Fast Region-Adaptive Defogging and Enhancement for Outdoor Images Containing Sky (# 2267)

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Introduction
Outdoor images has a much larger depth of field (DOF) that spans from the infinite sky to the nearby objects.
Challenge

Dehazing by traditional image enhancement techniques

➢ Outdoor scenes -- large span of depth of field (DOF);

➢ White objects and the sky regions tend to be over-enhanced with color distortions and halos;

➢ Complexity & efficiency
Contributions

➢ RADE -- region-adaptive image dehazing and enhancement for real-world hazy outdoor scenes with a large range of DOF.

✓ Replaceable plug-in region segmentation module;

✓ Luminance-inverted MSRCR (a Retinex-based method);

✓ Region-ratio-based adaptive Gamma correction;

✓ Seamless stitching.
Method
Method

Fig. Overview of the proposed RADE for defogging

Segmentation mask

Contrast-Limited Adaptive Histogram Equalization

CLAHE

Region Segmentation

Luminance-inverted MSRCR

Adaptive Gamma correction

Seamless Stitching

hazy input
grayish sky region

other part

white region

Dehazed output

Segmentation mask

standing mask

Thresholding

DCP

Clustering

DNN

Fig. Overview of the proposed RADE for defogging
Method

➢ Step 1: Segmentation
Fig. Overview of the proposed RADE for defogging
Method

➢ **Step 2: Luminance-inverted MSRCR**

✓ **Original MSRCR**

\[
R_{MSRCRI} = C_i \cdot R_{MSR}, \quad (2) \quad C_i = \beta \ln \left( a I_i / \sum_{c=1}^{N} I_c \right), \quad (3)
\]

✓ **Invert intensity (CVPR’18): Retinex-based method → Image dehazing**

\[
\text{Dehazing}(I) = 1 - \text{Retinex}(1 - I), \quad (4)
\]

✓ **Luminance-inverted MSRCR:**

\[
\text{Invert}_\text{MSR}(Y) = 1 - \text{MSR}(1 - Y), \quad (5)
\]

\[
J_{MSRCRI} = e^{R_{MSRCRI}} = e^{C_i \cdot R_{MSR}} = (e^{R_{MSR}})^{C_i} = (J_{MSR})^{C_i}, \quad (6)
\]
Method

Fig. Overview of the proposed RADE for defogging

- Region Segmentation
- Luminance-inverted MSRCR
- Adaptive Gamma correction
- Seamless Stitching

**Hazy Input**
- Grayish sky region
- Other part
- White region

**Dehazed Output**
- Segmentation mask
- Stitch mask

**Methodology**
- Region area count
- Region ratio estimation
- Gamma Parameter
- Gamma Transformation

**Fig.** Overview of the proposed RADE for defogging
Method

➢ Step 3: Region-ratio-based Adaptive Gamma Correction

\[
\text{ratio} = \frac{\text{the sky area + white objects area}}{\text{image size}} \tag{7}
\]

\[
G(J) = J^\gamma = J^{1+\alpha(1-\text{ratio})}, \quad 0 < \alpha < 1, \tag{8}
\]

(c) Segmentation   (e) $J_{MSR}$   (f) $\text{CR}(J_{MSRCR})$   (g) Gamma(39.54%)
Method

Fig. Overview of the proposed RADE for defogging
Method

➢ Step 4: Seamless Stitching -- fade-in & fade-out

\[ J_{out} = \left(1 - F_{k \times k} \ast M_{gray}\right) \cdot J_{other} + \left(F_{k \times k} \ast M_{gray}\right) \cdot J_{gray}, \quad (9) \]

\[ M_{gray} = \text{Mask}_{gray}(x, y) = \begin{cases} 
1 & (t_1 < Y(x, y) < t_2) \\
0 & \text{otherwise} 
\end{cases}, \quad (10) \]
## Method

### Summary of Differences from Previous Work

<table>
<thead>
<tr>
<th>Method</th>
<th>Ours</th>
<th>[4]</th>
<th>[5]</th>
<th>[13]</th>
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</table>
Experiments
Experiment

Advantages of RADE:

✓ Better visibility & less color distortions

Hazy Input

CAP (TIP’15) DehazeNet (TIP’16) NLD (CVPR’16) F-DCP (ICIVC’18) PDN (ECCV’18)
GDN (ICCV’19) MSRCR RADE (ours) CLAHE Inv-MSRCR (CVPR’18)
Experiment

Advantages of RADE:
- Better visibility & more details
- Color fidelity & sky-preserved
Experiment

- average gradient (AG), contrast ($\sigma^2$), information entropy (IE)
- color correlation (COR), fog aware density evaluator (FADE)

Table. Quantitative comparisons on LIVE 500 foggy image set

<table>
<thead>
<tr>
<th>Method</th>
<th>AG</th>
<th>$\sigma^2$</th>
<th>IE</th>
<th>COR</th>
<th>FADE</th>
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<tr>
<td>Input</td>
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<td>6.63</td>
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<td>CAP [9]</td>
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<td>DehazeNet [10]</td>
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<td>NLD [7]</td>
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<td>F-DCP [8]</td>
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<td>0.439</td>
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## Experiment

### Efficiency

Table. Comparisons of average runtime (in seconds)

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<td>LIVE-500</td>
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Experiment

➢ Efficiency

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➢ Ablation Study

Table. 4 Major processes & 4 segmentation methods

<table>
<thead>
<tr>
<th>Step</th>
<th>AG</th>
<th>$\sigma^2$</th>
<th>IE</th>
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<th>FADE</th>
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<tbody>
<tr>
<td>$J_{MSR}$</td>
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<tr>
<td>Treshold+RADE</td>
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<td>7.59</td>
<td>20.05</td>
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<td>0.439</td>
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<tr>
<td>K-means+RADE</td>
<td>18.95</td>
<td>7.60</td>
<td>20.05</td>
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<tr>
<td>DCP+RADE</td>
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<td>0.496</td>
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More examples
More examples
More examples
More examples
More examples
More examples
Conclusions
Conclusions

➢ Summary

We proposed RADE for image dehazing of both distant and nearby regions.
✓ Better visibility & more details;
✓ Effective & efficient;
✓ With color fidelity & sky-preserved.

➢ Future

✓ more accurate and adaptive segmentation for extreme cases;
✓ a global consistency regularization for more reasonable fusion.
Welcome to our poster! 
#2267

Thank You!

The MATLAB code for our paper: [https://github.com/lizhangray/FADE](https://github.com/lizhangray/FADE)