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Research on A Quantitative Assessment Model Based on Visual Perception in Low-Altitude Remote Sensing

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***Abstract*—In order to evaluate the recovery effect of the visible light band in the low-altitude remote sensing, the sensitivity and significance of the visual perception of the restored image are selected and optimized by the perceptual characteristics of the human visual system. Finally, the effective detail retention ability, Structure information, multi - scale similarity and visual fidelity. A kind of image - based image fog quantification evaluation model QAMVP is proposed based on visual perception. The experimental results show that the model has a strong judgment force on the object group with obvious difference in the image quality evaluation. The accuracy rate of the sample group is 92%. In the aspect of visual perception, , The MSE of the model index curve is obviously lower than the comprehensive evaluation method and the PSNR measurement method, which indicates that the model has certain advantages in the degree of visual perception and the correlation with the visual perception of the human eye. The results of the study can provide theoretical basis and practical guidance for the objective evaluation of the visible image in the low-altitude remote sensing.**

Keywords—Low-altitude remote sensing; Visible band; Visual perception; Quantitative assessment; Precision agriculture

I. INTRODUCTION

Low-altitude remote sensing technology which has the advantages of low cost, high reliability and real-time acquisition that has attracted a wide spread attention in various application field. using unmanned aerial vehicles with wide-angle cameras to get multispectral remote sensing images in visible band to process remote sensing image and monitoring information of farmland rapidly has been one of the important means of precision agriculture. However, there still hasn’t been a scientific and effective evaluation method on the quality of restored image. To provide reference, basis and improvement direction for the performance test of restoration processing of low-altitude remote sensing degraded image It’s a key step in the research of the application of visible image in precision agriculture, which has important significance in the research of UAV low-altitude remote sensing.

II. DESIGN MOTIVATION

For the restoration of degraded image in visible, band so far the research has got different effect. As picture 1(b-f) showed, is He, MDCP, Retinex, Tarel, Zhu5 most popular algorithms’ effect. However, how to evaluate the effect after restoration objectively and accurately, is still an important issue in the field of image processing. Based on the literature, objective evaluation methods of image quality are full reference type, half reference type and none reference type. UAVs taking the photos in visible band in Low-altitude remote sensing can’t refers to Standard clear image, which is no reference quality evaluation category. Zhu pointed out that Image quality degradation duo to Atmospheric Scattering also can’t refer to standard image, only can refer to degraded image.

a. Original image b. He algorithm c. MDCP algorithm

d. Retinex algorithm e. Tarel algorithm f. Zhu algorithm

Figure 1. Restored results of classic algorithms

So far, Non - reference evaluation method is mainly Evaluate the unilateral performance of the image(such as PSNR, Information entropy and Average gradient ratio).Though Simple and targeted, but can not from the overall quality of the image to restore the effect of the judge. So the result can has a certain degree of deviation compared with the real comprehensive performance results of restore image.

For example, PSNR measurement method is an objective criterion for evaluating images, is one of the most common and extensive image evaluation objective measurement methods. But, many literature points out that PSNR measurement method’s result can not be consistent with actual integrated visual quality. Using PSNR measurement method to evaluate picture 2(b-c), picture 2(b)’s PSNR value is 13.79, which is higher the picture 2(c)’s PSNR value’s 12.25. But in human’s eyes, picture 2(c) is better, which is Contrary to the results of the PSNR measurement method. Because PSNR measurement method only evaluates picture thought Image noise, ignoring the information contained by the picture.

a. Original image b. restore image (PSNR=13.79) c. restore image (PSNR=12.25)

Figure 2. Results of different method and its PSNR value

III. EAVALUATION MODEL DESIGN

A. *Evaluation and Optimization of Evaluation Factor*

The internal mechanism of HVS reveals the perception process of visual information, which can provide important guiding ideology for the comprehensive evaluation of image quality. Based on the study of human visual perception, this paper combines the auspicious knowledge of low-level remote sensing degradation image edge, contour distortion, low saturation, contrast reduction, overall brightness is large, and bionic simulation image visual perception,to propose a quantitative Assessment Model based on Visual Perception.

1) *Image effective detail maintain ability*

Human visual perception features show that the image contrast is not as high as possible, the contrast is too high for the recovery of the image is enhanced, the details are contrary to realism. Therefore, QAMVP defines an image effective detail retention capability factor L, which mainly reflects the ability of the restored image to eliminate noise and the "Halo" effect to influence the edge information.

The over-enhancement phenomena such as "Halo" effects of degraded image restoration processes, such as contours, depth of field, and so on, become wider and brighter. Therefore, the edge-enhanced detail intensity IHalo of the restored image can be obtained by summing the maximum pixel-point neighborhood of the corresponding region in the bright image of the restored image:

$$I_{Halo} = \frac{\sum_{x\in\phi}\left(\sum_{y\in\Omega(x)} I_{bright}(y)\right)}{n} \tag{1}$$

Where Ω (x) is the field where the center point is x, n is the number of pixels in the neighborhood, and Ibright is the bright channel image. Similarly, the brightness intensity IiHalo of the region corresponding to the original image is:

$$I^{i}_{Halo} = \frac{\sum_{x\in\varnothing}\left(\sum_{y\in\Omega(x)} I^{i}_{bright}(x)\right)}{n} \tag{2}$$

The over-enhanced approximation of the restored image is the difference between the two.

The total edge detail intensity LJ of the restored image can be solved by the Canny operator：

$$L_J = \sum I_J^{canny}(x) \tag{3}$$

Finally, the image effective detail retention capability factor L is reflected by the proportion of the edge of the restored image that enhances the detail intensity in the total edge detail intensity, which is:

$$L = \frac{(I_{Halo} - I^{i}_{Halo})}{L_J} \tag{4}$$

In equation (4), the smaller the L, the stronger the effective detail retention ability of the restored image, and the better the effect of suppressing the "Halo" effect.

2) *The degree of tone reduction*

When the restoration effect is good, the color of the image is truly coordinated, which is consistent with the degree of color shift in the visual perception. At this time, the histogram shape of the image before and after the restoration is substantially similar, so the histogram similarity can be used to measure the degree of hue offset of the restored image.

The Pasteur distance is used in statistics to measure the separability of two discrete probability distributions. In this paper, we define the calculation of histogram similarity from histDist. The mathematical expression is:

$$H = \sum \sqrt{p_1 \times p_2} \tag{5}$$

Where p1 and p2 are the probability distributions of the discrete points on the histogram before and after the restoration, respectively, and H is 1 when it is completely matched, and 0 is completely absent.

3) Structural information

The measure of the degree of change in scene structure is a good approximation of image perceived distortion. A large increase in the restoration of image structure information means over-enhancement and the introduction of noise, while a significant reduction represents the loss of detail information. Therefore, the structural information of the reconstructed image can be scientifically measured, and the realism and distortion of the restored image can be effectively evaluated.

An image I(x) can be expressed as a product of a reflection image R(x) and an illumination image L(x), which is:

$$I(x) = R(x) \cdot L(x) \tag{6}$$

The structure of the object in the scene is independent of the illuminance, so the texture information is extracted only for the reflected image R. The derivation of the reflection image R(x) is achieved by separating the illumination image by Gaussian kernel Gc(x):

$$R(x) = G_c(x) * I(x) \tag{7}$$

The similarity function is defined as S, and the reflection images R1 and R2 of the restored image are compared with the structural information, obtain:

$$S(R_{1,} R_2) = \frac{\sigma_{12}}{\sigma_1 \sigma_2} \tag{8}$$

among them,

$$\sigma_{12} = \frac{1}{M+1} \sum_{1}^{M} (R_{1,i} - \mu_1)(R_{2,i} - \mu_2) \tag{9}$$

M is the number of pixels; μ1 and σ1 are the mean and standard deviation of R1, respectively; μ2 and σ2 are the mean and standard deviation of R2 respectively.

4) Multi-scale structure similarity

Multi-scale Structural SIMilarity (MSSIM) is based on structural similar image quality evaluation factors, based on the HVS highly adaptable to natural vision systems. Compared with the single-scale structure similarity is only applicable to the specific situation, the multi-scale structure similarity has higher adaptability. The mathematical expression of MSSIM is:

$$MSSIM(x, y) = (l_M(x, y))^{\alpha_M} \prod_{i=1}^{M} \left[(c_i(x, y))^{\beta_i} (S_i(x, y))^{\gamma_i} \right] \tag{10}$$

In the above equation, the indices α_M, β_i and γ_i are used to adjust the relative importance of the different components of the formula.

5) Image visual fidelity

Visual Information Fidelity (VIF) reflects the perception that the image is the remake of the human eye by the HVS, similar to the process of extracting the valid information for the degraded image.

The traditional VIF carries out the fidelity calculation with the distortion less pattern as the reference pattern. In this paper, the original degraded image is used as the reference image, and the image information before and after the restoration is compared with the knowledge of the information theory. The results of the image fidelity evaluation are obtained. According to the above theory, VIF can be defined as:

$$VIF(x, y) = \frac{\sum_{j=1}^{s} \sum_{i=1}^{M_j} I(c_{i,j}, f_{i,j})}{\sum_{j=1}^{s} \sum_{i=1}^{M_j} I(c_{i,j}, e_{i,j})} \tag{11}$$

Where s is the number of scales of the image, Mj represents the number of image blocks on the scale j, and $I(c_{i,j}, f_{i,j})$ and $I(c_{i,j}, e_{i,j})$ are represented as mutual information. In general, the information obtained by the human eye is less than the original image, so the value range of VIF (x, y) is [0,1], the larger the value of VIF (x, y), the more the visual fidelity high.

B. The construction of the model

The above five visual sensory sensitive transcendental factors, from the aspects of the perception mechanism of HVS, and the characterization of degraded images of low-level remote sensing visible-band, the global weights and Measures of Image Quality Evaluation are carried out. Further ,By normalization and multivariate fitting analysis, we can come to the mathematical expression of QAMVP model as follows：

$$Q = \frac{(S)^{\alpha} \cdot \left(HistDist\right)^{\gamma} \cdot (MSSIM)^{\theta}}{(L)^{\beta} \cdot (1 - VIF)^{\varphi}} \tag{12}$$

In the above formula, Q is a comprehensive quantitative evaluation parameter, the larger the value of Q, the better the processing effect of the restored image. The five weight adjustment parameters,α，β，γ，θandφ,are the degree of sensitivity of the factors. According to the degree of degradation of the original image，we make the value is less than 0.

IV. TEST RESULTS ANALYSIS

In order to verify the stability of the QAMVP model, the specific experimental method is as follows:

A. Test image sample library build

Through the network search, UAV sampling, etc. to establish low-altitude remote sensing visible light band degradation image sample library, a total of 600 images. Then, randomly extract 200 pictures to build the test image sample library

B. Evaluation of the sample map library building

The HE and DCP algorithm were used to reconstruct the test image sample database, and 200 restoration results were obtained. The construction of the sample library was evaluated. Herein, the reason for selecting the HE method is that although the method improves the contrast of the image to a certain extent in the restoration process, the recovery result is likely to be enhanced, the visual perception is not coordinated, and the comprehensive restoration effect is poor; , The choice of DCP algorithm is because the algorithm is currently recognized as one of the best algorithms for recovering visual effects. Therefore, the statistical results of the two algorithms on the restoration of large-volume image processing should be obvious.

C. Comparison of evaluation methods

The QAMVP model, the comprehensive evaluation method in and the PSNR measurement method were used for comparative analysis. By evaluating the probability of the highest value of the DCP algorithm in the scatter plot of each evaluation method, it can reflect the evaluation performance stability of each evaluation method. The detailed experimental data scatter plot is shown in Figure 3 to Figure 5.

In the figure, the abscissa indicates the evaluation sample group number; the ordinate indicates the evaluation index value, the same figure is large, indicating that the recovery effect is better. Figure 3 is the QAMVP model to evaluate the sample map library of the evaluation index value of the scatter plot, which DCP recovery results of the high value of 184 indicators, accounting for 92% of all the figure, can be seen as The QAMVP model has an accuracy rate of 92%. Figure 4 is a comprehensive evaluation method to evaluate the sample map library of the evaluation index value of the scatter plot, which DCP recovery results of the index value of the high group of 156, accounting for 78% of all the graph, the accuracy of this test is 78 %. Similarly, Figure 5 is the PSNR measurement method to evaluate the sample map library of the evaluation index value of the scatter plot, which DCP recovery results of high indicators of 44 groups, accounting for 22% of all graphs, that is, the test The accuracy rate is 22%.

It can be seen that the QAMVP model has a strong judgment on the objective group with obvious difference in the sample evaluation effect of the sample pool, and it can be deduced effectively. It is excellent in the evaluation experiment of 200 groups The stability of the. Through the data comparison and analysis, the comprehensive evaluation method can also get the correct evaluation result to a certain extent, but the accuracy rate is lower than the QAMVP model. PSNR measurement method evaluation accuracy is poor, the reason should be sensitive to PSNR HE method of a certain indicator of the upgrade. From the other side, it is pointed out that the objective evaluation method based on single factor is easy to fall into the trap of one-sided analysis in the evaluation process, and it is necessary to ignore the characteristics of the integrated information.

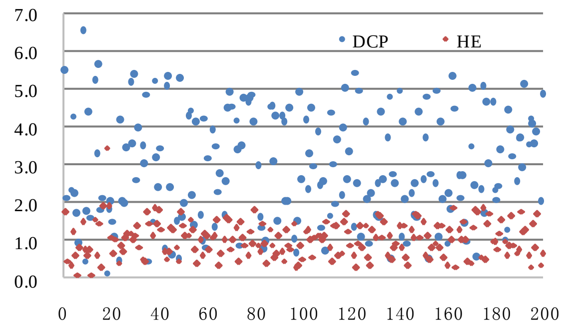

Figure 3. The evaluation scatter plot of QAMVP

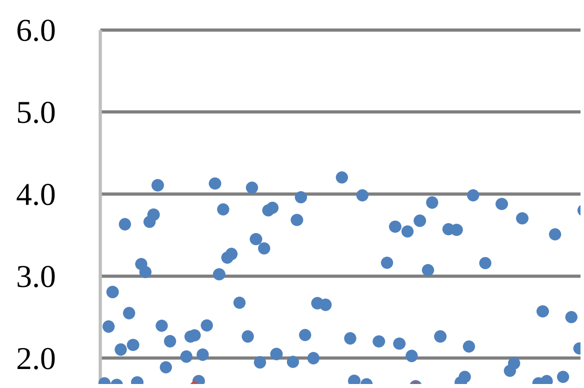

Figure 4. The evaluation scatter plot of comprehensive evaluation

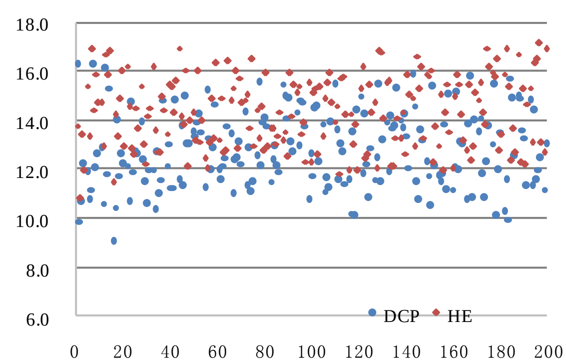

Figure 5. The evaluation scatter plot of PSNR evaluation method

V. CONCLUSION AND PROSPECT

low-altitude UAV remote sensing technology is one of the important means of fine agriculture, and it is of practical significance to carry out objective quantitative evaluation of the restoration of visible light band images in low-altitude remote sensing. Currently, in connection with the situation that the comprehensive quality evaluation of the reconstructed image is Emphasis on subjective evaluation, lacking of a scientific and objective quantitative evaluation system. Based on the perception of HVS, this article came up with an image quality evaluation model based on visual perception. The conclusion is as follows:

(1)The five low-altitude remote sensing degraded images visual perception sensitive a priori factors, which proposed by the QAMVP model, simulating the visual perception of the human eye, the subjective image performance evaluation, into a comprehensive factor to solve the mathematical problems, and it compensate for the single defect of the index in the traditional objective evaluation method. From the Visual perception perspective, a comprehensive evaluation analysis of the reconstructed image was made.

(2)Compared with the comprehensive evaluation method and PSNR measurement method, QAMVP model has its certain advantages in terms of evaluating performance stability, and obvious advantages in the aspect of visual perception as well as meeting performance.

(3)In this paper, the evaluation rate of 200 groups of evaluation samples is 92%,the value of MSE in two graphs of visual perception and meeting performance, are 0.075332 and 0.118076832 respectively, which shows that bases on visual perception, the model can evaluate the image of low-level remote sensing visible-band recovery effectively.

In the field of precision agriculture, application Technology of Low - level remote sensing visible light band image, will play an important role in the next period of time. With the involvement of large data acquisition and deep learning areas, the development of image quality evaluation methods, which based on visual perception ,will also get rapider and rapider..

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