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APPROXIMATION METHOD FOR DISCOVERY OF ANOMALOUS SIGNALS IN OPTICAL-ELECTRONIC DEVICES

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ABSTRACT: *The research is about registration of signals by optic-electronic devices. The subject of the current work is research of the approximative methods capability to discover anomalous signals in an impulse photometric device.*
The impulse photometric device ensures a high dimensional and timely resolution of the intensity distribution by natural optic emissions in the earth atmosphere and also light interference near the orbital station. The high spectral sensitivity and the dimensional resolution enable the research of fast processes, including pulsating polar lights, polar arcs, etc.

When we discover and identify distant objects, the input informational signal is a continuous process with medium dispersion and correlation function. In the optic-electronic system the signal is a combination of equal values in time.

KEY WORDS: *optic-electronic devices, signal registration.*

The research is about registration of signals by optic-electronic devices.

The aim of the paper is to research the use of the approximative methods to discover anomalous signals in impulse photometric devices.

The impulse photometric device gives a high dimensional and timely resolution of the intensity distribution by the natural optic emissions in the earth atmosphere and also light interferences near the orbital station. The high spectral sensitivity and the dimensional resolution enable us to explore the quick processes and to receive valuable information for the ecological sphere [2, 3, 5, 6] and the defence [4].

The input information signal $\lambda(t)$ when discovering and identifying distant objects is a continuous process with average σ_λ^2 and correlation function $R_\lambda(t)$. In the optical-electronic system the signal $\lambda(t)$ is an aggregate of equidistant values in time $\lambda(ti)$ ($ti = iT_0; i = 0,1,2...; T_0$ - period of discretization).

The principle of discovery of a distant object means that noise (background) signal, which enters in the registering tract of the device, has anomalous values $\lambda^*(ti)$ ($i = 0,1,2,..., \mathrm{n}$) to the information signal $\lambda(t)$ is approximated by Chebyshev's method [7] into a polynomial $\lambda_B(ti)$ with exponentiation $N-1(N \leq 1)$, and after that a factual error is calculated:

(1) $$\Delta^*(ti) = \lambda_B^*(ti) - \lambda^*(ti).$$

The a priori distribution of the approximation of $\Delta(ti)$ when there is no anomalous signal is:

(2) $$\Delta(ti) = \lambda_B(ti) - \lambda(ti),$$

where $\lambda_B(ti)$ – value of the approximation polynomial when there is no anomalous signal.

If the distribution is normal, it can be admitted that at $P = 0.99$:

(3) $$|\Delta(ti)P| = 3\sigma_\Delta(ti),$$

where $\sigma_\Delta^2(ti) = M[\Delta(ti)]^2$;

M - mathematical expectation.

Consequently, the identification of the limit value of the informational signal is boiled down to calculation of the dispersion error at the approximation $\sigma_\Delta^2(ti)$.

When calculating the limit value (3) and taking into account that the greatest anomalous errors in value are caused by the high order digits, it is necessary to evaluate the maximum number of the high order digits at which the existing anomalous error can be found with a determined probability $P_{OTKP} \geq 0{,}8$. The sought value is the ability to discover of the approximation polynomial.

If $\lambda(t)$ has a known correlation function $R_\lambda(t) = \sigma_\lambda^2 k_\lambda(t)$ [4], the manifestation of $\lambda(ti)$ is regular and it forms approximation polynomial:

(4) $$\lambda_B(ti) = \sum_{q=0}^{N-1} \sum_{k=0}^{n} \lambda(tk)Pq, \; n(k)Pqn(i).$$

On the basis of Chebyshev's polynomial [8],

(5) $$Pq,\ n(i)=\sqrt{\frac{(2q+1)n^{(q)}}{(n+q+1)^{(q+1)}}}\ \sum_{s=0}^{q}(-1)^s C_q^s C_q^s + s\frac{i^s}{n^s},$$

where $q=0,1,2...,N-1; i^s=i(i-1),...,(1-s+1)$ is a generalized exponent.

Taking into account that $i=\frac{ti}{T_0}$, the dispersion that is important for us will be:

(6 $$\sigma_\Delta^2(ti)=\sigma_\lambda^2\left[1-2\sum_{k=0}^{n}k_\lambda T_{OV}\sum_{q=0}^{N-1}Pq,n(k)Pq,n(i)+\sum_{i+0}^{n}\sum_{k=0}^{n}k_\lambda(l-k)T_0\sum_{q=0}^{N-1}Pq,n(l)Pq,n(i)\sum_{j-0}^{N-1}Pjn(i)\right].$$

When calculating the current factual error at the approximation (1), it is considered that an anomalous signal is registered at position i_a, which has an anomalous error σ_λ, i.e.

(7) $$\lambda^*(ti)=\left|\ \right|\begin{matrix}\lambda(ti)+\sigma_\lambda & \text{at } i=i_a\\ \lambda(ti) & \text{at } i\neq i_a.\end{matrix}$$

If we substitute equation (7) in (5) and the results are applied to (1), we receive the following for the factual error:

$$\left|\Delta^*(ti)\right|=\left|\Delta(ti)+\sum_{q+0}^{N-1}Pq,n(i)Pqn(i_a)-\delta i,i_a\right|\delta_\lambda,$$

(8) where $$ia=\left|\begin{matrix}1, i=i_a\\ 0, i\neq i_a\end{matrix}\right.$$

Analysing (8) together with (3), we notice that when the predefined probability of discovery $P_{OTKP}\approx 1$, and we can conclude that the minimal value of the anomalous error is:

(9) $$\left|\delta_\lambda\right|\geq\frac{2\left|\Delta(ti)\right|P}{\sum_{q=0}^{N-1}Pqn(i)Pqn(ia)\delta i,i_a}.$$

This allows the conclusion that the ability of the approximation capabilities of the approximation method when registering anomalous signals depends on the kind of the input information signal in the optical-electronic device and especially on the type of it correlation function.

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