Research on Quality Inspection Method of Digital Aerial Photography Results

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Abstract：*Photogrammetry is the main access to obtain geospatial information , the quality of the results will directly affect the follow-up results of the quality of surveying and mapping . Therefore , We need a comprehensive aerial photographic quality inspection results . Correct evaluation of the quality of digital images is an important but difficult to solve the research topic . Many of the current image quality evaluation mainly relies on the subjective judgments . With the rapid development of image acquisition and processing technology and people's increasing demand for image information, It has become increasingly important economic significance and practical value to research the objective evaluation method that can accurately reflect the subjective evaluation. In this paper , I analyzed the traditional methods and several cutting-edge methods of the digital image quality evaluation . According to the analysis and comparison of image quality evaluation methods , I forecast the development of the image quality evaluation methods. the methodology, based on modulation transfer function combined HVS model evaluation methods for image quality evaluation is expected to achieve breakthroughs in difficult problems. With the development of the image analysis and processing technology, especially the development of computer vision and intelligence technology, the difficulty of image quality evaluation also will be resolved.*

Keywords：*digital aerial photography results, quality evaluation, modulation transfer function, human visual system, gray prediction error, visual interests*

1. Introduction

With the rapid development of surveying and mapping , computer technology and CCD technology progress , aviation digital camera has become the main technical means to control the high resolution and precision aerial remote sensing and the aerial technology without contral, digital aviation photography has obvious advantages . In the process of the informatization surveying and mapping system construction , as an important foundation geographical data source , digital aviation photography will be more and more . The real-time data processing and automation of informatization surveying and mapping requests the automation and rapid response of quality inspection and assessment , and it is a challenge to how to check digital aviation photography results .

The content of aerial photography results quality is extensive , and it needs for the 100% inspection of data quality , flight quality , image quality and annex quality . Now it needs for a long time to use manual inspection method to check aerial photography results quality , and the efficiency is low . Digital aviation photography results also provide print pictures, but the picture is small , the overlap is big , and the number is big . so the manual inspection efficiency is lower . But digital aviation photography provides data , so it makes it possible to use the computer to check the quality comprehensively and carefully .

To sum up above all, in order to adapt to the needs of informatization construction of surveying and mapping system , basic surveying and mapping and post-disaster reconstruction , it needs to study the quality inspection methods of digital aviation photography results . This project aims to research and

analysis aerial photography quality inspection results based on current technology , research and establish digital aviation photography results quality inspection methods , and explore the flight quality , computer automatic quality inspection method . So it lays the foundation for the development of practical "digital aviation photography results quality inspection system" software

2. The traditional image quality inspection methods

2.1 Subjective evaluation method

According to some observers' assessment scales or their experience , The quality scores are given . all scores take averages and it is the subjective quality evaluation. Two kinds of observers are included , some are experienced experts , others are normal , because their experience and angle of concern is different , finally comprehensive consideration of the evaluation result is more persuasive .

Subjective evaluation includes two kinds of measurement scales , namely absolute scale and relative scale . So-called absolute scale is giving a score according to the quality of images , and the relative scale is giving a score according to the comparison of some image .

Subjective quality assessment standards

level	absolute scale	relative scale
1	very good	the best
2	good	More than the average
3	general	the average
4	poor	Below the average
5	very poor	the worst

Subjective evaluation method can better reflect the quality of images, but it excessively affected by the knowledge background , emotion , motive and fatigue etc . From engineering point of view , this kind of method is too time-consuming and is not described by mathematics model , so that it does not facilitate computer calculation .

2.2 Objective evaluation method

Using algorithm for image quality evaluation . This method is convenient , quick , easy to realize and . combined with the application system , but it is different from subjective feelings . Below are some typical image evaluation methods .

2.2.1 variance

Variance is a statistics which reflects the whole image gray-scale distribution . The variance is larger , the contrast is larger , Conversely , if the variance is smaller , the contrast is smaller . Computation formula is as follows

$$s^2 = \frac{1}{M \bullet N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left(f(i, j) - m \right)^2 \cdot \quad (1)$$

M and N are the row and the column of the image , $f(i, j)$ is the gray value , and m is the grayscale average .

2.2.2 Average gradient

Average gradient refers to reflect the degree of contrast images subtle . Computation formula is as follows

$$s^2 = \frac{1}{M \bullet N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left(f(i, j) - m \right)^2 . \quad (2)$$

M and N are the row and the column of the image ,

$f(i, j)$ is the gray value,

$\nabla_i f(i, j)$ is the gredient in row direction ,

and $\nabla_j f(i, j)$ is the gredient in column direction . Generally speaking , the average gradient is more bigger , the image is more clearer and contrast is good , but gradient gredient is affected greatly by noise .

2.2.3 Information entropy

Information entropy reflects image information abundance extent from the angle of information . According to the Shannon information entropy principle , Computation formula is as follows

$$H(X) = -\sum_{i=0}^{L-1} P_i \log(P_i) \quad (3)$$

.

L is the biggest grayscale level and P_i is the probability of the grayscale which value is i .

2.2.4 Mean-square error

MSE is a statistics which reflects image gray-scale between the original image and the transformation imag . Computation formula is as follows

$$MSE = \frac{1}{M \bullet N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (\hat{f}(i, j) - f(i, j))^2 . \quad (4)$$

MSE is Mean-square error , $f(i, j)$ is the gray value of the original image , $\hat{f}(i, j)$ is the gray value of the results image .

2.2.5 Peak value signal-to-noise ratio

PSNR is mainly used in evaluating image quality changes through compression, transmission and treatment , its nature is like mean-square error . Computation formula is as follows

$$PSNR = 10 \log_{10} \frac{256 \times 256}{MSE} \quad (5)$$

.

MSE is Mean-square error .

The information entropy can be used to compare information changes when images are compressed or

processed , but it is not appropriate to consider it as the standard of image quality . Because the information of the same remote sensing images in the same area but in different time is different .

MSE and PSNR can reflect the overal difference between the original image and the restore image , and can not reflect the local case like a bigger gray difference and a small gray difference among more pixels . Obviously all pixels can not be treated the same , thus it can not reflect the human visual characteristics .

3. Several new evaluation methods

3.1 Metho d based on modulation transfer function

Method based on modulation transfer function is objective , can transfer and is easy to measure , which is a comprehensive image quality evaluation method accord with evaluation standard . steps are as follows

Use edge extraction technology to obtain blade and determine the scope and direction of blade in the digital image .

Do re-sampling of blade and filter .

Get line diffusion function through derivation of blade brightness curve and obtain its equivalent width .

Obtaine modulation transfer function through fourier transform of line diffusion function .

Generally speaking, the low frequency part of modulation function decides image contrast , the high frequency part desides image details and clear expression abilit y . Therefore , we always hope modulation transfer function curve containing area that is bigger is better , thus we can use envelope area of the transfer function to judge image quality .

3.2 Method based on human visual system

It is a method that meets human visual system . The method is added up to some stage results of human visual system and its evaluation results can reflect people's subjective feeling . The typical model include three significant characteristics , namely the visual non-linear characteristics , the visual resolution sensitivity bandpass characteristics , the visual multi-channel structure and cover effect .

3.3 Method based on gray prediction error

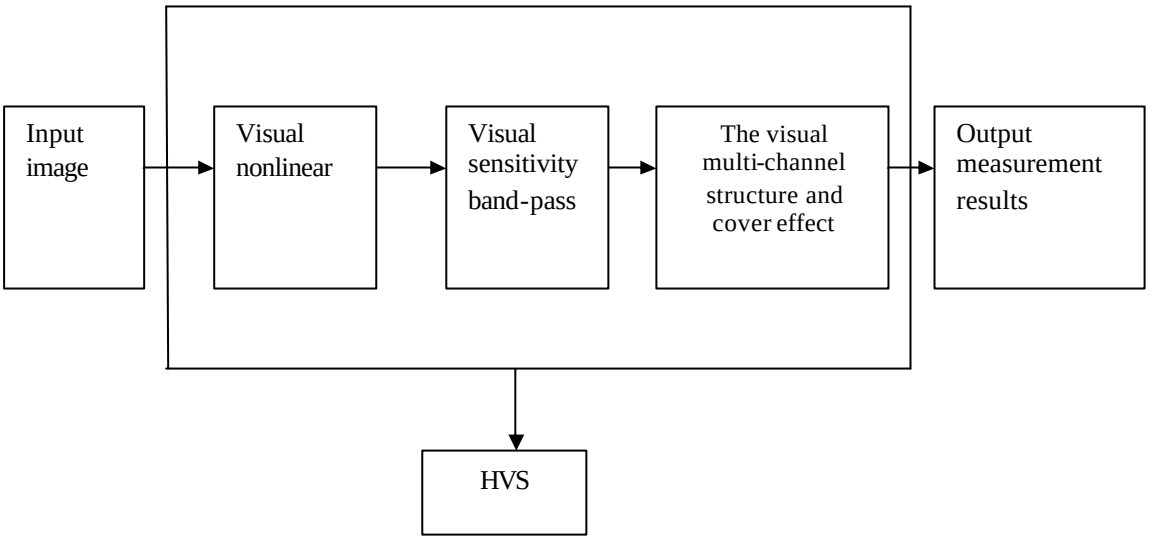
DPCM (differential pulse code modulation) system is a classical image linear coding system . It includes two basic premise . One is that images can be considered to be a smooth airport and its correlation function has nothing to do with pixel position , another is that image has high correlation in the local area , so image grey value of a point can be estimated though adjacent pixel grey value . This evaluation method is that comparing real and estimated values to get the images evaluation results .

Set $f'(m,n)$ as the estimate of pixel , $e(m,n)$ as estimated deviation , If use third-order prediction , then

$$\hat{f}(m,n)=a_1 f(m,n-1)+a_2 f(m-1,n-1)+a_3 (m-1,n). \tag{6}$$

$$e(m,n) = f(m,n) - \hat{f}(m,n). \tag{7}$$

According to the principle of least squares estimate and separation characteristics of image correlation function , we can get coefficients of gray estimate function .



$$a_1 = \frac{R(0,1)}{R(0,0)} \cdot a_2 = \frac{R(1,1)}{R(0,0)} \cdot a_3 = \frac{R(1,0)}{R(0,0)} \quad (8)$$

If coefficient values can be obtained , we can get the gray prediction deviation of images .

$$\hat{s}_e = \sqrt{\frac{1}{M \bullet N} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} [e(m,n)]^2} \cdot \quad (9)$$

Average variance of deviation accumu lation can be used to evaluate the quality .

3.4 Method based on fuzzy measure

The uncertainty of digital images contains both randomness of imaging process and mbiguity of their own . In gray fuzzy measure , using the method of fuzzy entropy , and fuzzy entropy reflects the overall image information and pixel gray average . In space fuzzy measure , method to calculate the area , perimeter , a degree of index and the image information of fuzzy sets , which reflects the geometrical characteristics of the i mage's fuzzy degree .

Such as gray measure method , at present the most influential method is the fuzzy entropy algorithm . It can reflect the average fuzzy degree of fuzzy sets pixel . A

two-dimensional image which grayscale is L and size is M x N can be considered to be a fuzzy array , and the membership of each element stands for the brightness degree compared to brightness levels .

Research shows that we can use S function to take the gray value of image space domain to mapping the eigenvalues of the fuzzy feature plane , and S function is defined as follows

$$P_{i,j} = S(x_{i,j}, a, b, c) = \begin{cases} 0 & x_{i,j} \le a \\ 2(\frac{x_{i,j} - a}{c - a})^2 & a \le x_{i,j} \le b. \\ 1 - 2(\frac{c - x_{i,j}}{c - a})^2 & b \le x_{i,j} \le c \\ 1 & x_{i,j} \ge c \end{cases} \quad (10)$$

$b = (a + c)/2$ is A boundary , and if $x_{i,j} = b$, then $P_{i,j} = 0.5$. $\Delta = c - b = b - a$ is bandwidth of mapping function .

3.5 Method based on visual interest

People in the observation and understanding the image are often interest of some areas , and these areas is called areas of interest . The whole image visual quality often depends on the quality of areas of interest and sometimes the drop quality of the area that is not intrested in is not be perceived . Method based on visual interest reflects intrest degree of the area of intrest through the weighted average for different areas .

Set only one intrest area can be in cluded in test image which is **A1** , and its area is S1 . areas that are not to be intrested which is A2 , and its area is S2 . The total area is **S=S1+S2** . Computation formula is as follows

$$IMSE = \frac{1}{S}\left[l_1 \sum_{(i,j)\in A_1} (f_{ij} - f'_{ij})^2 + l_2 \sum_{(i,j)\in A_2} (f_{ij} - f'_{ij})^2 \right]. \quad (11)$$

l_1 is the weighted value of A1 and $l2$ is the weighted value of A2 , and meet the equation $l_1 * S_1 + l_2 * S_2 = S$. The weighted value is bigger and the interest degree of the area is bigger . The formula of l_1 and l_2 as follows

$$l_2 = 1 - \frac{2k}{S}\sqrt{S_1(S - S_1)}. \quad (12)$$

$$l_1 = \frac{S}{S_1}(1 - l_2) + l_2. \quad (13)$$

$k \in [0,1]$ is adjustment factor , and it reflects the emphasis of the human eye to those areas that are not to be interested . We can see that if S1=0 then $l_2 = 1$ and if S2=0 then $l_1 = 1$ from the equation , at this tima IMSE degenerate into MSE . Traditional objective evaluation methods is the exception of this method . It can better reflect the subjective visual .

Method based on visual interest can better consistent with the subjective visual , but this method is still in the initial stage of study , there are still many problems to rearsh . such as , determine the areas of interest , how to do if the test image contains multiple areas of interest , and how to determine the weights of some areas etc .

4. Conclusions

Firstly , the progress of visual perception biological psychology experiment is the basic research of image quality evaluation , the human visual system (HVS) is based on this . A large number of experiments show that people's knowledge in visual perception is very poor .

Secondly , Continue to study the HVS model . The mature HVS model makes us not to find an analytical formula to simulate human visual process . But common evaluation model means easy to calculate like square error . It requires us to fully consider visual physiological and psychological tests and to use the latest mathematical tools for research .

Thirdly , method based on modulation transfer function combined with the HVS model is expected to solve problems of image quality evaluation . With the development of image analysis and processing technology , especially the development of computer visual and intelligent technology , the image quality evaluation difficulties will become a breakthrough .

References

[1] Xiong Xinghua, " Digital image quality assessment", *Science of Surveying and Mapping*, 2004,

[2] Xu Luan, The method to evaluate image quality,wavelet transform,luminance,definition,correlation,multi-scaling, ZheJiang University, 2003,

[3] Wang Kongqiao, "Quality Assessment of Digital Images", *MEASUREMENT & CONTROL TECHNOLOGY*, 2000,

[4] Wang Yu, " Explortion on digital image quality assessment method", *REMOTE SENSING INFORMATION*, 2004,

[5] YU Liang-fei, "The quality evaluation of digital mapping camera figital image", *Technological Development of Enterprise*, 2009,

[6] Wang Yu,, Hu Zi, Zhang Baoming " Research on digital image quality assessment", *Bulletin of Surveying and Mapping*, 2002,

[7] Wang Yu, Research on digital image quality assessment, Zhengz hou,Henan, 2001,

[8] Wei Zhenggang, Yuan Jiehui, Cai Yuanlong, " The History, Status and Future of Image Quality Evaluation" , JOURNAL OF IMAGE AND GRAPHICS, 1998,

[9] Zhang Man, Research on image quality assessment method, Shandong University, 2007,

[10] Xiong Xinghua, Zhang Li, "An Image Quality Evaluation Method Based on Gray Prediction Error" ,*Journal of Image and Graphics*,2004,

[11] Wei XiaoYan, The precison analysis and quality assessment of RS image data processing ,Tongji University, 2004,

[12]WANG Kong qiao; SHEN Lan\|sun; XING Xin,"A Quality Assessment Method of Image Based on Visual Interests" ,*JOURNAL OF IMAGE AND GRAPHICS*, 2000.