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SPECTRAL RESPONSE IN-FLIGHT ESTIMATION OF SICH-2 MULTISPECTRAL SATELLITE SYSTEM

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Abstract. A method for sensor spectral response estimation of Sich-2 multispectral satellite system based on satellite imaging of ground calibration test site is presented. A special parameterization of spectral response function of multispectral sensor is offered. Such parameterization provides an analytical solution of optical radiation transfer equations.

Keywords: satellite system, multispectral sensor, spectral response, ground calibration test site

Multispectral satellite imaging is the basis for most applications of remote sensing. Physical modelling requires exact spectral calibration of multispectral data sources. The spectral calibration objective is the spectral sensitivity determination in each spectral band of multispectral satellite system. It is impossible to carry out radiometric calibration of multispectral satellite system and radiometric correction of multispectral imagery without spectral sensitivity.

Spectral sensitivity in *j*-th spectral band $S_j(\lambda)$ is used to calculate the spectral radiance L_j [1]:

$$L_j = \int_0^\infty L(\lambda)\, S_j(\lambda)\, d\lambda \qquad (1)$$

here $L(\lambda)$ is at-sensor spectral radiance.

Spectral sensitivity determination by imaging of *i*-th test object even with a known spectral reflectance $\rho_i(\lambda)$ is mathematically incorrect problem. Registered spectral radiance (1) depends on the spectral irradiance $E_0(\lambda)$ on land surface, spectral reflectance of the object of imaging and the atmosphere spectral transparency $\tau(\lambda)$. Because the real width of the spectral bands of multispectral satellite system is quite small, it is possible to consider the spectral irradiance E_j and atmosphere spectral transparency τ_j as constants within ones.

For known $\rho_i(\lambda)$ it is impossible to restore the arbitrary $S_j(\lambda)$ function from (3) by the measured value of L_{ij}. It is offered to apply a parameterization of $S_j(\lambda)$ and $\rho_i(\lambda)$ functions for a solution of this incorrect problem. Spectral sensitivity is approximated by gaussoid with κ_j, λ_j and σ_j parameters:

$$S_j(\lambda) = \kappa_j \exp\left[-\frac{(\lambda-\lambda_j)^2}{2\sigma_j^2}\right] \qquad (2)$$

and spectral reflectance of objects of imaging is approximated by linear function with a_{ij} and b_{ij} parameters:

$$\rho_i(\lambda) = a_{ij}\lambda + b_{ij} \qquad (3)$$

Then the integral equation (1) becomes possible to transform into algebraic one, and gaussoid parameters can be found by least-squares method in the form of:

$$\begin{pmatrix}\kappa_j\sigma_j\\ \kappa_j\sigma_j\lambda_j\end{pmatrix} = \frac{1}{\sqrt{2p}}\begin{pmatrix}\sum_{i=1}^n b_{ij}^2 & \sum_{i=1}^n a_{ij}b_{ij}\\ \sum_{i=1}^n a_{ij}b_{ij} & \sum_{i=1}^n a_{ij}^2\end{pmatrix}^{-1}\begin{pmatrix}\sum_{i=1}^n b_{ij}\frac{p\,L_{ij}}{E_j\tau_j}\\ \sum_{i=1}^n a_{ij}\frac{p\,L_{ij}}{E_j\tau_j}\end{pmatrix} \qquad (4)$$

The outlined method has been tested using the “Sich-2” multispectral satellite image (Fig.1) of the ground calibration test site of National Space Facilities Control and Test Center (NSFCTC), Eupatoria, Crimea.

The ground spectrometry measurements of natural and artificial objects of NSFCTC were used for spectral calibration of the “Sich-2” multispectral satellite system. These measurements were carried out synchronously with satellite imaging. Spectral reflectance curves were linearized within each spectral band of the “Sich-2” multispectral satellite system.

Preliminary results of the “Sich-2” multispectral satellite system spectral calibration are illustrated by Fig. 2 plots.

As a comparison, Fig.3 shows the laboratory spectral sensitivities of working bands of the “Sich-2” multi-spectral satellite system [2].

The values of parameters obtained by calibration are in good agreement with the expected ones, although some instability of measurements and results dependence on test objects configuration were observed. Systematic shift of the central wavelength for 5–10% in a short-wave spectrum and systematic narrowing of the spectral band for 10–40% were registered.

The offered parameterization model is not the only possible. An approach to the numerical solution of system of integral equations (1) for arbitrary spectral reflectance of test objects is under study now.

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Fig. 1. “Sich-2” multispectral satellite image NSFCTC, November 8, 2011, 7.8 m spatial resolution, spectral bands 2 (0.61-0.68 μm), 3 (0.79-0.89 μm), 1 (0.50-0.59 μm)

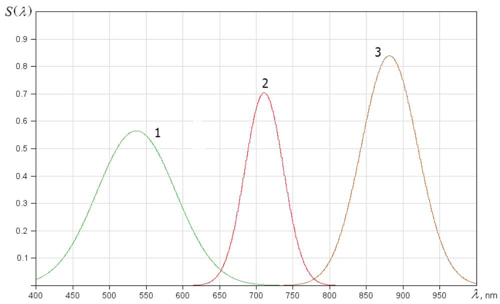

Fig. 2. Approximated spectral sensitivities of the “Sich-2” multispectral satellite system

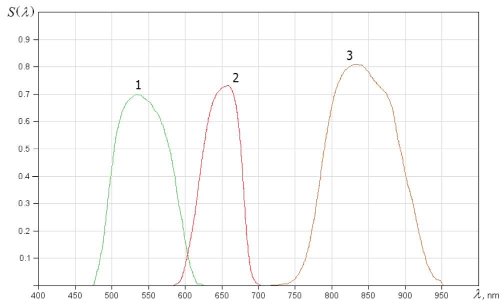

Fig. 3. Laboratory spectral sensitivities of the “Sich-2” multispectral satellite system

References

1. Stankevich S. A. Informativity of Earth remote sensing optical bands: the practical algorithms (Russian) // Space Science and Technology, 2008.- Vol.14.- No.2.- P.25-28.
2. Tyagur V. M., Likholit N. I., Kolobrodov V. G. Optical systems of space-borne multispectral scanners (Ukrainian) // Research Bulletin of National Technical University of Ukraine “KPI”, 2006.- No.6.- C.125-132.

ОЦІНКА СПЕКТРАЛЬНОЇ ЧУТЛИВОСТІ БАГАТОСПЕКТРАЛЬНОЇ ЗНІМАЛЬНОЇ АПАРАТУРИ СУПУТНИКОВОЇ СИСТЕМИ “СІЧ-2”

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Резюме. Представлено метод для оцінки спектральної чутливості багатоспектральної знімальної апаратури супутникової системи “Січ-2” за результатами космічного знімання тестових об’єктів наземного контрольно-калібрувального полігону. Запропоновано спеціальну параметризацію функцій спектральної чутливості багатоспектральної знімальної апаратури, що дозволяє роз’вязати систему рівнянь переносу оптичного випромінювання аналітично.

Ключові слова: супутникова система, багатоспектральна знімальна апаратура, функція спектральної чутливості, наземний контрольно-калібрувальний полігон

ОЦЕНКА СПЕКТРАЛЬНОЙ ЧУВСТВИТЕЛЬНОСТИ МНОГОСПЕКТРАЛЬНОЙ СЪЕМОЧНОЙ АППАРАТУРЫ СПУТНИКОВОЙ СИСТЕМЫ “СИЧ-2”

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Резюме. Представлен метод для оценки спектральной чувствительности многоспектральной съёмочной аппаратуры спутниковой системы “Сич-2” по результатам космической съёмки тестовых объектов наземного контрольно-калибровочного полигона. Предложена специальная параметризация функций спектральной чувствительности многоспектральной съёмочной аппаратуры, позволяющая решить систему уравнений переноса оптического излучения аналитически.

Ключевые слова: спутниковая система, многоспектральная съёмочная аппаратура, функция спектральной чувствительности, наземный контрольно-калибровочный полигон