Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 2, Issue 2, Pages 216-227, April-June 2018

Combined Contrast Enhancement and Noise Removal using Intrinsic Image Decomposition

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Article Received: 27 January 2018 *Article Accepted: 23 February 2018* *Article Published: 09 April 2018*

ABSTRACT

Propose to introduce intrinsic image decomposition priors into the decomposition models for contrast enhancement. At first the input color image is converted in to HSV for reducing the color artifacts and complexity of the process .Then each channel output is displayed using command in the Matlab. The color image is converted in to LAB space for calculating the weight W. The final output is the decomposed Reflectance and illumination layers obtained by intrinsic decomposition of V channel. This method is performed on Matlab. The proposed model is effectively solved by the Split Bregman algorithm. Then, by adjusting the illumination layer, obtain the enhancement result. To avoid potential color artifacts introduced by illumination adjusting and reduce computing complexity, the proposed decomposition model is performed on the value channel in HSV space. Experiment results demonstrate that the proposed method performs well for a wide variety of images, and achieves better or comparable subjective and objective quality compared with state-of-the-art methods. During the contrast enhancement process the flicker noise is added, the noise can be removed using the vertical component analysis in the frequency domain.

Keywords: HE: Histogram Equalization, HS: Histogram Specification, IQA: Image Quality Assessment, IGM: Internal Generative Mechanism, GM: Gaussian model, MP: Megapixel.

1. INTRODUCTION

Decoupling illumination and reflectance from an images is a long-standing problem in computer vision. In order to solve this problem, introduce a framework for decomposing an image into the product of an illumination component and a reflectance component. Due to the nature of the problem, prior information on shading and reflectance is mandatory. The proposed method adopts that pixels in a region with similar chromaticity values have the same reflectance. This assumption was used to minimize the l2 norm of the local per-pixel reflectance gradients to extract the illumination and reflectance components. To obtain smooth chromatic regions, texture was treated in a new style. Texture was removed in the first step of the algorithm and the smooth image was processed for intrinsic decomposition. In the final step, texture details were added to the intrinsic components based on the material of each pixel. In addition, user-assistance was used to further refine the results. The qualitative and quantitative evaluation on the MIT intrinsic dataset indicated that the quality of intrinsic image decomposition was improved in comparison with previous methods. The flicker noise is introduced in the video contrast enhancement. This is removed by nullifying the largest coefficient of the V component in the frequency domain of an image.

2. INTRINSIC IMAGE DECOMPOSITION

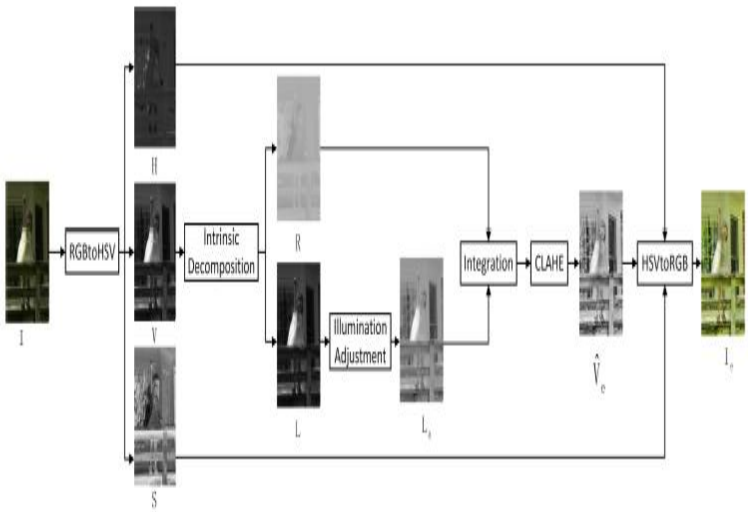
Intrinsic image decomposition means, splitting an image in to illumination and reflectance layer. Illumination layer gives an idea about how much light is incident in an image. The Reflectance layer gives the object structure by reflecting the light from the object. Intrinsic image decomposition is performed in the Value channel of an image. At first the image is converted in to HSV. The further processing is performed in the V channel. V channel gives an idea about the degree of white or black mixed with Hue. The Hue channel gives Color information. Enhancement methods can be classified into two categories. Histogram based and

Retinex based Histogram-based methods enhance image contrast by modifying histogram distributions. Retinex-based methods assume that the scene in humans eyes is the product of reflectance and illumination layers. This model is effectively solved by the Split Bregman algorithm.

Enhancement result is obtained by adjusting the illumination layer. Decomposition model is performed on HSV space. Flicker introduced during video enhancement is removed. Too bright and too dark images are removed. Flickering effect is very high in V component. Then nullify the largest coefficients if they are greater than a threshold.

3. CONTRAST ENHANCEMENT BASED ON INTRINSIC DECOMPOSITION

At first Input the image I. Then Convert RGB into HSV representation. V channel image is decomposed into Illumination (L) and Reflectance (R) layer. Then L layer is adjusted by Gamma mapping function 'La'.



La is multiplied by the R to get enhanced V channel image Ve. CLAHE is used to further enhance the local contrast of Ve. The enhanced result is denoted as Ve cap. HSV image is transformed to RGB space. Final result is the original color image I.

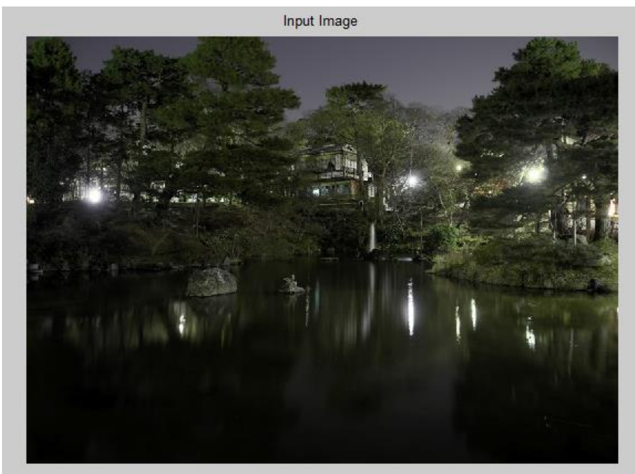


Fig1: Less contrast image

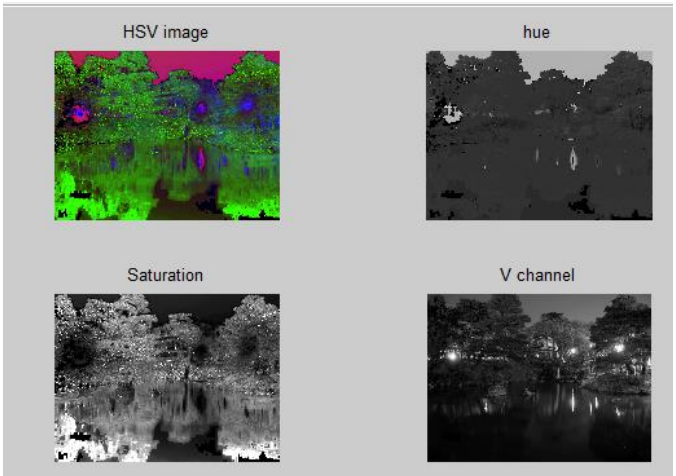


Fig 2: HSV converted image

After converting in to HSV, then the image is converted in to LAB space. In LAB space chrominance blue, Chrominance red and illumination information is dominant.

Fig 3: LAB image

4. ALGORITHM OF REFLECTANCE LAYER EXTRACTION

1. Read a colour image I
2. Convert colour image in to HSV.
3. Display the images in I, H, S, V.
4. Read the size of the V channel.
5. Convert the V channel image in to 3x3 patches IVK.
6. Convert the color image I in to LAB space to calculate the weight W.
7. Read the size of the LAB image LA.
8. Convert the LAB image LA in to 3x3 patches.

9. Extract the red channel matrix.
10. Extract the Green channel matrix.
11. Extract the Blue channel matrix.
12. Calculate the chromatic normalization L.
13. Read the size of the L.
14. Convert the L in to 3x3 patches, ILK.
15. Calculate the weight function wij.

$$w_{ij} = \exp(-\frac{||f_i - f_j||_2^2}{2\sigma^2}),$$

16. Solution to the reectance layer is obtained by

$$r^{k+1} = A^{-1}z,$$
$$A = \theta\mathbf{I} + \lambda M^\top M,$$
$$z = \theta(\frac{v}{l^k}) + \lambda M^\top(h^k - b^k),$$

17. Convert the reectance matrix in to 3x3 patches.
18. Map each of the 3x3 patch to the corresponding 3x3 patch of I.
19. Convert HSV to RGB format.

5. ALGORITHM OF ILLUMINATION LAYER EXTRACTION

1. Define dx and dy.
2. Apply FT on dx and dy to get fdx and fdy.
3. Illumination is directly obtained by using the equation

$$L^{k+1} = \mathcal{F}^{-1}\left(\frac{\mathcal{F}(\theta V/R^{k+1} + \beta L_0)}{\mathcal{F}(\theta+\beta) + \mu(\mathcal{F}^*(d_x)\mathcal{F}(d_x) + \mathcal{F}^*(d_y)\mathcal{F}(d_y))}\right),$$

6. ILLUMINATION ADJUSTMENT

It is used to enhance the illumination details.

They lighten the dark areas and Compress intensities in bright areas .In Log and Sigmoid functions loss of details in bright areas. So Gamma mapping function is used in illumination adjustment. The equation for Gamma mapping function is given below

$$L_a = 255 \times (L/255)^{1/\gamma},$$

Mapping function is used to enhance the global contrast. La is multiplied with R, to get Ve.

Fig 4: Illumination adjusted image

CLAHE is used to improve the local contrast of Ve. Finally, HSV to RGB conversion is performed inorder to obtain the contrast enhanced output.

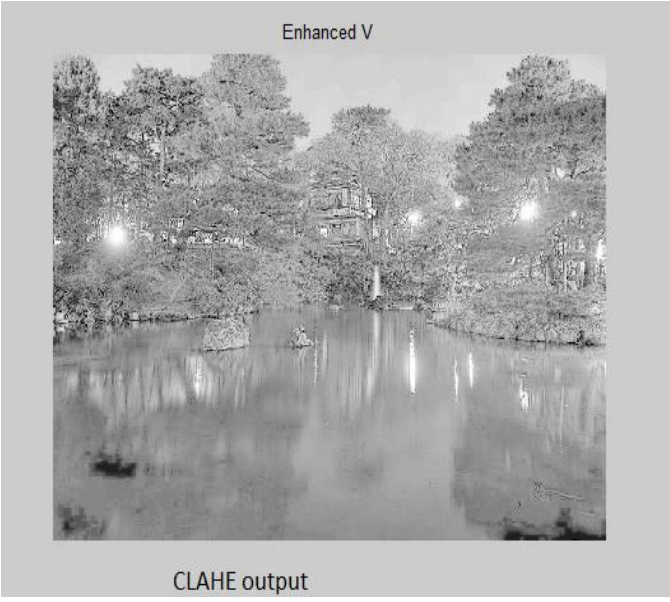


Fig 5: Local contrast enhanced image

After performing illumination adjustment and reflectance and illumination layer extraction the contrast of an input image is enhanced. In image contrast enhanced output is shown in fig 6.

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Fig 6: Contrast enhanced image

Fig 7: Low contrast video frame

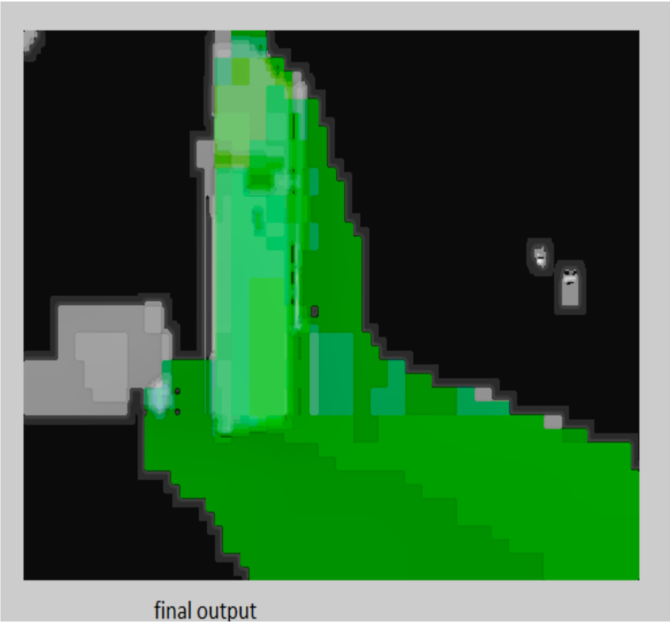


Fig 8: Contrast enhanced video frame with flicker

During video enhancement, flicker noise is introduced. It is mainly due to contrast difference between the two successive frames.

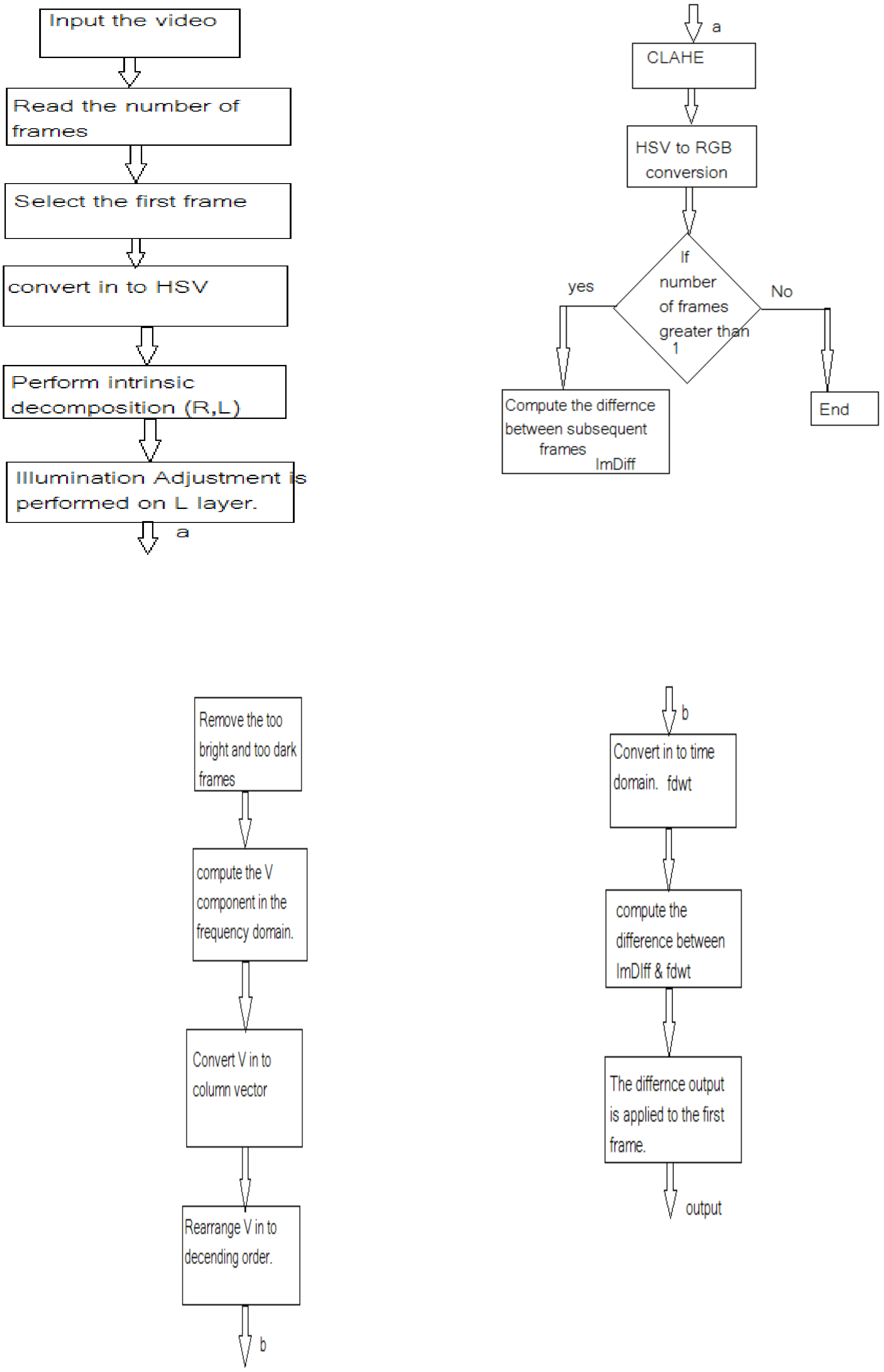
The flicker noise in a video enhancement is shown in the figure below. During video enhancement, at first input the video. Then read the number of frames in the video.

After enhancing the contrast of a video frame, flicker noise is introduced. Contrast enhanced video frame with flicker noise is shown in the figure 8

7. FLICKER REMOVING ALGORITHM

1. Select the video input.
2. Read the number of frames in the video.
3. Select the first frame.
4. Resize in to 300 X 300.
5. Convert the first frame in to RGB.
6. Read the number of rows, columns and dimension of the first frame.
7. Check that the number of frames is greater than 1.
8. Compute the difference between the two frames.
9. The output of the difference is imDiff
10. Read the number of rows, columns and dimension of the imDiff.
11. Too bright and too dark frames are neglected by selecting the cutoff.
12. The flickering should appears as an strongest periodic signal along the vertical axis of the image.
13. Flickering can be detected by finding coefficients in the frequency domain.
14. That represents flickering in the difference
15. image and nullify them.
16. Transform back in to Time domain.
17. Read the size of V(150X150).
18. Convert V in column vector (150*150 X 1).
19. Sort the column vector in to an descending order.
20. Nullify the largest coefficients, if they are greater than threshold
21. Reshape V in to 150X150.
22. Convert V in to time domain fdwt.
23. Compute the difference between fdwt and imDiff.
24. Add the difference output in to the first frame.

8. FLOWCHART REPRESENTATION OF THE ENTIRE PROPOSED METHOD



9. CONCLUSION

In this paper, propose to enhance images by estimating illumination and reflectance layers through intrinsic image decomposition. On the one hand, we constrain the reflectance layer to be piecewise constant according to the color similarity.

On the other hand, the illumination layer is enforced to be locally smooth. Since the decomposition model is non-convex and non-differential, we adopt the Split Bregman algorithm to iteratively solve this problem. After decomposition, perform Gamma correction on the illumination layer to boost the details globally. Then we adopt CLAHE to further enhance local details. Experimental results demonstrate that our decomposition model outperforms state-of-the-art image decomposition models in terms of image enhancement, and our enhancement method achieves the best subjective and objective quality for a wide variety of images.

For image enhancement, it may introduce flickering artifacts if it is applied directly to video enhancement. This artifacts is also removed using this method.

REFERENCES

[1] H. Sawant and M. Deore, "A comprehensive review of image enhancement techniques," International Journal of Computer Technology and Electronics Engineering (IJCTEE), vol. 1, no. 2, pp. 39–44, 2010.

[2] C. Wang and Z. Ye, "Brightness preserving histogram equalization with maximum entropy: a variational perspective," IEEE Transactions on Consumer Electronics, vol. 51, no. 4, pp. 1326–1334, 2005.

[3] H. Ibrahim and N. S. P. Kong, "Brightness preserving dynamic histogram equalization for image contrast enhancement," IEEE Transactions on Consumer Electronics, vol. 53, no. 4, pp. 1752–1758, 2007.

[4] D. Menotti, L. Najman, J. Facon, and A. d. A. Ara´ujo, "Multi-histogram equalization methods for contrast enhancement and brightness preserving," IEEE Transactions on Consumer Electronics, vol. 53, no. 3, pp. 1186–1194, 2007.

[5] A. M. Reza, "Realization of the contrast limited adaptive histogram equalization (clahe) for real-time image enhancement," Journal of VLSI signal processing systems for signal, image and video technology, vol. 38, no. 1, pp. 35–44, 2004.

[6] S.-H. Yun, J. H. Kim, and S. Kim, "Contrast enhancement using a weighted histogram equalization," in Consumer Electronics (ICCE), 2011 IEEE International Conference on. IEEE, 2011, pp. 203–204.

[7] K. Gu, G. Zhai, X. Yang, W. Zhang, and C. W. Chen, "Automatic contrast enhancement technology with saliency preservation," IEEE Transactions on Circuits and Systems for Video Technology, vol. 25, no. 9, pp. 1480–1494, 2015.

[8] K. Gu, G. Zhai, W. Lin, and M. Liu, "The analysis of image contrast:From quality assessment to automatic enhancement," IEEE transactions on cybernetics, vol. 46, no. 1, pp. 284–297, 2016.

[9] E. H. Land and J. J. McCann, "Lightness and retinex theory," JOSA,vol. 61, no. 1, pp. 1–11, 1971.

[10] D. J. Jobson, Z.-u. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," IEEE transactions on image processing, vol. 6, no. 3, pp. 451–462, 1997.

[11] "A multiscale retinex for bridging the gap between color images and the human observation of scenes," IEEE Transactions on Image processing, vol. 6, no. 7, pp. 965–976, 1997.

[12] M. Herscovitz and O. Yadid-Pecht, "A modified multi scale retinex algorithm with an improved global impression of brightness for wide dynamic range pictures," Machine Vision and Applications, vol. 15, no. 4, pp. 220–228, 2004.

[13] Z. Rahman, D. J. Jobson, and G. A. Woodell, "Retinex processing for automatic image enhancement," Journal of Electronic Imaging, vol. 13, no. 1, pp. 100–110, 2004.

[14] C. Xiao and Z. Shi, "Adaptive bilateral filtering and its application in retinex image enhancement," in Image and Graphics (ICIG), 2013 Seventh International Conference on. IEEE, 2013, pp. 45–49.

[15] R. Kimmel, M. Elad, D. Shaked, R. Keshet, and I. Sobel, "A variationalframework for retinex," International Journal of Computer Vision,vol. 52, no. 1, pp. 7–23, 2003.

[16] M. K. Ng and W. Wang, "A total variation model for retinex," SIAMJournal on Imaging Sciences, vol. 4, no. 1, pp. 345–365, 2011.

[17] X. Fu, Y. Sun, M. LiWang, Y. Huang, X.-P. Zhang, and X. Ding, "A novel retinex based approach for image enhancement with illumination adjustment," in 2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2014, pp. 1190–1194.

[18] X. Fu, Y. Liao, D. Zeng, Y. Huang, X.-P. Zhang, and X. Ding, "A probabilistic method for image enhancement with simultaneous illumination and reflectance estimation," IEEE Transactions on Image Processing, vol. 24, no. 12, pp. 4965–4977, 2015.

[19] S. Wang, J. Zheng, H.-M. Hu, and B. Li, "Naturalness preserved enhancement algorithm for non-uniform illumination images," IEEE Transactions on Image Processing, vol. 22, no. 9, pp. 3538–3548, 2013.

[20] Z. Liang, W. Liu, and R. Yao, "Contrast enhancement by non linear diffusion filtering," IEEE Transactions on Image Processing, vol. 25, no. 2, pp. 673–686, 2016.

[21] H. Barrow and J. Tenenbaum, "Recovering intrinsic scene characteristics,"Comput. Vis. Syst., A Hanson & E. Riseman (Eds.), pp. 3–26, 1978.

[22] E. Garces, A. Munoz, J. Lopez-Moreno, and D. Gutierrez, "Intrinsic images by clustering," in Computer graphics forum, vol. 31, no. 4. Wiley Online Library, 2012, pp. 1415–1424.

[23] J. Shen, X. Yang, X. Li, and Y. Jia, "Intrinsic image decomposition using optimization and user scribbles," IEEE Transactions on Cybernetics, vol. 43, no. 2, pp. 425–436, 2013.

[24] S. Bell, K. Bala, and N. Snavely, "Intrinsic images in the wild," ACM Transactions on Graphics (TOG), vol. 33, no. 4, p. 159, 2014.

[25] J. T. Barron and J. Malik, "Shape, illumination, and reflectance from shading," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 37, no. 8, pp. 1670–1687, 2015.

[26] Y. Li and M. S. Brown, "Single image layer separation using relative smoothness," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2014, pp. 2752–2759.

[27] D. Zosso, G. Tran, and S. J. Osher, "Non-local retinex—a unifying framework and beyond," SIAM Journal on Imaging Sciences, vol. 8, no. 2, pp. 787–826, 2015.

[28] B. V. Funt, M. S. Drew, and M. Brockington, "Recovering shading from color images," in European Conference on Computer Vision. Springer,1992, pp. 124–132.

[29] J. M. Morel, A. B. Petro, and C. Sbert, “A pde formalization of Retinex theory,” IEEE Transactions on Image Processing, vol. 19, no. 11, pp.2825–2837, 2010.

[30] R. Grosse, M. K. Johnson, E. H. Adelson, and W. T. Freeman, “Groundtruth dataset and baseline evaluations for intrinsic image algorithms,” in Computer Vision, 2009 IEEE 12th International Conference on. IEEE, 2009, pp. 2335–2342.

[31] Y. Li, F. Guo, R. T. Tan, and M. S. Brown, “A contrast enhancement framework with jpeg artifacts suppression,” in European Conference on Computer Vision. Springer, 2014, pp. 174–188.

[32] L. Wang, L. Xiao, H. Liu, and Z. Wei, “Variational bayesian method for retinex,” IEEE Transactions on Image Processing, vol. 23, no. 8, pp.

[33] W. Wang and C. He, “A variational model with barrier functionals forretinex,” SIAM Journal on Imaging Sciences, vol. 8, no. 3, pp. 1955–1980, 2015.

[34] X. Fu, D. Zeng, Y. Huang, X.-P. Zhang, and X. Ding, “A weighted variational model for simultaneous reflectance and illumination estimation,”in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2016, pp. 2782–2790.

[35] L. Shen, P. Tan, and S. Lin, “Intrinsic image decomposition with nonlocaltexture cues,” in Computer Vision and Pattern Recognition, 2008. CVPR 2008. IEEE Conference on. IEEE, 2008, pp. 1–7.

[36] Q. Zhao, P. Tan, Q. Dai, L. Shen, E. Wu, and S. Lin, “A closed-form solution to retinex with nonlocal texture constraints,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 34, no. 7, pp. 1437–1444, 2012.

[37] L. Shen and C. Yeo, “Intrinsic images decomposition using a localand global sparse representation of reflectance,” in IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, 2011, pp. 697–704.

[38] C. Rother, M. Kiefel, L. Zhang, B. Sch¨olkopf, and P. V. Gehler, “Recovering intrinsic images with a global sparsity prior on reflectance,” in Advances in Neural Information Processing Systems, 2011, pp. 765–773.

[39] S. Bi, X. Han, and Y. Yu, “An l1 image transform for edge-preserving smoothing and scene-level intrinsic decomposition,” ACM Transactions on Graphics (TOG), vol. 34, no. 4, p. 78, 2015.

[40] T. Goldstein and S. Osher, “The split bregman method for l1-regularizedproblems,” SIAM Journal on Imaging Sciences, vol. 2, no. 2, pp. 323–343, 2009.

[41] S. C. Eisenstat, “Efficient implementation of a class of pre conditioned conjugate gradient methods,” SIAM Journal on Scientific and Statistical Computing, vol. 2, no. 1, pp. 1–4, 1981.

[42] Y. Luo and Y.-P. Guan, “Structural compensation enhancement method for nonuniform illumination images,” Applied Optics, vol. 54, no. 10, pp. 2929–2938, 2015.

[43] Comparison results. [Online]. Available: https://1drv.ms/f/s!AjZd1mFVGyDGg0-fsoi-DrM8tJh3

[44] A. Mittal, R. Soundararajan, and A. C. Bovik, “Making a completely blind image quality analyzer,” IEEE Signal Processing Letters, vol. 20, no. 3, pp. 209–212, 2013.

[45] K. Gu, G. Zhai, X. Yang, and W. Zhang, “Using free energy principle for blind image quality assessment,” IEEE Transactions on Multimedia, vol. 17, no. 1, pp. 50–63, 2015.

[46] K. Gu, W. Lin, G. Zhai, X. Yang, W. Zhang, and C. W. Chen, “No-reference quality metric of contrast-distorted images based on information maximization,” IEEE Transactions on Cybernetics, 2016.

[47] S. Wang, K. Ma, H. Yeganeh, Z. Wang, and W. Lin, "A patch-structure representation method for quality assessment of contrast changed images," IEEE Signal Processing Letters, vol. 22, no. 12, pp. 2387–2390, 2015.

[48] K. Gu, D. Tao, J.-F. Qiao, and W. Lin, "Learning a no-reference quality assessment model of enhanced images with big data," IEEE Transactions on Neural Networks and Learning Systems, 2017.

[49] N. Hautiere, J.-P. Tarel, D. Aubert, E. Dumont et al., "Blind contrast enhancement assessment by gradient ratioing at visible edges," Image Analysis & Stereology Journal, vol. 27, no. 2, pp. 87–95, 2008.

[50] A. R. Rivera, B. Ryu, and O. Chae, "Content-aware dark image enhancement through channel division," IEEE transactions on image processing, vol. 21, no. 9, pp. 3967–3980, 2012.

[51] X. Guo, "Lime: A method for low-light image enhancement," in Proceedings of the 2016 ACM on Multimedia Conference. ACM, 2016, pp. 87–91.

[52] K. Dabov, A. Foi, V. Katkovnik, and K. Egiazarian, "Image de noising by sparse 3-d transform-domain collaborative filtering," IEEE Transactions on image processing, vol. 16, no. 8, pp. 20802095.