— PROGRAM ABSTRACTS/ALGORITHMS —

ANDISP: A Turbo Pascal program to analyze and display sampled data

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ANDISP is a Turbo Pascal program that analyzes, displays, and manipulates sampled data recorded with a PC-compatible data-acquisition system. The data analysis routines include "integrate/differentiate a channel," "rectify," "smooth," "filter," and "add/sub/mult/div a channel by a constant," as well as a routine that gives some basic statistics. The data manipulation routines are "copy a channel" or "copy the data buffer to a file." The versatile display routine can give either oscilloscope-type displays of a data channel or plots of publishable quality. Hardware requirements are an IBM-compatible microcomputer and an EGA color monitor.

As theories in cognitive psychology become more complicated, the demand for sophisticated experiments to test them and estimate their parameters increases. The traditional measures of reaction time and accuracy have served well; a classic example is the finding that the effect on reaction time of inserting new processes can be the same whether the processes are in series or in parallel (Townsend, 1972). But ultimately, such measures are limited in their resolving power. Although methods have been developed for distinguishing serial and parallel processes using reaction time alone (Schweickert, 1978; Townsend & Ashby, 1983), the number of issues that can be settled definitively with reaction time is likely to be small. For this reason, many cognitive psychologists are becoming interested in electrophysiological measures. As one example, Coles, Gratton, Bashore, Eriksen, and Donchin (1985) found evidence in ERPs and EMGs that a mental process during execution, but before completion, can send output to later processes.

Because of the many steps that are needed to analyze sampled EEG/EMG data, ANDISP was developed to be a stand-alone program that would give many of the measures used in analyzing and displaying complex electrophysiological signals. The routines can also be applied to many sampled-data situations. It should be remembered, however, that although the routines are well suited to signal analysis, ANDISP lacks the complex filtering routines that would be needed, for example, to remove eye-movement artifact (EOG) from a complex EEG waveform.

Hardware Requirements

ANDISP requires a PC- or AT-compatible computer equipped with an EGA monitor and at least 256K of memory. To plot data, an Epson-compatible, dot-matrix printer with graphics capability is needed. ANDISP was originally written to manipulate and analyze data that was recorded with a TECMAR 16-channel, 12-bit A/D data-acquisition system, but it could also be used with data sampled with an 8-bit or 16-bit A/D by changing some of the constants in a parameter file.

Program Overview

The program was written in a modular style, with each item on the display menu being a self-contained procedure. Because all of the routines need much of the same basic information, such as sampling rate, the number of points per channel, or the number of channels, many of the variables are defined as global. The program can be expanded easily, by writing a new function or procedure and adding it to the menu. Figure 1 shows the main menu of the program.

To avoid having to enter information about sampling conditions every time the program is run, a parameter file is used to store the sampling rate, the number of channels, and the A/D maximum volts and count values. For a given experiment, this information would be the same for many of the data files, and thus only one parameter file would be needed. The program "remembers" the name of the last parameter file used, which becomes the default parameter file. The parameter file information is echoed to the display after the data file has been read. A sample parameter file is shown in Figure 2.

Data File Format

The program is configured to handle six channels of data stored in a text file, but it can be modified to handle more channels or a different file format. The first line in the file contains experimental information such as the subject's identification, the data file name, the trial and experiment number, and so forth. The second line in the data file contains the first sample of each of the channels separated by a space, where each A/D value is an integer. The data are stored in columns of integer numbers, where each column represents a data channel. The last line in the data file is an end-of-file marker value of 9999—a number well out of the range of 12-bit A/D values. The data array is declared type "integer" to accommodate A/D values between -2048 and 2048. Figure 3 shows a sample data file.

The data files should reside on the same disk and in the same directory as ANDISP. The program expects that the input data file is an ASCII text file—that it can be viewed with the DOS "type" command and edited with a word processor.

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                                ANDISP MAIN MENU

1 - Display/Plot the data
2 - Add/subtract a constant value
3 - Find Maximum and Minimums
4 - Copy a Data Channel to Another
5 - Multiply/Divide by a Constant Value
6 - Differentiate a Channel
7 - Integrate a Channel
8 - Add/Sub two data Channels
9 - Take the Absolute Value of the Data
A - Read a new input file
B - 3-point Linear Smoothing
C - Edit, Write the Data Buffer to a File
D - Find Mean, Variance and Stnd. Deviation
E - Gaussian Smoothing Routine
F - Exit the Program
G - Filter Routine

Enter your selection :

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Figure 1. Program main menu.

Data Analysis Routines

The routines for analyzing data are: differentiation, integration, rectification, and smoothing. The operation of each of the routines is described briefly below.

Differentiation. This routine uses three points to compute the slope of the line at a point: one before the given data point and one after. Thus, the slope at point x is $[(x + 1) - (x - 1)]$, divided by two times the time interval between two adjacent points. For the first and last points, only two points are used. If the signal is noisy, it should be smoothed or low-pass filtered before the derivative is taken.

Integration. Integration is accomplished by setting the first item of a buffer to zero and by adding each item of the data array to the next so that each item in the data buffer is the sum of the preceding items. Because this sum can get quite large, there is the possibility of integer overflow. This is handled in a manner analogous to that for a hardware integrator—if the sum exceeds the range of the A/D values, the maximum A/D value is substituted for any sum greater (or less) than the maximum or minimum A/D value.

Another way to avoid clipping a waveform during integration is to scale the desired data channel before in-

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Welcome to ANDISP ver. 1.0 - a program to
and analyze and display A/D channel data.

Enter the name of the input data file : lg0101.dat

The last parameter file accessed was : andisp.prm
Do you want this parameter file ?(y/n)y

The sampling rate is           : 500/sec
Number of data channels is     : 6
The a/d volts/cnts factor is   : 0.009766
The sample time length is      : 2970 msec
The # of lines in the file     : 1485
The total number of points     : 8910
The data and parameters have been read in

press any key to continue

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Figure 2. Parameter file format.

Figure 5. Plot showing the use of level-shifting, rectification, smoothing, and integration.

The Display Routine

This routine will display each of the data channels on an EGA color monitor, and if a graphics printer (Epson or Panasonic type) is attached, typing "shift/PrtSc" will dump the screen image to the printer to produce crisp plots.

The selectable features are:

Line-plot/point-plot. The individual data points can be plotted or they can be connected for a continuous line-plot.

Automatic/absolute scaling. Automatic scaling will scale the plot to the screen, or absolute scaling will scale the plot to a given value. Absolute scaling is useful for making comparisons between plots.

Grid/no-grid. The user can select an oscilloscope-type grid to be displayed to aid in reading values off the plot.

Titles. The user can also have a title plotted on the top of each plot.

Window. A portion of the data channel can be expanded for better resolution by entering time end-points.

To illustrate some of the features of the program, Figure 4 shows an actual EMG waveform of a bicep muscle movement that was sampled at 500 Hz. Figure 5 shows the signal after it has been level-shifted to remove DC offset, rectified, smoothed to remove transients, and integrated. The integrated EMG waveform, a measure often used to elucidate muscle movements, shows that a large burst of muscle activity began at about 2,079 msec, as is evidenced by the abrupt change in slope. The display features that were selected for Figure 5 include line-plot, title, absolute scaling, and grid.

Conclusion

ANDISP can be used as a general laboratory tool for manipulating, analyzing, and displaying sampled data. The filtering, smoothing, and mathematical data-manipulation routines, combined in one program, are especially convenient. And the open design of the program allows for easy expansion or modification.

Availability: Copies of the source code, an executable version of ANDISP, documentation, and instructions for modifying the program are available from the author upon receipt of a self-addressed mailer and floppy-disk (any format).

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