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Improving the ease of use and efficiency of software tools

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Abstract. For developing countries it is very important to derive maximum use of data obtained from their own telescopes. This is not only related to maximizing science returns on capital investment, but also to maximizing science output. In this paper we describe how we are utilizing software tools to realize this goal. This paper discusses the design and main features of our software tools, and planned future developments. The primary vehicle for general data interpretation is through various interactive techniques of data visualization. Our software employs an object oriented approach which facilitates data processing for experienced users as well as being easier to learn for novice users. This leads to greatly increased efficiency in every phase of data analysis. For developing countries the kind of software we are developing and the virtual observatory concept holds out the hope of advancing capability and efficiency in scientific research.

Keywords. data analysis, software, object oriented programming, solar physics, virtual observatories

1. The Multi-Channel Solar Telescope

The Multi-Channel Solar Telescope (MCST) is a ground-based video magnetograph that can measure the solar 2-dimensional magnetic field and velocity field using different spectral lines. It is consists of a local magnetic field, full-disc vector magnetograph, full-disc H-alpha telescope, etc. It is one of the few integrated-function solar telescopes in the world. The MCST is used to investigate and predict solar magnetic activity and solar-terrestrial interaction effects. Users of its data include solar physicists, the Solar Activity Prediction Centre of Chinese Academy Sciences (CAS), the Space Environment Prediction Centre of CAS, university students and the public.

2. Frequently encountered problems

The following problems usually cost the user plenty of time: programming data analysis codes or codes to translate between various data formats; data calibration; image manipulation, etc. These operations are often carried out using software developed by other users and supported on a best-effort basis. If these problems can be solved in an integrated way, then usability of the data will be greatly enhanced. The easier it is to utilize the data, the higher will be the processing efficiency and resulting data processing gains. Researchers can then pay their attention to solving scientific problems rather than solving data processing problems.

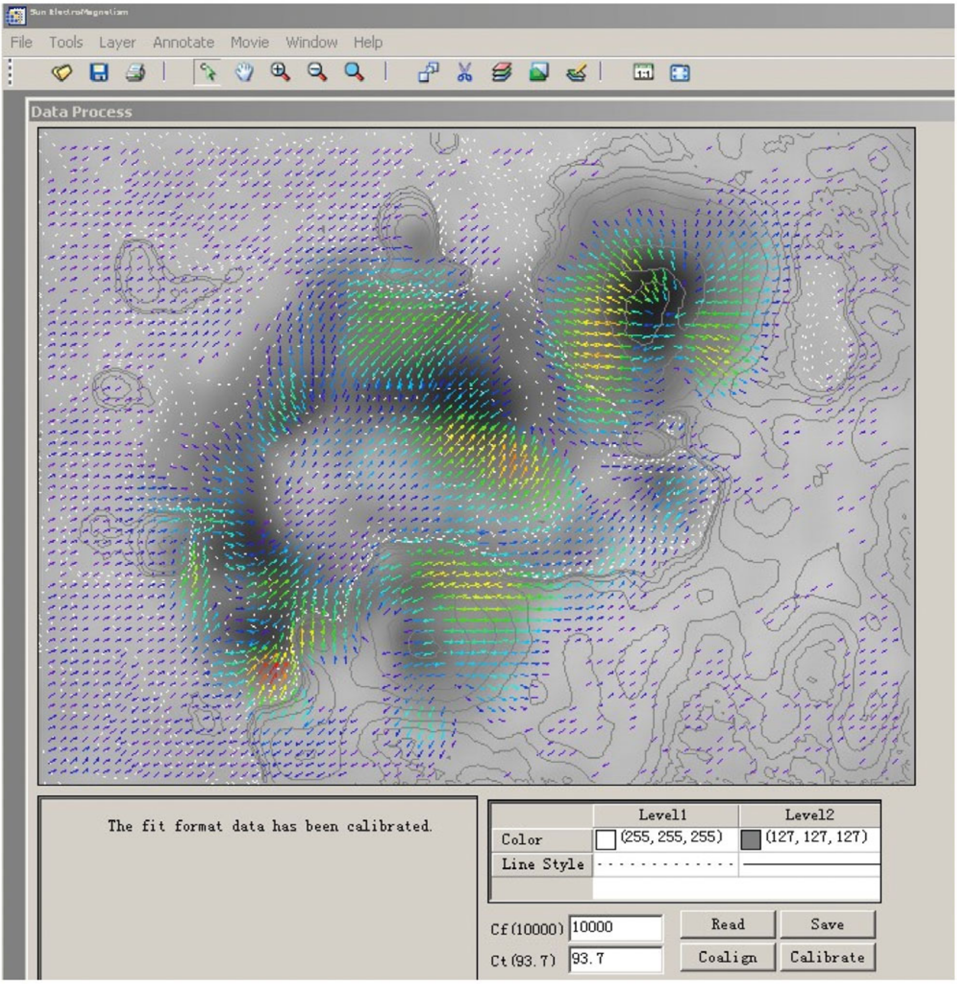

Figure 1. Calibrating an image.

3. Software tools

3.1. *Functionality designed into our software*

We have devised a robust platform for improving the efficiency of data processing. In developing the system we focused on the frequently encountered problems mentioned above and developed tools to:

- analyse data from different instruments;
- transform efficiently raw or processed data between different formats;
- calibrate data;
- co-align images;
- adjust parameters dynamically;
- annotate graphics;
- produce images with arbitrary numbers of rows and columns;
- save images in any common format for presentation or publication;
- produce graphs, contour plots, histograms and animations;
- process data as single files or in batch mode.

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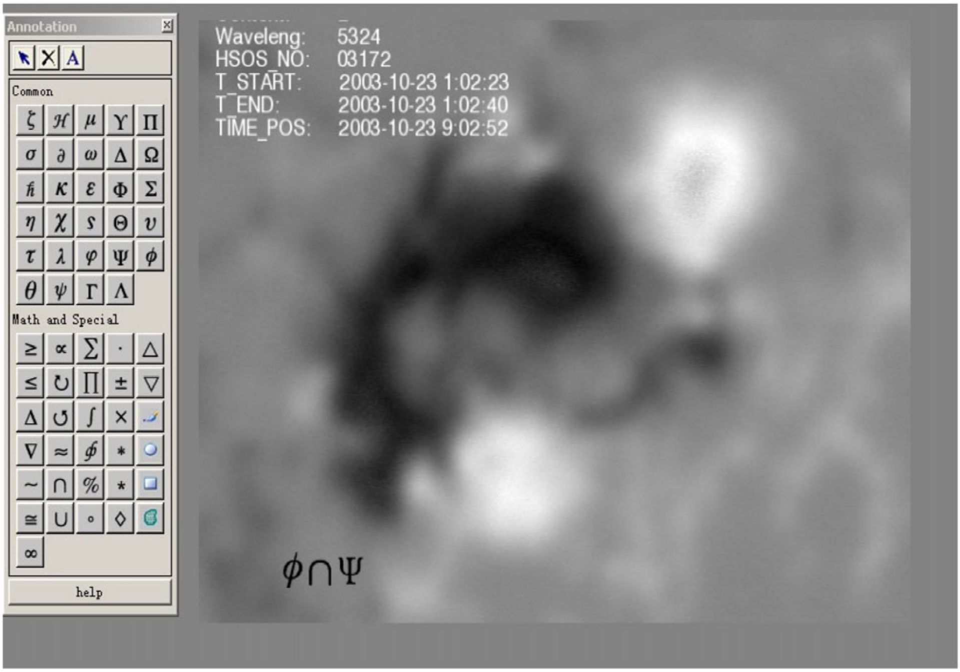

Figure 2. Annotating an image.

These software tools lead to a number of important advantages from the user perspective.

(*a*) Users no longer have to know or care how many bits per pixel images have, or how many rows and columns images have when combining data from different instruments. These data attributes are now all transparent to the user.

(*b*) Likewise the availability of data in various formats no longer presents a problem. It is now easy to translate between the old local data format and FITS, PS, JPEG or GIF.

(*c*) Data calibration is best handled locally by experts who apply all the necessary instrumental corrections so that users can concentrate on using the data. The calibration processing of our vector magnetograms is an example of this. This requires several steps such as: changing the size of the stored data array to the size of the CCD; reduction of bias noise; co-alignment of L, Q, and U data; computing components of magnetic field along the of line of sight and the horizontal azimuthal angle of the horizontal component; and eliminating an uncertainty of 180 degrees.

(*d*) Co-alignment of images is used in making vector magnetograms and movies.

(*e*) Adjusting parameters dynamically becomes fast and simple with object oriented software.

(*f*) We have gathered symbols and characters that are frequently used and placed them in a palette for easy use (Fig. 2). These include commonly used mathematical symbols, arrows, lines, various shapes (circle, triangle, rectangle, etc.). The user can easily change the position, size, colour, etc. of these symbols.

(*g*) Likewise the attributes of graphical objects, such as line type, thickness and colour may be readily changed to create expressive images.

(*h*) Output results of graphics processing are now easily produced to user-specified image sizes.

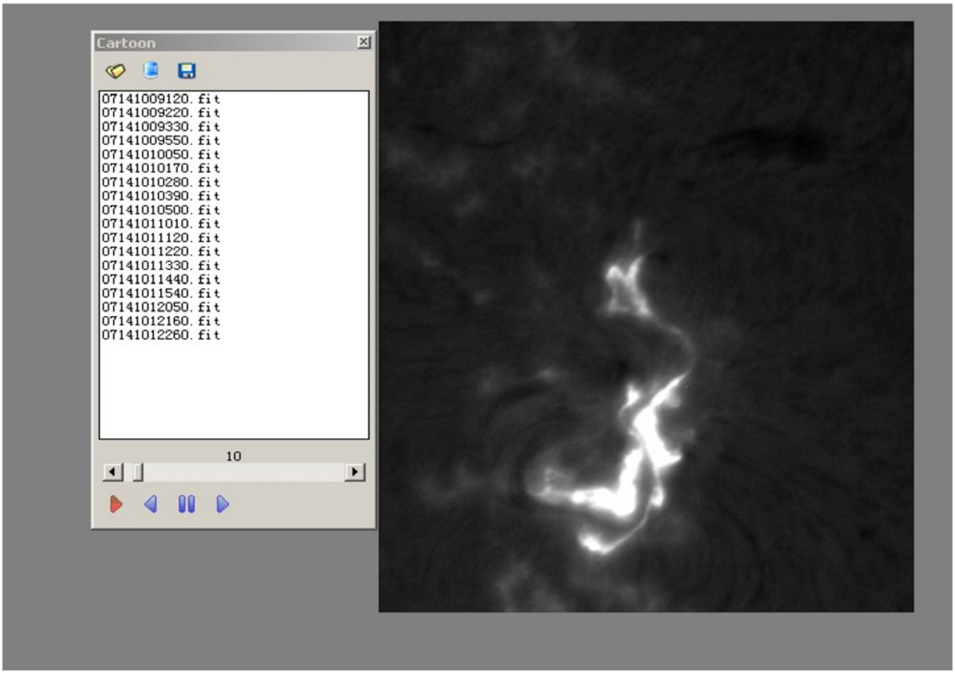

Figure 3. Calibrating an image.

(i) Files can be processed individually or in batches, thus facilitating processing of large data sets.

3.2. *Principal software functions*

The principal functions of the software are:

- Reading data in FITS format and in our old local format;
- Making and displaying graphics: graphs, images, contour plots, histograms, and movies;
- Calibrating data;
- Adjusting dynamically various elements in graphics such as line style, axis titles, colours and so on (Fig. 1);
- Adjusting dynamically parameters during the data processing (e.g. Fig. 1);
- Zooming in or out of an image;
- Cropping an image or cutting from an image;
- Annotating graphics, as shown in Fig. 2;
- Writing images in FITS and several other common image formats, and writing movies in MPEG and AVI formats;
- Deriving information from images, locally and globally (Fig. 4);
- Converting from the old local format into FITS, and vice versa; also converting from FITS into PS, JPEG, GIF, etc.;
- Online help for all user functions.

3.3. *Features*

The main features of the software are:

- Higher data processing throughput;
- The algorithms allow dynamic adjustments to key parameters, as shown in Fig. 1;.

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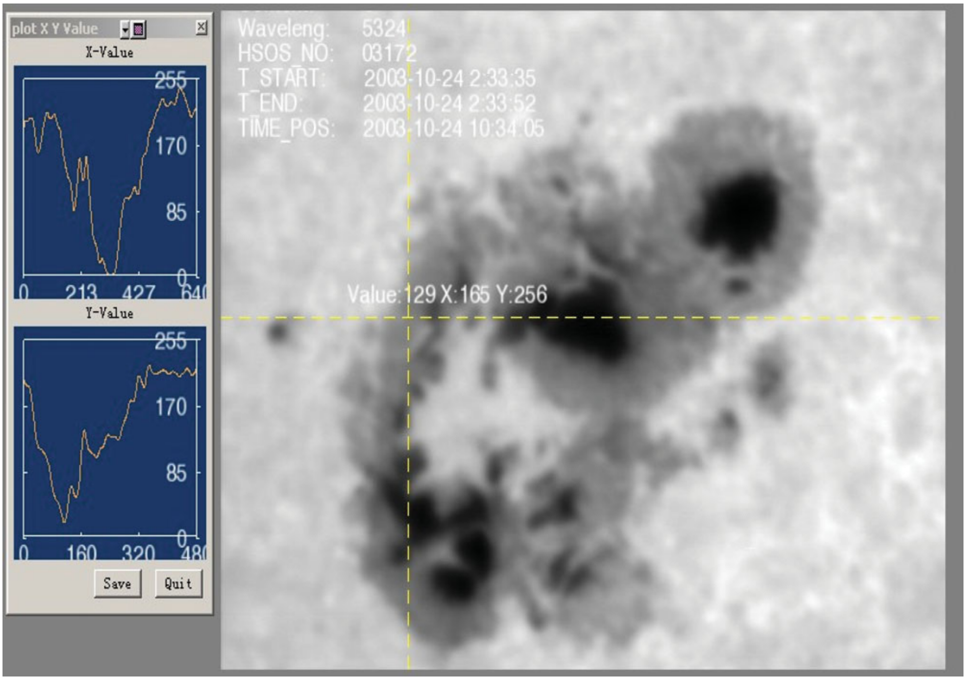

Figure 4. Transects of intensity values in an image.

- The software is menu-driven with a graphical user interface;
- The software can be used in a flexible manner to allow easy viewing and fine tuning of various parameters;
- The software is independent of other proprietary software, such as IDL.
- The software is built in a modular fashion and may be easily extended by adding more modules.

4. Future developments

Thus far we have discovered several software problems and limitations which are being addressed. Future plans for further development of the system include the addition of a log of software changes and new data products. We plan to add more functions, such as roll-correction, stretching, translation, solar rotation-compensation, etc. We also plan to introduce on-line database access and on-line data processing capabilities.

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