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Event Triggered Data Acquisition in the Rock Mechanics Laboratory Upgrades and Revisions

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Abstract

This paper describes updates and revisions to the data acquisition computer program DATAVG. DATAVG was first described in "Event Triggered Data Acquisition in the Rock Mechanics Laboratory", [Hardy,1993]. DATAVG has been modified to incorporate numerous user-requested enhancements and a few bug fixes. In this paper these changes to DATAVG are described.

Contents

1 Background

DATAVG has served as the basic data collection system for the Sandia National Laboratories Geomechanics Department Rock Mechanics Laboratory since late 1992 and is documented in [Hardy, 1993]. As is normal for any software product, experience has shown weak points and a few bugs. There have been no changes in the basic operation of the program. The original design goal was "Lean and Mean" data recording with a minimum of frills. While features have been added, this philosophy has been preserved.

Most changes have been user interface enhancements. Support for new hardware has been added as well. There have also been bug fixes which are discussed below. Fortunately, no bugs have been located during use which effect accuracy of recorded data.

2 Modification Tracking

Changes to the original code, [Hardy,1993], are documented by maintaining a running list of comments at the beginning of each source code file. In this list the date and a description of each change are discussed. By using this technique, traceabilit y of all changes is maintained. Any time sufficient changes have been added to warrant a version number change, a compressed archive of all files needed to create the version is created for a permanent record.

In the following sections, entries from these comments are printed and elaborated on to complete discussion of the change. Sometimes, changes involve more than one file. In these cases, all related comments, wit h a line added to identify the affected file, are grouped for discussion as a unit.

In several inserted comment blocks you will see a backslash preceding an underline, (\-). These are inserted to allow automatic typesetting of source code listings by LaTeX. This feature was used in the original report, [Hardy,1993], which contains full source code listings, but is not used in this paper. Since the comments were lifted intact, these markings are retained.

The changes are discussed below in two categories: enhancements and bug fixes. Changes are discussed by first printing the comment(s) describing the change, then by adding discussion of the change.

3 Enhancements

```
/* DATAVG . C                                                    */
/* March 25, 1993                                               */
/*  DATAVG now looks for it's K500. CFG files in the DATAVG directory. */
/*  Changed version to 1.10 in DATAVG. H                  RDH    */

/* DATAVG.H                                                      */
/* March 25, 1993                                               */
/*  Version increased to 1.10                             RDH    */
```

This change allows placement of DATAVG programs and data in any directory on the disk. The original version of DATAVG looked only in the current directory' for its configu-

ration file. Placing the configuration files in one standard place eliminated the need to keep copies in the current working directory.

```
/* 500LIB . c                                                    */
/* May 25, 1993                                                  */
/*    Changed AMM2 to use differential inputs conditionally      */
/*    if Single\-Ended is not defined.  RDH                      */
```

This change allows useofthe AMM2 board in either eight or sixteen channel mode. In our normal configuration, the AMM2is used as an eight-channel differential input board. It is wired to a connector which contains our six machine channels and two double banana jacks.

After making this patch, it is possible to use this board in single ended mode for applications which require greater channel counts, possibly eliminating the need for additional boards.

```
/* DATAVG . C                                                    */
/* June 25, 1993                                                 */
/*    Changed get\ _setup() so it will read setup files created with more */
/*    or less than MAXCHAN channels.                    RDH     */
```

This change enabled us to increase the maximum channel count in D ATAVG and use our previous setup files. Channels greater then MAXCHAN as defined at compile time are ignored.

```
/* 500 LIB .C                                                    */
/* June 25, 1993                                                 */
/*    read\ _AIM7 ( ) removes the board gain so readings are in  */
/*    volts .  This allows use of the board for low voltage      */
/*    inputs.                          RDH                      */
```

We needed to use the low level voltage input capability of the AIM7 board which has ±100mv capability. The previous driver version used this board only for thermocouple inputs.

```
/* 500 LIB .C                                                    */
/* August 4, 1993                                                */
/*    Added AIM3A driver                RDH                      */
```

We added a few new systems at this time. The old AIM3 board was no longer available and the new board has increased capabilities. A new driver was needed to use the AIM3A.

```
/* DATAVG . C                                                    */
/* October 20, 1993                                              */
/*  Installed disk buffering to increase recording speed         */
/*  Changed version to 1.11 in DATAVG. H                RDH      */

/* DATAVG . H                                                    */
/* October 20, 1993                                              */
/*  Version increased to 1.11                           RDH      */
```

This change was made in response to a request for increased speed. A test series involving high strain rates required increased recording speed. A few data points would be recorded and it was desired to hold off disk writes until the test was over. By installing a disk buffer in memory this requirement is met.

```
/* DATAVG.C                                                          */
/* November 1, 1993                                                  */
/* Changed call to init\_500() to include a mode flag for the AMM2.  */
/* The mode flag indicates single ended vs differential input mode.  */
/* Mode is selected by examining the channel count in the setup      */
/* file K500.CFG.                                          RDH       */

/* DATAVG.H                                                          */
/* November 1, 1993                                                  */
/* Version increased to 1.12                               RDH       */

/* 500LIB.C                                                          */
/* November 1, 1993                                                  */
/*    Changed init\_500() to accept a mode flag for the AMM2.        */
/*    The mode flag indicates single ended vs differential           */
/*    input mode.                                          RDH       */
```

The threeentries above refer to changes made to allow run timedefinition oftheAMM2 board configuration. In thefile K500.CFGyou find the definitions for all boardsin thecrate. As noted in the original document, [Hardy,1993], the number ofchannels supported bya board is found along with the board name and slot number. If auserneeds more channels, and can use single ended inputs, he/shecandefine the AMM2 as sixteen channels. When DATAVG finds a channel count greater than eight, it changes the mode flag so the driver can be properly configured.

```
/* DATAVG.C                                                          */
/* December 23, 1993                                                 */
/*  Inserted DataTranslation 2801 board support.           RDH       */

/* DATAVG.H                                                          */
/* December 23, 1993                                                 */
/*  Inserted DataTranslation 2801 board support. Computed board      */
/*  protocol used for this board.                                    */
/*  Version increased to 1.13                              RDH       */
```

There was adesire to use DATAVG with additional hardware for increased flexibility in the lab. This change enabled DATAVG to use a DataTranslation 2801 board which was installed for other uses. Keithley interface boards are required anyhow for clock support and DATAVG still requires an AMM2 board. This was only an additionto DATAVG.

```
/* DATAVG.C                                                          */
/* January 28, 1994                                                  */
```

```
/*  Added code to allow changing the number of readings to average      */
/*  at load time.  The first line of K500.CFG contains the segment      */
/*  address optionally followed by a comma(,) and decimal number which  */
/*  is the number of readings to be averaged before recording a data    */
/*  point.  This allows a trade off between filtering and speed.        */
/*  Zero is an invalid count which is replaced by the pre-defined       */
/*  default  Num\_To\_average.  Negative values are replaced by their   */
/*  absolute value.                                          RDH        */

/* 500LIB.C                                                             */
/* January 28, 1994                                                     */
/*    Added auto-scaling to the AIM3A driver.              RDH          */
```

The AIM3A has programmable input gain and this new driver uses the gain to increase resolution for low level signals. The gain is dynamically changed to obtain best resolution for the current input value.

```
/* DATAVG.C                                                             */
/* March 18, 1994                                                       */
/* Changed check\_channels() to continuously read and display the       */
/* input voltage for the channel in question. Previously operator       */
/* intervention was required to view a new reading.          RDH        */
```

This change was made for operator convenience. We always had the channel check function, but it required pressing akeytoobtain anew reading. This was a major inconvenience when adjusting a machine. Usually, two people were required before this change.

```
/* DATAVG.H                                                             */
/* March 18, 1994                                                       */
/*  Changed window handling to allow for 20 windows in banks of 4.      */
/*  check\_channels() displays continuously until keypress.             */
/*  Version increased to 1.2                                 RDH        */

/* DATAVG.C                                                             */
/* March 22, 1994                                                       */
/*  Changed window drawing and setup routines to allow multiple pages   */
/*  of windows.  Windows are displayed in pages of up to four at a time */
/*                                                           RDH        */
```

At the request of the staff, multiple pages of plots were added. It was decided that four plots was enough on one screen, but several pages could be implemented with rapid switching by using “PageUp/Down” keys. The window code was rewritten and resulted in oneof the most useful changesto DATAVG.

```
/* DATAVG.C                                                             */
/* March 24, 1994                                                       */
/*  Added Keithleyboxserialnumber to the K500.CFG file. This is at      */
```

```
/* the end of the first line following the segment address and average */
/* count.  This information is output in the data header file for      */
/*  system traceability.                                          RDH  */
```

This change helps us trace system use and calibration records. Before this timeit wasnot obvious which computer was used for a given test making calibration traceability difficult. This change resulted in the system identification being placed in each data header file.

```
/* DATAVG.C                                                           */
/* March 31, 1994                                                     */
/* Setup chart is now printed to the file SETUP.PRN when exiting from */
/*  init\_channels(). show\_setup() now has an option to use this     */
/* file or the printer.                                               */
```

Several staff members missed the setup summary chart available from the old PDP11 version of DATAVG. This change made the chart available in afileor hard copy ifa printer is attached. Later the hard copy option was eliminated as will be discussed below.

```
/* DATAVG.C                                                           */
/* April 6, 1994                                                      */
/* Added support for operation without a Keithley box attached. To    */
/* use this feature you must \#define NOKEITHLEY.              RDH     */

/* DATAVG.H                                                           */
/* April 6, 1994                                                      */
/* Added support for a Schaevitz LVDT board as a computed channel     */
/* driver.                                                            */
/* Added support for a Data Translation 2801 or 2805 board.    RDH    */
```

This change cut us loose from the Keithley box and allowed portable operation. We could now operate with portable computers without carrying extraequipment. The portable machine had been used with software which was changed for each test. DATAVG gave us a single program solution usable by people who did not know the inner workings of the program. Some features of the previous program were removed, but we felt this was acceptable.

```
/* 500LIB.C                                                           */
/* April 7, 1994                                                      */
/*    Moved AMM2 initialization code to a separate function.          */
/*    This allows creation of a DATAVG version which does not         */
/*    use Keithley boards except for the 500-IBIN-A interface.        */
/*    initialization of the AMM2 will time out if the board is        */
/*    not present.                                             RDH    */
```

This was a code cleanup. The driver code became more modular with the AMM2 setup removed from the other configuration.

```
/* DATAVG.C                                                          */
/* June 24, 1994                                                     */
/* Changed zero flag display in gen\_show\_setupo to Y or N instead */
/* of 1 orO.                                                RDH      */
```

This improved readability of the setup printout. Some operators found it difficult to interpret asetup sheet containing Yes/No information in 1/0 form.

```
/* DATAVG.H                                                          */
/* July 14, 1994                                                     */
/*  Added pseudo boards to the boards[] array. This allows run time */
/*  configuration of add in board drivers.  Increased the size of    */
/*  SerialNumber and BUFFER.                                RDH      */
```

This is a decision which made operation more general. To the operator there was no obvious change. As discussed in the original paper, pseudo boards are used where computations are required to obtain the required information. Thisis most used to linearize thermocouple data which are obtained from voltage readings. This feature can be used in other waysifrequired. For example, sample stress maybe computed from load and pressure readings if the sample and piston areas are known.

```
/* DATAVG.C                                                          */
/* November 11, 1994                                                 */
/* Changedinit\_channels()so the first point zero question has the  */
/* 'current value as default.  This value will be changed only if the */
/* user requests a change.                                 RDH      */
```

In the previous version, the first point was used as a zero offset by default. If a test was stopped for configuration change, this option reverted although it had been disabled originally. After this change, the previous option was retained by default. The advantage was quicker restarts with less hassle and chance for error.

```
/* DATAVG.C                                                          */
/* November 16, 1994                                                 */
/* Changed place\_plots() to use screen space completely. When three */
/* windows are active on a page, one will be full screen width.      */
/*                                                         RDH      */
```

Before this change, there was a blank portion on the screen if some windows were not in use. Frequently, three plots were needed for a test. This resulted in waste of screen resources. This change makes full use of available screen real estate.

```
/* DATAVG.C                                                          */
/* January 27, 1995                                                  */
/*  Changed scaling and trigger interval prompts to read ENGINEERING */
/*  U N I T S .                                            RDH      */
```

Many operators were confused by the original prompts. This led to some strange results when trigger intervals were not as expected. This change cleared up many problems encountered during test configuration.

```
/* DATAVG . C                                                          */
/* May 23, 1995                                                        */
/*  Added code to produce a setup confirmation file similar to the one */
/*  produced on exit from setup\_channels(). This file is named using */
/*  the data file name core with the type ''.PRN'' appended. This file */
/*  is produced by get\_file\_name(). The production of this file by  */
/*  setup\_channels() was removed.                              RDH     */

/* DATAVG.H                                                            */
/* May 23, 1995                                                        */
/*  Version increased to 1.24                                  RDH     */
```

This helped totiethe setup summary file to the test. Previously, there was only one filename used. If an operator saved asetup and then wanted thesummary from aprevious test hehad aproblem. It was not insurmountable but was inconvenient. After this change the summary files were not overwritten so the problem was eliminated.

```
/* DATAVG.C                                                            */
/* May 26, 1995                                                        */
/* Added code to my\_init\_graph() to deactivate any unused windows.   */
/* This was done to allow removal of previously defined windows. RDH   */
```

This allowed removal ofa plot during atest. When the X-axis channel is-l, the window is not active. Ifa user wanted to remove a plot, he/she could redefine the window during a test. This change made it completely go away and reclaimed the screen space for other windows.

```
/* 500LIB.C                                                            */
/* July 12, 1995                                                       */
/*    Auto-scaling is optionally implemented on the AMM2 board         */
/*    to increase resolution of small signals.  Both the local         */
/*    10X gain stage and global 10X gain stage are used as             */
/*    needed.                                                  RDH     */
```

This is acompile-time option. Later, this became the default since no reason to remove it could be seen. Calibration procedures require making readings which verify operation in this input range.

```
/* DATAVG.C                                                            */
/* September 20, 1995                                                  */
/* Added X,Y coordinate display.  This feature displays the last point */
/* coordinates in a sub-window at the top of each data window. This    */
/* feature is toggled by pressing F10.  When this display is active we */
```

```
/* get the effect of graphic and digital meter display simultaneously. */
/* The meters are correct even if the point is outside the window      */
/* boundaries.                                              RDH        */

/* DATAVG.H                                                            */
/* September 20, 1995                                                  */
/* Version increased to 1.26                                  RDH      */
```

In one fieldtest, the plots were off screen and the operator didnot wishto zoom them. This prompted a discussion about how to determine what was going on. We decided that adigital display, in addition to the plot, would be helpful. An additional advantage would be the ability to read input values accurately without interpolating plots.

```
/* DATAVG.C                                                            */
/* October 9, 1995                                                     */
/*  Added auto start capability.  This allows DATAVG to run from       */
/*  AUTOEXEC.BAT to recover from power failure or for use by untrained */
/*  operators.  To enable this feature, the file AUTO.DAV must be in   */
/*  the current working directory.                                     */
/*    In the file AUTO.DAV the first line must contain the complete    */
/*  name of the setup file.  The second line must contain the complete */
/*  name of the data file and the third line contains the number of    */
/*  data points to record before closing the data file.                */
/*    The functions setup\_auto(), disable\_auto() and copy\_file()    */
/*  were added to facilitate this feature.             RDH             */

/* DATAVG.H                                                            */
/* October 9, 1995                                                     */
/*  Added auto\_start\_flag.  Used during auto start from autoexec.bat */
/* increased version to 1.27                                  RDH      */
```

This change was inresponse toa need to use DATAVGin the creep lab. In this application we are faced with long term tests and reliability is needed. Additionally, unattended field tests are enabled by auto-start features. If power fails then returns the computer will reboot and DATAVG will, start over using the same files. The time channel will reset to zero which marks the restart point.

This feature also allows untrained operators to collect data as requested by simply turning the computer on at the desired time. When sufficient data have been collected, they may turn the computer off. In combination with auto-start operation, we configure DATAVGto close the data file after each reading is recorded so no data are lost during a power failure. This cycle may be repeated for the duration of a test sequence.

```
/* DATAVG.C                                                            */
/* May 17, 1996                                                        *   /
/* Added code to read and display calibration expiration due date. If */
/* calibration has expired, the display is blinking reverse video.     */
/* This feature requires a change in the K500.CFG file. A new line is */
```

```
/* inserted after the first line containing the address, etc. This */
/* line must hold the calibration due date formatted ''MM/DD/YYYY''. */
/* This format is important since DATAVG reads each field separately. */
/*                                                          RDH      */
```

This change was a response to an observation ofa machine out of calibration. The sticker was difficult read and therefore ignored. This change places the calibration due date on screen above the main menu. If calibration expires, the message changes to reverse video with red characters showing the date calibration expired. Operation is allowed to continue so calibration may be performed.

```
/* DATAVG.C                                                          */
/* May 17, 1996                                                      */
/* Changed the display mode during channel check. I am now using     */
/* forty column CGA mode to increase viewing distance. This makes    */
/* operation easier when adjusting equipment.          RDH           */
```

This is an operator convenience change only. When setting gauges on a sample it is convenient to use the channel check feature of DATAVG. In this mode of operation, DATAVGdisplays the input voltage for the channel in question. If the operator is working at a considerable distance from the computer the screen display was unreadable. The operator had to make a guess and go read the display then try again. With the larger text in the forty column mode, the display can be read from twenty to thirty feet which saves a lot of running around.

```
/* DATAVG.C                                                          */
/* August 22, 1996                                                   */
/*  Printer option removed from show\_setup(). This option is no longer */
/*  needed.                                             RDH           */
```

We no longer have printerson our laboratory computers. If the operator attemptsto print hard copy, the computer hangs and must be rebooted. This is an inconvenience we donotneed sothe offending option was eliminated.

4 Bug Fixes

```
/* DATAVG. C                                                         */
/* May 25, 1993                                                      */
/* Fixed bug in channel setup function. It was possible to set       */
/* channels greater than MAXCHAN.                          RDH       */
```

This fix prevented overflowin a buffer pointer. When the pointer went outof bounds, it allowed creation of channel structures where there should be none. The extra structures caused DATAVG to crash in several cases. Fortunately, crashes occurred at the start ofa test instead oflater when they may have caused data loss.

```
/* 500LIB.C                                                          */
/*  June 25, 1993                                                    */
/*    Corrected timing error in read\_ad(). Fast machines did        */
/*    not wait long enough before starting conversion.  RDH          */
```

```
/* DATAVG.H                                                          */
/* June 25, 1993                                                     */
/*   Changed definition of SIXTEEN              RDH                  */
```

This change was needed to account for faster processors. The original value gave sixteen micro-seconds delayon an XT class computer. When restarted using faster machines, the delay was no longer sufficient.

```
/* DATAVG.C                                                          */
/* July 15, 1993                                                     */
/*  Fixed bug which caused time errors. Time stepped back at 1sec.   */
/*  intervals due to counter cascading.                  RDH         */
```

This error caused the time to drift backward $1\mu s$ per second. While this error would not have substantial effect in normal laboratory operation, (it is 10^{-4}%), the cumulative effect might be noticed in long term tests.

```
/* 500LIB.C                                                          */
/* July 15,  1993                                                    */
/*    Added SLOW conditional to insert delay between channel         */
/*    selection and digitization.      RDH                          */
```

This change allows increased settling time for some boards which cannot handle large differences between channel input values.

```
/* DATAVG.C                                                          */
/* August 3, 1993                                                    */
/* Fixed bug in validate\_file\_name(). Was truncating at eight      */
/* characters if a file type field was present.            RDH       */
```

The validate-file_nameo function is usedto remove characters which DOS does not like in file names. It is a tricky piece of code which must process each part of a file name to insure validity. This function is used in several programs soit was later moved to alibrary and rewritten to makeit more general. The change mentioned here fixed a problem which only happened ifafile type field was present.

```
/* DATAVG.C                                                          */
/* August 8, 1993                                                    */
/* Fixed bugwhichcausedTest\_IDto get too long after repeated        */
/*  save\_setup() and  get\_setup() calls.                 RDH       */
```

The leading space in the setup file was not removed from this string. If the file was read repeatedly, these spaces accumulated until the buffer overflowed. Buffer overflow is a problem in "C" which can cause strange behavior.

```
/* DATAVG . C                                                        */
/* December 22, 1993                                                 */
/*  Converted calls to exit() to de\_init().This was done to         */
/*  insure that interrupt vectors are reset.  de\_init() now takes   */
/*  a character pointer to allow passing an error message before     */
/*  program termination.                                  RDH       */
```

When aprogram traps interrupt vectors it is REQUIRED to restore them on exit. If this is not done, the computer will crash when the next program is started.

```
/* DATAVG.C                                                          * /
/* December 22, 1993                                                 */
/*  Minor changes were made to get\_setupo. This was done to assist */
/*  error trapping if invalid setup files are encountered.      RDH   */

/* DATAVG.C                                                          */
/* January 26, 1994                                                  */
/*  Inserted code in setup\_window() to reject equal values for min and */
/*  max.  This was done to eliminate floating point errors while     */
/*  computing scale factors.                                    RDH   */
```

This fixed a big problem in the graphics routines. When the endpoints ofan axis are equal the length is zero. Since the length is used in computing the fraction of the window width where this point is placed, the code blows up with zero length axes. A zero length axis is not very informative and, while it is possible to trap "divide by zero" errors in the graphics routine, it is better to prevent the problem in the first place.

```
/* 500LIB.C                                                          */
/* February 14, 1994                                                 */
/*    Found and fixed a bug in the AIM3A auto-scaling                */
/*    algorithm.  The gain range selection was not working          */
/*    correctly.                                              RDH   */
```

Auto scaling can be tricky. This bug was found while checking calibration after the new board was installed.

```
/* DATAVG.C                                                          */
/* March 24, 1994                                                    */
/* Added a special case in get\_setup() so the code will run with    */
/* either an AIM3 or AIM3A board installed. Externally these boards */
/* are interchangeable, their drivers are not. This code will not   */
/* work if both boards are installed in a single system.       RDH   */
```

This change was required by addition ofthenew AIM3A boards. The AIM3A boardis functionally equivalent totheolder AIM3 board from theoperator's viewpoint.

Sometimes, an operator needs to use a different computer tocontinue atest series after a break. It is desirable to use the previous setup file to insure consistent data file formats. Ifthe computers are equipped with different boards, DATAVG must adapt sothe previous setup will work.

```
/* DATAVG.C                                                          */
/* April 8, 1994                                                     */
/* current\_page and empty\_page[] are initialized when loading a    */
/* setup file.  current\_page is reset when a test is started.       */
/* When data recording is started the zero offset flags are cleared */
/* to facilitate restarting a test. This allows a restart without   */
/* glitches in the data.                                             */
```

```
/* When querying for the board to use, only active boards are listed. */
/* This was done to allow more boards to be listed with a partially */
/* filled main frame.                                          RDH   */

/* DATAVG.H                                                          */
/* April 8, 1994                                                     */
/* Added zero\_offset\_flag to the ch structure. This flag controls */
/* whether a channel has a zero offset applied. Formerly, this       */
/* function was merged with the zero variable which stored the offset */
/* value at run time.  Adding a new variable allows a test to be     */
/* stopped and restarted without glitches in the data.         RDH   */
```

This change was implemented after atest was stopped to changed scale factors. The machine range was incorrect and it became obvious that full scale would be exceeded. When data recording resumed, the zero offsets were incorrectly set andaspike was obvious in the data. The problem was correctable during data reduction but could be preventedby changing the code. See the changes listed in the DATAVG.C file above.

```
/* DATAVG.C                                                          */
/*May 24, 1994                                                       */
/* NOKEITHLEY is defined in the makefile. Two different versions are */
/* produced by make.  One is NOKEITHLEY and the other used Keithley */
/* hardware.                                                   RDH   */
```

This change is a coding cleanup, not a bug fix. When non-keithley operation was added this definition was located in the main code file, DATAVG.C. This led to inconvenience since the code had to be changed to create the two versions. By moving the definition to the makefile, both versions may be automatically generated.

```
/* DATAVG.C                                                          */
/* June 24, 1994                                                     */
/* Added code to trap inactive channel numbers to setup\_window(). */
/* This prevents errors when plotting data from channels which are */
/* no longer being used.                                       RDH   */

/* DATAVG.H                                                          */
/* June 24, 1994                                                     */
/* Increased version number to 1.21                            RDH   */
```

Thecode mentioned here preventsan operator from referencing achannelin aplot setup until the channel has been defined. Previously DATAVG workedon the honor system and trusted operators to define their channels before starting data recording. This trust was sometimes misplaced.

```
/* DATAVG.C                                                          */
/* July 14, 1994                                                     */
/*  Clear Total\_points at start of data collection. This prevents    */
/*  plotting old data if recording is restarted without exiting DATAVG. */
/*  Changed place\_plots() to prevent display of no longer active     */
/*  windows.  This was a problem if a run was stopped and the window */
/*  count was reduced.                                    RDH         */
```

Sometimes, theoperator would endatest then start another without leaving DATAVG. Some plot information was initialized when the program' started. When DATAVG was started fresh for each test, no problem existed, but strange plots appeared if asecond test was started while still in DATAVG . Initialization ofthese variables wasmoved sothey would be properly set for each test.

```
/* DATAVG.C                                                          */
/* July 20, 1994                                                     *     /
/*  Added error trapping to get\_setup(). Hopefully this will catch */
/*  corrupted setup files.                                RDH         */
```

At this time we had problems with setup files. Any error in the file caused DATAVG to abort.

```
/* DATAVG.C                                                          */
/* July 20, 1994                                                     */
/* Added a dummy device driver to trap calls to uninitialized channels */
/* At startup and get\_setup() all channel drivers are pointed to this */
/* trap driver until the channel is defined.                RDH      */
```

This dummy driver prints amessage and returns. It prevents program abortion. Later, it was moved to the driver library code to trap computed channel problems.

```
/* DATAVG.C                                                          */
/* September 19, 1994                                                */
/*  Removed calls to closegraph() in de\_init() and redraw\_windows(). */
/*  These calls were redundant and could possibly cause lockup of the */
/*  program.                                              RDH         */
```

These calls did cause problems. Apparently, they allocate memory in the Borland library code and donot return it. When an operator repeatedly switched pages of windows memory was exhausted. The program then locked and required re-booting.

```
/* DATAVG.C                                                          */
/* September 19, 1994                                                */
/* Removed a full screen plot from redraw\_windows(). This code was */
/* originally used to prevent problems if a blank plot page was      */
/* displayed.  This condition is now prevented so the code is no     */
/* longer needed.                                        RDH         */
```

When multipage plots were first added, there was a problem with display of a page containing no windows. The problem was fixed by always doing a full screen plot before creating the real windows. This was a quick fix which allowed the requested change in a timely manner but was never satisfactory. The change implemented here removes the full screen plot which became unnecessary by changing the code to prevent drawing empty pages.

```
/* DATAVG.C                                                    */
/* September 21, 1994                                          */
/* Fixed init\_channels() so it will not increment the default channel */
/* number beyond MAXCHAN. Channel numbers > MAXCHAN or < 0 are  */
/* trapped and a message is printed.                           */
/* Version increased to 1.22 in DATAVG.H.              RDH     */
```

The channel counter was not properly terminated. It is possible to use channels with high numbers while skipping over lower numbered channels. No harm was done during data recording, but it can cause problems during program setup and it is confusing tothe operator.

```
/* DATAVG.H                                                    */
/* September 21, 1994                                          */
/* Put dummy\_driver() pointers in' boards[] array.            */
/* Increased version to 1.22                           RDH     */
```

This is error trapping. dummy.drivero is atrap routine which catches calls to uninitialized hardware. Placing pointers in the boards[] array insures the traps will be effective. See the note above which references this change.

```
/* 500LIB.C                                                    */
/* October 3, 1994                                             */
/*    Added channel range checking to analog input routines.   */
/*    This should not be needed but it is insurance.   RDH     */
```

DATAVG checks channel numbers before passing them to the driver routines. This range check was implemented just for the sake ofproducing more reliable code. As you will see later, it also caused aproblem with the AIM7 board driver which had tobe addressed by additional exception code.

```
/* 500LIB.C                                                    */
/* October 4, 1994                                             */
/*    Removed a delay loop from read\_ad(). This 100P was      */
/*    after start of conversion. Apparently, it caused some    */
/*    instability in reading conversion status.        RDH     */
```

The reason for this problem is not clear, however, removal of this delay settled the matter.

```
/* DATAVG.C                                                          */
/* October 6, 1994                                                   */
/*  Deleted get\_int(), get\_float() and validate\_file\_name().      */
/*  These functions are now taken from RDHLIB which has been added to */
/*  the link list. These functions are used widely in other programs. */
/*                                                          RDH      */

/* DATAVG.H                                                          */
/* October 6, 1994                                                   */
/*  Changed this header to include RDHLIB.H. This allows use of the  */
/*  library functions in their form at compile time. The make file was */
/*  changed to use RDHLIB in the link list.                 RDH      */
```

The two entries above were made to allow consistent useofmy library functions by several programs. Until this time, several programs used these functions but contained their own copies.

When changes were needed, it was a real job to insure all copies were identical, Placing these functions, and several others, in a library simplified consistent use in a variety of places.

```
/* DATAVG.C                                                          */
/* November 11, 1994                                                 */
/* Changedcodeso computed channel drivers are not called if the      */
/* scale factor is zero.  This was a problem during channel setup or */
/* recall of setup files.                                  RDH       */
```

Computed channel drivers contain their own initialization code. When the scale factor is zero, there cannot be any output and they will not be called at run time. It is therefore unnecessary to call them at setup time.

```
/* DATAVG.C                                                          */
/* May 5, 1995                                                       */
/*  Added calls to closegraph() in the ''page\_up'' and ''page\_down'' */
/*  routines.  This should remove the "out of memory" errors. RDH    */

/* DATAVG.H                                                          */
/* May 5, 1995                                                       */
/*  Version increased to 1.23                              RDH       */
```

This change was installed because DATAVG would crash when paging through asetof windows. There was aproblem with memory allocation which eventually consumed all free memory until the program crashed. See the note above, (September 1994), where these calls were removed from de_init() and redraw.windowso.

```
/* DATAVG.C                                                          */
/* July 17, 1995                                                     */
/* Added code to trap error codes returned by input channel drivers. */
/* On receipt of invalid channel numbers or slot numbers, drivers    */
/* return -100.0.  This value is invalid and should generate some sort */
/* of error response.  At this time, the program is aborted with an  */
/* error message.                                        RDH         */
```

This is not very friendly behavior. It was addressed in apatch the next day.

```
/* 500LIB.C                                                          */
/*  July 17, 1995                                                    */
/*    Functions set\_global\_gain() and set\_slot() were added       */
/*    to facilitate clean code. They are used in a number of         */
/*    other functions. These are static functions.     RDH           */
```

This is not really abugfix. It was implemented to clean up the code and reduce repeated code in several board drivers.

```
/* 500LIB.C                                                          */
/* July 17, 1995                                                     */
/*    Input functions were modified to do more complete range        */
/*    checking on input data.  The channel number and card slot      */
/*    are now tested to insure proper values are supplied.           */
/*    This should prevent problems if someone edits a setup          */
/*    file and makes input channels into computed channels.  It      */
/*    will, also, trap conditions where the original hardware        */
/*    was configured the AMM2 for sixteen channels and the           */
/*    current machine is configured for eight channels.  RDH         */
```

This problem addressed aboveis most likely to occur when transporting a setup file from a portable system to a laboratory machine. Some portable computers use the AMM2 in the single ended mode to increase channel count.

```
/* DATAVG.C                                                          */
/* July 18, 1995                                                     */
/*  Added code to get\_setup() to trap invalid setup file entries.   */
/*  This function now returns a status code which is used to route   */
/*  execution to init\_channels() for corrective action by the user. */
/*  This should trap most problems before the above patch is needed. */
/*                                                        RDH         */

/* DATAVG.H                                                          */
/* July 18, 1995                                                     */
/*  Version increased to 1.25                             RDH         */
```

When an operator edits a setup file it is possible to create an invalid entry. This new code detects invalid channel setup entries and transfers execution to init_channels() so the operator can correct the entry.

This action replaces the previous method of issuing a cryptic message and aborting the program. The operator is given a chance to correct the entry and continue the test.

```
/* DATAVG . C                                                          */
/* October 10, 1995                                                    */
/* Replaced calls to closegraph() with calls to Text\_Mode().          */
/* replaced call to open\_graph() in redraw\_windows() with call to    */
/*  Graph\_Mode(). In datavg\_init() I open graphics and save the      */
/* mode to enable restoration later. These changes were made in an     */
/* attempt to eliminate program crashes during graphics manipulations. */
/* Graphics are opened in datavg\_init() and closed in de\_init()      */
/ *    o n l y .                                    RDH                 */
```

This finally fixed the memory leak which caused the crash. The leak was caused by Borland graphics code as discussed in two places above, (September 1994 and May 1995). This problem should have found earlier but was not.

```
/* 500LIB.C                                                            */
/* October 18, 1995                                                    */
/*    Corrected range checking in read\_AIM7(). This driver            */
/*    excluded channel 32 which is the junction temperature            */
/*    channel.                                          RDH            */
```

This board is seldom used for temperature readings. However, when it isused for this purpose, the reference temperature is needed. The board contains sixteen channels and the driver enforced this limit. Unfortunately, the sixteen channel limit prevented accessto channel 32 which is the terminal block junction temperature. Special case code has been added to allow channels zero through fifteen and 32.

```
/* DATAVG.C                                                            */
/* April 1, 1996                                                       */
/*  Added a line to my\_init\_graph() to prevent window numbers going  */
/*  beyond the maximum.  This code only effects the prompt string. RDH */
```

Prompts were asking for window information on invalid windows. This change implements range checking to eliminate the problem.

```
/* DATAVG.C                                                            */
/* August 23, 1996                                                     */
/* Added code to clear Data\_file\_name if auto-start fails to read    */
/* a valid data file name.                              RDH            */
```

This change was prompted by an invalid auto-start file. Somehow, an incomplete file was created. DATAVG would not operate properly until it was removed.

5 Future of DATAVG

DATAVG is doing a good job in the Rock Mechanics Laboratory. Time and experience have validated the design philosophy in DATAVG. This program does what is needed in an easily used manner. Continued use for the foreseeable future is anticipated.

In the future the author would like to make a major revision of DATAVG. This revision would probably be a total rewrite using more object oriented methods. The possibility of moving DATAVG into a Windows[1] environment has been discussed. However, the hardware supported by DATAVG would make programming under Windows difficult at best.

Experience in maintaining DATAVG has shown places where the code could be cleaned up and made more readable. The code can probably be better partitioned to consolidate functions which are now near duplicates. This would make the program smaller and probably easier to maintain. Further, some of the inner workings of device drivers can be hidden by using better object oriented design.

[1] Windows is a trademark of Microsoft Corporation

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Bibliography

[Hardy,1993] Robert D. Hardy, *"Event Triggered Data Acquisition in the Rock Mechanics Laboratory"*, SAND93-0256, Sandia National Laboratories, Albuquerque, NM, 1993.

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