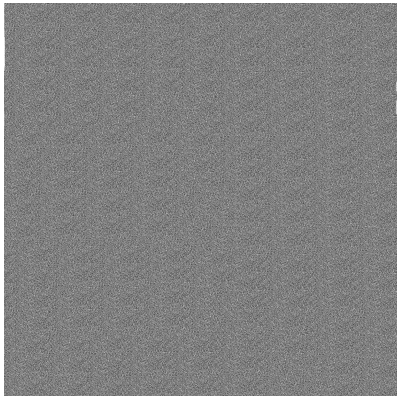


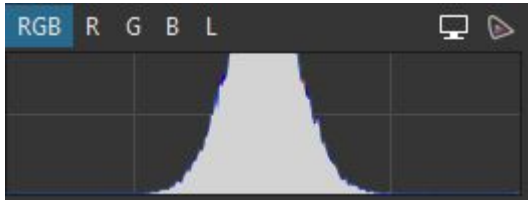
Clear View Plus applied at 100% capacity



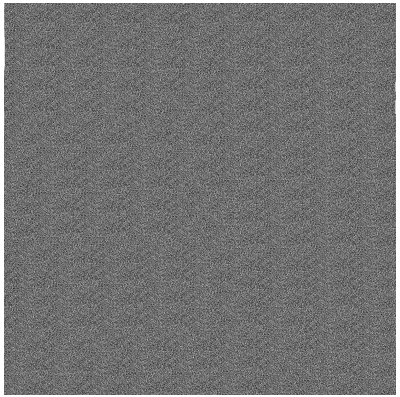
Applying to white noise

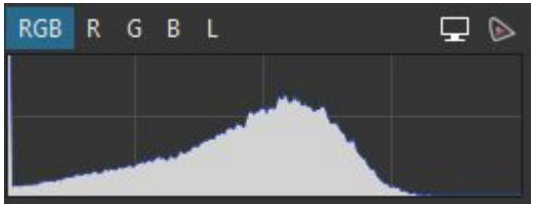
Original image





Clear View Plus applied at 100% capacity





Algorithmic point of view (guess)

Input image

Clear View plus output (75%)

Pre-processing

Probably : converting to a specific color space, or normalizing the intensity values.

Airlight estimation

This is a important step in every dehazing algorithm

Transmission map estimation

Crucial for understanding how much haze affects different regions of the image.

Transmission map refinement

Guided filtering or regularization, to produce a more accurate and visually appealing result.

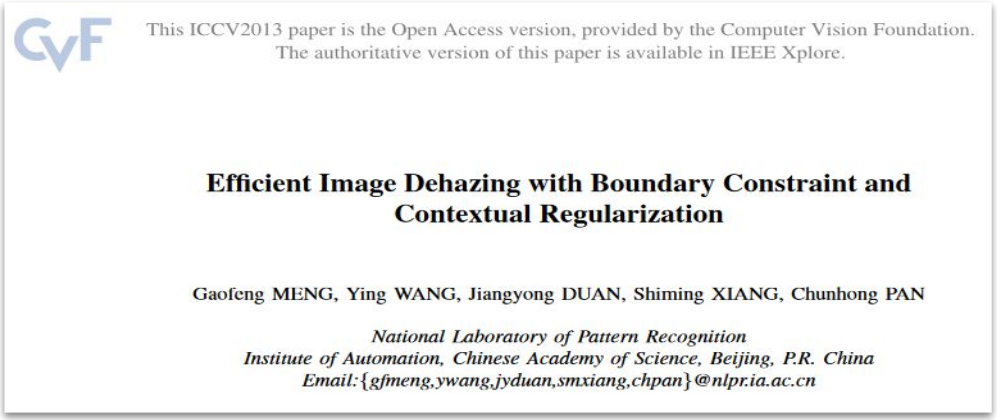
Dehazing

Using the estimated airlight and refined transmission map, recover the original image

post-processing

Probably : improve lighting and contrast

Recreating Clear View Plus



This ICCV2013 paper is the Open Access version, provided by the Computer Vision Foundation.
The authoritative version of this paper is available in IEEE Xplore.

Efficient Image Dehazing with Boundary Constraint and Contextual Regularization

Gaofeng MENG, Ying WANG, Jiangyong DUAN, Shiming XIANG, Chunhong PAN

National Laboratory of Pattern Recognition
Institute of Automation, Chinese Academy of Science, Beijing, P.R. China
Email:{gfmeng,ywang,jyduan,smxiang,chpan}@nlpr.ia.ac.cn

Given a hazy image model : $$\mathbf{I}(x) = t(x)\mathbf{J}(x) + (1 - t(x))\mathbf{A}$$

I(x) : observed image
J(x): the scene radiance
t(x): transmission
A: global atmospheric light

We want to retrieve the scene radiance : $$\mathbf{J}(x) = \frac{\mathbf{I}(x) - \mathbf{A}}{[\max(t(x), \epsilon)]^{\delta}} + \mathbf{A}$$

δ : medium extinction coefficient

Key points of the proposed method

The proposed method relies on 3 main contributions

Boundary Constraint on Scene Transmission

Derived from the observation that the scene transmission should be close to 1 (i.e., no haze) at the boundaries of the radiance cube.

Mathematically:

$t(x) \approx 1$, for $x \in \partial\Omega$ where $t(x)$ is the scene transmission at pixel location x, and $\partial\Omega$ represents the boundary of the radiance cube.

Contextual Regularization

The authors propose a contextual regularization term that is based on a weighted L1-norm.

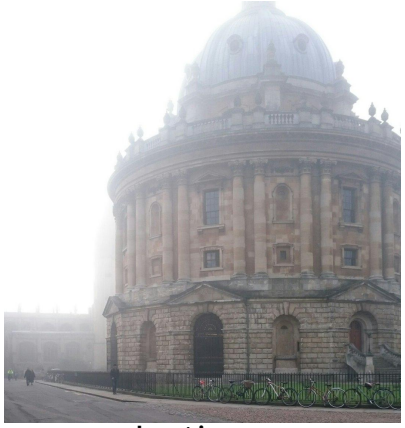
This regularization term encourages spatially coherent transmissions while preserving sharp edges and corners.

Efficient Optimization Scheme

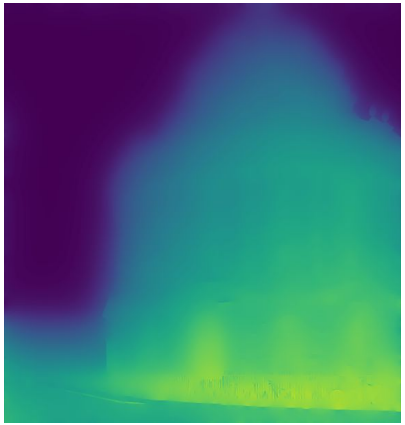
The authors presented an efficient optimization scheme to solve the formulated optimization problem for recovering the unknown transmission map.

The optimization scheme involves the use of an augmented Lagrangian method with a split Bregman iteration. This approach enables the method to quickly dehaze images of large sizes.

Key points of the proposed method



Input image



transmission map

dehazed image

Airlight estimation

The airlight (A) is estimated by analyzing the brightest pixels in the dark channel of the input hazy image.

Initial Transm. Map Estimation

An initial transmission map is calculated using the scattering model and the estimated airlight value.

Boundary constraint

A boundary constraint is derived from the radiance cube, to impose constraints on the scene transmission.

Contextual Regularization

The initial transmission map is refined by applying a soft matting technique with contextual regularization. use L1-norm-based regularization term to ensure smoothness and sharpness in the recovered transmission map.

Refined transmission map

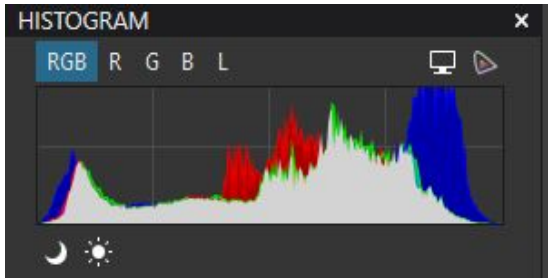
The result of the soft matting and contextual regularization is a refined transmission map (t_refined) that better represents the haze distribution in the image.

Recover scene radiance J(x)

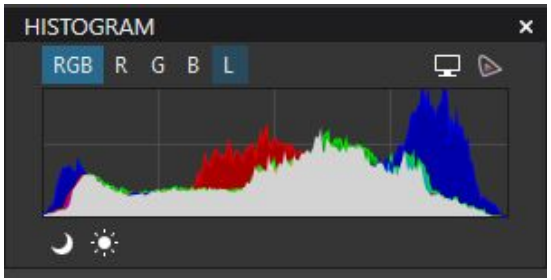
The refined transmission map and airlight value are used in conjunction with the atmospheric scattering model to recover the haze-free scene radiance

Clear View Plus vs the proposed method

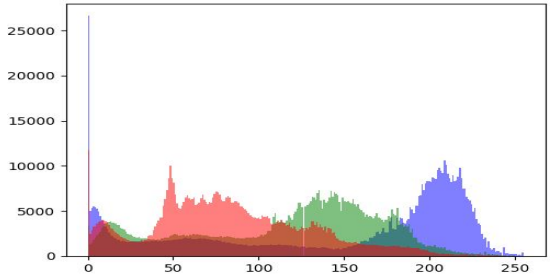
Hazy image



Clear View Plus applied at 50% capacity

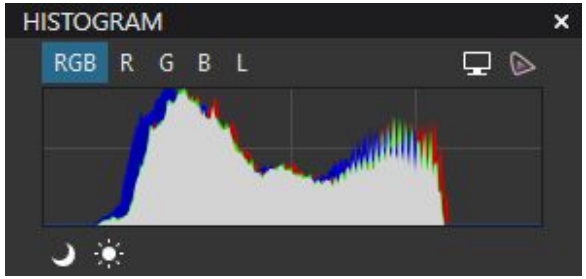


Ours

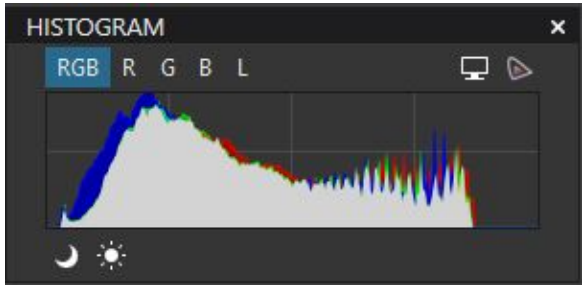


Clear View Plus vs the proposed method

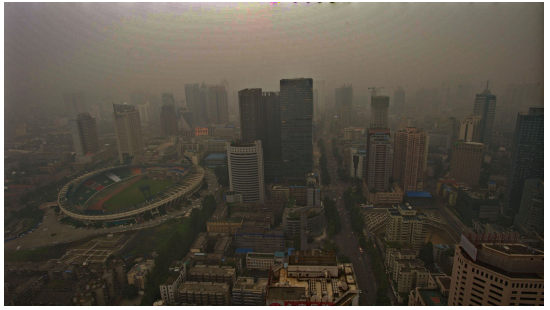
Hazy image

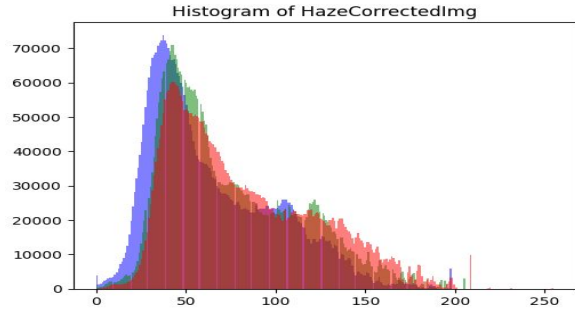


Clear View Plus applied at 50% capacity



Ours

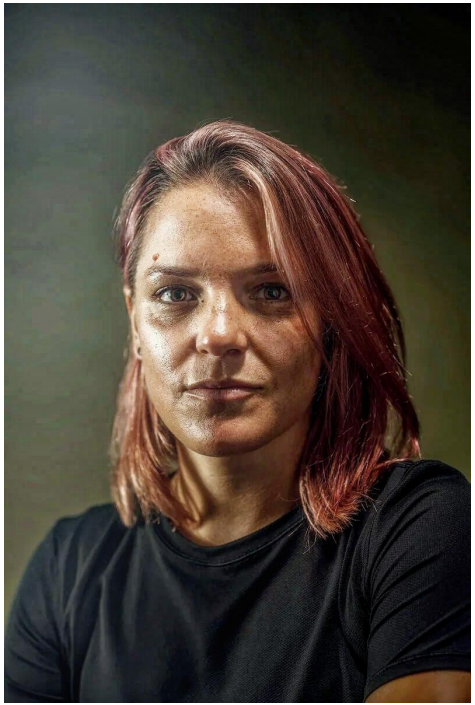




Clear View Plus vs the proposed method

Hazy portrait

Clear View Plus applied at 50% capacity

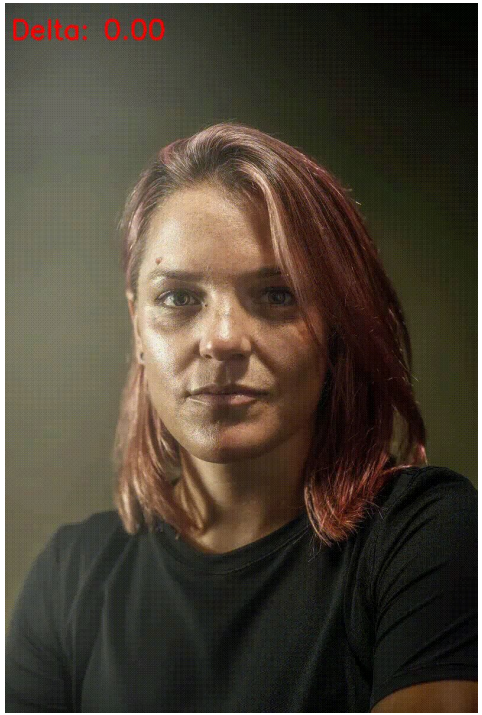


- Introduction of noise
- overexposed

Ours

effective haze removal
well exposed, a bit more contrasty

Effect of the dehazing parameters delta



- When delta is close to 0, The refined transmission map will be heavily influenced by the global atmospheric light A. In this case, the dehazing algorithm might not effectively remove haze, and the output image may still appear hazy.

- As the value of delta increases, the refined transmission map relies more on the original transmission map and less on the global atmospheric light A.

- When delta is close to 1: The refined transmission map becomes very close to the original transmission map. the algorithm over-enhance the image, resulting in an unnatural or overly processed appearance.

Where do we go from here

What can be done next

- Parameter tuning: Perform a systematic search or optimization for the parameters (e.g., C0, C1, delta, regularize_lambda) to find the best values that produce the most visually appealing and accurate dehazed images.
- Multi-scale approach: Apply the dehazing algorithm in a multi-scale manner, where coarse-to-fine processing is employed to better preserve details and edges at different scales.
- Real-time processing: Optimize the algorithm's implementation for real-time or faster processing, which can be useful in applications such as video dehazing or real-time computer vision systems.
- Learn the dehazing process (https://paperswithcode.com/task/single-image-dehazing): several deep learning methods based on various architectures (GAN, CNN)

Thank You!