Near-Infrared Depth-Independent Image Dehazing using Haar Wavelets

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Contents

Image dehazing

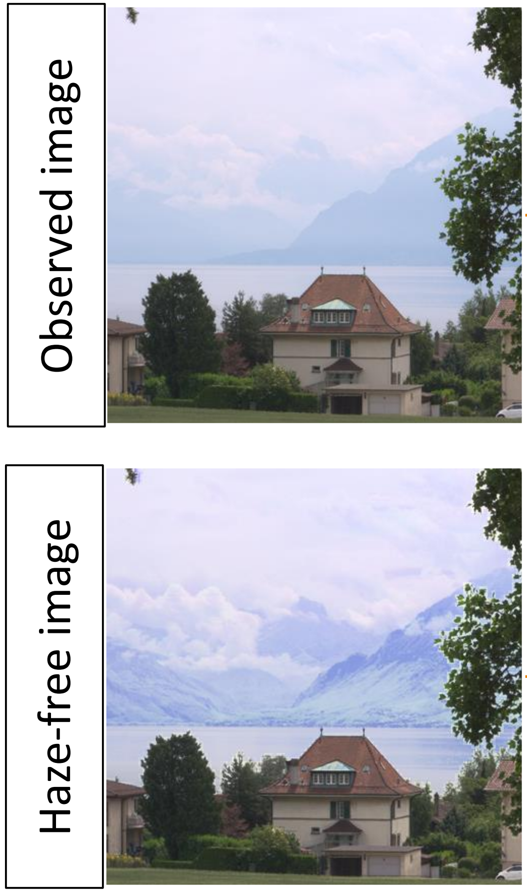


Image degradation model:

Medium transmission

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

Global airlight color

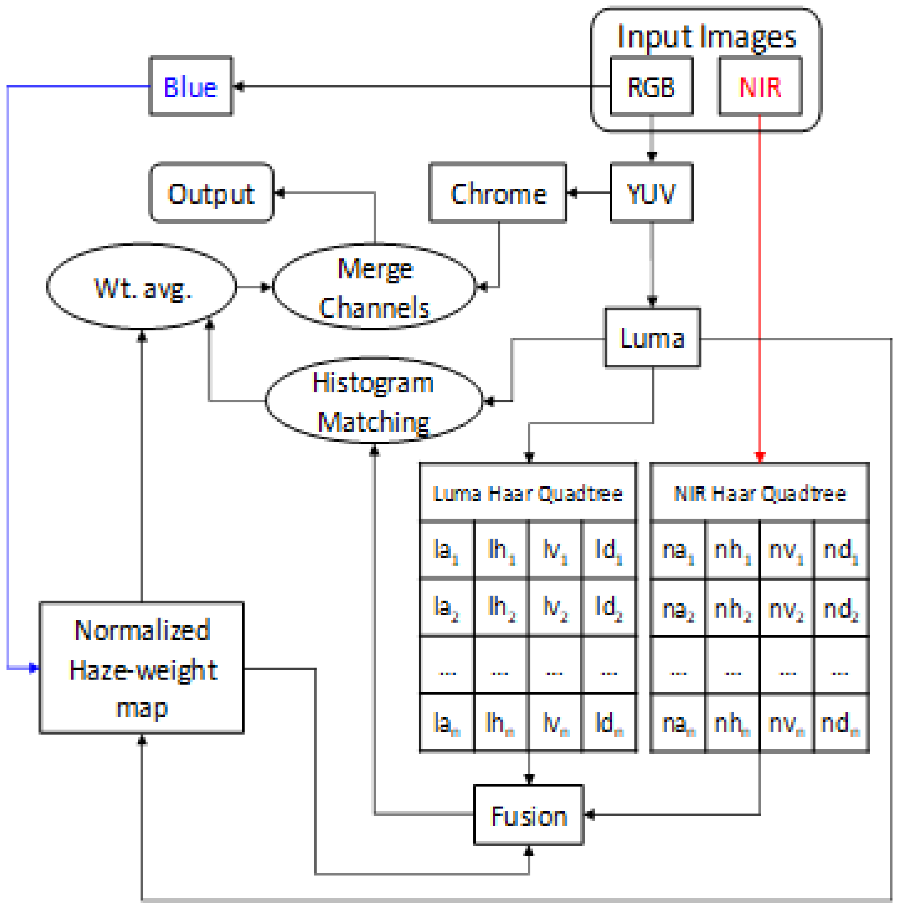
Conventional methods: Based on Single-Image

Authors and References	Approach	Comments
Ren et.al. (2016)	A multi-scale deep network based on hazy images and corresponding transmission maps	• Uses both coarse-scale net and fine-scale net • Superior performance on both synthetic and real-world images
Cai et.al. (2016)	An end-to-end deep network called DehazeNet by estimating medium transmission map	Uses a novel nonlinear activation function in DehazeNet
He et.al. (2016)	Difference-structure-preservation prior to produce an optimal transmission map from a single input image	Utilizing the optical model and modifying initial transmission map
Zhu et.al. (2015)	Color attenuation prior algorithm from a single input hazy image	Superior in terms of both efficiency and the dehazing effect
Fattal (2014)	Markov random field model augmented with connection between pixels of similar attributes	Producing complete and regularized transmission maps given noisy and scattered estimates
He et.al. (2010)	Image prior-dark channel prior to remove haze from a single input image	Most local patches in outdoor haze-free images with some pixels of very low intensity in at least one color channel
Tan (2008)	Cost function using Markov random fields, optimized by graph-cuts and belief propagation	• Applicable for the neighboring pixels with identical airlight values • Produces unrealistic over-enhanced images • Used for both color and gray images

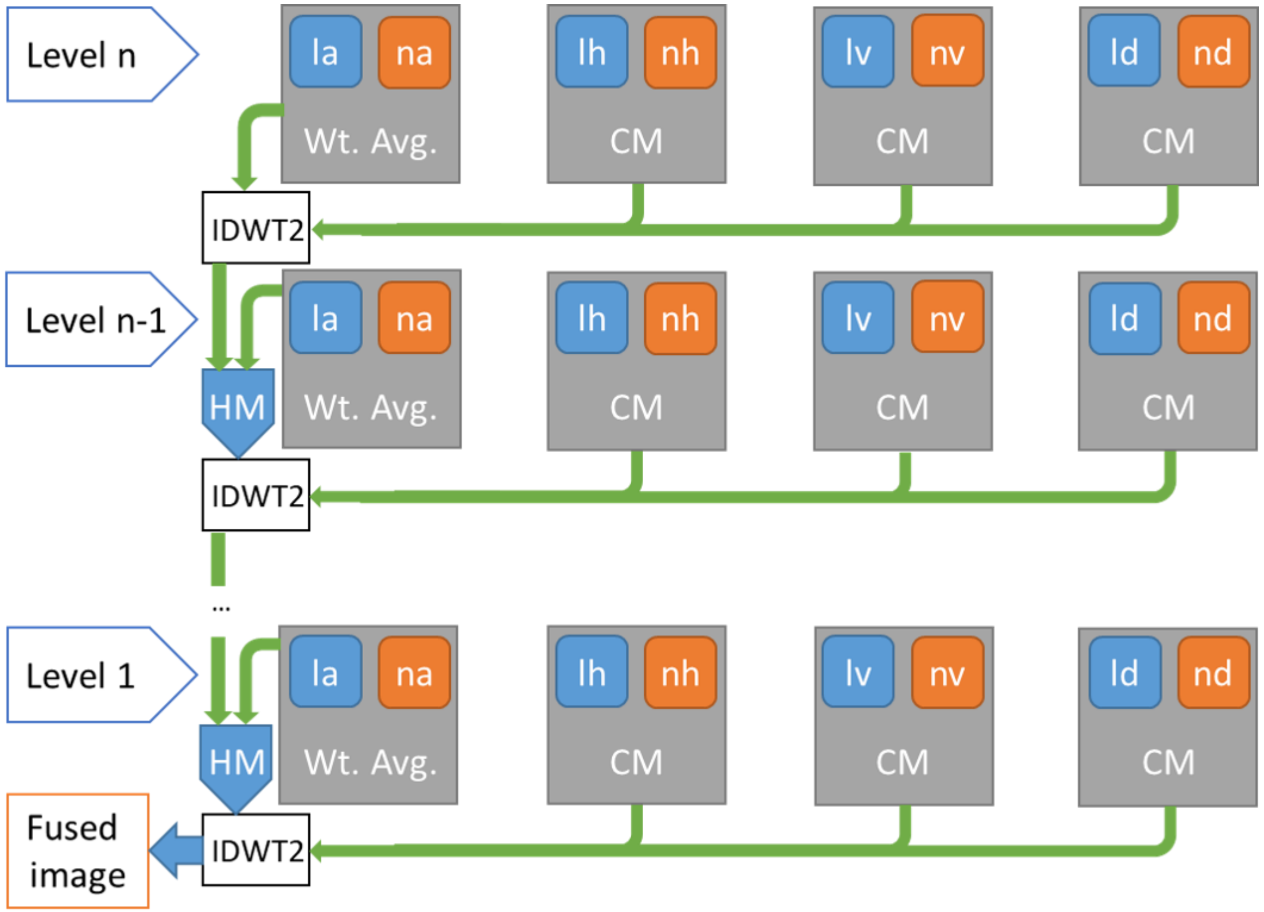
Conventional methods: Based on Near-infrared Image

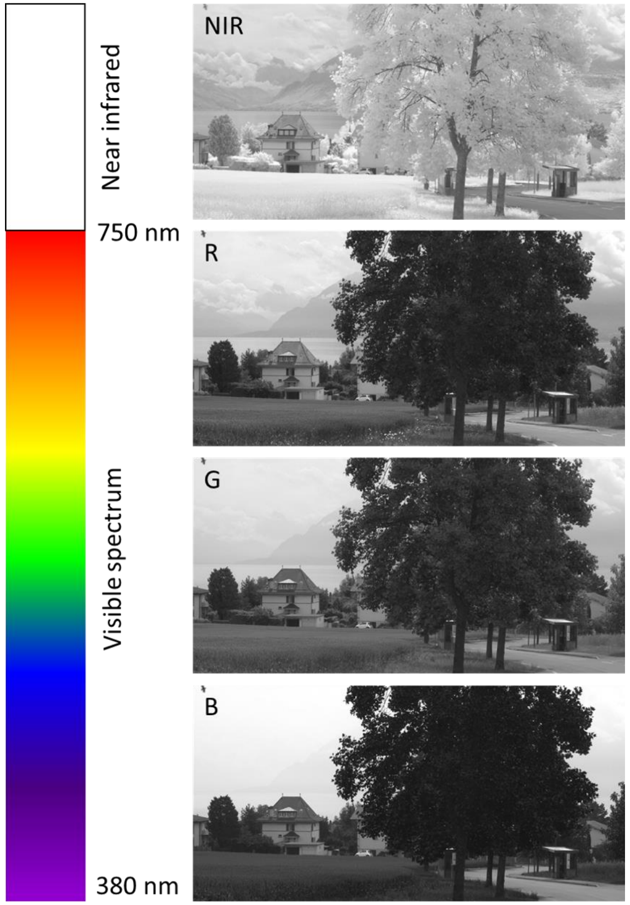
Authors and References	Approach	Comments
Dümbgen et.al. (2018)	Hyperspectral fusion of RGB and NIR images considering intensity inconsistencies for photorealistic image dehazing	Dehazing results on real images with no radiance or artifacts in hazy regions
Jang and Park (2017)	Fusing the HF components of the RGB and NIR images in a local patch of hazy images	Enhancing the detail layer of a hazy RGB image while maintaining the base layer using single image dehazing method
Son and Zhang (2017)	Coloring method through a contrast-preserving local linear mapping model	Enable to transfer the colors from the RGB image to the generated NIR image
Feng et.al. (2013)	Utilizing the dissimilarity between RGB and NIR for airlight color estimation, followed by optimization framework	Improving the detail recovery and the color distribution of images
Schaul et.al. (2009)	Multiresolution approach using edge-preserving filters to minimize artifacts	Dehazed color image output without requiring hazing, airlight detection or depth map generation

Proposed method

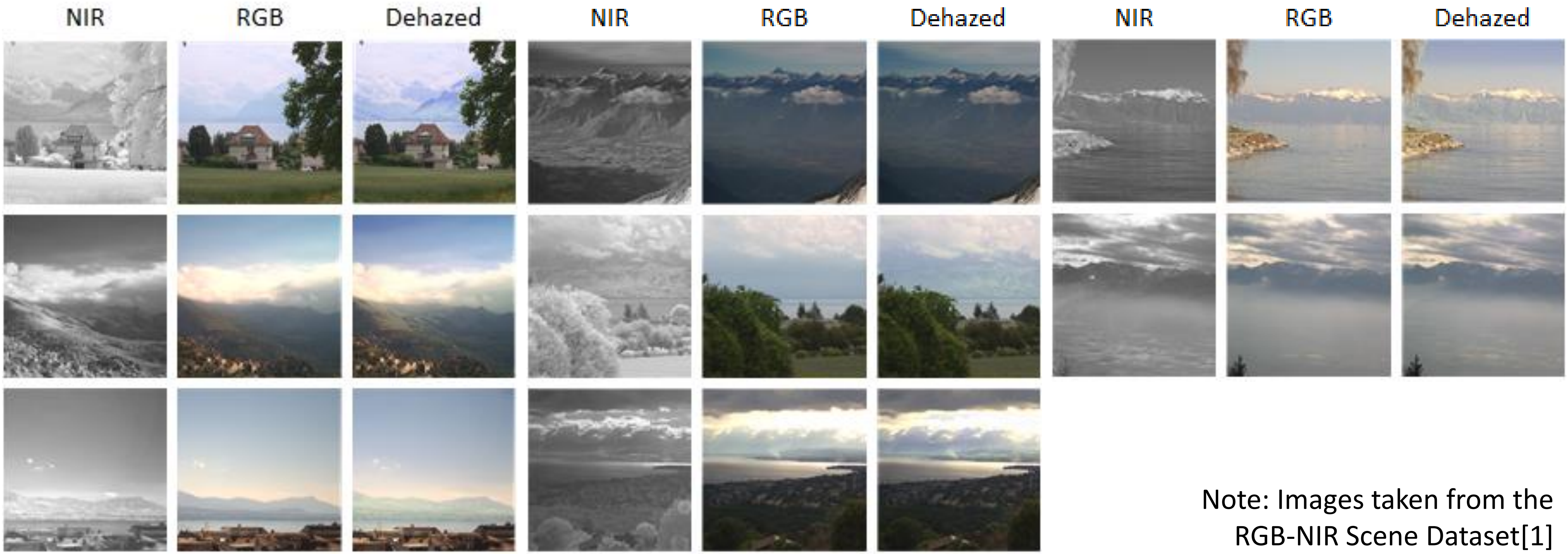


Fusion algorithm



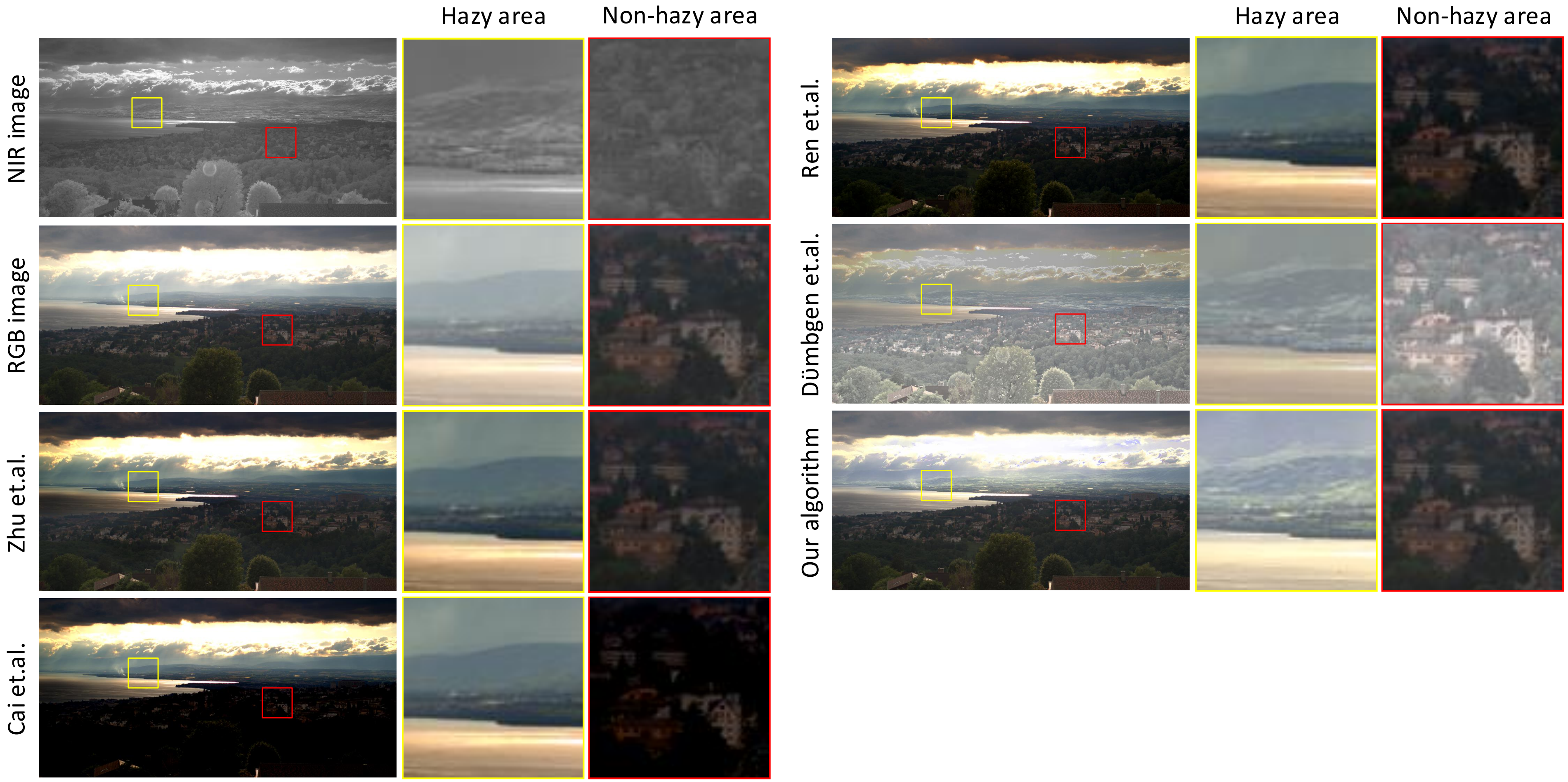


Results: Qualitative Analysis



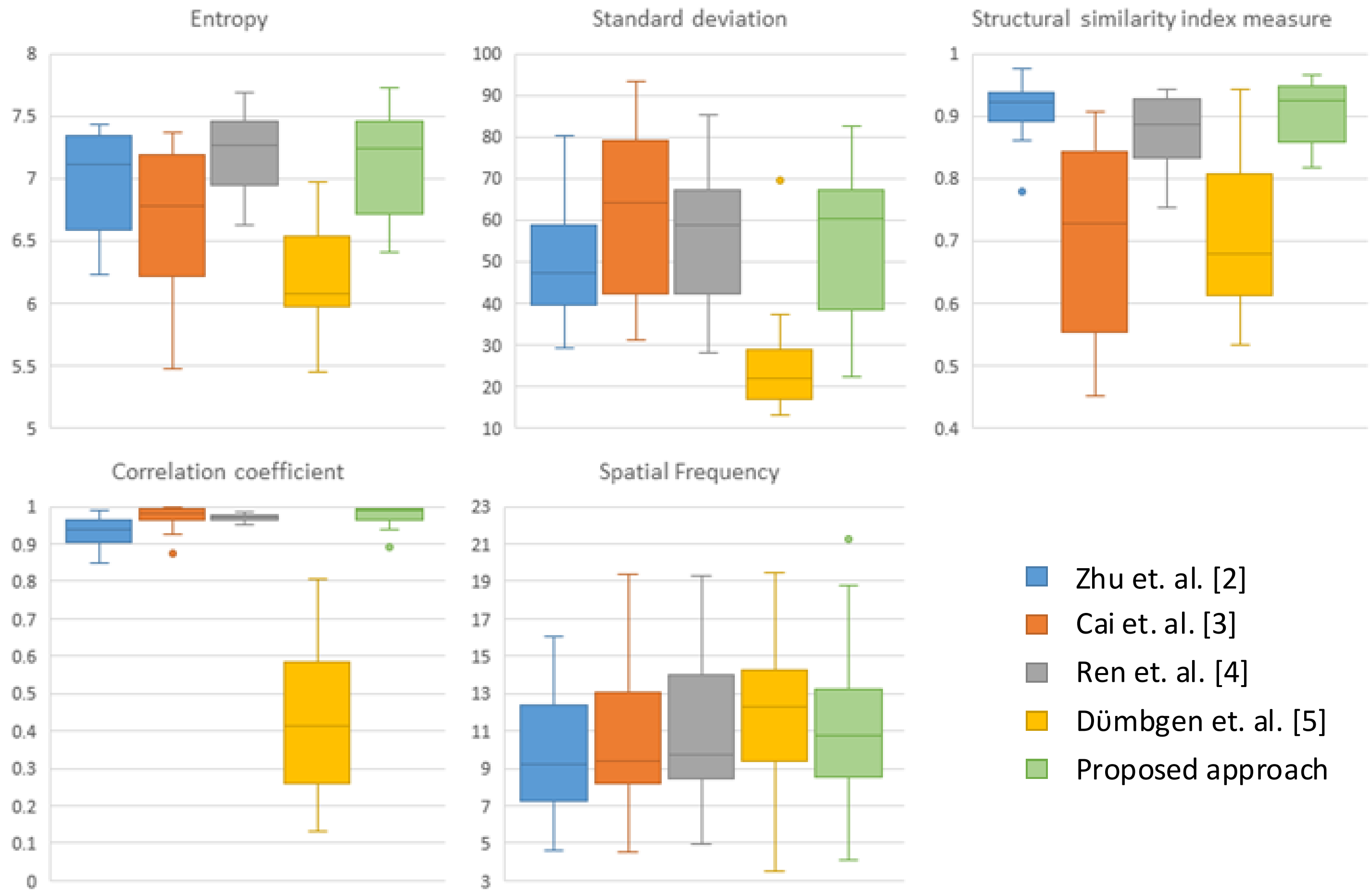
Note: Images taken from the RGB-NIR Scene Dataset[1]

Results: Qualitative Analysis (contd.)



Results: Quantitative analysis

- Based on different fusion metrics:



Results: Quantitative analysis (contd.)

- Based on the blind measures of Hautière et.al.'s method[6] (best values are indicated in bold):

		Zhu et.al.	Cai et.al.	Ren et.al.	Dümbgen et.al	Proposed
country/0000_rgb	e	-0.024	-0.003	**0.063**	-0.220	0.043
	σ	**0**	28.625	0.345	**0**	**0**
	$\bar{r}$	0.967	0.806	1.033	1.084	**1.104**
country/0008_rgb	e	**1.016**	0.952	0.784	-0.056	0.621
	σ	**0**	0.002	0.027	**0**	**0**
	$\bar{r}$	1.462	1.310	1.456	1.556	**1.809**
country/0021_rgb	e	0.013	-0.101	0.014	-0.124	**0.137**
	σ	**0**	8.752	0.004	**0**	**0**
	$\bar{r}$	1.033	1.073	1.019	1.592	**1.668**
country/0039_rgb	e	0.178	-0.199	**0.370**	-0.030	0.200
	σ	**0**	38.437	1.318	**0**	**0**
	$\bar{r}$	1.027	0.865	1.119	**2.581**	1.270
mountain/0000_rgb	e	0.068	-0.0134	**0.273**	0.211	0.191
	σ	**0**	26.381	2.639	**0**	**0**
	$\bar{r}$	1.017	0.790	1.048	**3.704**	1.260

Conclusion

- We address the task of image dehazing by using a pair of RGB and NIR images.
- We design a depth-independent image dehazing fusion algorithm using the Haar wavelets that combines color information from RGB image and edge information from its corresponding NIR image.
- We devise a method of generating a probability-based haze map which properly weights the color and edge information to overcome the presence of artifacts that produce over-enhanced unrealistic images.
- Experimental results demonstrate the effectiveness of our proposed method over the state-of-the-art methods with the final recovered images having better color distribution and revealing more details on benchmark scenes.

References

1) M. Brown and S. Süsstrunk, “Multi-spectral sift for scene category recognition,” in CVPR 2011. IEEE, 2011, pp. 177–184.
2) Q. Zhu, J. Mai, and L. Shao, “A fast single image haze removal algorithm using color attenuation prior,” IEEE transactions on image processing, vol. 24, no. 11, pp. 3522–3533, 2015.
3) B. Cai, X. Xu, K. Jia, C. Qing, and D. Tao, “Dehazenet: An end-to-end system for single image haze removal,” IEEE Transactions on Image Processing, vol. 25, no. 11, pp. 5187–5198, 2016.
4) W. Ren, S. Liu, H. Zhang, J. Pan, X. Cao, and M.-H. Yang, “Single image dehazing via multi-scale convolutional neural networks,” in European conference on computer vision. Springer, 2016, pp. 154–169.
5) F. Dümbgen, M. E. Helou, N. Gucevska, and S. Süsstrunk, “Near-infrared fusion for photorealistic image dehazing,” Electronic Imaging, vol. 2018, no. 16, pp. 321–1, 2018.
6) N. Hautière, J.-P. Tarel, D. Aubert, and E. Dumont, “Blind contrast enhancement assessment by gradient ratioing at visible edges,” Image Analysis & Stereology, vol. 27, no. 2, pp. 87–95, 2008.

THANK YOU