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Estimation of Duration of the Rectangular Optical Pulse with Unknown Background Intensity[1]

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Abstract—The quasi-likelihood and asymptotically maximum likelihood algorithms of duration estimation have been synthesized and analyzed. The losses in estimation accuracy caused by a priori lack of knowledge of background intensity were also found.

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A model of optical pulse with rectangular intensity profile is used in many applications of optical communications and optical detection and ranging [1–7]. Let us consider an estimate of the unknown duration of optical pulse with rectangular intensity profile in the presence of Poisson background. The estimation of optical pulse duration with a priori unknown intensity, but a priori known background intensity, was investigated in [7]. In the present paper, unlike [7], it is assumed that the pulse intensity is known a priori, however the intensity of Poisson background is not known a priori. We shall assume that over time interval $[0, T]$ a realization of Poisson process $\pi(t)$ with the following intensity is observed:

$$\lambda(t) = \beta s(t) + \alpha_0,$$

$$s(t) = \begin{cases} 1, & 0 \le t \le \tau_0, \\ 0, & t < 0,\ t > \tau_0, \end{cases} \tag{1}$$

where α_0 is the unknown intensity of background; β is the a priori known pulse intensity; τ_0 is the unknown pulse duration that can take on values from interval $[T_1, T_2]$, where $0 < T_1 < T_2 < T$. If background intensity α_0 is known, the estimation of pulse duration τ_0 can be performed by using the maximum likelihood method [8]. This method implies that the duration estimate is determined by the position of the largest maximum of the logarithm of likelihood ratio functional (LRF).

An expression for LRF logarithm [9] has the form:

$$L_0(\tau) = \pi_\tau \ln(1 + \beta / \alpha_0) - \beta\tau, \tag{2}$$

where $\pi_\tau = \int_0^\tau d\pi(t)$. Correspondingly, the maximum likelihood estimate (MLE) is determined as follows:

$$\tau_{0m} = \arg\sup L_0(\tau), \quad \tau \in [T_1, T_2]. \tag{3}$$

However, if duration τ_0 and background intensity α_0 are unknown, the LRF algorithm depends on two unknown parameters

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