A REVIEW OF FACILITIES REQUIRED FOR COMPUTER GRAPHICS IN AN INFORMATION ORIENTED ENVIRONMENT*

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ABSTRACT

Since its birth in late 1950, computer graphics has successfully been applied to numerous disciplines enhancing their domains and enriching the results. Nevertheless, it is only recently that computer graphics began its integration into the information oriented environment.

This paper is intended to review related facilities suitable for such an environment. The review will be based on the available literature and experiences from existing information systems; including geographic, statistical, management and research information systems.

INTRODUCTION

In ancient civilizations, man used graphical methods for communication long before letters were invented. The practice became more precise when it was used to express quantitative information. For example, the numbers shown below can be considered as graphical representations of quantities:

Roman Numerals	I	II	III	. . .	X	XI
Classical Chinese & Japanese	一	二	三	. . .	十	十一

Evolving from relatively primitive practice, the 18th and 19th centuries came to be known as the "golden age" of statistical graphics [11,13]. For example, Johnson's Graphic Statistics of Canada (ca 1887 [7]) shows many sophisticated graphs. To overlay variables, some of them use as many as five colors. Figures 1-2 have been reproduced from the original copy to show that they are remarkably similar to the graphs used today.

Graphical analysis and presentation of complex information are becoming popular among busy managers and professionals [6]. They are accumulating experience in making decisions quickly from graphical summaries of financial data [15], statistical data [4,5] and other research and managerial data. Thus, in an information age, it seems natural to integrate computer graphics with information systems. Experience has shown, however, that the integration is not easily achievable due to some fundamental reasons including:

a) historically speaking, computer graphics and information systems developed separately [5];

b) integration of separate applications is not researched in the usual academic environment;

c) because of a) and b) above, problems are not often articulated, allowing mistakes to accumulate.

This paper is an attempt to present some problems and possibilities for:

a) practitioners who must integrate computer graphics into information systems serving diverse needs;

b) researchers who are interested in developing a graphic system integrable at a high level.

In the subsequent sections, general requirements will be discussed followed by a review of computer graphics facilities suitable for an information oriented environment.

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* Any views expressed are those of the author and do not represent the policy of Statistics Canada.

GENERAL REQUIREMENTS

The following matrix shows the relationship that exists between computer graphics and data:

COMPUTER OUTPUT \ COMPUTER INPUT	DATA	IMAGE
DATA	TRADITIONAL NON-NUMERIC COMPUTING	PATTERN RECOGNITION, FEATURE EXTRACTION
IMAGE	COMPUTER GRAPHICS	IMAGE ENHANCEMENT

(Matrix due to A. Rosenfeld [14])

In a traditional environment, facilities are separated to support the non-graphic box from the rest. For example, financial data are processed in the non-graphic box and they can be plotted only if they leave the box and enter the graphic box, never to return. Similarly, in a statistical information system, data may be plotted to expose a certain pattern. However, in a traditional environment, the information in the pattern cannot be used as it cannot re-enter the non-graphic box for further computation.

The above examples demonstrate several disadvantages including:

a) information is not fully utilized;

b) it takes longer to produce information in a graphical form;

c) it is impractical to design tools that can be used directly by non-EDP persons.

Generally speaking, for computer graphics integrated in an information system, facilities are required to support the above matrix as a whole rather than individual boxes separately.

HARDWARE RELATED

In attempting integration, experiences [2,5] show that the hardware must ensure the close relationship necessary between graphics and data processing. Hence. there seems to be two dimensions to hardware related issues:

1) choosing graphic devices;

2) determining their interaction with mainframes.

In an organization where substantial information systems exist, they are likely used for a variety of purposes. It is also likely that the information users in such an organization are accustomed to the trade-off between the cost associated with obtaining the information, and the possible gains generated by it.

To accommodate reasonable flexibility, a range of devices seems to be required. Roughly speaking, devices can be grouped into the following three categories:

- graphic display,
- permanent copy,
- graphic input,

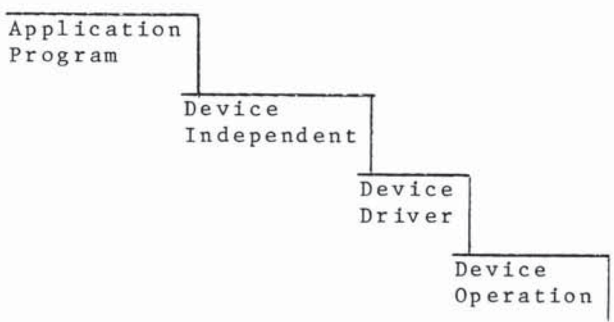
In the display category, there are: refreshed displays, storage displays, plasma panel displays and so on. They vary in price as well as functionality. In a dynamic environment, interactive display devices are essential. They can be selected depending upon such factors as resolution, the need for color, impact on the mainframe, and cost. Generally speaking, an inexpensive device seems to do the job unless specialized functions (e.g. high-resolution permanent copy) are required.

In the permanent copy category, a wider range of devices seems to be necessary as they must produce tangible results. This category consists of two groups, one using plotting and the other using variations of the camera. For the former, there are pen-plotter, ink-jet plotters, electro-static plotters, and printers using laser, dot-matrix and thermal plotting. Figures 3-5 were produced by a pen-plotter, dot-matrix and thermal printers, respectively. For the latter, output media are types of films, which are available in different sizes. The quality of the results are dependent on the display device and the camera attached to the device.

As graphic devices are changing rapidly, acquiring new and expensive devices can be risky unless suitable software is available. In an environment where diverse applications are integrated, the risk seems greater than in situations involving specialized applications.

SOFTWARE ENVIRONMENT

The diagram below may give a perspective of integrated graphic facilities in a vertical direction [3]:



In an information oriented environment, at the highest level, three major facilities are required:

- data management,
- quantitative analysis,
- integrated graphics.

The first two items are pre-requisites in most information systems, and graphics must be an integral part.

Graphic software must be able to drive a variety of devices. In terms of the diagram, this entails specifying devices from a high level. The following table shows an example from SAS/GRAPH [9,10], which is often used in information systems [1]:

Independent	Graphs
PROC GCHART; VBAR SEX;	a bar chart
PROC GPLOT; PLOT Y*X;	a line graph
PROC G3D; PLOT Y*X=Z;	a 3-D graph

Dependent	Device
%INCLUDE(TEK4027);	4027 display
%INCLUDE(ZETA8);	Zeta-8 plotter

As an example of integration in a horizontal direction, Figure 6 contains ALDS [12].

SUPPORT ENVIRONMENT

One of the most important facilities for any system is the availability of user support. However, such human resources are in short supply while the size of the user community increases. Although some research work is ongoing in the area of "expert systems", the support problems will likely remain for some time. The concept of technology transfer seems another possibility, though it too seems human-resource intensive.

CONCLUSIONS

High-level integration of computer graphics is no doubt the challenge of the future. It is difficult, but the pay-off is large if it can be achieved [14]. It happened in CAD/CAM [8]. It can happen in information systems.

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Figure 1.

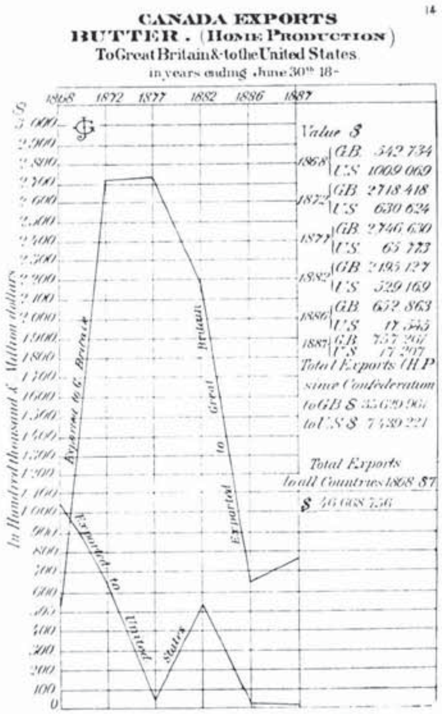


Figure 2.

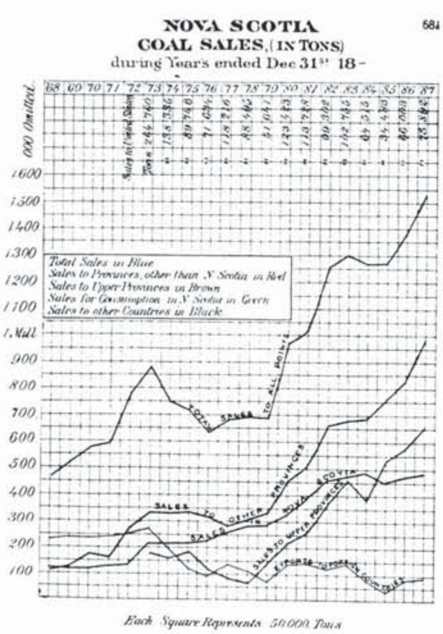


Figure 3.

POPULATION AGE PYRAMID: 1981 AND 1971, YUKON

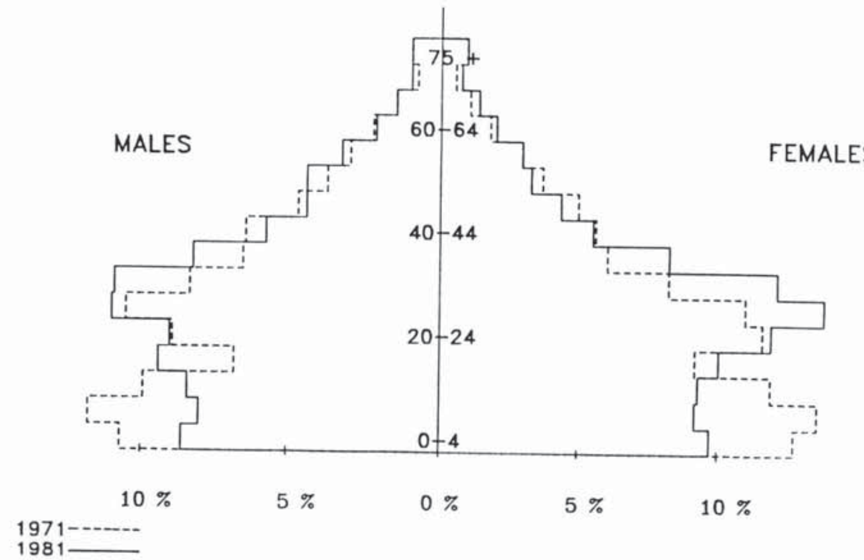
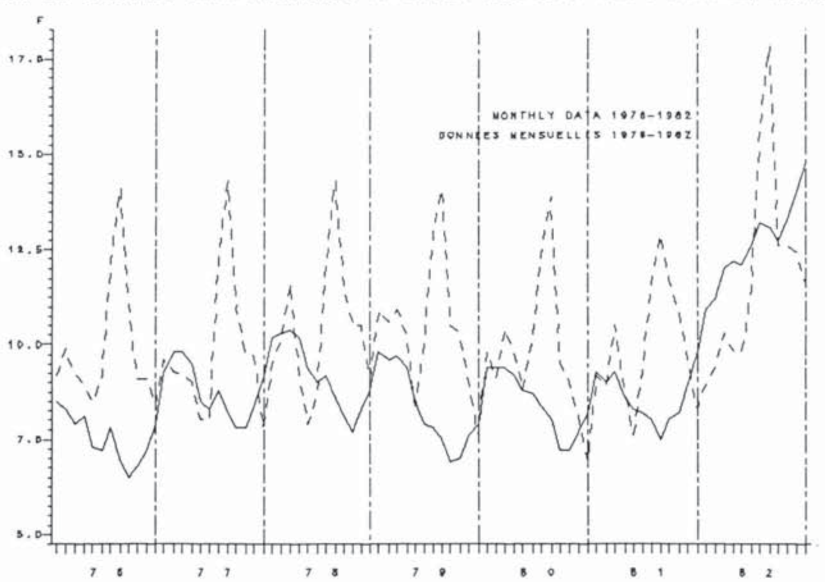


Figure 4.

UNEMPLOYMENT RATES OF FULL-TIME AND PART-TIME LABOUR FORCE, CANADA
TAUX DE CHOMAGE CHEZ LES ACTIFS A TEMPS PLEIN ET A TEMPS PARTIEL, CANADA



UNEMPLOYMENT RATES OF FULL-TIME LABOUR FORCE (——) TAUX DE CHOMAGE CHEZ LES ACTIFS A TEMPS PLEIN
UNEMPLOYMENT RATES OF PART-TIME LABOUR FORCE (- -) TAUX DE CHOMAGE CHEZ LES ACTIFS A TEMPS PARTIEL

Figure 5.

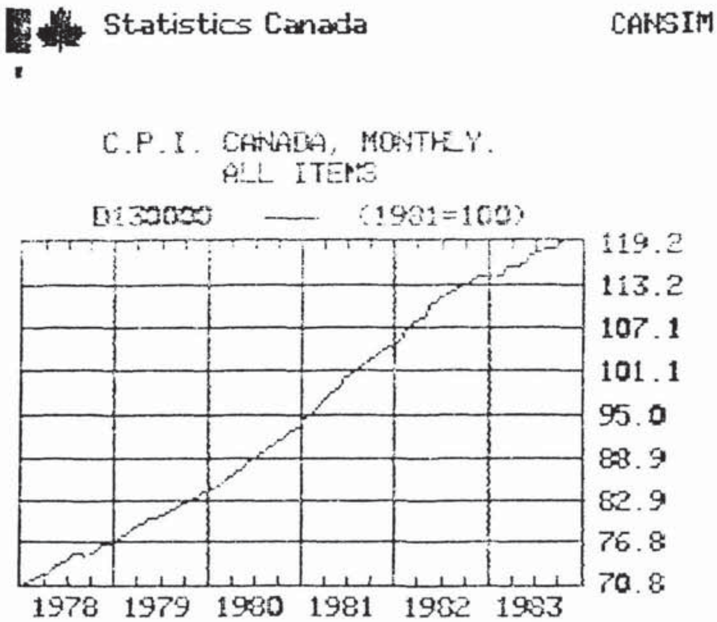


Figure 6.