EXPOSURE ADJUSTMENT OF SATELLITE CAMERAS

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ABSTRACT

Luminance and contrast of satellite images are largely determined by exposure status of the onboard camera. Only with appropriate exposure level can the output Digital Numbers(DN) be contained within the dynamic range of the camera and be distributed as evenly as possible, thus acquiring images can retain the most information details. With a higher exposure level, bright parts of the image may be saturated and cause information loss. While with a lower level, output Digital Numbers may concentrate at lower parts of the dynamic range and leave the high dynamic range unused, causing reduction of the image contrast. Therefore, during the imaging process, exposure status of the satellite camera has to be set appropriately for effective picturing of earth objects.

Radiant energy of exposure is composed of integration time and radiant luminance, the level of exposure can be regulated with adjustment of aperture size or change of CCD array integration time. In this paper, firstly the theoretical bases that relate to exposure adjustment are analyzed, then, the exposure adjustment in means of integration time adjustment is discussed with experiments on the Beijing-1 small satellite.

The radiance luminance that enters the camera aperture is determined by sun elevation angle, object reflectance or emissivity, camera spectral response, atmospheric conditions, etc. In this paper affections of these factors are discussed with determining of the factor ranges and with results from the 6S atmospheric model simulation. Analyses show that sun elevation angle and reflectance are the two major factors that affect the radiance luminance.

The imaging process of CCD cameras includes photo-detection, charge transfer, charge conversion, amplification, quantification, etc. With discussion of the process from exposure to Digital Number, the digital output change that corresponds to the input luminance change is also analyzed and tested with Beijing-1 small satellite. The relation is proved to be linear.

Integration time of the camera onboard Beijing-1 small satellite can be adjusted from 6.4 μs to 4799.2 μs with an increment of 0.8 μs .Analysis of the images acquired from the current integration time status shows that most of the images are underexposed, the exposure level should be heightened, thus a new strategy of adjusting the integration time considering object type and sun elevation angle is proposed with analysis of the DN numbers of representative objects and simulation with 6S atmospheric model. Comparison of the images acquired before and after adjustment is done with Signal Noise Ratio, Modulation Transfer Function and classification ability. The results show that better images can be acquired with the adjusted exposure strategy.

Systematic discussion about exposure adjustment is conducted in this paper, and practical experiment is also done with satellite that is in operation. Results from the paper show that for satellite cameras that have defined bits of quantification, appropriate adjustment of the exposure level can surely improve quality of the acquired images. Although experiments in this paper are mostly with the Beijing-1 small satellite, the theories are universal, and the methods can still be applicable to other satellites just with adjustment of the parameters.

REFERENCES

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