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VisIVO: a VO enabled tool for Scientific Visualization and Data Analysis

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Abstract. VisIVO is a package for supporting the visualization and analysis of astrophysical three-dimensional data and has several built-in tools which allow the user an efficient manipulation and analysis of data. We are integrating VisIVO with VO services: connection to VO web services, retrieval and dealing with data in the VOTable format.

Key words. Astronomical data – Virtual Observatory – Visualization – Numerics

1. Introduction

Data represent a critical issue for scientists and, in particular, astronomers. Observational instruments (telescopes, satellites...) produce enormous quantities of images and information. Computers and numerical simulations generate huge amount of data. All these data must be stored, managed and analyzed. These steps require a great human effort, large scale facilities and efficient, powerful tools.

We present VisIVO, a software for the visualization and analysis of astrophysical data, which can be retrieved from the Virtual Observatory framework. VisIVO is VO standards compliant and supports the most important (and popular) astronomical data formats such as FITS, HDF5 and VOTables. Data can be retrieved directly connecting to an available VO service (like, for example, Vizier (Ochsenbein 2000)) and loaded in the local computer memory where they can be further selected, visualized and manipulated. VisIVO can deal with both observational and simulated data and it is particularly effective in handling multidimensional datasets (e.g. catalogues, computational meshes...). It is completely open source and the first release can be downloaded from the web site http://visivo.cineca.it. At present the software is fully tested only for Windows XP platforms and the version for Linux is in progress.

This work is only one of many different applications that the Italian astronomical community is developing in the VO framework. This effort is led and coordinated by the National Institute for Astrophysics (INAF), in collaboration with other institutions like, CINECA, the largest Italian academic supercomputing centre.

1.1. VisIVO overview

VisIVO is specifically designed to deal with multidimensional data. Catalogues or numerical simulations, rather than 2D images, represent the basic target of VisIVO. Different quan-

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tities can be visualised and treated at the same time. The architecture of VisIVO strictly reflects the structure of a typical scientific application built on the Multimod Application Framework (Viceconti et al. 2004). On this framework VisIVO implements all the elements that are specific to the visualization and analysis of astronomical data.

VisIVO embodies a select object, apply operation utilization metaphor which is somehow similar to that of many graphical commercial applications (such as Adobe PhotoShop). The usage of VisIVO generally begins with an operation of data loading. Data types that are currently supported by the application are VOTables, FITS, HDF5, Tipsy, VTK as well as binary and ascii raw data (dump of memory).

The standard data structure produced during loading/importing/modifying any type of data is called VME. It is represented in the VME tree (in the contextual menu) as a VME node. The VME tree is a hierarchical structure which links all VMEs currently loaded in the program. In order to display data loaded in the VME tree, it is necessary to instantiate a View and associate it with the chosen VMEs. A View is a rendering window that gives a particular representation of the VME tree. VisIVO currently supports the following Views: Points, Volume Rendering, Isosurface, Glyph, Stereo, Histogram. Each view displays data according to a specialised visualization pipeline. It is possible to instantiate several Views and each View can display a different subset of the VME tree. This is a point of strength of VisIVO as many specialised views, displaying different (or same) data, can be instantiated and data can be manipulated and analysed independently of the views displayed. The properties of the selected view (e.g. camera perspective, axes, logarithmic scale) can be adjusted via the contextual menu.

In order to analyse and modify data loaded in the VME tree, a set of operations are available to the user. There are operations that simply modify the data, operations that perform some statistical analyses on data and operations that do both things. All of these generate output VME nodes that can be displayed according to the type of output (e.g. a VME output that represents statistical 2D data can be thus displayed in a Histogram View). Every element instantiated throughout the use of the program may have an interface to communicate with the user. There are interfaces that are always visible (e.g. toolbar, contextual menu) and interfaces that are generated/destroyed as a result of an an event, to be instructed on the current status of the program (i.e. selected VME, selected View and running operation) in order to manage the GUI accordingly.

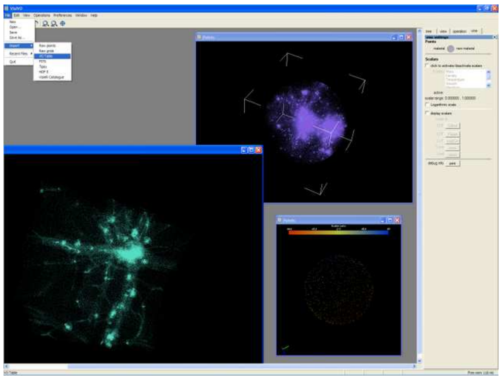

Fig. 1. VisIVO visualizing simultaneously raw data, FITS data and data from a VOTable as points with associated scalar data. On the left a typical operation graphical user interface.

VisIVO supports several visualization techniques for data. Unstructured points are visualizad as pixels. The user can set the transparency of the pixels and their color. It is possible to color each pixel differently, according to an associated quantity. For example, gas particles can be colored by their temperature (e.g. blue for cold particles, red for hot particles). Points can be also described with glyphs (solid geometrical shapes), whose shapes and size can be parametrized to some physical quantities associated with data.

Mesh-based data can be visualized with two different techniques, isosurfaces and volume rendering. Isosurfaces are surfaces characterized by a given fixed value of the plotted quantity. They separate regions with higher values from regions with lower values. Different isosurfaces can be calculated and visualized at once. They can be characterized by different colors, according to the contour value. Using the volume rendering technique, different values of the quantity are represented by different colors and different transparencies. The overall effect is a cloud appearance.

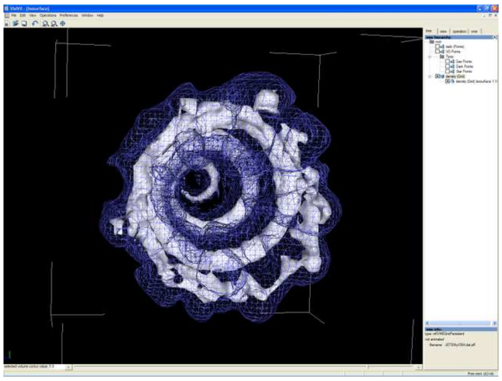

Fig. 2. An example of isosurface view, two isosurfaces are represented with two different material settings.

Two dimensional visualization, graphs, curves, and HTML file browsing are included. In both cases the implementation is quite simple and basic. Furthermore, stereographic view is supported.

1.2. Interacting with the VO

In a first phase of development, the only possible interaction of VisIVO with the VO was off-line. Data could be downloaded from usual on-line services in a standard format like VOTables or FITS and visualized by the software. However, now, VisIVO is able to query directly the VizieR web service to retrieve data from it and visualize them as if they were local data. This functionality allows the user to visualize and analyze remote data. The interaction with the service is trasparent to the user. The user must only to fill specified fields with the parameters defining the data he want to download. The result of this operation will be a list of catalogues, and selecting one of them, data will be visualized as it they were in a file.

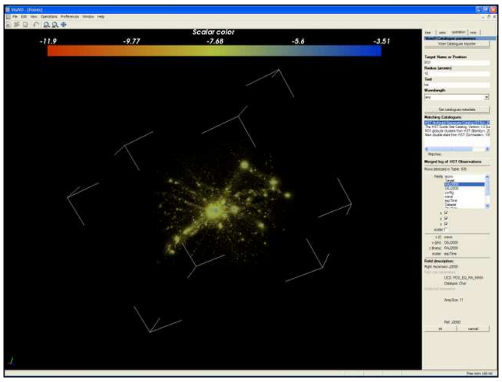

Fig. 3. On the left of this image the fields to be filled to query the VizieR web service. In the next release of VisIVO the interface will change to allow the user to filter the results of his search.

1.3. Future development and conclusions

VisIVO represents the first experience of an immersive Visualisation and Data Analysis Tool in astrophysics. The internal structure is based on the VTK library, written in C++, and all the analysis tools consist in specific modules that we have implemented in an ad hoc manner. The interface with the VizieR web service is a work in progress in the sense that we modify and add functionalities to the interface as soon as they are implemented on the server side of the service. We are also working on the interoperability between VisIVO and Aladin (interactive software sky atlas), this will allow the user to gather further data from Aladin and obtain 2d images of the selected points in the 3d view. VisIVO will use the grid services to execute external tools in a dataset and can be integrated into a VO theoretical data center to obtain a preview and a pre-analysis of data that users want to consider.

References

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