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DEVELOPMENT OF SOFTWARE FOR THE
MSFC SOLAR VECTOR MAGNETOGRAPH

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The Marshall Space Flight Center Solar Vector Magnetograph is a special purpose telescope used to measure the vector magnetic field in active areas on the surface of the sun. This instrument measures the linear and circular polarization intensities (the Stokes vectors Q, U and V) produced by the Zeeman effect on a specific spectral line due to the solar magnetic field from which the longitudinal and transverse components of the magnetic field may be determined. Beginning in 1990 as a Summer Faculty Fellow in project JOVE and continuing under NASA Grant NAG8-1042, the author has been developing computer software to perform these computations, first using a DEC MicroVAX system equipped with a high speed array processor, and more recently using a DEC AXP/OSF system. This summer's work is a continuation of this development.

The existing MSFC Vector Magnetograph measures polarization intensities at points in a square array of 128 x 128 pixels which cover a field-of-view (FOV) of about 5 by 5 minutes of arc. At the present time, a new magnetograph is under construction which will provide considerably higher resolution, up to a maximum of 1024 x 2048 pixels covering a FOV of 4 by 8 arc-minutes. Initially, programs are being written to process arrays of 512 x 1024 pixels, later to be expanded when the full resolution of the instrument is realized.

The computation of the longitudinal and transverse components of the magnetic field is described by Hagyard et al (1982)[1]. Once the Stokes vectors P_V, P_Q, and the azimuth angle ϕ are determined, the magnetic field components are then computed by evaluating polynomials in P_V and P_Q at each point of the data array. The coefficients in these polynomials are dependent on the inclination angle Ψ (angle to the line-of-sight) of the magnetic field vector at any point. The calculation is straightforward for points along the neutral line where $\Psi = 90°$, but the result is less accurate for points away from the neutral line where Ψ varies from 0 to 90°. A new method was developed by Hagyard and Kineke (1995)[2] to calculate the magnetic field components by evaluating the polynomials at points away from the neutral line by an iterative process using an individual set of polynomial coefficients which correspond to the inclination angle of the field at each point in the array.

The software to implement the magnetic field computations by the new method is written in Interactive Data Language (IDL), which supports efficient vector and array processing capabilities. However, since the new iterative algorithm involves evaluating polynomials having coefficients which depend on Ψ, it was necessary to implement the iterative processing in external FORTRAN subroutines called by IDL, since IDL is very inefficient when a data dependency exists. Originally, the programs were developed on a MicroVAX 3600 running the VMS operating system, and reasonable execution times (< 1 minute) were realized for the 128 x 128 pixel arrays produced by the existing magnetograph. The present effort is to migrate the IDL and FORTRAN routines to an AXP/OSF system which has considerably greater speed and memory capacity to handle the high resolution data arrays produced by the magnetograph now being assembled. A problem was encountered when it was discovered that the IDL documentation and

examples describing the calling of external subroutines on AXP/OSF systems were in error. When the software vendor (Research Systems, Inc.) provided the correct documentation, the process worked properly.

A major part of the programming effort has been directed to the development of a "user friendly" interactive graphical user interface which exploits the windowing capabilities available in the OSF1 operating system (X windows). The IDL language supports a series of "widgets" which can be manipulated to produce buttons for making selections from a set of options, sliders for the selection of a number from a given range of values, text boxes for keyboard input and a draw widget for plotting the results. In most cases, the user makes selections and chooses numerical values by means of a pointing device (mouse). In a typical execution of the IDL profile SPOT, the user first sees menus for the selection of input data files. The desired directory and files can be chosen by highlighting the selection and pressing (clicking) a mouse button. Next, the menu shown in figure 1a appears, where the user can change the constants used in the magnetic field calculations by clicking the appropriate box and entering the data from the keyboard. In addition, "YES/NO" button options are available to save the constants, save the calculated magnetic field components in output files, or plot the resulting magnetogram on the display. Clicking the "OK" button causes the profile to continue, whereupon the user sees the menu of figure 1b, where the number of iterations of the polynomial evaluation algorithm is chosen. The IDL profile then calls an external

Magnetograph Calibration Profile

CK	UOBAR	X2 (%)
4.395000	0.0001050	-1.60000

PVO	ROBAR	X3 (%)
0.0000000	0.0000690	2.84000

Save constants in /usr/users/kinekej/ar6659/b13439f.h? ◇ YES ◆ NO

Save B-files in /usr/users/kinekej/ar6659/? ◇ YES ◇ NO

Plot Results on Display? ◆ YES ◇ NO

OK	CANCEL	HELP

Figure 1a

Magnetograph Calibration Profile

Select Number of Iterations:

◇ 0 ◇ 2 ◇ 3 ◇ 4 ◆ 5 ◇ 6 ◇ 7 ◇ 8 ◇ 9

OK	CANCEL	HELP

Figure 1b

Sat Aug 19, 1995
GRAM
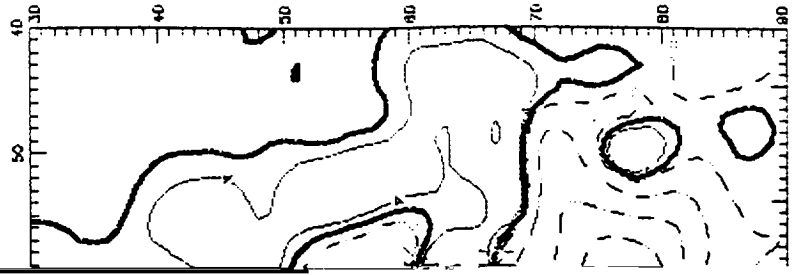
Clearly, the software development process for the new magnetograph is just beginning. Preliminary tests indicate that for 512 x 1024 pixel arrays, execution times with five iterations of the polynomial evaluation algorithm are on the order of several minutes, which is certainly quite reasonable. Considerable programming remains to be done to provide for additional calculations, such as the production of plots in the heliocentric coordinate system. The author intends to submit a new proposal to continue his work in January, 1996. The assistance and cooperation of all of the members of the staff of the MSFC Vector Magnetograph Laboratory is greatly appreciated by the author, for it made his five week visit a pleasant and intellectually stimulating experience, despite the exceptionally hot weather.

References

1. M.J. Hagyard, N.P. Cummings, E.A. West and J.E. Smith: "The MSFC Vector Magnetograph," *Solar Phys.* 1: 31-51, 1982.

2. M.J. Hagyard and J.I. Kineke: "Improved Method for Calibrating Filter Vector Magnetographs," *Solar Phys.* 158: 11-28, 1995.