Optical-electronic multiprocessors computer systems controlled by input images parameters

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ABSTRACT

We present a new class of optical-electronic reconfigurable image processing systems, controlled by the parameters of the input image. The systems use multiprocessors and are distributed. We describe two different optical processors, each performs the Fourier transform and correlation with an adaptive filter or with a fixed set of filters.

Keywords: correlation, image, processor, optical, reconfigurable, system

1. INTRODUCTION

The new concept of a computer architecture whose data sampling is controlled by the maximum spatial frequency of the input image is proposed[1]. In Sec.2, we describe the system's architecture. We then describe the electronic units (Sec.3.) and two optical processors (Sec.4). They are reconfigurable and distributed computer systems. When the order in which the units are used is varied, the system is reconfigurable. The control module can be a specific internal control processor or an external PC. The last version of the system is more flexible and allows simpler software algorithm development. Both optical processors implement the Fourier transform (FT) on input data as well as correlations using adaptive filters (using a joint transform correlator[2]) or using a fixed set of filters, accessed with a 2-D array of laser diodes[3]. In Sect.5, we present different methods for using the units of the system, when the input image contains one or several objects. The speed of the system is summarized in Sec.6. We show that by controlling the input sampling, based on the maximum input spatial frequency, we can decrease the processing time by a factor of 1.6 to 3.7. Comparative analysis of the different systems is presented (Sec.7) taking into account the time expenditures, speed of functioning, the number of stored standards, the necessity of preliminary recording of the holographic filters, the flexibility of the systems, their dimensions, and their power consumption.

Optical Pattern Recognition XVI, edited by David P. Casasent, Tien-Hsin Chao,
Proceedings of SPIE Vol. 5816 (SPIE, Bellingham, WA, 2005)
0277-786X/05/$15 doi: 10.1117/12.604312

2. THE ARCHITECTURE OF THE BASIC IMAGE PROCESSING COMPUTER SYSTEM

The architecture of the image processing computer system (IPCS) is presented in Fig.1.The system consists of an image preprocessor (PP), a unit that performs image coordinate transformation (CT), a system that performs output correlation plane analysis (CPA), a fast memory (FM) and a multi frame slow memory (SM), and an image complexity analysis (ICA) unit. All of the above units are electronic ones. The system also contains either an optical joint transform correlator (JTC) or an optical frequency plane correlator that uses a laser diode array that addresses a fixed optical filter bank. A controller completes the set of units. Fig.2 shows a photo of the system with the electronic portion on the right (one card per unit) and with one of the optical processors shown to the left. The electronic portion of the system is 300x400x250mm including the power supplies and the optical processor portion is 600x700x250mm.

The image preprocessor (PP) reduces noise and locates separate candidate objects in the input. The coordinate transform (CT) module together with the JTC is used to produce space variant processors that produce scale and rotation – invariant features using Mellin and polar CT's [4]. It can also produce a normalized object image with scale, rotation, and shift effects removed. The optical JTC module determines the scale, rotation and location of each input object. For the present system, input images use assumed to be 256x256 pixels.

The classification of the systems depend on the type of optical processor used (JTC or laser diode array, LDA) and the type of controller used as shown in Table 1.

Table 1. Classification of IPCS

Type of controller	Built-in control computer		External control computer	
Type of optical processor	JTC	LDA	JTC	LDA
Type of IPCS	IPCS-1.1	IPCS-1.2	IPCS-2.1	IPCS-2.2

These computer systems allow one to identify one or a group of objects that can have different position, angular orientation, and scale, and can also determine all of the required parameters of the objects. The systems can realize scaling and rotation of the images, image edge detection, and calculation of the coordinates of the objects. We now more fully detail each of the units of the system.

3. UNITS IN THE ELECTRONIC PROCESSING MODULE

We now discuss the various units in the electronic processing module (upper portion of Fig.1). The preprocessor (PP) performs various 3x3 filtering on the input image, specifically median filtering (to remove salt and pepper noise) and Sobel filtering [5] to produce edge - enhanced data. Each of these operations is performed in 20ms (half of the European TV frame rate of 40 ms). This PP digital unit uses cellular logic and employs 9 separate elementary processors. It was fabricated in