THE McGRAPH SYSTEM

A. S. Malowany, K. C. Campbell, T. McNeil
McGill University

Abstract

McGraph is a general purpose graphic display system based on refreshing CRT images from files stored on a disk buffer. One application program, the regression analysis program (RAP), developed using the FORTRAN language and subroutine style of programming is discussed. Currently the GRIN2 graphics language is being installed on the McGraph System.

Resume

McGraph est un système graphique destine à l'emploi général qui réalise la régénération de l'image sur écran par l'entremise de mémoire sur disque. Le programme d'analyse par régression (RAP) , développé en utilisant le language FORTRAN et le style de sousroutine, est présenté. A ce moment, l'on procède à l'installation du language GRIN2 sur le systeme McGraph.

McGraph is a general purpose graphics display system intended for a variety of research applications ranging from pattern recognition, system modelling and optimization to computer aided design. In this paper we propose to describe our experience using this system as well as our current endeavours.

The McGraph system is based on refreshing CRT images from files stored on a disc buffer and is summarised in figure 1. Details of the display processing unit hardware design [1] were presented at our last Man Computer Communications Seminar [2]. The PDP-8 computer with 4K of core attends to man-machine interactions such as light pen, joy stick and tracking cross servicing. The PDP-15 computer with 24K of core and its 512K of disc storage serves for the compiling and execution of the main program. A variety of system handler programming such as software character generation, disc updating by the PDP-8, and slaving of the PDP-8 to the PDP-15 were required and assembler or machine language programming was generally used here.

Our first program developed for the interactive disc oriented graphics facility was a regression analysis program [3]. The nature of this application involves many computations such as the calculation of regression equations and residuals for plotting so it was convenient to use the FORTRAN language and subroutine style for this programming. Up to 99 cases in 18 variables can be studied interactively by means of histograms, plots, residuals, model equations, mean square fits, and correlations. This program was very useful in evaluating many features of the McGraph system. The PDP-8

core size easily accomodates the monitor and Data disc handler (1000 and 400 octal locations respectively) as well as the light pen servicing. The 30 cps disc refresh rate is well suited to the phosphor chosen. The image illumination level as well as the software character set are quite pleasant. Disc track space has not been a limitation to date. Each track can store some 12,000 graphic instructions. This has permitted us to prestore all the menus displayed during the regression program in track 16 and to simply switch on the relevant parts by editing the display bit in the appropriate header words. The totality of the information necessary for the regression analysis displays represents 2451 words, i.e. one fifth of the track's capacity. A display such as the plot shown in Fig.2 takes about 725 words. Our most complicated alphanumeric character (8) is implemented using 26 words. The ability to store display results on different tracks and then manually switch between them was found to be very useful and to considerably reduce the need for hard copy. The operation of the light pen for interacting with the menus is now satisfactory but this required a software patch consisting of the addition of a couple of dummy instructions before a new header. This is required if a file is particularly short and is due to a finite delay in responding to the light pen hit.

The regression analysis program has been debugged and used in a modelling study for the compression strength of cement in terms of physical characteristics, chemical composition and process parameters using industrial data supplied by Canada Ciment Lafarge. It was also useful in assessing results of different models used in the clinical testing of glomerular filtration rate in children at the Montreal Childrens Hospital.

The wider range of applications envisionned has led us to modify and install Bell Telephone's BELLGRAPH on our system [4]. Here we profited from some forty man-years of development in implementing the GRIN2[5,6] graphics language on the McGraph system. Modifications were required because BELLGRAPH uses a GE 645 main computer feeding a DEC PDP-9 with 8K of core and a core refreshed display instead of our hardware shown in Fig.1. Using GRIN, a researcher can easily write the graphics control programs required to define an interactive system tailored to his own area of interest.

The language provides those functions universal to all graphics systems. For example, in one statement a programmer can enter a light button in a menu and connect it to the appropriate subroutine. Data managing statements enable one to build complicated pictures from a set of primitives and describe these pictures in terms of a hierarchy of picture parts. Input statements allow the user on-line to call attention to a picture part at any level in the hierarchy using the light pen. Input from two keyboards, a set of eight pushbuttons and the tracking pattern are also supported. Using a program written in this language, the user can construct pictures relevant to his problem and analyse them. Fig.3 shows the tracking pattern as well as the eight pushbuttons which have been implemented as lightbuttons on our system. The language is also open-ended. That is new statements are easily generated and inserted into the language.

The associated data structure represents each display by a directed graph consisting of nodes connected by uni-directional branches. Each node can be considered a picture part . A branch pointing to a node represents one instance of the part. Picture parts defined in turn by their parts are reflected in the data structure by branches

connecting one node with several lower nodes. Data associated with each instance can be stored at any level in data blocks connected to each branch. The terminal nodes, or leaves, contain the actual display commands of the primitives. Hence the data structure contains data for both analysis and display. The example in fig.3 shows the result of repeated manipulations using the MOVE and COPY functions and the triangle primitive.

The operating system provided with this system performs dynamic memory management for both GRIN programs and the data structure. That is, as more data is created, or when a subroutine is called, the system allocates core space for it. Conversely, when data is destroyed, or a subroutine ends execution, the space is freed. The operating system also handles all I/O, schedules GRIN programs, and permits multiprogramming.

Multiprogramming is especially attractive in the McGraph environment. The intensive real-time load such as display refresh and light pen tracking is performed by the PDP-8. Once a picture is transmitted to the PDP-8, the PDP-15 can return to a background program without affecting the display.

Future work is intended to capitalize on this feature. A GRIN interface with the FORTRAN compiler's output would result in a dual language system capable of high level computations and graphics.

References

1) Fabi, R. J., The design and construction of a disc oriented graphics system, M.Eng. Thesis, McGill University, Feb. 1971.
2) Malowany, A., Levine, M.D., Marin, M., Fabi, R., Bakerdjian, V., Nguyen, V.T., 2ed Man Computer Communications Seminar, Radio and E.E.Division, NRC, May 31, 1971, pp 20.
3) Thibault, P.T., A disc oriented graphics system applied to interactive regression analysis, M. Eng. Thesis, McGill University, July 1972.
4) McNeil, T.O., A general purpose graphics system for a small computer, M. Eng. Thesis, McGill University, Submitted March 1973.
5) Christensen, C., Pinson, E.N., Multi-function graphics for a large computer system, Proc. AFIPS, Fall Joint Computer Conference, Vol.31, pp697-771, 1967.
6) Williams, R., A survey of data structures for computer graphics systems, Computing Surveys, Vol. 3, No.1, March 1971, pp 1-21.

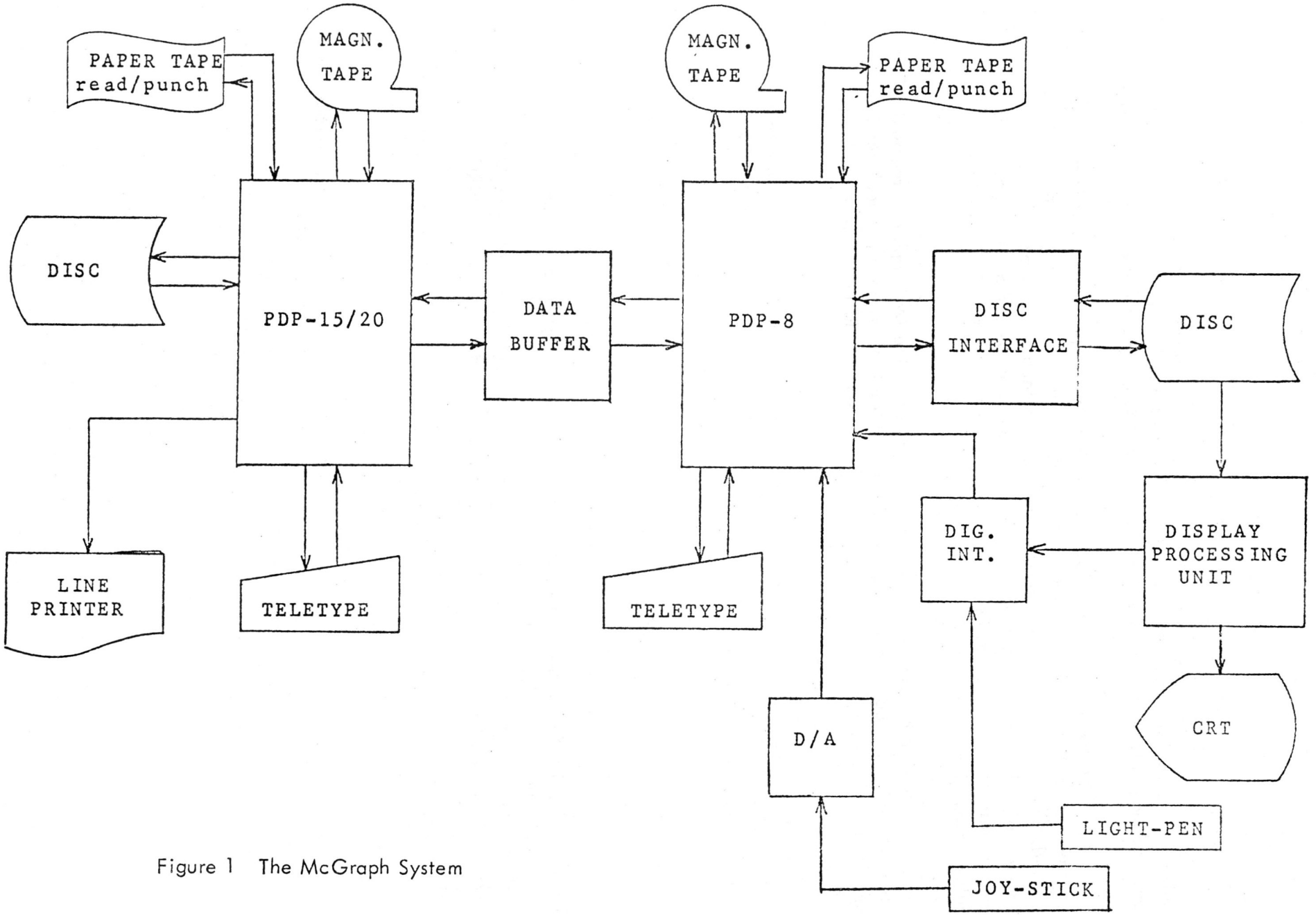
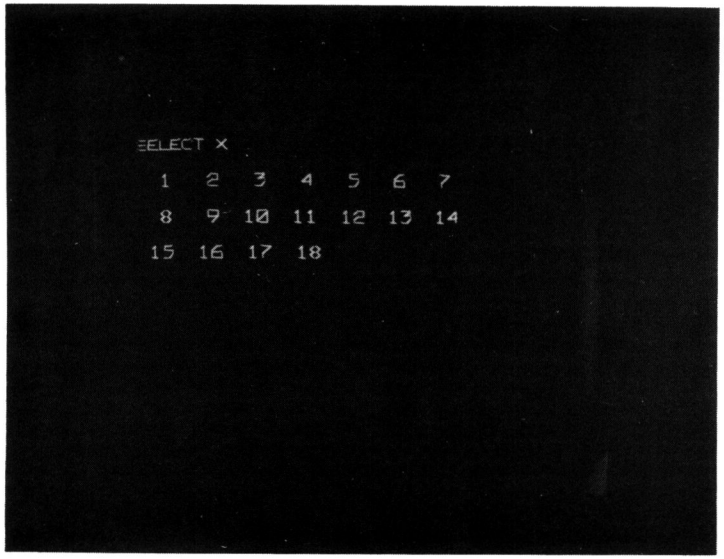


Figure 1 The McGraph System



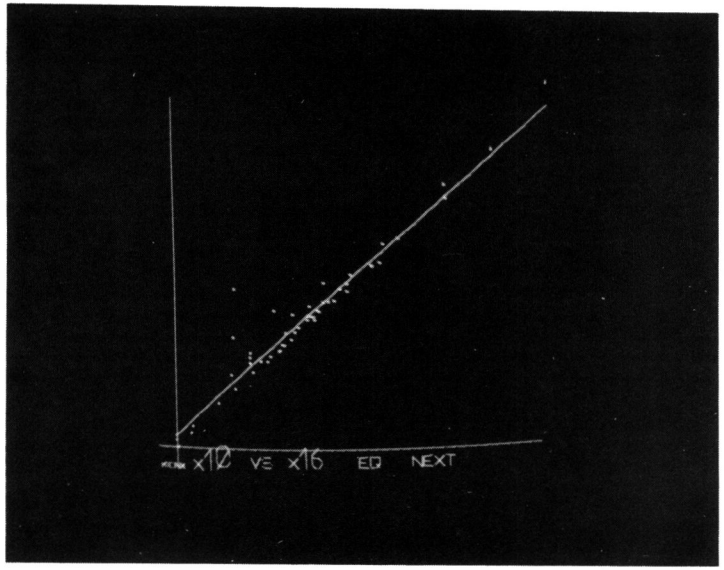
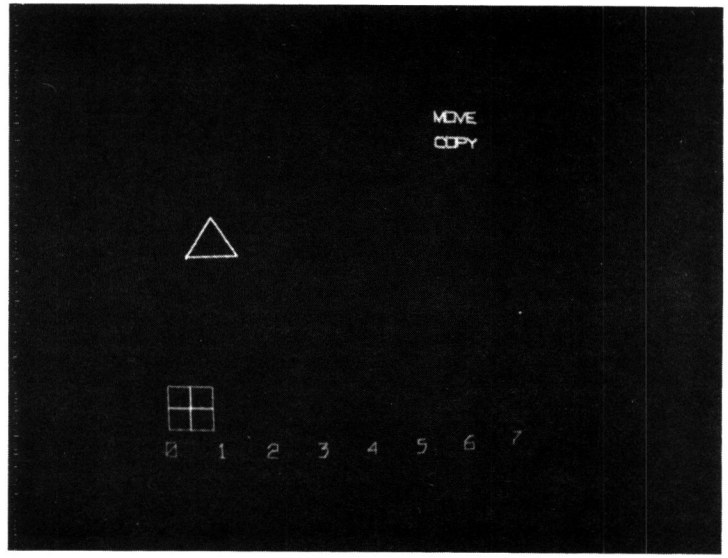


FIGURE 2 REGRESSION DISPLAYS



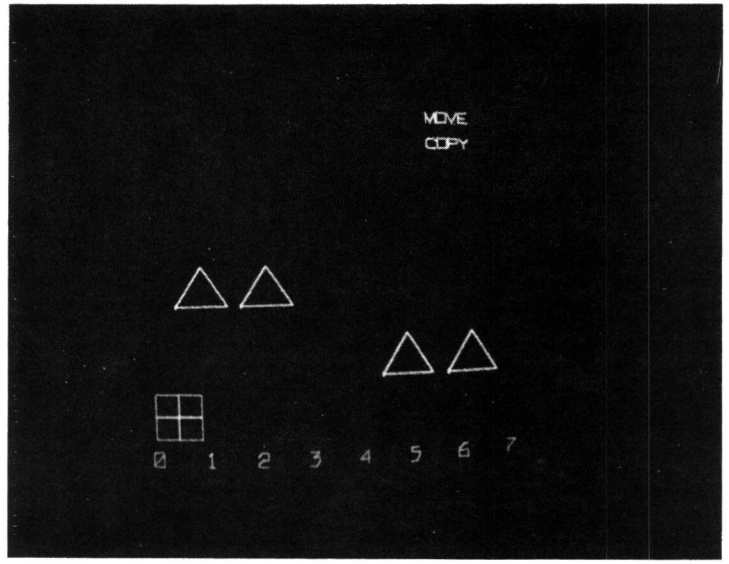


FIGURE 3 GRIN DISPLAYS