THE DIFFERENTIAL BRIGHTNESS MEASUREMENT AND THE EXPOSURE SYSTEM OF AERIAL PHOTOGRAPHY

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ABSTRACT

This paper analyzes the exposure control principle in the process of aerial photography. Acquiring the optimum exposure is a key to improve the image quality of photography. The method of using differential brightness measurement and mean differential brightness control exposure has been advanced through analyzing the strong and weak points of various exposure light measuring methods and by means of sensor filter and microcomputer. The affected factors of all related aspects, the different mathematical models of calculation and exposure control or the method of calculation, diagram have been analysed, which provides the way for realizing this system.

INTRODUCTION

In the process of black/white and color aerial photography, the ground object brightness range of aerial photography is changeable, if the spectral radiation brightness range of object can be recorded linearly on sentitized material and the optimum space frequency response can be got, to a considerable degree, it depends on the acquirement of optimum exposure and the development of optimum condition. Controlling this condition will become the important research project of the present aerophotography, too.

Owing to photography being carried out through atmosphere, such a changeable medium under the condition of dynamic flying, its object brightness and brightness range will be changed with terrain, flying height, the angle of solar altitude, atomospheric transparency, vegetation and the spectral characteristic of object. In order to correctly determine its object brightness and brightness range, it is necessary to adopt a real—time multi—points and light measurement for new diffretential brightness measurement and exposure system.

On the basis of application of modern photographic camera and film, automatic developing equipment and sensitized instruments, in determining the effective sensitivity of photographic film, the aerial objects can be scanned by silicon linear array sensor of craft carrier and differenness and brightness ratio. Calculating exposure and developing contrast coefficient is in controlling the developing process. Image displacement shall be calculated so that the matching of optimum aperture shutter can be selected and differential mean brightness can be utilized to control exposure, all of which will enable the air photographers to control and acquire better image quality.

THE PRINCIPLE OF ACQUIRING OPTIMAL EXPOSURE

The quality of thotographic image is manifested on the property of record, resolution and measurement for detailed objects. The record property shows that the object spectral energy is in density mode for linear expression ability.

The resolution and measurable property show the capability of resolution and measurement for minimum adjacent object, including the geometric and physical characteristics of objects.

The experiments prove that the size of image grain formed on the same sensitized material is mainly dependent on the size of forming latent image center. Therefore, it is very important to obtain the optimum exposure. From Fig. 1 it can be seen that, the corresponded density value of maximum resolution Rmax is about D=1.0, the corresponded $\triangle$logH of its Rmax 0.8 is the optimum exposure range. In order to enable all the objects of various brightness range to be recorded within optimum density range (D0.4 ~ 1.6), different r value is needed, in the developing process so as to get different exposure latitude $\triangle$logH and to obtain different brightness ratio for object so that all of these can be within the density range of optimum resolutioin for sensitized material. Fig. 2 and Fig 3 show the relations of the maximum resolution and contrast as well as latitude, object brightness proportion.

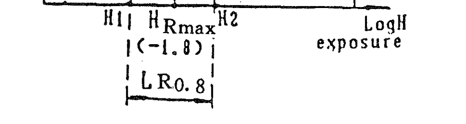

Fig. 1 Exposure and resolution curve

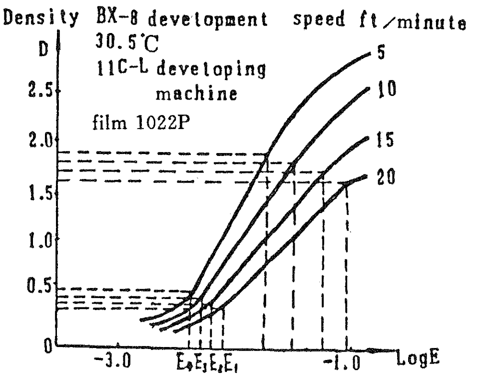

Fig. 2 The characteristic curve of film 1022P

Because the aerophotographic platform generally is a high speed flying machine, it is important to calculate image displacement and select the matching of optimum aperture and shutter in acquiring optimum exposure so that exposure can be done at a short shutter speed.

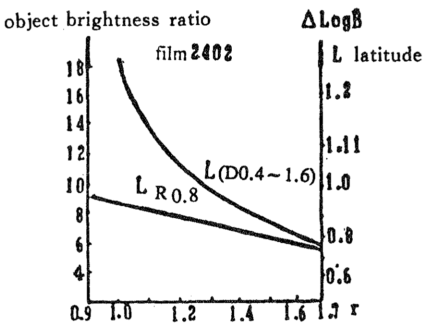

Fig. 3 The relation curve

Resolution will be reduced in using large aperture while reducing shutter time so as to reduce image displacement will rely on the application of large aperture. It is a feasible method to select higher sensitivity and better resolution film and use image displacement compensation camera. brightness ratio

It is quite necessary to add the same band filter on camera and sensor so as to eliminate atomosphere scattering effects. The real multiplier of filter is calculated by the following formula:

Kf=Kl • AV • h

The formula of exposure calculation using mean brightness is:

$$t = \frac{K^2 \cdot Kf}{\overline{B} \cdot S_{Do+0.85}} \cdot C$$

The formula of exposure calculation using minimum brightness is:

$$t = \frac{K^2 \cdot Kf}{\overline{B}_{small} \cdot S_{Do+0.3}} \cdot C'$$

Kf—practical filter multiflier

AV—the vignetting coefficient of camera

h—the correction of film color sensitivity

K—aperture number

t—shutter coefficient

$\overline{B}$—object mean brightness

$\overline{B}$small—minimum mean brightness

S—Sensitivity

C. C'correction constant

THE DETERMINATION OF DIFFERENTIAL MEAN BRIGHTNESS

What the automatic exposure control for most aerial camera presently uses is the method of integral determination object brightness, the objects of tigh brightness and low brightness within sensor visual angle are mixed up, the photographed comprehensive output is a mean value of weighting. In terms of the resolution characteristic curve of sensitized material, the point of mean brightness value should be in the position of characteristic curve D# =Do+0.85; and the whole brighness range will be in the part of straignt line of characteristic curve, i.e. within D 0.4 ~1.6. However, the proportion of object brihgtness can not be measured by integral light measuring, and the proportion and meaurement value of bright object and dark object can not be reflected. As a result, the development r value can not be selected in accordance with the brightness proportion. It will cause deviation in the following three conditions: while the object brightness ratio is especially great, the development r is fixed, and the corresponded latitude of optimum density range is also fixed, at this moment the density of high brightness part will be over D1.6, and the part of low density will be less than D0.4. When the to high brightness object is great and the low brightness object is smaller, the correspondant density of integral mean brightness at this moment is 1.0. The object of low brightness part will be below 0.4 and the exposure is unsufficient. While the low brightness area is great and the high brghtness area is smaller (e.g. open space in forest), the part of high brightness will appear over great density and overexposure. The worst situation is that as water surface appears mirror reflection, or snow mountains, small pieces of cloudes, white sandy beach show up, the other object density will be reduced or even film scrapped by overpowerful reflection value.

Another methed to determine exposure by minimum brightness is on the basis of $S_{Do+0.3}$ as exposure so that the point density come to Do+0.3. The accuracy and reliability of this method is dependent on the minimum brightness which can be measured within format, and it should avoid to product a great change for the minimum brightness jumping in the photographic process, especially several large area bright objects continuously come out or the minimum brightness has not been collected, so that exposure will be reduced and the density of bright object will fall off to D0.4, unsufficient exposure will appear.

In order to overcome the weakness of the above two methods, a system of differential mean brightness exposure is designed. The system involves 30 silicon photo — conductive elements and 30 lines will be scanned on each sheet and 900 points in total. After removing the overlarge brightness automatically, 30 maximum values and 30 minimum values will be taken to extract the mean maximum brightness and the mean minimum brightness, and to calculate the brightness proportion of object and r value. Through the changes of development r value the density range and exposure latitude can be accordant with the brightness proportion of object, even if the whole piece of object is bright, it also can be image—formed at optimum resolution about D1.0, the resolution of photographic results can br improved and enhanced in overall.

$$r = \frac{\triangle D}{\triangle \log B}$$

△D — select the suitable density difference of photographic film,

△logB—logarithm of object brightness B

THE MATCHING OF SENSOR SENSITIVE RANGE AND PHOTOGRAPHIC FILM

The accordance of sensor spectral sensitive curve and film sensitive range is a fairly important problem. It is found through the experiment that the general illuminometer is registered in terms of human eye effects, its sensitive band peak is at green — yellow band, and the sensitive curve of general panchromatic film at green band is concave, so more than 1/2 step tolerance will appear while using in the sky above forest area. The sensitive band peak of silicon elements is at 800～900μm, in order to match with the common use film, three channel filters are collocated, which can be changed and selected.

The sensitive wave crest of silicon photoelectronic elements is at $\lambda = 800 \sim 900\mu m$, the spectral correction must be carried out, so as to match with the sensitive curve of film used. In accordance with 1022P black and white film produced in China, kodak 2402 black and white film of U. S. A., 1821 color infrared negative film produced in China, three changeable channels should be collocated, so that the comprehensive spectral response curve of sensor will be consistent with film sensitive curve through filter correction.

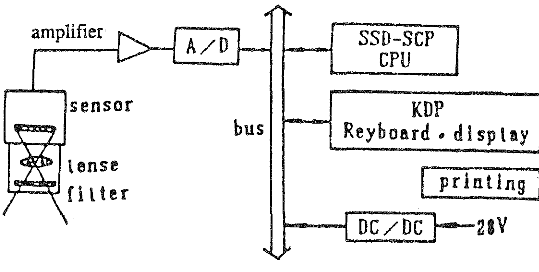

Fig. 4 The hardware system

THE MEASURING SYSTEM

The sensor adopts f－58mm lense, there are 30 pixels with each size 1 × 1mm on focal surface, the differential lighted angle is 1. 2°, such a size particularly fit large scale photography. Photo electric current of sensor is amplified by amplifier, the analog data will be transmitted into SSD chip micro－computer after transforming, the exposure measuring value can be displayed and printed once every 3 seconds, its system diagram can be seen from the following figure.

In measuring 900 values every time, the smoothing processing will be done on the overlap between adjecent photos, as the mean brightness is changed step by step, four times smoothing can meet the requirements. Therefore, in acquiring exposure data, as long as over 12 seconds are available to accumulate data, the correct exposure parameter can be displayed and printed, generally it is only equal to the time of each flight line preparation for entering into flight line, sampling flying in large area is not reqired.

The system is also possible to have the function of minimum brightness exposure control, which provides another choice for specific photography.

SUMMARY

The purpose of acquiring photographic optimum exposure is to enable the object brightness range to be imaged on the part of straight line of sensitized material characteristic curve of optimum resolution, to select optimum aperture and control image displacement as small as possible so as to get optimum image quality. To realize this goal, a primary attempt has been made for the research and experiment of this system and various experiments. The work aforementioned has been carried out through the cooperation of the Research Institute of Surveying and Mapping, the National Bureau of Surveying and Mapping and the General Aviation Co. of China.

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