VisIVO, a VO-Enabled tool for Scientific Visualization and Data Analysis: Overview and Demo

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VisIVO is a visualization package developed in collaboration between INAF (Catania Astrophysical Observatory) and CINECA (the largest Italian academic supercomputing center) with the specific object of supporting visualization and analysis of astrophysical data. The package is written in C++ and it is completely open source.

Goals:

- **N-Dim (N>2)** Visualization of Astrophysical data (MAIN)
- Astrophysical Data Analysis (on the fly)
- Interaction with Databases
- Interaction with distributed resources
- VO compliance
- Educational and outreach applications

VisIVO is not (specifically) for:

- Visualization of low dim data (dim <= 2)
- Image processing
- 2D plots

Strasbourg, March 15, 2005
VislVO and the Virtual Observatory (VO)

**The VO:** all the world data on the desktop, analysable with tools made available through a standard interface

**VO-TECH:** EU – FP6 Specific Support Action

**VislVO:** Italian Contribution to the VO-TECH – DS6

**VO-TECH:** Integration of new technologies into the European Virtual Observatory
VisIVO Team

INAF – Astrophysical Observatory of Catania

Becciani Ugo (permanent staff)
Comparato Marco (young fellow)
Alessandro Costa (permanent staff)
New Position (young fellow – Full Time)

CINECA

Claudio Gheller (permanent staff)
New position (permanent staff)

MAF – STAFF

Web Site (introduction, downloads, documentation…)
http://visivo.cineca.it
VisIVO components requirements:

- standard and high performance programming language
- flexible and powerful high-level graphics library
- open source, multi-platform components
VisIVO overview

Completely based on open source products.

Exploitation of the results of 2 EU funded projects:

- **Multimod**
  (http://www.tecno.ior.it/research/biomechcomp/projects/multimod/mm_home_page.html)

- **Cosmo.Lab** (http://cosmolab.cineca.it)

Basic Visualisation technology and software architecture

Astrophysics specific tools (readers, analysis algorithms…)

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The Visualization ToolKit (VTK)

The graphics functionalities of VisIVO are based on VTK

- VTK is an Open Source tool developed by Kitware inc. (http://www.kitware.com): 3D computer graphics.
- VTK can be used with different languages (Tcl/Tk, Java, Python)
- Can be run on Linux (Unix) and Windows (PC and Mac OSX)
- Largely used to implement scientific tools

Technical Characteristics

- More than 700 C++ classes
- Extended set of 3D Widgets
- Surface Rendering and Volume Rendering
- Data interaction: good efficiency
- Rendering windows: easy use of lights, cameras and actor properties
**The Multimod Application Framework (MAF)**

**Introduction:** (from the web site, http://www.cineca.it/B3C/MAF/)

The Multimod Application Framework (MAF) is an open source freely available framework for the rapid development of applications, based on the *Visualization Toolkit* and other specialised libraries. It provides **high level components** that can be easily **combined** to develop a vertical application in different areas of scientific visualisation.

Developed by the Visualization Team of Cineca, the University of Bologna and “Istituti Ortopedici Rizzoli”

Special thanks for the continuous support and help to Cineca Visualization Team experts Cinzia Zannoni, Silvano Imboden, Marco Petrone and Paolo Quadrani.
The MAF architecture

VisIVO has been developed as a MAF application. Its architecture can be summarized according to the following schema:

- **High Abstraction Level**: specific of the user application (VisIVO)
- **Low Abstraction Level**: general purpose high-level services
- **Multimod Foundation Layer**: provides basic software components
The High Abstraction Level (HAL)

The HAL is the specialized part of the code. It consists in:

libraries, which add new and specific functionalities to the code.

Libraries are developed:

- According to MFL and LAL rules
- using MFL components
- using VTK components
- integrating other libraries

the driver code

defines and initializes the application

The HAL can be thought as specular to LAL, but external to the core application. It can be developed with no worries about MAF integrity. Finally, part of HAL functions can be added to LAL or MFL.
VisIVO on the top of MAF

**VisIVO is our HAL.** Its implementation has actually required changes at all levels (part of our needs were beyond expected requirements). In particular:

**MFL:**
- new implementation of VME to support large particle based dataset with associated properties (scalar fields)

**LAL:**
- integration of the new particle VME
- Specific viewer to visualize particles and properties (transparency, colors, glyphs)
- Introduction of permanent GUIs, to change parameters on the fly
- Introduction of interpolated time evolution (in progress)
However, most of our work is related to the development of specific functionalities. We have focused on the following main topics:

- **Importers** – classes which allows to read data files
- **Database access** – dealing with SQL databases (starting now)
- **Web services interaction** – dealing with the Virtual Observatory
- **Data analysis functions** – manipulation of data to get derived results
- **Data viewers** – how to graphically represent data
Importers:
input = file
output = VME

Classes which allows to read data files in different formats. At present we support:

- **RAW binary format** (particles and grids)
- **HDF format** (subset for particles)
- **FITS format**
- **VOTables**
- **Tipsy format**
- **VTK Format**

Binary dump of memory (C I/O style). Positions followed by N scalars for particles.

Support only for particle files. To be extended. **HDF5 libraries imported**

Fully supported. **CFITSIO library imported**

Fully supported. **XALAN and XERCES libraries (for XML parsing) and VOIndia C VOTables library imported**
Operations:
Input = VME (one or more)
Output = VME (one or more)

Classes which allows to handle data files in order to extract meaningful information. At present we have implemented

- **Randomizer**: extraction of random subset of data
- **Power Spectrum**: calculates of the spectrum of a periodic particles distribution
- **Correlation Function**: computes the correlation function of a particles distribution
- **Minkowsky functionals**: estimates the geometry and the topology of a particle distribution
- **Points splatter**: distributes a particle field on a regular mesh
Classes which allow to map data to images according to specific algorithms

- **Points viewer**: maps points to pixels and to glyphs (shapes)
- **Isosurfaces**: draws surfaces that divide grids higher and grids lower than a given value
- **Volume rendering**: renders grids with colors and transparencies (cloud effect)
- **2D graphics**: visualizes curves and plots
- **HTML browser**: for documentation and help pages

**Viewers**
Input = VME
Output = image
VisIVO: what is there NOW

• The 0.1 version of VisIVO can be downloaded from the web site (http://visivo.cineca.it)
• It implements the functionalities shown in the previous three slides
• It is the binary version for MS Windows XP (Linux porting is in progress… expected by June 2005)
• Documentation is not yet ready (coming soon !!!)
• Source code can be downloaded using anonymous CVS access
• Contribution, contributors, collaborations are welcome !!!

Note for sources distribution.

Software requirements:
• MS Visual C++ 6
• CMake 1.6 (patch 7)

CVS access:
CVSROOT = :pserver:anonymous@sirio.cineca.it:/server/project/cvsrepos
PASSWORD: no password required
Checkout module openMAF
Checkout module cosmoMAF
Development projects and active collaborations

Data mining algorithm, in collaboration with the Universities of Napoli and Salerno, AstroNeural project.
(http://people.na.infn.it/~longo/Ricerca/ASTRONEURAL/astroneural_main.html)

Aims and applications of AstroNeural:
User friendly tool to perform clustering and data mining in high dimensionality spaces

**Aims**
- Clustering & pattern recognition in high dimensionality spaces
- Visualization (VisIVO)
- Classification
- Parametrization of images
- Modeling of massive data sets

**Applications**
- Astrophysics
- Genetics
- Geophysics
- High energy physics
- Atmospheric physics
- Etc.
Development projects: WS access

Connecting VisIVO, a C++ application, to a Web Service

- Asked for the wsdl of the web service
- Used the wdsl2ws tool to create the client stubs (C++ classes)
- Created objects of these classes in VisIVO
- These objects, using the Axis C++ library, are our interface to the Web Service
- Test case: VizieR service
- GUI to the service: in progress
Development project: VisIVO Server

- MAIN TASK: VisIVO move some functionalities on Server Side
- Development of a Pilot Project for a TVO (DS4): data from simulation
  - Requirement Study
  - Data Format Interface
  - Run of analysis tools (off-line)
  - Data extraction
    - Preliminary data selection and preview
  - Data download
  - VO compliant data access and data output
  - Integration with VisIVO Client
  - .............
VisIVO – Integration in a Data Center

Web Services

- File transfer
- Structured Data handling and analysis
- Job execution and monitoring
- Visualization Steering

Middleware/wrappers

- SFS, AFS...
- DBMS
- SP4, CLX, A3K...

Browser (Application Service Portal)

WSDL /SOAP

Security

Strasbourg, March 15, 2005
**Vis/VO in one slide**

Visualization of N-dimensional data (N > 2)
Open Source
MS Windows (porting to Linux in progress)

**Present Release:** 0.1

**Downloads:**
From web site (binaries only)
http://visivo.cineca.it
From CVS
CVSROOT = :pserver:anonymous@sirio.cineca.it:/server/project/cvsrepos
PASSWORD: no password required
Checkout module openMAF
Checkout module cosmoMAF

**Software requirements:**
MS Visual C++ 6
CMake 1.6 (patch 7)

**Libraries:**
VTK 4.2 (graphics)
wxWindows (GUI)
CFITSIO (Fits files)
HDF5 (HDF Files)
VO India C++ lib (VOTables)
Xalan, Xerces (XML)
Axis C++ (WS)

**Documentation:**
User Guide (almost ready)
On-line (almost ready)
Developer Guide (who knows…)
Examples (in the distribution)

**Contributions and collaborations:**
…are welcome!!!