Graphical Overlays on Two Dimensional Spatial Grids

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31 May 1983 — 12 August 1983
PROJECT REPORT

INTRODUCTION

The National Center for Atmospheric Research collects massive amounts of data covering all aspects of atmospheric research yearly. Because of such endeavors NCAR has had to develop sophisticated mechanisms for the collection of the data, preparation of the data for analysis by the computer, and analysis of the results. In past years a lot of the work in making the data useful involved the development of software specifically structured for a particular data type.
The task of data reduction is partly achieved by using the General Processor (or GENPRO) software system. GENPRO is a data processing (DP) system with the capability to manipulate broad classes of both scientific and engineering type data, to reduce the amount of software development that is required to keep up with the expansions and upgrades of atmospheric measuring systems. The capabilities that GENPRO provides are accessing, archiving, creating, editing, calibrating, displaying, and analyzing scientific or engineering variables.

GENPRO is unlike other typical Data Base Management Systems in that the data for GENPRO does not have to be loaded into a rigid, predefined data base. The inputting and processing of diverse formats of data can be performed by this software system without having to first require the data to be loaded into single decodeable format by the typical Data Base Management System. Simple system applications such as reading and printing a small data set or complex problems such as the processing of high-rate turbulence data of the Research Aviation Facility of NCAR can be selected by the user.

Once the use of GENPRO has been mastered, the software needed for analysis can just be "pulled off the shelf". The system that allows such access includes a DRIVER (manager) and a number of functional code modules (operations) which are independent. An operation is really a collection of code which performs data processing functions such as filtering, plotting, writing tape input, etc. All needed capabilities could be available in an operation set depending on which application is to be performed.

In the past, several difficulties were associated with scientific data processing. Some of these problems were:

a. Ways of adding individual analysis codes to existing software was too complex.

b. There was no mechanism for universal interchange of scientific data.

c. There were too many data processing tasks to perform with insufficient programming support.

d. Difficulty in trying to standardize the various number of different data formats.

e. Neither display of simple input or output nor display of new data could be done without having to write new software.

f. There was no easy way of merging data from multiple sources for purposes of display and comparison.

These difficulties were studied and when GENPRO was devised, strong emphasis was placed upon the attributes of flexibility, ease-of-use, portability, and maintainability.

Portability of GENPRO is shown in the use of its programming language. GENPRO code is written in NCAR modified IFTRAN which was developed by David J. Kennison, who wrote documentation on it in October of 1982 and updated that documentation on June 15, 1983. This preprocessor accepts any mix of FORTRAN
66 or 77 as input and will create standard FORTRAN as output. This language is currently available on virtually every computer at NCAR including most of the 16 bit mini-computers.

Maintainability is directly related to the portable features which are due to the fact that IFTRAN is a structured language and logical program functions are often isolated into subroutines.

Flexibility is shown by GENPRO's manipulation of preprocessor run time assignments. The preprocessor I used was called IFTRAN. The IFTRAN preprocessor is a FORTRAN program which reads an input file containing a program written in the IFTRAN language (which is FORTRAN plus some extensions) and writes two output files, one containing an indented listing of the input file and the other containing a FORTRAN translation of the input file.

The IFTRAN preprocessor tailors FORTRAN output into easy-to-read, indented target language at run time through a feature which is called Conditional Compilation. Using this feature, detailed diagnostics can be activated or deactivated and global array sizes can be set in single statements and spread rapidly and excessively through the whole code.

IFTRAN is easier to read because some of the annoying bookkeeping details of FORTRAN can be avoided. One can parameterize his/her own code and express different versions of that code all in one deck, which as a result simplifies maintenance.

Modularity of GENPRO is displayed in its ability to perform logical operations on data, those being ones which are assembled in a building block structure which can be easily arranged.

GENPRO is very usable because it is Directive Driven. The operations of the program are controlled by free-form, column independent Directives that are usually cards in a batch group on data lines. Errors or discrepancies are searched for by doing several validity checks as an internal part of the program. If any fault is found, a warning or error message is printed.

As for a system overview, GENPRO is a batch oriented software system which consists of a library of independent functional operations, a secondary library of support subroutines shared by the operations and the Driver, plus a data management component.

Since there has been so much mention of drivers, let's list exactly what its job is. The driver acts as a data manager. It allocates available memory space, checks for overflows of storage arrays, regulates the flow of data of functional operations, and performs several other services for the operations. These tasks are fixed at system creation time or selected by the user at run time. The operations receive data in amounts called cycles which are logical records. It is typical that during a run the driver may call the operation more than one time but the number of cycles of data made available to an operation will probably vary from call to call.

GENPRO has in its set about 12 different operations, but only a subset of the total needs to be loaded at one time for a particular application. The Driver
must always be loaded; however, the only other operation(s) needing to loaded
is/are the one(s) needed for the application. Let's say we are trying to do
an application which involved the merging and plotting of data from two dif-
ferent sources. The only operations needed might be INPUT and PLOT as indi-
cated by the following figure.

Figure 1

SNAPSHOTS

TAPE  INPUT  CALIB

X

Y

An explanation of the operations are:

INPUT - Reading data (X) from disk or tape into computer memory.

PLOT - Plots of selected raw variables from data set X.

CALIB - Puts raw variables through calibration tables or polynomials.
      Data set X is changed to data set Y.

Plots of both raw and calibrated data are generated so the results can be com-
pared by examination. The series of functions that have been applied to the X
set of input data is called an Operation Stack. There are several applica-
tions that can be performed on data at one time given that the following hold
true:

a. That the operations be arrangeable in any order within the stack, with
   the only exception that the Input Operation appears first.

b. That any or all twelve operations of GENPRO be acceptable to the stack.

c. That any of the Operations are repeatable as often as desired.

Within GENPRO there are only two types of variables, independent and depen-
dent. The dependent variable is processed as a function of some independent
variable. Some examples of dependent variables may be pressures, wind speed,
temperatures, etc.; for independent variables, time distance, frequency, etc.

For illustration of dependent variable plots, refer to the chart of vertical
wind velocity (page 5A) measured in meters per second. A display of indepen-
dent variable plots is illustrated by the chart of interrelated aircraft and
meteorological data (page 5B).
As mentioned earlier, the Driver handles data management for the system. This encompasses a translation process in which directive commands are interpreted. These commands are responsible for driving software for each case and for arranging them according to general data structure. Also entailed is an allocation process in which available memory space is accessed for the job as needed. If there isn’t enough available memory space, the job is either split into several steps that don’t require as much space or terminated with an error message given.

Sometimes it is necessary to retrieve data from the past or get data from the future. This can be accomplished by using GENPRO. The only thing that does have to be done is to specifically state how much is needed during the initialization stage and the Driver will make the data available at each call. There are also controls to specify break points in the data. When the end of a job is reached, the Driver will print the operation and time for each case and then check for remaining processes. Of course if the user’s input happens to be wrongly specified, then termination is due to occur. But, GENPRO lists all the errors of a certain level or class before the program is exited and stopped. This is to eliminate multiple running of the program due to the errors which might be found.

At times there are problems with gaps in data or ‘noisy’ data. GENPRO handles the gaps by putting user defined values in the general INPUT operation. These valves act as placeholders and can be picked up by following operations. Generally these placeholders are ignored by subsequent operations. GENPRO utilizes the DESPIKE operation to handle this problem. This operation detects and corrects wild points in data.

The programmer does not have to be concerned about whether or not the sources are represented in the same character format because this information is given in the INPUT operation on a one-bit level, given that this format is one that is known and is of a desirable one-bit level.

Before, merging multiple sources was a painstaking operation because special software had to be implemented. This problem has been virtually eliminated due to the reusable feature of the INPUT operation of GENPRO. Now one can get multiple data sets at one time and the only factor that is used as a restriction on how many can be merged is the amount of memory of the machine available for use.

Just as the INPUT operation is reusable so is the OUTPUT operation. Any combination of the variables being processed including repeats can be created. A stripping facility is provided by GENPRO as well as one for depositing the stripped values onto tapes or other storage media.

For the plotting of data, a frame can contain from one to ten different plots with each plot having up to ten curves and a variety of options that go with them such as scaling, titling, and background grids. There are two commonly used plot types:

a. Time Series - Plots of one or several variables against the independent variable.
FOUR time series of vertical wind velocity ($W$) on a plot frame.
From top to bottom: Unfiltered $W$; then, $W$ filtered with 15, 25, and 99 equal weights respectively.
A plot frame of 3 interrelated aircraft and meteorological parameters: vertical wind velocity (W), pitch angle, and attack angle.
b. X versus Y - Plots of one or several variables against the same number of
other variables.

GENPRO plotting uses the portable NCAR System Plot Package. The System Plot
Package is a group of routines used to form simple plotter instructions. Only
the most basic routines for scaling and plotting line segments, character
strings, and annotated axes are included in this group. The System Plot Pack-
age being used depends upon which computer the job is running on, but applica-
tions program interface is unvarying. This package can be run on the CDC 7600
because it is automatically loaded by the NCAR 7600 operating system, while
metacode is produced for fiche and DICOmed recorders. Metacode is always pro-
duced for the CRAY-1 and the target plotting device is selected for the gen-
erated metafile from use of appropriate Job Control Language commands. If
special capabilities are needed the plot package can be tailored to meet those
needs. Probably these needs will be satisfied by using the Scientific Comput-
ing Division Graphics Utilities, which allow for more complicated use of utili-
ty routines which in turn use the System Plot Package. These utilities con-
tain a detailed set of explanations for the high-level graphics routines that
are part of the SCD'S Graphics System. The two most valuable design features
of this system are its independence and its portability. Its device indepen-
dence becomes evident when one realizes the fact that no knowledge needs to be
known beforehand of the displaying device. So, a user can execute a program
on virtually any computer that has the Graphics System installed and that pro-
duces a metacode file. Then either remotely or locally, now or later, a post-
processor is run that will translate the metacode file into a code that is
decipherable by an intended graphics device. This system is portable in the
sense that its code can be transferred to several different computing environ-
ments. The following three features are a result of this portability:

a. The code for machine-dependent, non-standard functions is localized in a
   set of 14 primitive service routines.

b. The system’s language is high-level FORTRAN.

c. Because of a hierarchy, modular structure, the possibility of crashing
   the system due to a local error is reduced and possible trouble spots are
   isolated.

Although the SCD Graphics System is versatile, it is only up to a certain
point. Its capabilities are best suited for scientific and technical data,
including operations that deal with scatter diagrams, annotated graphs, data
for representing two- or three-dimensional data fields, and data for generat-
ing high quality text fonts. This system is not well suited for bar charts,
pie diagrams, or text fonts of commercial quality.

GENPRO at this time is being used to process sets of data which are collected
by the NCAR aircraft onboard data acquisition systems. Digital magnetic tape
that contains binary representations of aircraft parameters and atmospheric
variables are generated by the GENPRO system. The fact that RAF supports
research with several aircraft that have different instrumentation and data
systems that change frequently to keep up with the change in requirements of
the various research projects, and that large volumes of data have to be col-
lected are the reasons for using batch processing software which has multiple
functions and is flexible. After such data have been processed, quality control checks are made which provide the user with calibrated digital data and microfiche or microfilm that contains tabular data and plots of approximately 100 meteorological variables, aircraft parameters, etc.

The GENPRO software system is also being used by the Convective Storms Division of NCAR to input data from nine different aircraft data formats and to output a standard set of microfilm plots of aircraft and meteorological variables.

My contribution to this system was the task of developing a FORTRAN subroutine that could selectively add text strings, geographic outlines, and empirical curves to two-dimensional plots.

These plots were to include both a Latitude ordinate and a Longitude abscissa. The content and amount of information to be overlayed onto the plot grid was to be arbitrarily selectable at execution time and text strings were to be of variable size. The subroutine interfaces with both the GENPRO and SUPMAP software packages. (The SUPMAP software package is one which generates continental or U.S. state outlines according to one of nine projections whose origin and orientation are user selected.) The plots are enclosed by a rectangular frame and only material within this frame is plotted.
CONCLUSION

It has been concluded from the results of this project that the GENPRO Software Package is indeed capable of performing the tasks for which it was designed. This package does have the features needed to graph the data of scientists' and engineers' projects.

I have also concluded that IFTRAN is a suitable language for implementing GENPRO. Not only is IFTRAN easily coded and read, it is also implementable on a wide variety of machines.
ACKNOWLEDGMENTS

I would like to at this time take a few moments to give credit to some of the people who either directly or indirectly helped me get this project in proper perspective.

First there is the group of Martha Aguilar, David Armstead, Vonda Gieseby and Lisa Rothrauff. There are not words enough to express the thanks that I would like to give these people. They took valuable time out of their schedules to help us with any problem, no matter how trivial it was. They have made my stay here truly a pleasurable one.

Credits also go to my supervisor, Bob Lackman, who originated this project and Erich Thanhardt, who worked diligently and was very patient with me while working on this assignment.

Even though I did not interact with everyone in SCD, I would still like to thank the division as a whole. Those people whom I did have a chance to talk with such as Walter Macintyre, Dick Sato, Bonnie Gacnik, William "Buck" Frye, Dave Rennison, John Humbrecht and Greg McArthur, just to name a few, were very cordial and seemed to be more than willing to assist me with whatever problem I had. Most people in that division seemed genuinely interested in what I was doing.
REFERENCES


