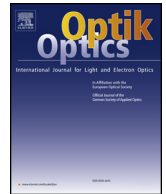




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Original research article

Impact analysis of lens shutter of aerial camera on image plane illuminance

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ABSTRACT

In order to obtain high resolution aerial images, in addition to adopt high transfer function of optical system and high quality imaging medium, the exposure time of the shutter should be properly controlled, so as to make sure the appropriate exposure of the CCD sensor. The paper applies an aerial mapping camera shutter the structure and working principle of the mirror, presents the mirror shutter algorithm of the working period of luminous flux, on the basis of radiation theory. The paper also analyze the transfer relations of the object and image of the light energy on the optical system with large field of view, short focal length and large relative aperture. The experimental results show that the illumination precision of image plane improved by 8.9%, compared with the traditional algorithm and the gain exposure of CCD sensor is closer to the actual light energy. In addition, these design can also provide theoretical reference for image uniformity correction, CCD gain adjustment and variable density neutral filter processing.

1. Introduction

Aerial photography is an important means to obtain the target information [1]. As a device to control exposure, the shutter is an important part of aerospace camera. If the quantity of exposure can not be properly controlled [2], high resolution images will not be obtained. The overexposure or underexposure will lead to loss of target information, and camera performance and function will not play well.

Based on the development of the digital aerial photography camera, the edge illuminance of content mirror surface with large field of view relatively seriously decline, compared with center of the optical system. In order to improve the resolution of image edge, exposure has to be increased 2–3 times, which will lead to the inner part of the field exposure, uniformity, lower contrast and declined image quality. In order to improve the field image quality, the changed density plating membrane filter is usually applied in optical system, which reduce the inner part of the photo exposure two-thirds in the center and almost none in the corner [3]. Although this process can reach the requirement of uniform illumination, but lost a part of light energy, reduces the image plane illumination value. Therefore, it is necessary to analyze the impact of the shutter working process on the surface illumination based on radiation theory [4].

2. Structure design of shutter

Combining with the camera shutter operating characteristics and technical parameters, we develop a aerial shutter mechanism

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Fig. 1. Photograph of Shutter.

between the mirror. The shutter has a wide range to adjust exposure time, high optical efficiency and adjustable exposure time [5].

The target camera belongs to the type of surveying and mapping camera, so the shutter can't affect the calibration precision of inside azimuth element. Therefore, we can only adopt the central type shutter. The shutter is mainly composed of blade, slow shutter shell, transmission gear train and drive motor and so on. The material object of shutter is shown in Fig. 1. The shutter controls the rotation of the blade so that the opening of the fast blade and the slow blade is exposed by the light beam.

The fast blade controls the exposure time, and the slow blade controls the exposure cycle, which is equivalent to the light brake.

2.1. Design of shutter-blade

The air gap between the lens group of the optical system is quite small, and the aperture stop is also placed in the middle of the air gap location. So the distance between the blade and the aperture stop and lens group is only 0.4 mm. In order to ensure the reliability and service life of the shutter structure requirement, the rotational inertia of the blade and shaft parts must be reduced. So the shutter blade material compose of high elastic modulus carbon fiber composite material [6]. The 3D model of the blade is shown in Fig. 2.

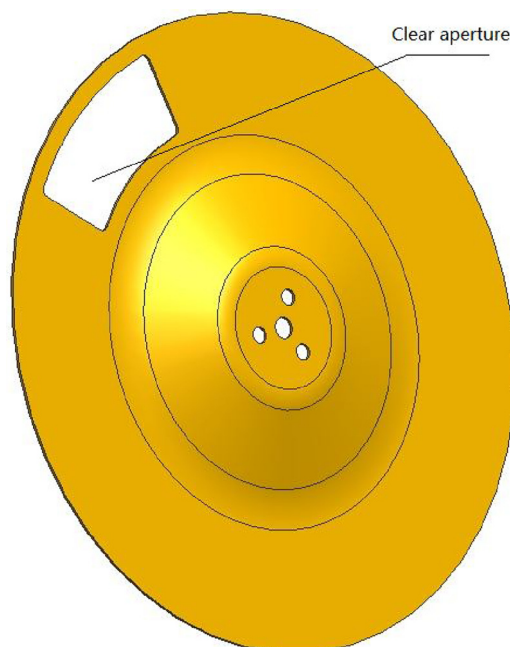


Fig. 2. Three-dimensional Model of Shutter-blade.

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