Assignment 5: Image Enhancement and Restoration

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1 Introduction

Image is the foundation of human visual system, and gives a concrete and intuitive impact on people. However, the quality of a virtual image is reduced during the image acquisition, transmission and conversion processes. Therefore, we need to improve the quality of the degraded images by using some image processing methods.

In this assignment, there are three tasks that you need to finish. At first, you need to implement two approaches for image dehazing and compare the results of different dehazing methods by using two evaluation measures. After that, you should use five traditional image processing methods for underwater image enhancement and restoration. At last, you need to achieve the work of Li *et at.* [1].

2 Dataset

2.1 D-HAZY

For single image haze removal, the dataset you can use is called D-HAZY [2], which contains 1400+ pairs of images with ground truth reference images and hazy images of the same scene. And it is built on the Middelbury [3] and NYU Depth [4] datasets that provide images of various scenes and their corresponding depth maps.

For task 1, you need to download the dataset from the link: Hazy image dataset and Haze-free image dataset. The dataset contains 100 clear images and 100 synthetic hazy images which I chose from D-HAZY. You need to use the whole synthetic hazy images for image dehazing and compare the results based on the evaluation measures. If you want to get all the images of the dataset, the download link is D-HAZY. Figure. 1 shows some examples of the dataset.

2.2 Underwater image dataset and air image dataset

The training dataset contains 300 underwater images from the Internet, and 400 air images from SUN dataset [5]. For test dataset, there are 20 underwater images. To save the computational expense, I resized all the images into a size of 32×32.

You can get the images from the link: Task 2 and Task 3. From Figure. 2, we can see some examples of our dataset. You should use these images for task 2 and task 3.

Figure 1: (a) An example image in the hazy image dataset. (b) An example image in the haze-free image dataset.

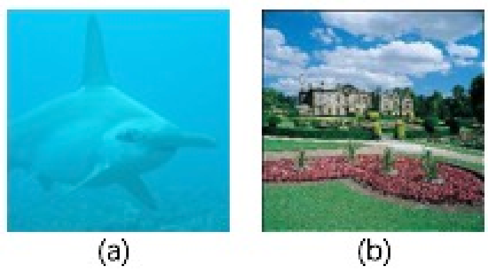

Figure 2: (a) An example image in the underwater image dataset. (b) An example image in the air image dataset.

3 Task 1: Image dehazing

In this task, you will implement two image dehazing methods on the hazy image dataset to get different results.

- Dark Channel Prior [6].
- DehazeNet [7].

You can choose any programming language to implement this task, such as MATLAB, OpenCV, or C++, etc. Then you need to compare these methods based on PSNR and SSIM [8]. From this task, you can learn how to remove haze from the air images, and understand the theory of image dehazing. Put your codes, dataset, experiment results, and evaluation results into a folder named Task1_YourName.

4 Task 2: Underwater image enhancement and restoration based on traditional methods

In this task, you will use five methods to implement underwater image enhancement and restoration.

- CLAHE [9].
- Retinex [10].
- White balance [11].
- CAP [12].
- NON [13].

CLAHE, Retinex and White balance are the classical image enhancement methods. Moreover, CAP and NON are the integrated dehazing methods. You need to implement all these methods on underwater image dataset to get different results. Then you need to compare these methods based on UIQM [14]. Put your codes, dataset, experiment results, and evaluation results into a folder named Task2_YourName.

5 Task 3: Underwater image color correction based on weakly supervised color transfer

In this task, you will achieve the work of this paper 'Emerging From Water: Underwater Image Color Correction Based on Weakly Supervised Color Transfer' [1]. This work is based on CycleGAN [15]. For loss function, they propose a structural similarity index measure loss, which makes the content and structure of the outputs same as the inputs, meanwhile the color is similar to the images that were taken without the water. The framework of the proposed method is shown in Figure. 3. The model contains two mapping functions $G : X \rightarrow Y$ (forward) and $F : Y \rightarrow X$ (backward), and associated adversarial discriminators D_Y and D_X.

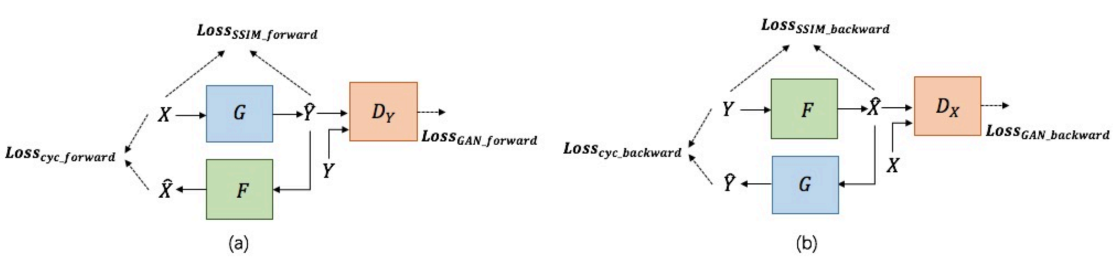

Figure 3: Diagram of the framework. (a) Forward networks. (b) Backward networks.

So how do we achieve the work of this paper? There are two parts.

5.1 Network architecture

First, we need to implement the network architecture. In this paper 'Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks' [15], the author presents an approach for learning to translate an image from a source domain X to a target domain Y in the absence of paired examples.

The goal is to learn a mapping $G : X \to Y$ such that the distribution of images from $G(X)$ is indistinguishable from the distribution Y using an adversarial loss. Because this mapping is highly under-constrained, they couple it with an inverse mapping $F : Y \to X$ and introduce a cycle consistency loss to enforce $F(G(X))$ similar to X (and vice versa). And the model is shown as Figure. 4.

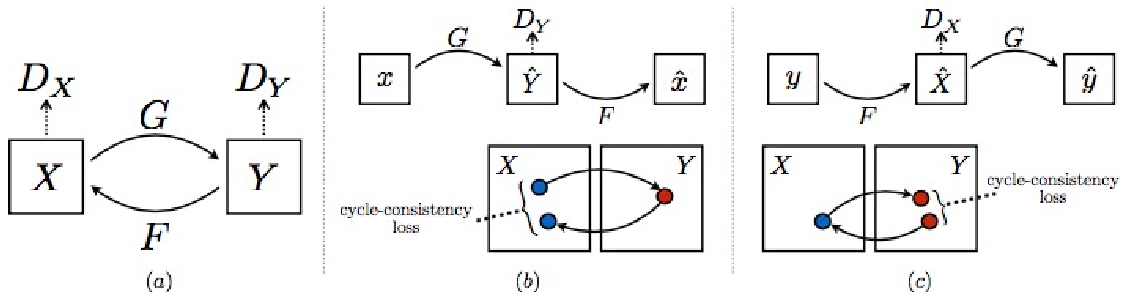

Figure 4: (a) The model contains two mapping functions $G : X \to Y$ and $F : Y \to X$, and associated adversarial discriminators D_Y and D_X. (b) Forward cycle-consistency loss: $x \to G(x) \to F(G(x)) \approx x$. (c) Backward cycle-consistency loss: $y \to F(y) \to G(F(y)) \approx y$.

Because you will implement this work on your own computer, you need to do some changes :

- I recommend that you use this code : CycleGAN-TensorFlow, and make changes on this code.
- You need change the dataset, use our underwater image dataset as X, and the air image dataset as Y.
- You need to change the network structure. For the generator, you should adjust the encoder which only has two convolutions. Besides, the transformer only has two resnet blocks, and the decoder also has two convolutions. For the discriminator, you need to decrease to four convolutions. From Figure. 5, you can see the architecture of the generator which you finally realize. Figure. 6 shows the architecture of the discriminator.

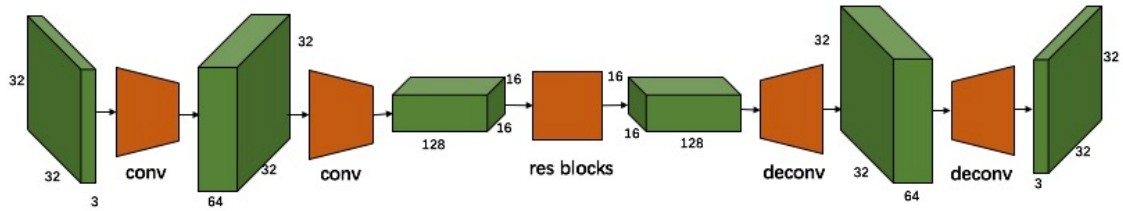

Figure 5: The architecture of the generator.

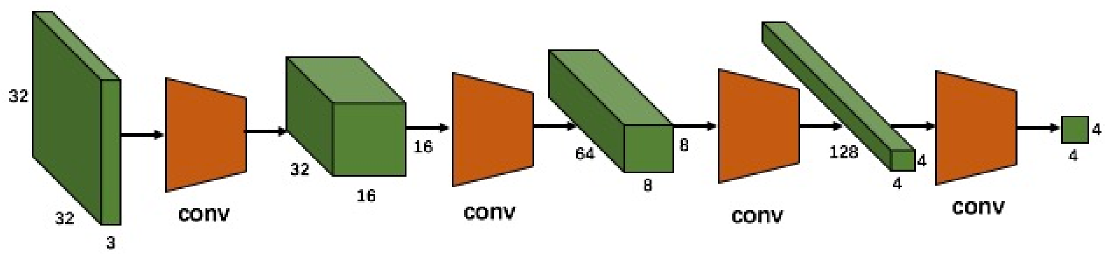

Figure 6: The architecture of the discriminator.

5.2 Loss function

In this paper 'Emerging From Water: Underwater Image Color Correction Based on Weakly Supervised Color Transfer', the authors design a multiterm loss function including adversarial loss, cycle consistency loss, and structural similarity index measure loss (SSIM loss). All you need to do is add SSIM loss to the networks.

- About the theory of SSIM loss, you can learn more from the paper : 'Emerging From Water: Underwater Image Color Correction Based on Weakly Supervised Color Transfer'.
- About the code of SSIM loss, you can refer to this code : SSIM loss, and find out the part you need to add to the networks. You can also achieve it according to your own understanding.

Finally, put your codes, dataset, experiment results, and evaluation results into a folder named Task3_YourName.

6 Evaluation

In this part, you will compare the quality of image dehazing algorithms and underwater image processing methods by using three evaluation measures.

6.1 Image dehazing

For task 1, you need to use two evaluation measures :

- Peak Signal to Noise Ratio (PSNR).
- Structural Similarity index (SSIM).

Compare all methods on each evaluation measure. You can choose Python or MATLAB to implement these two evaluation measures. Put your codes into a folder named Evaluation_1_YourName.

6.2 Underwater image processing

For task 2 and task 3, you need to use one evaluation measure :

- Underwater Image Quality Measure (UIQM) [14].

Compare all methods on this evaluation measure. You can choose MATLAB to implement this evaluation measure. Put your codes into a folder named Evaluation_2_YourName.

7 Submission and grading

After various parts of the assignment are completed, the following files including :

- Your datasets.
- Your codes.
- Your results.
- A PDF report containing your results and the analysis of your experiments.

Zip all your files and submit your assignment to `ouceecv@163.com` with the subject : YourName_Assignment5.zip. The name of your zip file should be the same as your email subject.

Be sure to finish and submit Assignment 5 before the due date July 01, 2018. Then I will grade your assignment based on your files. Table. 1 is a breakdown of how each part of this assignment is scored :

Part	Points
Task 1	10 points
Task 2	25 points
Task 3	40 points
PSNR SSIM	5 points
UIQM	5 points
Report	15 points
Total points	100 points

Table 1: The score of this assignment.

If you have any questions, you can contact lujingyuouc@163.com.

References

[1] C. Li, J. Guo, C. Guo, Emerging from water: Underwater image color correction based on weakly supervised color transfer, IEEE TSPL (99) (2017) 1–1.

[2] C. Ancuti, C. O. Ancuti, C. D. Vleeschouwer, D-HAZY: A dataset to evaluate quantitatively dehazing algorithms, in: ICIP, 2016, pp. 2226–2230.

[3] D. Scharstein, H. Hirschmüller, Y. Kitajima, G. Krathwohl, N. Nešić, X. Wang, P. Westling, High-resolution stereo datasets with subpixel-accurate ground truth, PR (2014) 31–42.

[4] N. Silberman, D. Hoiem, P. Kohli, R. Fergus, Indoor segmentation and support inference from rgbd images, in: ECCV, 2012, pp. 746–760.

[5] J. Xiao, J. Hays, K. A. Ehinger, A. Oliva, A. Torralba, SUN database: Large-scale scene recognition from abbey to zoo, in: CVPR, 2010, pp. 3485–3492.

[6] K. He, J. Sun, X. Tang, Single image haze removal using dark channel prior, in: CVPR, 2009, pp. 1956–1963.

[7] B. Cai, X. Xu, K. Jia, C. Qing, D. Tao, DehazeNet: An end-to-end system for single image haze removal, IEEE TIP 25 (11) (2016) 5187–5198.

[8] H. Zhao, O. Gallo, I. Frosio, J. Kautz, Loss functions for neural networks for image processing, Computer Science 3 (1) (2017) 47–57.

[9] K. Zuiderveld, Contrast limited adaptive histogram equalization, Graphics Gems (1994) 474–485.

[10] J. M. Morel, A. B. Petro, C. Sbert, Fast implementation of color constancy algorithms, in: Color Imaging XIV: Displaying, Processing, Hardcopy, and Applications, 2009, p. 724106.

[11] Y. C. Liu, W. H. Chan, Y. Q. Chen, Automatic white balance for digital still camera, IEEE TCE 41 (3) (1995) 460–466.

[12] Q. S. Zhu, J. M. Mai, L. Shao, A fast single image haze removal algorithm using color attenuation prior, IEEE TIP 24 (11) (2015) 3522–3533.

[13] D. Berman, S. Avidan, et al., Non-local image dehazing, in: CVPR, 2016, pp. 1674–1682.

[14] K. Panetta, C. Gao, S. Agaian, Human-visual-system-inspired underwater image quality measures, IEEE JOE 41 (3) (2016) 541–551.

[15] J. Y. Zhu, T. Park, P. Isola, A. A. Efros, Unpaired image-to-image translation using cycle-consistent adversarial networks, in: ICCV, 2017.