Application of optoelectronic components in intelligent systems

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ABSTRACT

The creation of modern intelligent systems based on artificial intelligence requires solving the complex problem of high-speed processing of large amounts of information. The article substantiates the direction of perspective development of optoelectronic means combining electronic processing with optical input/output of data arrays. An example of the implementation of an optical channel classifier based on smart-pixel matrices is given as part of an optoelectronic classifier. Each smart-pixel matrix has electrical control inputs and the ability to process the input optical signals electronically with the output of the result in the form of optical signals.

Keywords: optoelectronics, smart-pixel matrix, optical interconnection, intelligent system

1. INTRODUCTION

The solution of modern problems related to the parallelization of computing processes in intelligent systems is impossible without the involvement of optical and optoelectronic technologies [1-4]. This is due both to the implementation of alternative approaches to image representation and processing [5-7] and to the creation of optoelectronic processors with three-dimensional interconnects. In such processors, optical connections and optoelectronic elements are used along with electrical ones to organize the exchange of information [8].

2. BACKGROUND AND RESEARCH METHODS

As shown by the results of placing processor structures in FPGA chips for complex computing procedures, the only drawback is the significant amount of filling the chip's I/O ports. Therefore, when increasing the dimension of the internal element matrix, a situation is possible when the internal resources of the chip are not fully utilized, but the number of I/O resources is not enough for parallel input of the entire computational matrix.

Thus, the actual solution to the problem of parallel input of large volumes of two-dimensional data arrays into the processor remains the use of optoelectronic means for which the transmission and switching of large amounts of data with a bandwidth of more than 1Tbps is effective [1].

In addition, modern developments in the field of optoelectronic integrated circuits (IC) are characterized by the combination of information input/output in optical form, and internal processing in electrical form. Such optoelectronic IC are called "smart-pixel matrices" and are based on matrixes of vertical-cavity surface-emitting lasers (VCSELs) [9-11].

Purpose of work. The goal of this study is to show the possibilities of using optoelectronic elements in modern intelligent systems.

3. FEATURES OF THE USE OF OPTOELECTRONIC INTEGRATED CIRCUITS

The use of optoelectronic IC based on smart-pixel matrices largely depends on their main characteristics, namely: the density of smart-pixels in the matrix, the total number of optical inputs/outputs, functional complexity, and overall performance [9-10].

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Thus, high-performance (more than 100 Mbps) and with a small number of optical inputs/outputs (10-104) optoelectronic IC are used in switching systems, optoelectronic interconnect boards, and specialized high-performance computing devices. Matrices with a large number of optical inputs/outputs (more than 105) are used in displays, analog optical processors, optoelectronic neural networks, and optical storage devices [9-11].

Moreover, the use of electro-optical light modulators based on liquid crystals, transparent ferroelectric ceramics, and quantum-dimensional structures [8] as part of smart-pixel matrices provides the functions of electrically controlled spatial time light modulators and storage matrices with optical reading of information and the possibility of targeted overwriting of information by electronic means [1,12].

4. APPLIED ASPECTS OF THE USE OF OPTOELECTRONIC MEANS

At present, there are developments of an optical vector-matrix multiplier, which actually implements optical information processing in the optical path of an optoelectronic classifier (Fig. 1) [12].
The optical channel of the classifier (Fig. 1) consists of a matrix of light emitters, a controlled mask, a matrix of photodetectors and microlens matrices. To simplify the consistency of individual components, there is a need for a single manufacturing technology for such important elements of the classifier optical channel as the light emitter matrix and the photodetector matrix. Under this condition, the problem of consistency of the optical channel components will be simplified to matching light and photoelectric matrices with a spatial-time light modulator (STLM) as a controlled mask. The separately proposed version of the optical channel of the optoelectronic classifier is shown in Fig. 2 [12].

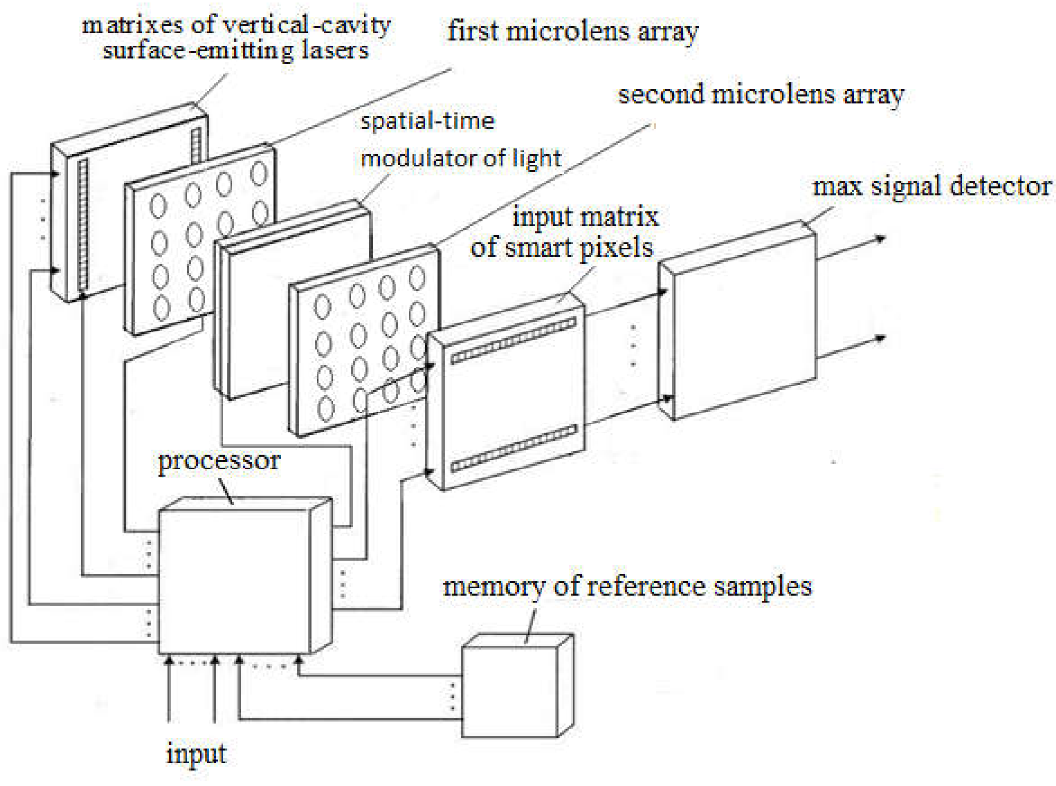

Figure 1. Structure of an optoelectronic classifier.

Thus, the optical channel of an optoelectronic classifier contains an optically coupled light emitting array STLM, a photodetector array, and two microlens arrays located between the light emitting array and the STLM and between the STLM and the photodetector array. The input and output information of the optical channel is transmitted electronically, and the operations that take place inside the channel are transmitted optically.

This makes it expedient to use smart-pixel matrices [10-12] as light and photoelectric matrices of the optical channel of an optoelectronic classifier (Fig. 1).

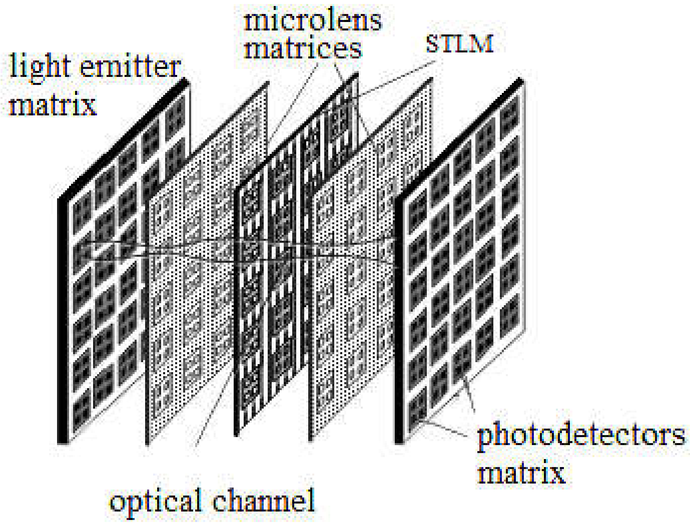

Figure 2. Optical channel of the optoelectronic classifier.

An alternative to optoelectronic means based on smart-pixel matrices can be considered optoelectronic computing environments with a dynamically changing architecture, the basic unit of which is a photorefractive reversible storage medium [2,13,14].

At the same time, developments in the field of creating 3-D optical IC and computing structures [3,12], optoelectronic frequency-dynamic models of neuroelement, and efficient optical information transmission channels between optical IC allow us to approach the construction of promising basic computing facilities for intelligent systems on the basis of the latest optical element base, taking into account known architectural solutions.

5. RESULTS

Thus, among the promising areas are, first of all, optical applications in neural networks [15], hybrid intelligent systems with artificial intelligenc [16], and optoelectronic processors for image recognition [12]. In addition, the use of optoelectronic means and 3-D optical communication channels will effectively solve the problems that arose during the previous implementation of projects to solve such applied problems as, for example, neural networks and optoelectronic processors for processing multilevel images [17,18,19].

Thus, in combination with the optoelectronic element base, parallel methods of image processing and analysis and pattern recognition allow building highly efficient means for multi-channel processing and switching of dynamic images in real time. Among the advantages of the optoelectronic implementation of computing components is the possibility of parallel processing and switching of two- and multidimensional data arrays of large dimensionality in real time. Among the disadvantages are the complexity of data presentation and high requirements for hardware reliability and accuracy.

6. CONCLUSION

Taking into account the growing requirements for parallelism of data processing, the need to create massive interconnections and the use of large amounts of memory, there is no alternative to the promising development of optoelectronic means that combine the advantages of optics with the capabilities of electronics and are associated with the further development of well-known models that are focused on the creation of processor systems with advanced functional and intellectual properties.

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