Chapter 3
Methods of Reception and Signal Processing in Machine Vision Systems

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ABSTRACT

The chapter covers development of mathematical model of signals in optoelectronic systems. The mathematical model can be used as a base for detection algorithm development for optical signal from objects. Analytical expressions for mean values and signal and noise components dispersion are cited. These expressions can be used for estimating efficiency of the offered algorithm by the criterion of detection probabilistic characteristics and criterion of signal/noise relation value. The possibility of signal detection characteristics improvement with low signal-to-noise ratio is shown. The method is proposed for detection of moving objects and combines correlation and threshold methods, as well as optimization of the interframe processing of the sequence of analyzed frames. This method allows estimating the statistical characteristics of the signal and noise components and calculating the correlation integral when detecting moving low-contrast objects. The proposed algorithm for detecting moving objects in low illuminance conditions allows preventing the manifestation of the blur effect.

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INTRODUCTION

The dynamic development of engineering and technology over the past decades has led to the possibility of technical implementation of the potentially high capabilities of optoelectronic systems. The main advantages of optoelectronic systems are high accuracy of object location, high range resolution, and high angular resolution. All listed above makes it possible to widely use optoelectronic systems in solving machine vision problems in various fields.

The basis for creating and improving machine vision optoelectronic systems is an understanding of the physical processes of optical radiation generation and propagation, as well as the development and use of the reception and optical signal processing theory taking into account the special features of their space-time structure, wave, corpuscular and statistical properties.

The purpose of this work is to increase the efficiency of the machine vision optoelectronic systems by creating mathematical models, methods and algorithms of signal processing that take into account physical, statistical features of optical signals and the effects of interaction of the received optical radiation with the elements of the optoelectronic system.

The work consists of the following parts:

- Intended use and methods of improvement of optoelectronic systems.
- Physical and mathematical model of signals in optoelectronic systems.
- Imaging in optoelectronic systems.
- Statistical properties of signals in optoelectronic systems.
- Mathematical model of signal detection in optoelectronic systems.
- Image processing in optoelectronic systems.
- Application of accumulation methods for image processing of stationary objects in optoelectronic systems.
- Method for detecting moving objects in optoelectronic systems.

Trends in the improvement of machine vision optoelectronic systems aimed at increasing efficiency and threshold of magnitude require enhancement of time and energy resolution; improvement of signal and image processing methods; expanding the range of observing conditions in which the system can be effectively applied; expanding the range of tasks performed by systems. The development of these directions is based on the in-depth study of physical processes of optical radiation generation and propagation, which determine the wave and corpuscular properties of light; development of optical signal reception and processing methods taking into account the special features of their space-time structure. It is also productive taking into account additional statistical features of input optical signals and output electrical signals.

Spatial resolution and energy detection tasks are performed by signal and image processing based on the threshold and correlation detection methods. The most common model of the output signal used for creating the signal processing methods is based on the description of an uncorrelated Gaussian random process. However, in practice, the signals obey other statistics, and the realization of optimum signal reception assuming that the signals have Gaussian statistics does not always lead to good results. Nowadays, more and more attention is paid to signal processing methods which take into account additional statistical characteristics of received signals.

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