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Getting Started with the Starlink Java Infrastructure and Applications Set

V1.0b

Contents

1 Introduction - Starlink Java Data Reduction and Analysis Software

Starlink is developing a set of Java data reduction and analysis tools and Java data access classes. The new Java tools and classes are needed to produce applications in the Virtual Observatory (VO) era, and to complement the AstroGrid and other VO capabilities such as the International Virtual Observatory Alliance Data Model

You can view a section of a proposed International Virtual Observatory Alliance Data Model, including HDX, NDX and Table data structures with the WCS astrometry library at

http://www.starlink.rl.ac.uk/java/java.htm

2 The Starlink environment and Login Scripts

In order to use the software the user should be using the C-shell or tc-shell and must source the Starlink `login` and `cshrc` scripts if you are using the full Starlink Software Collection. These scripts set up the required aliases and environment variables needed to run the software. The STARJAVA package has its own `login` and `cshrc` files found in `/star/starjava/etc` which only initialise the Java Software.

For the full Starlink Software Collection (including STARJAVA):

```
% source /star/etc/login
% source /star/etc/cshrc
```

or STARJAVA on its own:

```
% source /star/starjava/etc/login
% source /star/starjava/etc/cshrc
```

The Starlink Software Collection is now available on your machine and can be run in the usual manner.

2.1 Requirements for Running STARJAVA

STARJAVA needs the SUN Java Runtime Environment (JRE) and Java Advanced Imaging JAI packages, both are supplied on the Starlink Summer 2003 CDROM as the JRE package. Currently the JRE is at version 1.4.1_02, and the JNI at version 1_1_2-rc.

If you experience problems with JRE v1.4.1_02 distributed with RedHat 9.0 CD, such as problems with the Java Plugin for Mozilla, or Java crashes due to signals (usually SIGSEGV). Then a possible cure is to set the environment variable LD_ASSUME_KERNEL,

```
% setenv LD_ASSUME_KERNEL 2.4.1
```

2.2 STARJAVA for Microsoft Windows

3 Applications and Utilities

3.1 TREEVIEW

TREEVIEW is a graphical browser for hierarchical data structures written in Java. It knows about Starlink NDF and HDS data structures, as well as many other types of data such as file systems, zip and jar files, XML documents, FITS files and VO Tables. TREEVIEW is under active development, see http://www.starlink.ac.uk/treeview for the latest information.

3.1.1 List of features

Treeview deals with the following generic forms of node:

- Arrays: These are found within FITS SIMPLE/IMAGE HDUs, Starlink HDS/NDF files and Starlink NDX structures, and represent an N-dimensional hypercube of numbers. They have the following views:
  - 1-d arrays (e.g. spectra) can be displayed as a line plot
  - 2-d arrays can be displayed as an image at 1x magnification; this does not require loading the whole image, so can be fast even for large arrays
  - The values of the pixels in even very large arrays can be viewed in a scrollable 1-d or 2-d table. Again, the whole array does not need to be loaded, so this is fast
  - Higher-dimensional (>2d) arrays can be shown as image slices through the array along any axis
  - Three-dimensional arrays can be viewed collapsed (by averaging over some or all planes) along any given axis to give an image
  - Statistics (mean, variance etc) of an array can be calculated.
  - An external program SPLAT can be launched for detailed analysis of 1-d spectral data An external program SoG can be launched for detailed inspection of 2-d image data
- Tables: These are found in a variety of formats including TABLE/BINTABLE FITS extensions and VOTable files (more formats will be supported soon). They have the following views:
  - Table data is shown in a compact scrollable table.
  - Table has full JTable functionality - columns can be moved around, widths altered etc.
  - All available column and table metadata can be displayed in a tabular format
  - An external program TOPCAT can be launched for detailed examination of the table
- Treeview understands the structure of the following kinds of nodes and can display them hierarchically:

- FITS files:
  * Each Header+Data Unit (HDU) in the FITS file is displayed
  * FITS header cards are displayed
  * BLANK values and BSCALE/BZERO scaling are handled properly
  * Simple FITS files and IMAGE, TABLE and BINTABLE extensions are recognised
  * All array views described above are supported for SIMPLE/IMAGE HDUs
  * All table views described above are supported for TABLE/BINTABLE HDUs
  * WCS information can be read from headers using a variety of encodings
  * WCS information can be plotted over image pixels or showing array extent for 2-d images
  * WCS information can be displayed in different FITS/non-FITS encodings
- Starlink NDF files:
  * All array views described above are supported.
  * Magic bad values are treated properly.
  * The co-ordinate Frames can be viewed in several formats (native, XML and a variety of FITS encodings)
  * The extent of a 2-d array in any of its WCS co-ordinate Frames can be displayed, with a grid plotted.
  * NDF HISTORY components are shown
- Starlink HDS container files:
  * The structure of arbitrarily complicated HDS files can be seen.
  * All array views described above are supported for array components.
- VOTable files:
  * Compact display of complicated VOTable structures
  * Most aspects of VOTable hierarchical structure are understood
  * All FIELD and PARAM metadata can be viewed in a tabular form
  * TABLEDATA, FITS and (so far untested) BINARY table data support
  * Relative or absolute, local or network URLs for FITS files
  * XML content of any VOTable element can be seen
  * VOTable DTD stored locally for standalone operation
- XML documents:
  * Hierarchical view of XML documents
  * Summary or full display of each node can be seen
  * Known structures (NDX, VOTable) embedded in larger documents are recognised
  * Many standard XML encodings supported
- Zip files:
  * Zip (PKZIP-like) and Jar archives displayed like directory structures
  * Many node types within archive can be viewed as if they were normal files
- Tar files:
  * Tar archives displayed like directory structures

        * Many node types within archive can be viewed as if they were normal files
    - Starlink NDX structures:
        * NDFs, FITS files and suitable XML files can be viewed as NDXs or as their native type
        * All array views described above are supported
        * WCS information can be plotted over image pixels or showing array extent for 2-d images
        * WCS information can be displayed in various formats (XML, FITS, AST)
    - Starlink HDX containers:
        * Hierarchical view of contained resources
        * XML view can be seen
    - Directories:
        * Hierarchical view of file systems
    - Files:
        * Hex dump or text content of file can be shown.
        * File system information is displayed.
    - Compressed data:
        * Files compressed in gzip or bzip2 format can be viewed.
        * Hex dump or text of uncompressed content can be shown.

- Other features:
    - Basic on-line help system
    - Popup "alter-ego" menus allow nodes to be seen in different aspects (e.g. view a VOTable as an XML document) or reloaded to reflect change of underlying data
    - Demonstration data is integral to the tool and can be viewed at any time to investigate Treeview capabilities

Support Page at http://www.starlink.ac.uk/treeview

Documentation for treeview is available in the form of online help in the program itself.

TREEVIEW can be run from the shell prompt (when the Starlink login scripts have been sourced, see above) by typing treeview with the name of a file you would like to look at:

```
% treeview [file ...] &
```

or simply just

```
% treeview &
```

3.2 SPLAT

SPLAT is a new graphical tool for displaying, comparing and analysing astronomical spectra stored in NDF, FITS and TEXT files.

SPLAT can read in many spectra at the same time and then display these as line plots. Each display window (of which there can be many) can be used to view one or several spectra at the same time. Display windows can be interactively zoomed and scrolled, centered on specific wavelengths, provide continuous coordinate readout, produce printable hardcopy and be configured in many ways. They also provide the basis for interactive analysis facilities. All of these functions are displayed in a visually rich format, that is intended to appeal especially to occasional users of spectral data analysis facilities.

The analysis facilities provided allow the fitting of a polynomial to selected parts of a spectrum and the fitting of Gaussian, Lorentzian and Voigt profiles to emission and absorption lines. Other useful facilities are the ability to "animate" and perform simple mathematical operations on spectra.

Health Warning: At present only an example set of useful analysis facilities are available in SPLAT. In it's current state it's really just intended to give a strong flavour of the sort of tasks that could be done in an integrated graphical environment (although the set of things it does at present are expected to be useful). More facilities will be provided in future releases.

Finally SPLAT can be programmatically extended by the use of "plugin code" and command-line scripts. It can also be remotely controlled through a socket-based mechanism. Pointers to the details of how to do this are available in the full documentation.

Documentation

The main source of documentation for SPLAT is Starlink User Note 243 SPLAT, which is also the on-line help. If you have SPLAT installed on your machine then you should be able to view this using the "Help" menu. Otherwise (if you just want a look) you can find it on-line.

Initially you should work you way through the getting started, displaying more than one spectrum and basic control of a plot view sections.

SPLAT can be run from the shell prompt (when the Starlink login scripts have been sourced, see above) by typing splat with the name of a spectrum file you would like to look at:

```
% splat <spectrum_file> &
```

or simply just

```
% splat &
```

Support Page at http://www.starlink.ac.uk/splat

3.3 FROG

FROG is a new graphical tool for displaying, comparing and analysing time series data.

See the support page for further information.

Support Page at http://www.starlink.ac.uk/frog

FROG can be run from the shell prompt (when the Starlink login scripts have been sourced, see above) by typing:

```
% frog &
```

3.4 SoG

SoG - Son of GAIA - is an extension of ESO JSkycat which can display our new HDX/NDX format, as well as FITS and NDF images.

SoG implements a number features, which include:

- Ability to load, save, print, and display images in FITS, JPEG, GIF, PNG, and other formats
- Image operations (zoom, pan, manipulate the colormap, set cut levels, ...)
- World coordinates support
- Support for compressed FITS images (gzip, H-compress)
- Access local and web based astronomical catalogs and image servers
- Support for local catalogs and editing catalog tables
- Plot the results of catalog searches as image overlays
- Draw graphics interactively on the image
- Save graphics and catalog query results in FITS tables with the image, for later redisplay

Using web-service interfaces it can be remotely controlled and used to display images (as it currently does from Starlink Treeview). In the fullness of time it is expected to provide similar features to GAIA (but working within the Grid).

See the support page for further information.

Support Page at

http://www.starlink.ac.uk/sog

SoG can be run from the shell prompt (when the Starlink login scripts have been sourced, see above) by typing:

```
% sog &
```

3.5 TOPCAT

TOPCAT - Tool for OPerations on Catalogues and Tables, a viewer/editor for astronomical tabular data, including FITS table extensions and VOTable documents. TOPCAT is a viewer and editor for tabular information. It has been designed to be able to deal with large astronomical tabular data, but is not restricted to astronomical use. It can read and write a number of different astronomically important formats, including FITS tables, VOTable documents, relational databases such as ORACLE, and more formats will be added.

Here is a list of its main features:

- View/edit table data in a scrollable browser
- View/edit table and column metadata
- Re-order or delete columns
- Insert 'synthetic' columns (algebraic expression)
- Sort rows on the values in a given column
- Define row subsets in various ways
- Plot columns against each other, distinguishing different subsets
- Calculate statistics on each column for some or all rows
- Write modified table out in original or different format
- Launch other programs (Mirage)

Please note: TOPCAT is a new product under active development, and the currently released version is beta software.

Documentation for TOPCAT is available in the form of online help in the program itself.

Support Page at http://www.starlink.ac.uk/topcat

TOPCAT can be run from the shell prompt (when the Starlink login scripts have been sourced, see above) by typing:

```
% topcat &
```

Invoked with no arguments, this will pop up the "Open Table" dialogue window.

Alternatively, you can supply command-line arguments giving the name(s) of one or more tables to load - filenames or URLs with optional fragment IDs following a '#' character, or JDBC table specifiers, for example

```
% topcat dsscat.xml &
```

or

```
% topcat cat1.fits#1 cat1.fits#2 http://astro.org/data/m31.xml
```

3.6 Tablecopy

Tablecopy is a simple command-line tool for copying tables from one format to another. If you have a normal Starlink installation it can be invoked by just using the '`tablecopy`' command. Supplying the `-help` flag gives its usage message:

```
% tablecopy -help

    Usage: TableCopy [-ofmt jdbc|text|votable|fits|mirage] in-table out-table
```

In general you give the name of the input file followed by the name of the output file as command-line arguments. The `-ofmt` flag should also normally be used to determine the format of the output table, but the tool will sometimes guess the format based on the output filename given; for instance an output filename with the extension '.fits' indicates a FITS file, and the extension '.xml' indicates a VOTable.

In some cases the name of the output file can be given as '-' which indicates that it should be written to standard output. This can be used to see a table's contents at the terminal, for instance

```
% tablecopy -ofmt text tables.fit#2 -
+-------------+---------------+--------------+
| FLUX        | DELTAX        | DELTAY       |
+-------------+---------------+--------------+
| 0.13405019  | -1.1666666E-5 | 8.3333333E-7 |
| 0.12064518  | -1.1666666E-5 | 8.3333333E-7 |
| 0.108580664 | -1.1666666E-5 | 8.3333333E-7 |
| 0.0977226   | -1.1666666E-5 | 8.3333333E-7 |
    ....
```

The same considerations apply to the input and output table names and formats as for the TOPCAT application. Full details can be found in TOPCAT's online help (which can be invoked from within the package or with the invocation '`topcat -help`'), but the following is a summary:

3.6.1 Input table

The following describe the table formats which can be read (i.e. copied from). In most cases the specified name can be a URL or a filename, and may refer to a resource which has been compressed using the gzip or bzip2 formats. The input format does not need to be specified, it is sensed automatically from the named resource.

- FITS binary and ASCII tables can be read. Unless otherwise specified, the first TABLE or BINTABLE extension in the file will be used. If a later extension is required, this is specified by giving the extension number after a '#' at the end of the table location. The first extension (first HDU after the primary HDU) is numbered 1. Thus in a compressed FITS table called 'spec23.fits.gz' with one primary HDU and two BINTABLE extensions, you would view the first one using the name 'spec23.fits.gz' or 'spec23.fits.gz#1' and the second one using the name. 'spec23.fits.gz#2'. The suffix '#0' is never used for a legal FITS file, since the primary HDU cannot contain a table.

- Any VOTable which conforms to the VOTable 1.0 specification should be readable. Unless otherwise specified, the first TABLE element found in the named document will be used, so in the (common) case that the document holds exactly one table, giving the filename will display that sole table. To display a table other than the first, you must indicate the zero-based index of the TABLE element in a breadth-first search after a '#' character at the end of the table specification.

  Here is an example VOTable document:

  ```
  <VOTABLE>
    <RESOURCE>
      <TABLE name="Star Catalogue"> ... </TABLE>
      <TABLE name="Galaxy Catalogue"> ... </TABLE>
    </RESOURCE>
  </VOTABLE>
  ```

  If this is available in a file called 'cats.xml', then the name 'cats.xml' or 'cats.xml#0' refers to the Star Catalogue, and 'cats.xml#1' refers to the Galaxy Catalogue.

- Some support is provided for files produced by the World Data Centre for Solar Terrestrial Physics based at the Rutherford Appleton Laboratory. The format itself apparently has no name, but files in this format look something like the following:

  ```
  Column formats and units - (Fixed format columns which are
  single space seperated.)
  ------------------------
  Datetime (YYYY mm dd HHMMSS)            %4d %2d %2d %6d       -
                                          %1s
  aa index - 3-HOURLY (Provisional)       %3d                   nT

  2000 01 01 000000  67
  2000 01 01 030000  32
      ...
  ```

  This handler is experimental; it was reverse-engineered from looking at a couple of example data files in the target format, and may not be very robust.

- With appropriate configuration, tablecopy can access the results of queries on SQL compatible relational databases such as MySQL. This requires installation of an appropriate JDBC driver specific to that database as well as, of course, access to such a database locally or over a network. You will need to ensure that the driver is installed by defining the 'jdbc.drivers' property appropriately and ensuring that the named Driver class is available from your classpath when running tablecopy.

  Database queries have the form

  ```
  jdbc:<driver-specific-url>\#<sql-query>
  ```

  See the TOPCAT help system for more detail on this topic.

3.6.2 Output table

The following subsections describe the formats to which tablecopy can write (i.e. copy to). To ensure that you are writing in the right format, use the appropriate '`-ofmt`' command-line flag.

- Using the '`-ofmt fits`' flag, a two-HDU FITS file is written. The first (primary) HDU is a minimal dummy one, and the second is a BINTABLE extension containing the table data.
- Using the '`-ofmt votable`' flag, an XML file is written which conforms to the VOTable DTD. It will contain a single TABLE element containing a TABLEDATA element. Note that since this encodes all the data as in-line XML text elements, it is not too suitable for very large tables (though such tables can be written).
- Using the '`-ofmt text`' flag, an ASCII representation of the table data is written. This is intended for human consumption rather than as a machine-readable format, though if there are many columns it may still be difficult to see what is going on. The table and column metadata (except for the column names themselves) are not written in this case.
- Using the '`-ofmt mirage`' flag will write to a format suitable for use as input to the *Mirage* tool. Mirage is a powerful standalone Java tool developed at Bell labs for analysis of multidimensional data. It uses its own file format for input.
- Using the `-ofmt jdbc` flag can create a new table in a supported SQL database if a suitable JDBC driver is installed. The output resource name has the form

  ```
  jdbc:<driver-specific-url>\#<new-table-name>
  ```

  See the TOPCAT help system for more detail on this topic.

4 CLASSES

4.1 Native Interfaces and HDX data model

- JNIAST - a Java wrap of the Starlink AST coordinate manipulation library.

  Support Page at http://www.starlink.ac.uk/jniast

- JNIHDS - a Java wrap of the Starlink HDS hierarchical data storage library.

  Support Page at http://www.starlink.ac.uk/jnihds

- HDX - a flexible, extensible, data model for astronomical images, tables and other metadata; and a data access layer, consisting of Java packages which handle the XML and URIs involved, and cast a variety of local or network resources into the HDX data model.

  Support Page at http://www.starlink.ac.uk/HDX

4.2 General Classes in STARJAVA

Starlink Java Infrastructure - the next generation of Starlink astronomical data software. Much of this is still under active development, but it includes the ARRAY, AST, FITS, HDS, NDX, TABLE, TASK, UTIL and VOTABLE packages:

- ARRAY V0.2 N-dimensional array manipulation and I/O (new)
- ASTGUI V1.0 AST specific UI components (new)
- COCO V1.0 Java UI for Coco (new)
- FITS V0.1 Starjava-specific FITS access (new)
- HDS V0.1 Non-native HDS utility classes (new)
- JAIUTIL V1.0 Utility classes for JAI (new)
- NDX V0.1 N-dimensional astronomical object manipulation and I/O (new)
- PAL V0.1 Positional Astronomy Library (new)
- RV V1.0 Java UI for RV (new)
- TABLE V0.3 Generic table manipulation and I/O (new)
- UTIL V0.1 Miscellaneous utillity classes (new)
- VOTABLE V1.0 VOTable I/O (new)

Third party classes:

- AXIS V1.0b2 Third generation Apache SOAP (new)
- DOM4J V0.1 Third party DOM access library (org.dom4j.*) (new)
- JETTY V4.0.4 HTTP Server and Servlet Container (new)
- JUNIT V3.7 Third party unit testing framework (junit.*) (new)
- TAMFITS V0.93 Third party basic FITS acccess (nom.tam.*) (new)

4.3 STARJAVA Class Documentation

Javadocs for Starlink Java Classes can be seen at:

http://www.starlink.ac.uk/starjavadocs

or locally at file:///star/starjava/javadocs/index.html

There are miscellaneous documents in /star/starjava/docs/ for individual package information and third party application documentation. Each subdirectory in /star/starjava/docs/ is named after the package and contains is documentation.

5 License and Source Code

The above Java applications and classes are released under the GNU GPL licence. The source code CVS repository can be viewed via cvsweb at

http://cvsweb.starlink.ac.uk

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7 Acknowledgements

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