OPTICAL ELECTRONIC COMPUTER SYSTEMS DESIGN IN STATIONARY AND DYNAMIC MODES

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ABSTRACT

The theory of designing the optical-electronic image processing computer systems has been presented. A model of parallel image processing system has been considered, that is based on the principle of function decomposition. The implementation possibilities of different image processing operations with the help of optical and electronic computer means have been analyzed. A structure model of computer system has been examined, that is a conveyor of parallel computer devices. The evaluation of time outlay in the system, while processing an image or a series of them has been made. The differences of time outlay from conveyor length change and the correlation of optical and electronic devices and processing time in them have been exposed. The designing method of image processing systems in static mode has been elaborated. There are presented the results of investigations of the influence of the median square deviation, the influence of time of the processing in the modules on the throughput capacity of the system under the different electronic and optical modules quantity. According to the results of investigations the recommendations of increasing the system's throughput the capacity are formulated. On the basis to these recommendations, the system design method of image processing in the dynamic mode is elaborated.

Keywords: computer system, model, conveyor, optical, electronic

1. INTRODUCTION

Over the last years a significant progress was achieved in the development of special and general - purpose electronic multiprocessor computer systems[1-3]. Such systems are characterized by a high productivity (up to hundreds billions operations per second). Although they are complicated and consume a significant power that in some cases limits the employment sphere.

The significant results have been obtained in the construction of the optical and optical-electronic processors with acceptable weight - size characteristics and high throughput[4,5]. High productive processors, which implement different operations of preliminary image processing, image features extraction and invariant pattern recognition have been developed.

However the analysis shows that not all of the image processing operations can be implemented at present by the help of the optical processors. Besides, optical computers are characterized by the limited flexibility. Therefore the construction of high productive efficient computer systems for image processing is connected with the development of multiprocessor systems, which are based on the combination of optical and electronic structures, optimal distribution of the solving problem function among the processing devices of different type.

A number of questions, which are connected with the investigation and development of the theory of image processing optical-electronic computer systems design are being presented in this paper.

In section 2 a model of parallel image processing system have been considered. In section 3 the implementation possibilities of different image processing operations with the help of optical, electronic computer means have been analyzed. In the section 4 there have been made the system time outlay evaluation during the processing of several images.

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In section 5 there have been presented the method of image processing system design in static mode at different processing devices resources. In section 6 are presented the results of investigations of the influence of the median square deviation, the influence of time of the processing in the modules on the throughput capacity of the system under the different electronic and optical modules quantity. According to the results of investigations the recommendations of increasing the system's throughput capacity are formulated. On the basis to these recommendations, the system design method of image processing in the dynamic mode is elaborated. An example of image processing computer system design is presented in section 7.

2. MODEL OF PARALLEL IMAGE PROCESSING

Let the image processing problem be determined in the following way: $W\{P(x,y)\}\rightarrow RO$, where W - is the function of image processing; P(x,y) - initial image; RO - the processing result, which can be an image or numerical data.

The most of the image processing problems can be represented in the form of a linear sequence of separate sub problems. The decomposition principle utilization allows to organize parallel processing of two types: in time and in space. Parallel processing in time consists in organization of the sub problems conveyor, which are implemented consecutively.

The spatial concurrency means that on each step of the conveyor processing, the parallel processing of the whole image or its separate fragments is organized. The last type of concurrency is defined by the fact that we can point out some classes of operations while proceeding the image processing. They are executing at each of the image pixels, over separate regions of the image or over the whole image. In other words, to obtain the result, we need local (as in the first two cases) or global (as in the last case) initial information. While working with the local information, the image can be represented as a set of sub images, which are processed by the corresponding set of processor units. The spatial concurrency can be implemented by the help of processor units set of electronic or optical type.

According to the above-mentioned, the model of the parallel processing of the images can be represented in the following way:

$$RO = C_h\{\underset{i}{U}[\underset{j}{W^j_i}(P_{ij})]\},$$

where C_h - the superposition operation, i - the step number of the conveyor; U - the processing results union operation during one of the conveyor steps; j - the image fragment number; Wji- the operation of the processing of the j-th image fragment on i-th step; Pij- the j-th image fragment on i-th step.

This model can be also represented in the form of the operator:

$$P(x,y)=>\{W1\}_{M1}\rightarrow\{W2\}_{M2}\rightarrow...\rightarrow\{Wk\}_{Mk}=>RO.$$

The peculiarity of the presented model consists of the maximum level of disparalleling of image processing operations that ensure the high productivity of the computer system, which implements this model. The productivity also depends on the element base which is utilized. In connection to this fact let us look through the implementation possibilities of different image processing operations applying optical and electronic computer means.

3. THE ANALYSIS OF IMPLEMENTATION POSSIBILITIES OF IMAGE PROCESSING OPERATIONS WITH THE HELP OF OPTICAL AND ELECTRONIC COMPUTER MEANS

The utilization of optical and electronic processing devices during some step of the conveyor system of image analysis will be defined by some factors.

At first, from the way of initial image forming. The image can be formed by the help of electronic or optical means. The analysis of image forming units (IFU) characteristics showed that electronic and optical IFU provide the identical