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Range Estimation of a Fluctuating Target during the Probing with a Sequence of Rectangular Optical Pulses[1]

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Abstract—Dispersions of the range estimates have been obtained by using the local Markov approximation method. Losses in the estimate accuracy caused by the target fluctuation were also determined.

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Systems of optical location make a wide use of pulse sequences featuring the squared form of intensity [1–3], etc. In paper [3] characteristics of the maximum likelihood estimate (MLE) of range of a stable target during the probing with a sequence of rectangular optical pulses were found. However, many real targets are fluctuating [1, 2]. Target fluctuations and the physical effects accompanying the scattering and propagation of light in various media lead to the situation where the intensity of individual pulses of the received sequence of optical signals is generally unknown. In view of the above let us consider the range estimate of the fluctuating target.

Let us assume that the fluctuating target is located at distance R_0, while the optical signal travels with the speed c. Then the intensity of a target-scattered signal can be written in the form [1–3]

$$s\left(t, R_0, a_{0k}\right) = \sum_{k=0}^{N-1} a_{0k} I\left[\left(t - 2R_0 / c - k\theta\right) / \tau\right]. \tag{1}$$

Here a_{0k} is the a priori unknown, due to target fluctuations, intensity of the kth optical pulse, θ is the repetition period, τ is the duration of one pulse, while $I(x) = 1$ at $|x| < 1/2$ and $I(x) = 0$ at $|x| > 1/2$. Let us assume that the sequence of optical pulses having intensity (1) is observed during the time interval $[0; T]$ against the background of optical noise with intensity ν and the observation time is more than the duration of the entire sequence (1), i.e. $T > N\theta$. Then, realization $\pi(t)$ of the Poisson process with intensity $\nu + s(t, R_0, a_{0k})$, where R_0 and a_{0k} are the a priori unknown target range and intensity of individual pulses, will be available for processing. Individual pulses do not overlap since the pulse ratio of sequence (1) is assumed to be high enough ($\theta/\tau > 2\ldots3$).

Initially let us consider quasi-likelihood estimate (QLE) $\hat{R}_q$ of range R_0. This estimate shall be obtained by using the maximum likelihood algorithm synthesized under an assumption that the target is stable [3] and intensities of all pulses of sequence (1) are equal. At the equal intensities of pulses of sequence (1) the term of the logarithm of the likelihood ratio functional (LRF) depending on the unknown range can be written as follows [3]

$$L_q\left(R\right) = \sum_{k=0}^{N-1}\left[\pi\left(2R / c + k\theta + \tau / 2\right) - \pi\left(2R / c + k\theta - \tau / 2\right)\right] = \sum_{k=0}^{N-1}\pi_k\left(R\right). \tag{2}$$

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