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The IDL Astronomy User's Library

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Abstract. IDL (Interactive Data Language) is a commercial plotting, image processing, and programming language that is widely used in astronomy. Although IDL is a powerful language for spectral and image processing, it does not contain applications specific to astronomy. Therefore, in 1990 I created the IDL Astronomy User's Library (AUL), which is a collection of astronomy-related procedures written in the IDL language, available via anonymous FTP from *idlastro.gsfc.nasa.gov*.

I summarize recent developments in the IDL language of particular interest to astronomers. I then mention some additions to the IDL Astronomy Library since the previous report of Landsman (1993). Finally, I critically examine possible drawbacks to the use of IDL for astronomical data analysis.

1. Introduction

IDL[1] (Interactive Data Language) is a commercial plotting, image processing, programming, and graphical user interface (GUI) development language. It is a language designed to allow much more rapid scientific data analysis than is possible using FORTRAN or C. Features of IDL that promote this "hands-on" approach to data analysis include an interpreted, vectorized compiler, an expressive syntax, and numerous built-in spectral and image processing functions.

IDL is widely used in astronomy, especially in the analysis of space-based data, and in the fields of solar and planetary astronomy. Recent examples of astronomical software packages based on IDL include Bloch et al. (1993), Brekke (1993), McGlynn et al. (1993), Ewing et al. (1993), and Hall et al. (1994). In this paper I summarize recent additions to the native IDL language and to the IDL Astronomy User's Library, and consider possible drawbacks to the use of IDL for astronomical data analysis.

2. Enhancements to IDL

IDL has undergone substantial evolution since its initial release in 1982. Recent enhancements to IDL of particular interest to astronomers include the following:

[1]Research Systems Inc., Boulder CO

- IDL is now available for Microsoft Windows, Macintosh OS, most Unix workstations, and Vax/Alpha VMS. Little or no programming is required to transport IDL software between these different platforms.
- Many of the routines from the book "Numerical Recipes" (Press et al. 1992) are now licensed and incorporated into native IDL. The ease of use of the popular "Numerical Recipes" routines is significantly enhanced within the interpreted IDL environment, as the routines can be tested at the command level, and the results immediately printed or plotted.
- Native IDL now supports numerous disk file formats including CDF, HDF, netCDF, TIFF, GIF, and JPEG. (Complete FITS and STSDAS I/O support is available from the IDL Astronomy Library.) Note that because IDL operates in virtual memory, most steps of a procedure can be written without any particular disk format in mind. One simply needs an initial procedure call to convert a disk file into IDL variables, and a final procedure call at the end of the session to write variables back to disk.
- The GUI (widget) development tools have been significantly enhanced. For example, it is now possible to design a GUI without writing any code. The IDL widgets require a significantly higher level of programming sophistication than the traditional IDL command-line programming. Nevertheless, the widget tools are sufficiently simple that astronomers can develop their own personalized GUI tools, with only a modest investment of programming time.
- IDL is now sold by distributors in Japan and throughout Europe. About one-third of the users of the IDL Astronomy Library come from outside the United States.

3. Recent Additions to the IDL Astronomy User's Library

IDL is a general software package, used in such fields as remote sensing and medical imaging, in addition to astronomy. As such, it does not contain any procedures specific to astronomy. In 1990, I created the IDL Astronomy User's Library (IAUL), which is a collection of astronomy-related procedures written in the IDL language, available via anonymous FTP from idlastro.gsfc.nasa.gov (Landsman 1993). Astronomy-related IDL software contributed from the community is checked for appropriateness, accuracy, and programming standards. Thus, the site is intermediate between an unmoderated bulletin board and a unified data analysis package. The IAUL does not contain any instrument specific software, although it does contain pointers to other anonymous FTP sites containing instrument specific IDL software. (Anonymous FTP sites exist containing IDL reduction software for the *IUE*, *HST*/GHRS, *COBE*, *SOHO*, and *ROSAT* instruments.)

An important addition to the IAUL is the support for the 25 astronomical coordinate systems discussed by Greisen & Calabretta (1995). The coordinate conversion software was written by Rick Balsano and the more complicated transformations were verified by Imannuel Freedman. Additional procedures exist that recognize three ways that the world coordinates may be stored in FITS keywords: (1) the original FITS/AIPS system with a reference pixel, rotation, CROTA2, and pixel scale CDELTi, (2) the IRAF/ST ScI system with a reference pixel and a coordinate description matrix CDi_j, and (3) the Greisen & Calabretta proposal which includes both a pixel scale and a rotation and skew matrix. The software also recognizes headers from the ST ScI Digitized Sky Survey and will apply the appropriate nonlinear transformation to the pixel coordinates.

A recent contribution from Tom McGlynn is a generalized FITS reader that supports both variable-length binary tables, and random groups. An especially important feature of this software is that binary table columns are directly mapped into the tags of IDL structure arrays. The full IDL data analysis capabilities (e.g., plotting, sorting, and subscripting) can then be applied to the structure variable.

Other recent additions to the IAUL include mathematics and statistics code to complement the intrinsic "Numerical Recipes" routines. Examples include code for principal components analysis (Murtagh & Heck 1987), Kolmogorov-Smirnov statistics, and cubic-spline smoothing.

4. Drawbacks of IDL?

Every language has its strengths and weaknesses. In this final section I examine five possible drawbacks a hypothetical astronomer might make to the use of IDL for his data analysis.

1. *IDL is an interpreted language, and thus slower than compiled languages such as* FORTRAN *or C.* This statement is technically true, but properly vectorized IDL code suffers little performance penalty compared to FORTRAN or C. (IDL code is usually most readable when it is properly vectorized, so that, in this case, "the good coincides with the beautiful.") In fact, IDL often outperforms pedestrian FORTRAN or C code, since the many built-in image and spectral processing functions of IDL are highly optimized. For the rare cases (such as generalized median filters) where the code cannot be vectorized, and where performance speed is crucial, IDL offers several different ways to link to a FORTRAN or C program, including a fast dynamic link to the executable.

2. *The use of virtual memory in IDL is not suitable for very large images.* While the virtual memory capabilities of workstations have dramatically improved in the past few years, it is also true that the increase in the size of CCDs has been just as dramatic. Very large ($\gtrsim$ 16 MB) images can still be processed with IDL, but the array must be processed in pieces, so that the simplicity of the IDL code is then lost.

3. *Professor X cannot use my IDL software since she does not have an IDL license.* This objection is valid, although Professor X can probably decipher the algorithm, since the IDL syntax was designed for clarity rather than brevity. In addition, IDL supports remote procedure calls (RPC), so that a licensed client can support a server without an IDL license.

4. *I cannot find a galaxy surface photometry package in IDL.* Most astronomical software is not written in IDL, and the software in the IDL Astronomy Library is an order of magnitude less complete than that in the large public domain systems such as IRAF or MIDAS. For this reason, IDL is unlikely to be an astronomer's sole working environment, although it is likely to be his preferred environment for developing new code.

5. *I am not going to purchase an IDL license when there is public domain software available.* The purchase of a commercial license can be worthwhile if it saves programming time and costs, and significantly enhances one's data analysis capabilities. Some IDL features are duplicated by various types of public domain software. IDL may or may not be a worthwhile investment, depending on an astronomer's needs, skills, and budget.

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