closer to the original image than the train lights. Because the light area of the train lights area is larger than that of the goose area. In word image, the evaluation parameters are the results of the research conducted by the auxiliary researchers. On this basis, it is necessary to cooperate with the visual inspection results to achieve better results. For example, train lights, for three different algorithms, the results are greatly different after zooming in, but people can feel very sensitively that the effect of DhNet should be the closest to the reality.

But the human eye has some differences compared to the evaluation index. For example, high sensitivity to low spatial frequency contrast. The difference in brightness is more sensitive than the difference in saturation. Perception result for a certain area is affected by surrounding information.

5.6. Quantitative Evaluation

PSNR is used as a measure of the reproducibility quality of codecs using lossy compression such as image compression. The signal in that case is the original data, and the noise is caused by the compression as an error. Normally, the higher the PSNR, the higher the image quality, but in some cases, despite the low PSNR, humans may perceive it as close to the original image, so when comparing codecs used for compression, the value of PSNR should only be used as a guide. While using PSNR numbers for comparisons, it must be taken as applicable. The numbers are theoretically valid only when comparing the results of the same original image with the same codec [81] [82].

However, PSNR is weaknesses sometimes, there are some images that have the same value of PSNR, the difference can be seen easily by human eyes. SSIM stands for brightness, contrast and structure of objects in images. It is calculated by comparing each of the them. Although the calculation formula is more complicated than PSNR, it can be seen that SSIM can output appropriate values that match the appearance of humans. The data of the SSIM tends to 1, it is more similar it is to the original image [82] [83].

As the realization of structural similarity theory, structural similarity index defines structural information as independent of brightness and contrast from the perspective of image composition, reflecting the attributes of object structure in the scene, and modeling distortion as a combination of brightness, contrast and structure. The value is used as the estimation of brightness, the standard deviation as the estimation of contrast, and the covariance as the measurement of structural similarity.

In my work, the three algorithms has been used, it is DCP, DbGAN and DhNet algorithm in order to calculate the PSNR and SSIM values of eight representative images. Combined with the human eye visual inspection, we make some analysis about two parameters and find the following conclusions.

It seems that the values of the PSNR average rises in figure 5-6. The value of PSNR increases for each image in order to DCP, DbGAN and DhNet, then two proposed algorithms have better image quality than DCP algorithm. At last, Although the value of DhNet is higher accuracy than DbGAN's, it is necessary to analyze separately.

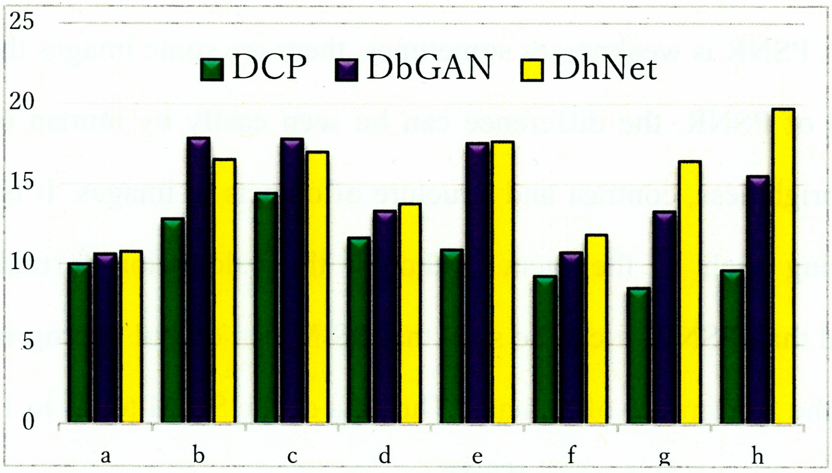

Figure. 5-10 Value of PSNR

Another, the value of SSIM average of proposed method rises as figure 5-7, the value of DhNet was higher than the value of DbGAN, and the value of DCP is larger than the other two proposed algorithms.

SSIM is more complicated than PSNR, and gets something closer to the difference perceived by humans. Since humans are not so conscious of changes in brightness, the SSIM value increases.

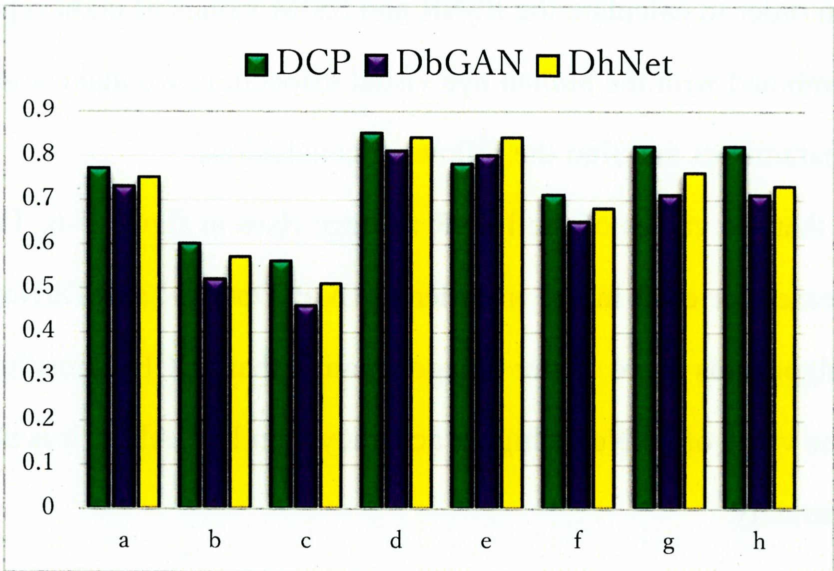

Figure. 5-11 Value of SSIM

6. Software Works Tools for Test

Image de-noising, image restoration and image dehazing are usually used by the visual inspection of researchers to distinguish hand breakage. On this basis, various evaluation indexes or parameters are supplemented, such as PSNR, SEM, SSIM and so on. In order to make the image of the research object more intuitive and convenient to compare the tiny differences of each detail of the image before and after the corresponding dehazing, two tools are specially developed to help the project team to conveniently compare the test results while scientific research is carried out to save time and improve work efficiency.

6.1. Algorithm Hybrid Generation System

The mixed effect display system of the two algorithms, according to a certain proportion, will share the two algorithms to form the final dehaze image effect and display. The proportion of the two algorithms in operation processing is fixed, and the proportion can be adjusted flexibly and changed online at any time, with the total proportion unchanged. The corresponding renderings may also show different demisting renderings with different proportions of the two algorithms. In this way, it is helpful for visual inspection and researchers to improve the current algorithm. In order to understand the test results at any time, the tool software is specially written to help understand the different types of hazy image in a macro way. When the parameters change online, the renderings of the two algorithms superimposed on the dehaze image are completed. The specific operation is: drag the parameter bar in the upper part of the tool software with the mouse, and you can change the haze at any time The dehaze image is generated online by the tool of e-removal, which is convenient to understand the de haze effect and specific parameter value of the algorithm more intuitively. As shown in figure 6-1.

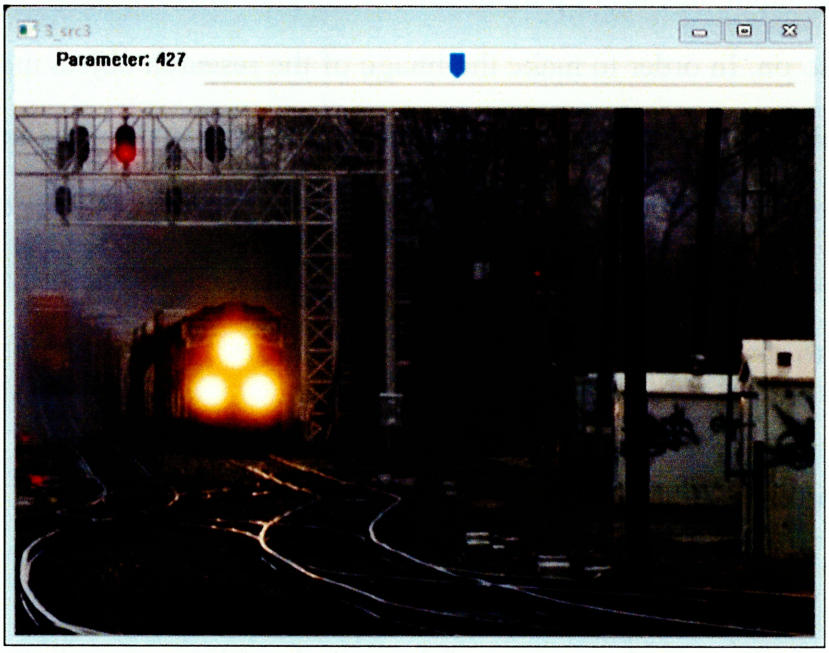

Figure. 6-1 Simulation of two algorithm weighted distribution system

Comparing the two algorithms, for different hazy images, the best scale effect will appear. Through this method, we can directly observe various and hazy image states and the fitness of the two algorithms, so that in the future research, we can consider the image classification and further study the adaptability of the algorithm to hazy image processing.

The innovation of this development tool is that it will use the DbGAN and

DhNet methods to calculate and segment the processed effect by percentage, and display it intuitively for researchers' intuitive reference, which is more beneficial to the improvement of the algorithm.

6.2. Demisting Effect Comparison System

The development tool is completed with JS, the small system is very intuitive, and can be online, like a screen of a switch, the curtain dividing line divides the image into two, the left side is hazy image, for example the processing diagram of a certain algorithm, and the right side is another haze removal rear image corresponding to this diagram. Through the double arrows in the middle of the mouse drag tool interface, drag left and right back and forth to realize the intuitive comparison of each detail of the image before and after dehazing, then, it can also be used as an intuitive comparison of the effects of two different dehazing algorithms, which is helpful for the online display of the results before and after research and processing, and the impression is more intuitive and clear. In the figure 5-14, the small area marked by the red circle is the position of the slider. Of course, you can also click any area of the interface through mouse to realize the fixed-point division of the interface division.

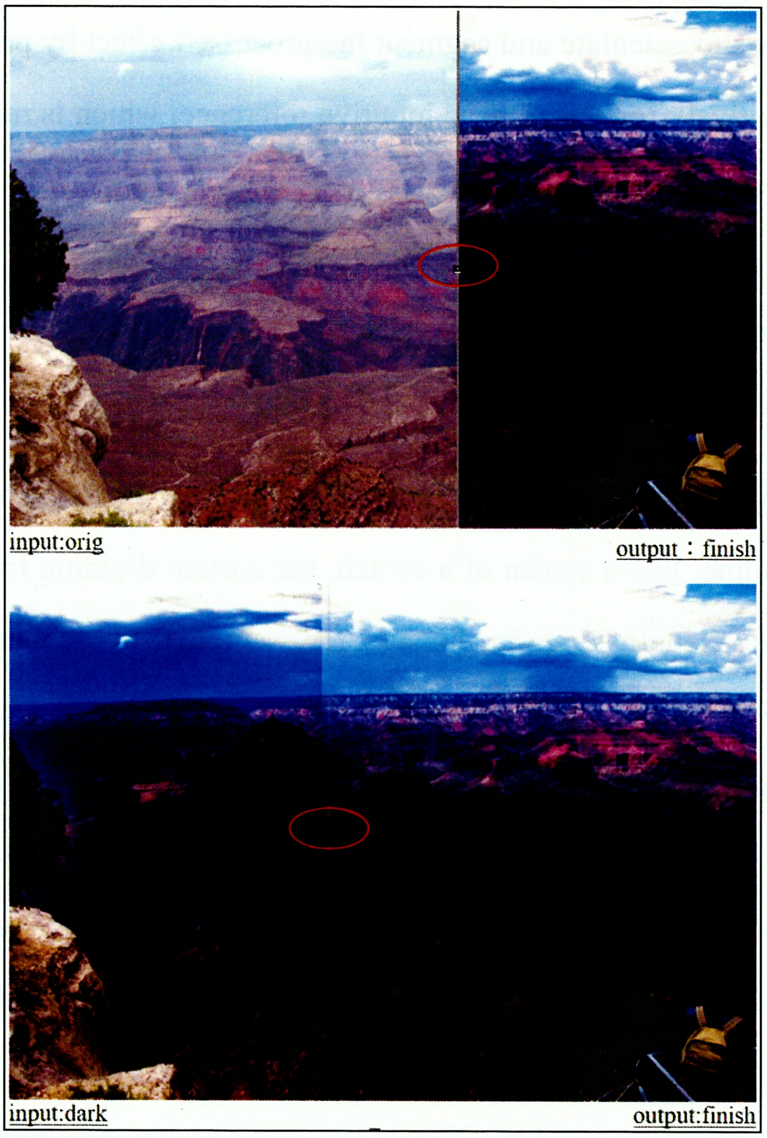

Figure. 6-2 comparison system of different treatment methods

6.3. Summary

The two software systems, one is local version, the other is based on Web version, which is easy to use. The system can be shared in the research room, or there may be considered to be put on the Internet for open use by researchers. The system has the advantages of simple operation, specific function, flexible contrast, obvious effect, convenient display, flexible range adjustment and strong practicability. These two systems are rare research helpers. At present, we are considering the registration of software copyright protection.

7. Conclusions

7.1. Conclusions and Recommendations

In the research field of image dehazing, there are some defects in the typical algorithm for the processing of the highlighted area of the hazy image, the particularity of single image dehazing. Two proposed methods were submitted, DbGAN and DhNet respectively. These algorithms solve the above two requirements well. In this work, two deep learning architectures are proposed, the one is DbGAN, it solve the problem of DCP haze removal highlight area, to propose DbGAN network algorithm that design generator and discriminator. From the DCP method of the previous method, it happened to incorrect removal in bright areas of the image that could not be accommodated. In order to determine the attention area of the image I introduce the target map, and add to the GAN model imitating because the areas are prominent usually. Further, as a target map, the feature map extraction function of the geometric architecture of the image is demonstrated, for each layer, the receptive field of the feature is spread, it is possible to output a focused layer by training while being a good complement to define the features simply of centering on the GAN texture. After restoration, the effect of dehazing in the highlighted area is well realized, which makes up for the shortcomings of DCP algorithm. The other deep learning architecture is DhNet, which is used to remove haze information from a single image. Using dilated convolution neural network of high frequency detail content, the mapping function between detail layer of clear image and hazy image is learned. In the absence of real haze-free image, we use the collected natural hazy image for deep learning. The research results show that the deep learning of convolutional neural network, as a technology widely used in high-level visual tasks, it can be used to deal with hazy images under severe weather conditions, which has a good application prospect for the future automatic driving, remote sensing data clarity processing, public place camera monitoring technology and other fields. Using PSNR and SSIM evaluation indicator, the advantages are obvious in image quality and calculation efficiency. The higher the value of PSNR, the better distortion the image will have. In the verification experiment, the average value of PSNR is higher than DCP, consistent with the results of visual verification. Then through the use of dilated convolution neural network, it is not necessary to use a deep network level to complete the training and learning task of hazy image.

7.2. Future Work

In the future, I want to build a model that can absorb the change of weather by deep learning of big data acquired at different times and different weather conditions of surveillance cameras installed in the same position.

In the research field of image dehazing, there are some defects in the typical algorithm for the processing of the highlighted area of the hazy image, and the particularity of single image dehazing. In the future, the combination of channel mechanism and pixel attention mechanism. For example, the application of deep learning, taking into account the weighted information characteristics of different channel features, it may become a new trend in the research of demisting algorithm. In addition, on the basis of basic block structure, local residual learning and feature attention, thin haze area or low frequency connected by multiple local residual, as well as main network architecture attention means, it will be the focus of scientific research workers. Further, based on the feature fusion structure of different levels of attention, the feature weights are adaptively learned from the feature attention module to give more weights and add the important features and other algorithms. Because the shallow information can be retained and transferred to the deep layer, they will be used in the dehaze algorithm.

With the development of computer hardware and software, as the processing performance of the CPU and GPU increases, the time of deep learning will be shortened, it will be more convenient for the demand of image real-time processing, and it will be more used widely in production practice. The research of image dehazing technology will usher in a better development opportunity.

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Publications Lists (peer reviewed)

This thesis involve the following publications during my PhD period. The most concept and algorithms are published in (in chronological order):

[1] R. Ma, S. Zhang, "Implementation of Chemical Structure Formula Online Editing System Based on Flex Framework", *Science Journal of Kanagawa University*, Vol.28, pp.9-14, 2017.

[2] R. Ma, S. Zhang, "Color Image Dehazing in Dark Channel Prior based Image Local Features", *2018 International Conference on Computer, Communication and Network Technology*, pp.432-436, 2018.

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Appendices

GPU	Graphics Processing Unit
PSNR	Peak Signal-to-noise Ratio
MSE	Mean Squared Error
SSIM	Structural Similarity
DCP	Dark Channel Prior
RGB	red green blue
MRF	Markov Random Fields
MCA	Morphological Component Analysis
SVM	Support Vector Machine
PCA	Principal Component Analysis
HVS	Human Visual System
CNC	Contrast Naturalness Colorfulness
CNI	Color Naturalness Index
MLP	Multi-layer Perceptron
TM	Target Map
CNN	Convolutional Neural Network
DL	Deep Learning
TNRD	Trainable Nonlinear Reaction Diffusion
BReLU	Bilateral Rectifier Linear Unit
ML	Machine Learning
LReLU	Leaky Rectifier Linear Unit
HSV	Hue, Saturation, Value

GAN	Generative Adversarial Network
DCGAN	Deep Compositional Gan
GAMN	Generation Antagonistic Mapping Network
DbGAN	Dark Channel Prior base of Generative Adversarial Network
DhNet	Dehaze Network