

TOPCAT Corner Plot

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Abstract. TOPCAT is a desktop GUI tool for working with tabular data such as source catalogues. Among other capabilities it provides a rich set of visualisation options suitable for interactive exploration of large datasets. The latest release introduces a Corner Plot window which displays a grid of linked scatter-plot-like and histogram-like plots for all pair and single combinations from a supplied list of coordinates.

1. Introduction

TOPCAT¹ (Taylor 2005) is an established desktop GUI application for working with tabular data. It has many capabilities including manipulation of data and metadata, Virtual Observatory access, and crossmatching, but one of its particular strengths is to enable interactive exploratory analysis of large tables. Such tables may have millions of rows and hundreds of columns.

Exploration of such bulky and high-dimensional data is facilitated in TOPCAT by provision of a number of highly configurable and responsive interactive visualisation windows, focussed on presentation of point clouds over a wide range of densities. Features include scatter plots in 1, 2 and 3 dimensions, the ability to label points with shapes, vectors, error bars and text, extensive options for colouring points by density or additional coordinates, and the ability to plot arbitrary combinations of table columns using a powerful expression language.

The most recent release, v4.9, introduces a new “Corner” plot window, which presents a grid of scatter-plot-like and histogram-like plots for all pair and single combinations of a supplied list of coordinates. This provides a simultaneous view of all the 2-d and 1-d projections of a high-dimensional dataset, which can be a valuable aid for identifying interesting features in complex data. An example is shown in Figure 1. This plot type is also available as the command `plot2corner` in STILTS (Taylor 2006), the command-line counterpart of TOPCAT.

This type of visualisation is not novel; it has been used since the 1980s (Cleveland 1993) under the names “*Scatter Plot Matrix*”, “*SPLOM*”, “*Pairs Plot*” and “*Corner Plot*”, and graphics packages producing them exist for instance in Python, R and IDL. Its adoption here benefits from the performance, interactive features and ease of use provided by the existing application GUI, and gives TOPCAT users a new tool for exploring high-dimensional data.

¹<http://www.starlink.ac.uk/topcat/>

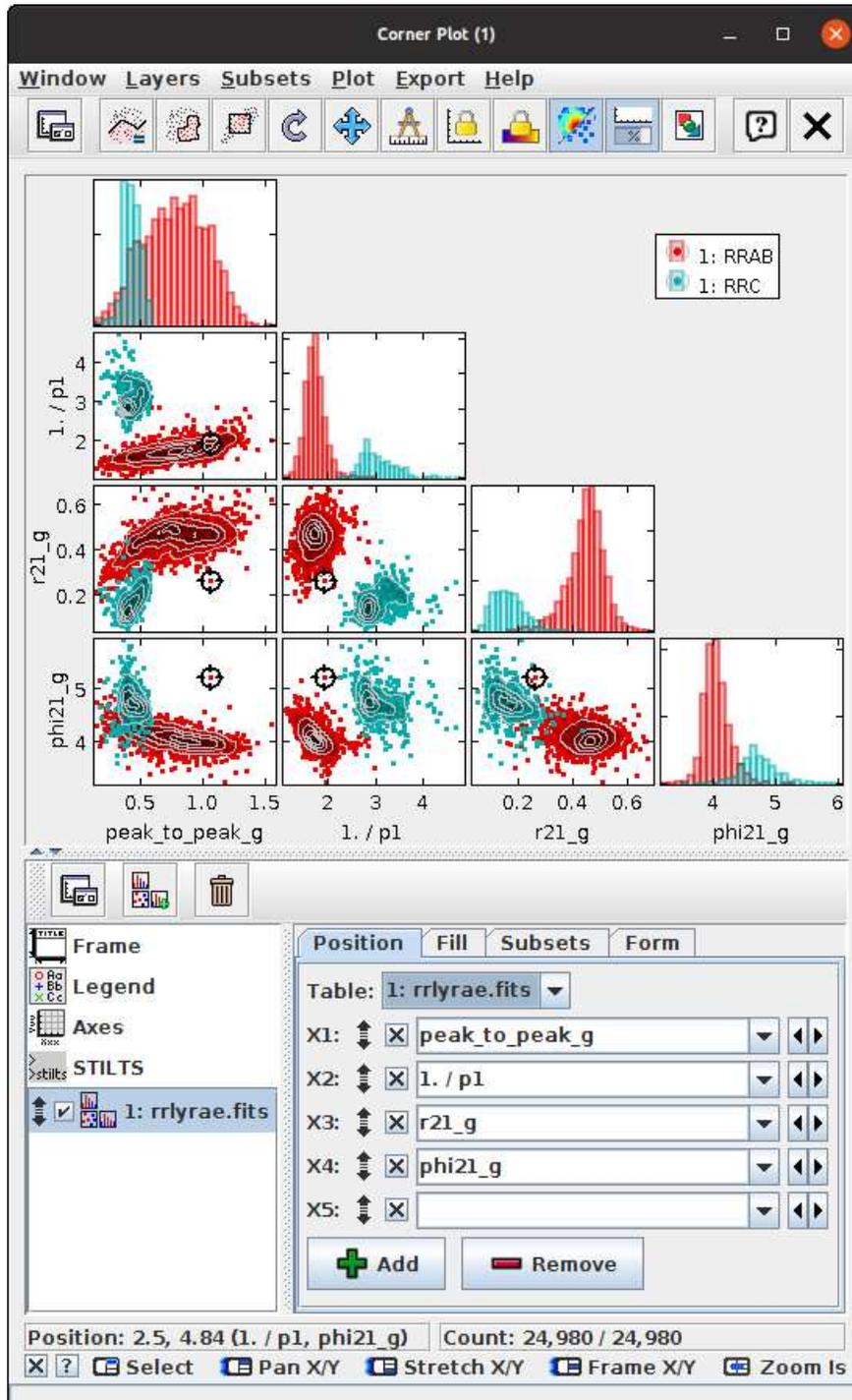


Figure 1. Corner Plot Window showing variability relationships between two different classes of RR-Lyrae stars; data is from Gaia DR1 (Clementini et al. 2016).

2. Features

The Corner Plot shares its features with the other TOPCAT visualisation windows:

Ease of use: coordinates can be added, deleted and reordered with a few mouse clicks

Interactivity: each panel can be panned and zoomed in one or two dimensions easily using the mouse, and the other panels in the same row/column adjust to keep the axes aligned

Linked Views: graphical selections and point highlighting on one panel are immediately visible in the other panels (and in other windows)

Overplotting: multiple datasets, selections and plot types can appear in each panel

Calculations: coordinates can be existing columns or algebraic expressions based on them

Scalability: multipanel displays for millions of rows are quite responsive even on modest hardware

Flexibility: many plotting and shading options are available alongside simple scatter plots and histograms: transparency, weighted density maps, contours, KDEs, text labels, etc

Configurability: interactive controls can specify lower/upper/full panel matrix, logarithmic or inverted axes, axis labels, grid line drawing, colour map adjustments, etc

The linked views, especially in combination with interactive graphical region selection (blob drawing), make it very easy to identify regions, populations or points that are apparent in one coordinate plane and see where they appear in the other displayed planes.

To facilitate setting up plots with many panels, an extra “Fill” control is provided which allows easy selection of coordinates, including an option to use all pair differences (or ratios) from a selection of columns, for instance all pairwise colours from a list of magnitudes (or fluxes)

3. Implementation

Assembling multiple plot panels in this way is not conceptually difficult, and the TOPCAT codebase already provided most of the data handling infrastructure required, as well as some support for multi-panel plots. However, implementing a plot type with multiple panels derived from a single set of input coordinates broke some of the assumptions in the existing plotting framework. This meant that significant code restructuring was required, especially for the graphical and command-line user interfaces, so implementation was quite time-consuming.

4. Future Work

The new corner plot is working quite well, but not perfectly. In particular the axis labelling developed for other plot types can become overcrowded and imperfectly aligned. Some performance improvements could be made by concurrent plotting of multiple panels and eliminating some duplicated work. Usage in the field may come up with other bugs, complaints or suggestions. If this plot type proves popular, improvements may be made in future, in line with user feedback. Other possibilities for multi-panel plots may also be investigated.

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References

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