# Proper guidance image generation based on saliency factor for better transmission refinement in image dehazing


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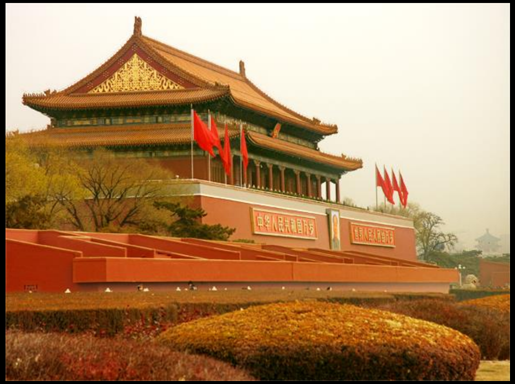
# Introduction

## Image Dehazing:

- Restore haze-free images from corresponding hazy images





- The first step before other higher computer vision tasks

  Object detection, Pedestrian detection, OCR…

# Introduction

## Model of hazy image formation

Airlight (eg. (0.9, 0.85, 0.88))

$$I(x) = J(x) * t(x) + A(1- t(x))$$

Hazy image

Haze-free image

transmission

$$t(x) = e^{-\beta d(x)}$$

# Introduction

Model of hazy image formation

$$I(x) = J(x) * t(x) + A(1- t(x))$$

$$J(x) = \frac{I(x) - A(1- t(x))}{t(x)}$$

A: Global airlight, relatively easy (Eg. largest luminance in each channel)

t(x): Pixel mapping, hard to estimate √

# Introduction

Existing Method:

- Using addition information (multiple image/depth… )
- Single image haze removal √

$$I(x) = J(x) * t(x) + A(1 - t(x))$$

underdetermined equation

Need prior or supposition

# Introduction

Single image haze removal:

- Dark Channel Prior [He et al. CVPR'08]
- Color Attenuation Prior [Zhu et al. TIP' 15, 24(11)]
- Maximum Reflectance Prior [Zhang CVPR'17]

} region / neighbor based prior

Eg. Dark channel Prior

$$\min_{x \in \Omega(y)} \left( \min_{c \in \{r, g, b\}} J^c(y) \right) \longrightarrow 0$$

$$\tilde{t}(x) = 1 - \min_{x \in \Omega(y)} \left( \min_{c \in \{r, g, b\}} \frac{I^c(y)}{A^c} \right)$$

# Introduction

Single image haze removal – learning based method:

- Random forest [Tang et al. CVPR'14]
- DehazeNet [Cai et al. TIP'16 25(11)]

← Local maximum/minimum

↓

blocky artifacts

How to solve blocky artifacts?

Guided image filtering

a filter transferring the structure of guidance image to filtering output

# Introduction

Traditional usage of guided image filtering in image dehazing:

Input p
Rough estimated t(x)

Guide I
Input hazy image

Output q
Refined transmission t(x)

has exactly the same structures and details

Problem: Contrary to $t(x) = e^{-\beta d(x)}$

# Introduction

Traditional usage of guided image filtering in image dehazing:

- Refined transmission and input hazy image have exactly the same structures and details
- Problem: Contrary to $t(x) = e^{-\beta d(x)}$

texture details are blurred

depth change regions are remained

Natural idea: better guidance image

# Methodology

texture details
are blurred

depth change regions
are remained

Capture depth change region

# Methodology

Feature of hazy image:

- Neighboring pixels at same depth

Disparity are degraded by haze

similarity

Majority

- Neighboring pixels at different depth

Disparity are enhanced by haze

discrepancy

Rare

# Methodology

Depth change region

↓

Rarely appeared pixel pairs ← co-occurrence histogram based saliency detection

↓

Higher saliency value

# Methodology

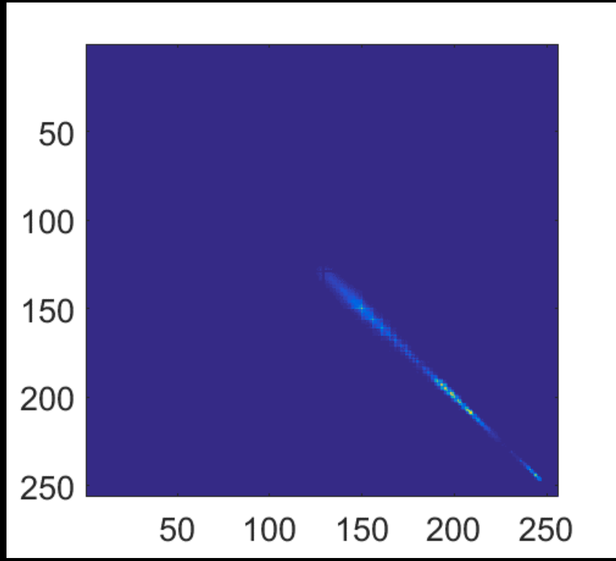
co-occurrence histogram based saliency detection

Input single channel image:

$$Im = \min_{c \in \{r, g, b\}} (I)$$

1. co-occurrence histogram COH

$$COH = [coh(m,n)]$$




Rarely appeared pixel pairs

Higher saliency value

# Methodology

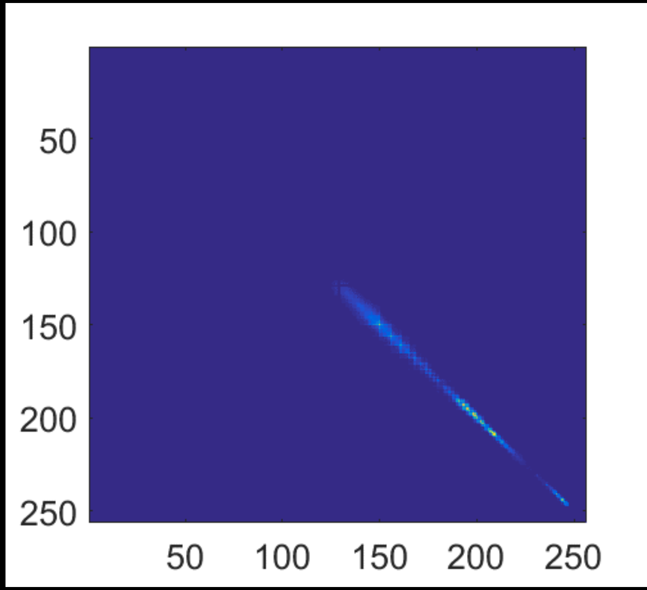
co-occurrence histogram based saliency detection

Rarely appeared pixel pairs

Higher saliency value

2. normalized co-occurrence histogram NCOH

$$NCOH = \frac{COH}{\max(COH)}$$



# Methodology

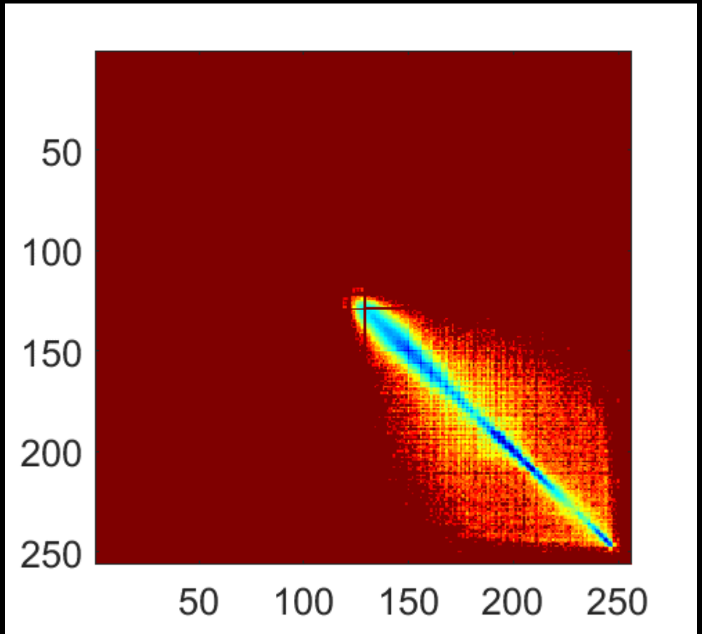
co-occurrence histogram based saliency detection

Rarely appeared pixel pairs

Higher saliency

3. saliency value of each intensity pair

$$s_p(m, n) = -\ln(NCOH)$$



# Methodology

co-occurrence histogram based saliency detection

3. saliency value of each intensity pair

$$s_p(m, n) = -\ln(NCOH)$$

$$s(m, n) = \min_{(x, y) \in \Omega} s_p(m, n)$$

Rarely appeared pixel pairs

Higher saliency

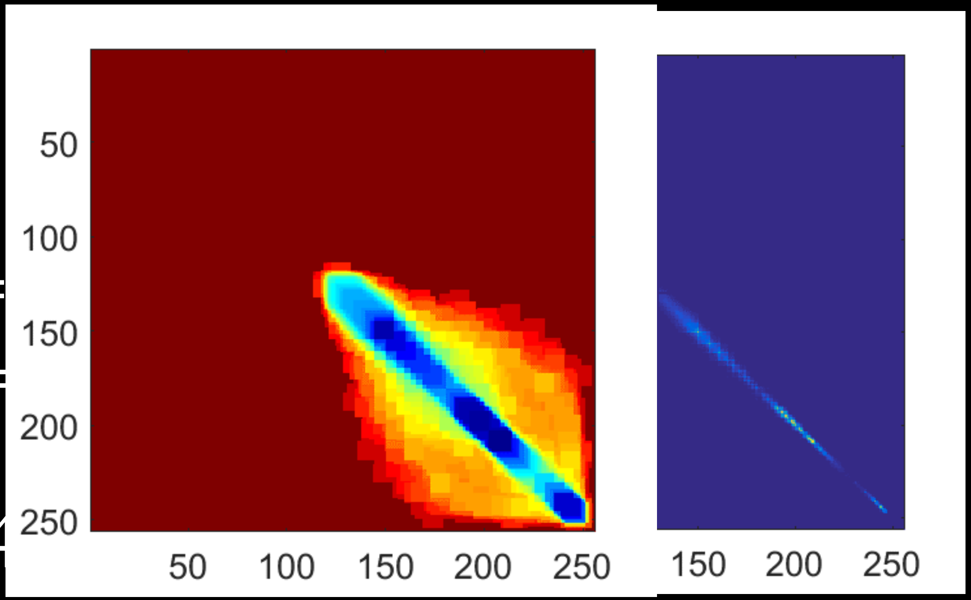
COH

Suppose:

(48, 102) =

(49, 100) =

(47, 101) (4



# Methodology

co-occurrence histogram based saliency detection

Rarely appeared pixel pairs

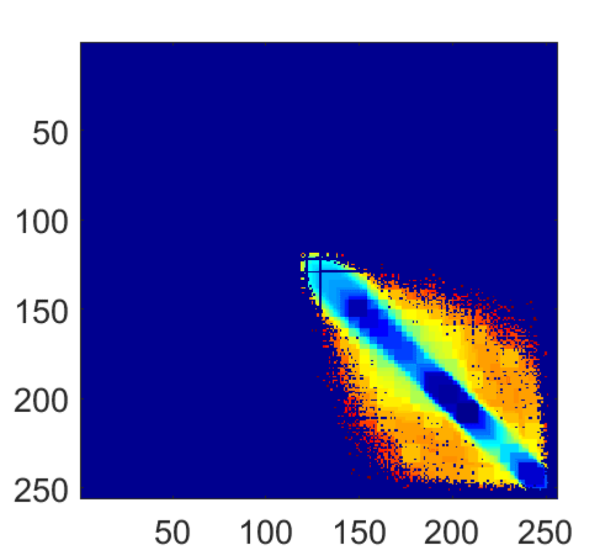
Higher saliency

3. saliency value of each intensity pair

$$s_p(m, n) = -\ln(NCOH)$$

$$s(m, n) = \min_{(x, y) \in \Omega} s_p(m, n)$$

$$s(COH = 0) = 0$$



# Methodology

co-occurrence histogram based saliency detection

4. saliency map of each intensity pair

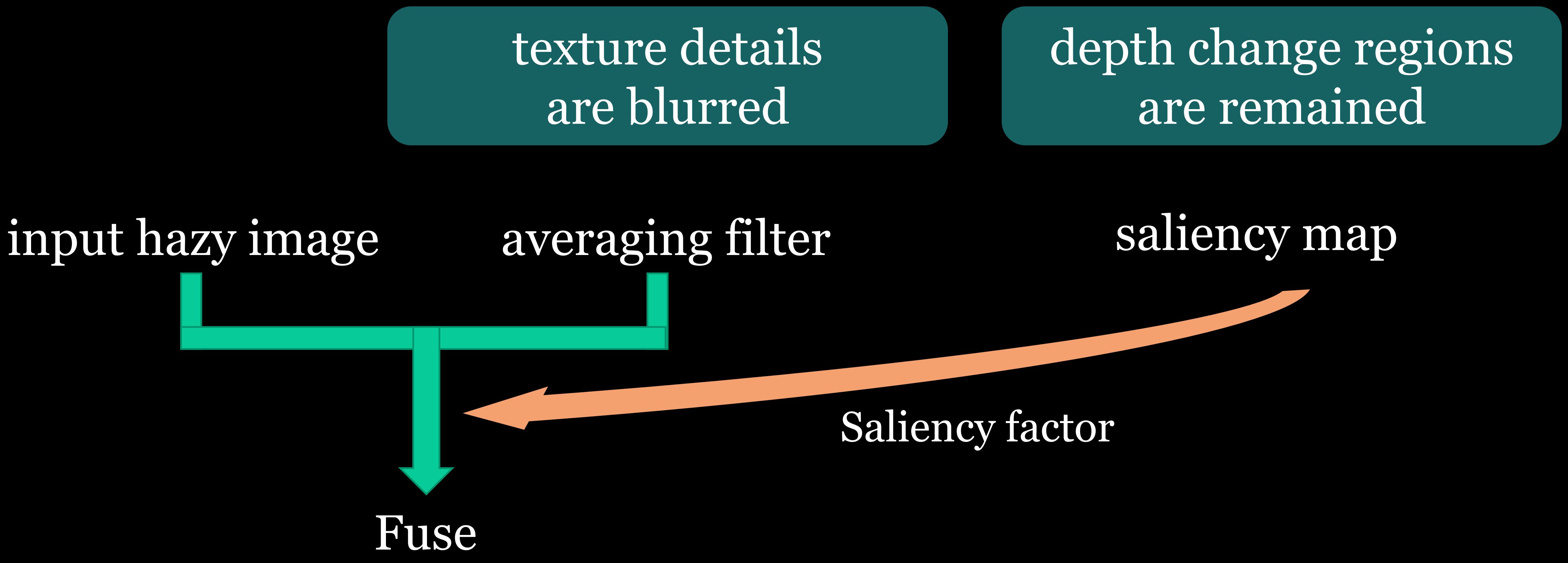
$$sa(i, j) = \sum_{i'=i-r}^{i+r} \sum_{j'=j-r}^{j+r} s(Im(i,j), Im(i',j'))$$

Rarely appeared pixel pairs

Higher saliency

# Methodology

Proper guidance image generation



# Methodology

Saliency based guidance image generation

only marks pixels on the edge
Not include pixels around them

$$d(x,y) = \frac{E(x, y)}{\sigma}$$

$$F(x) = \max_{y \in \Psi(x)} \frac{sa(y)}{d(x,y) + 1}$$

$$G = F^{*}G_1 + (1 - F)G_2$$

# Methodology

# Methodology

# Result

$e = 1.2548 \quad r = 1.0960$

$e = 1.5978 \quad r = 1.5588$

# Result

$e$ = 0.0708 $r$ = 1.3000

$e$ = 0.0741 $r$ = 1.5084

# Result

$e = 0.4310 \quad r = 1.4301$

$e = 0.4890 \quad r = 1.9263$

# Result

$e$ = 0.2520   $r$ = 1.2365

e = 0.3178   $r$ = 1.4736

# Thanks !