SESSION XII DATA GENERAL USERS' MEETING

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Dual on-line computers for research in cognitive psychophysiology

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A laboratory configuration is described in which two compatible minicomputers are used to collect psychophysiological data and to generate a complex visual display. The two computers are part of independent systems used by different research groups for psychophysiological experimentation and cognitive reaction time research. With minimal additional requirements, however, it is possible to link the function of the two machines and greatly expand experimental possibilities. Two real-time applications are discussed, as well as other advantages of having compatible processors, such as simplified program development.

The ratio of laboratory computers to researchers has continued to increase in recent years because of the decreasing cost of hardware and other factors. As computers become more numerous in psychology departments, the interconnection of two or more machines has greater feasibility and may yield major benefits with little additional cost. The possibilities for such relationships might also be an important consideration in the decision to purchase a particular new computer.

There are a number of possible ways to combine two or more computers and achieve greater maximum computing power. The method of interconnection considered in this paper is restricted to a link formed by a common input-output (I/O) channel. Computers so connected are said to be "loosely coupled." "Directly coupled" computers, on the other hand, share some common memory, a necessary requirement for a true multiprocessor system (Enslow, 1974). Also not considered in this paper are hierarchical connections between, for example, a laboratory computer and a larger campus computer that is used to further process the collected data (Gillman, Lapin, & Buckley, 1974), or the recently popular combination of a laboratory minicomputer and a microprocessor that performs special real-time functions (Brignell & Young, 1979). The discussion in this paper centers on our experience at Simon Fraser University with two Data General NOVA 3 minicomputers. After a description of the physical layout and the intercomputer link, two specific applications are mentioned, followed by some general considerations.

LABORATORY FACILITIES

The laboratory facilities consist of one room containing both computers and two nearby experimental control rooms, each with adjoining subject booths (see Figure 1). Of the two computers, one is a minimally configured NOVA 3/12 system with 16K memory and peripherals that include dual floppy disks and a CRT display controlled with direct memory access (DMA). This computer is connected to the laboratory used primarily for research in cognitive psychology. The data collected are for the most part buttonpress responses produced in a choice reaction time paradigm. The CRT display is used to present a variety of visual stimuli to the subject. The other NOVA 3D computer is part of a much larger system with 32K memory and numerous peripherals, including cartridge disk, magnetic tape, line printer, plotter, analog-to-digital converter, as well as a CRT. This computer is connected to the other nearby laboratory complex and is used primarily in psychophysiological experiments, in which large amounts of data, such as EMG and EEG, are collected and stored on digital magnetic tape. The CRT is used to present the sampled data to the experimenter for visual inspection.

THE INTERCOMPUTER LINK

The hardware link between the two computers consists simply of a cable connecting each machine's 16-bit digital I/O interface. Each computer is essentially

Figure 1. Simplified schematic diagram of the laboratory facilities.

a peripheral device to the other computer. Since each processor does not directly access the disk files of the other computer, this configuration does not require either of the special-purpose hardware devices sold by Data General, the interprocessor buffer (IPB), or the multiprocessor communications adapter (MCA). The connection described is currently used to conveniently transfer contents of disk files from one machine to the other. The program LINC (written primarily by John Palmer), when executed on both machines allows the operator to designate which computer is to send the specific data and which is to receive. Transmission is performed by 8-bit parallel asynchronous means.

A major use of this connection is for the development of software for the smaller system. Programs can be much more conveniently written on the larger system, after which LINC is used to transfer the compiled program to the smaller computer. Also of some use is the ability to transfer files of data collected on the NOVA 3/12 to the NOVA 3D for listing on the line printer.

REAL-TIME APPLICATIONS

Experimental data acquisition and control programs have been written for the independent operation of each computer with their corresponding laboratories. For the NOVA 3D, a general-purpose digitization program allows

data to be collected in a manner that allows a form of "backward averaging" in real-time. Briefly, the program continuously digitizes from 1 to 16 channels of analog data and maintains the most recently collected data in temporary storage on disk. When a digital trigger pulse is received, data collected for a specified time before and after the trigger are displayed on the CRT in the laboratory and then output to magnetic tape. The program described is currently being used to investigate the EEG and EMG occurring prior to, and during, self-initiated movements.

One such application, concerning the role of visual information and expectations on the perceived weight of lifted objects, uses the NOVA 3/12 to produce a visual display that was originally developed for a quite different experiment. The NOVA 3/12 CRT display presents different-sized rectangles that indicate to the subject the size of the unseen object being lifted. The NOVA 3D computer is used to record the transduced lifting movements and the prelift muscle activity (EMG), both of which are influenced by the apparent size of objects of equal weight (Davis & Brickett, 1977; Davis & Roberts, 1976).

Another real-time application that is ideally suited to this dual computer system was originally implemented with a single computer (a Hewlett-Packard 2116b) that only produced the visual display and so required all data to be recorded on FM tape for later analysis. In this preliminary study (Brickett, 1975), the digitized EEG from two competing subjects was used to modify the "paddles" in a computer-generated ping-pong game. A serious disadvantage of the off-line analysis was the problem of eye movement artifacts in the EEG. With the present dual computer system, the experimenter can scrutinize the data for artifacts as the experiment proceeds and reinstruct the subject if necessary. The game display is in the process of being implemented on the NOVA 3/12. Once this is done, the present data acquisition program requires only minor modifications in order for the NOVA 3D to communicate the sampled EEG values to the NOVA 3/12, which then uses this input to determine the position of the paddles in the game.

GENERAL CONSIDERATIONS

In conclusion, if an investigator requires more computing power than that provided by a single mini-computer, buying another mini of the same type is probably not the most economical solution. For applications such as generating CRT displays, other methods include adding a microcomputer, or possibly expanding the capabilities of the present system with additional memory, and so on. However, for the increasingly common situation of a number of researchers in the same department having their own laboratory computers,

unless the machines are fully utilized, the benefits to be gained from connecting two machines are of minimal cost and should not be overlooked.

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