Title :	VIALACTEA WP5 Deliverable Item 5.3 3D Visual Analytic Front- end module and Visual Analytic portlets for the Science Gateway – v1		
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1. Introduction

A 3D-aided visual analytics environment allows the astronomers to easily conduct research activities using virtual reality methods for multidimensional data and information visualization. It provides real-time data interaction to carry out complex tasks for multi-criteria data/metadata queries on subsamples selection and further analysis, or real-time control of data fitting to theoretical models.
The VIALACTEA visual analytics environment is implemented as a client-server application where all data, models, analysis tools, data-mining/machine-learning tools and information is enclosed in a standardised, homogeneous and interoperable framework handled via a Science Gateway.

This document is the explanatory supplement of the 3D Visual Analytic client.

The version 1 of the software is the deliverable 5.3 (D5.3) of the Work Package WP5 of the VIALACTEA project. The deliverable D5.4 (software version 2) will update this document.

The D5.3 delivery package is constituted of:

- The 3D Visual Analytics Version 1 software source code (visualanalytics_v1.tgz archive); due to the file size, the code is available on the VIALACTEA Wiki under the page “Deliverables”, section “WP5” subsection “D5.3”.

- The software explanatory supplement information (i.e. this document)

2. Applicable & Reference documents.

Doc. Ref.	Title	Ref.	Issue	Date
AD1	Radio Cube Data Access Services for VIALACTEA	VL-OATS-RP-2015-001	1	14/04/2015
AD2	D5.1: Infrastructure architectural design	VL-OACT-RP-2014-001	1.1	30/04/2014
AD3	New machine learning tools updates	VL-OACN-DI-2014-001	2	25/09/2015

3. Acronyms and Abbreviations

RDB	Relational DataBase
FITS	Flexible Image Transport System
Project	The VIALACTEA Project
SED	Spectral Energy Distribution
TAP	Table Access Protocol
VLKB	ViaLactea Knowledge Base
VO	Virtual Observatory
VTK	Visualization Toolkit

4. 3D Visual Analytics frontend module

4.1. Software dependencies

The 3D visual analytics client is a cross-platform application and runs on Linux, Windows and Mac OS.

It consists of a set C++ classes for the core functionalities using Qt for the user interface. The adopted rendering engine is the Visualization Toolkit. VTK is an open-source, freely available software system for 3D computer graphics, image processing, and visualization that supports a wide variety of visualization algorithms .

NAME	VERSION	URL
VTK	6.20	http://www.vtk.org/VTK/resources/software.html
Qt	5.2	https://qt-project.org/downloads
gcc	>= 4.1	
cfitsio	3.10	http://heasarc.gsfc.nasa.gov/fitsio/fitsio.html

4.2. Build Instruction

To build the application open VisIVODesktop.pro file with Qt Creator app (Installed with Qt environment).

Edit this file setting the *INCLUDEPATH* and *LIBS* path according to your system configuration.

Using Qt Creator it is possible to build and run the Visual Analytics frontend.

4.3. 3D Visual Analytics architecture design

According to the Architecture design document [AD2], the development of the application follows the architecture depicted in Figure 1.

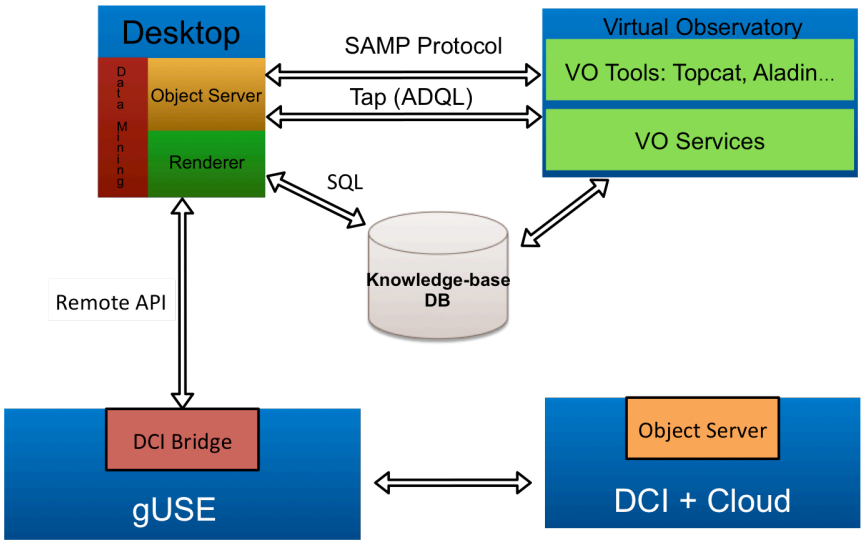

Figure 1. Architecture design of the 3D Visual Analytics module

The visual analytics framework is designed employing a client – server approach.

In the client there are three macro blocks detailed as follows:

- Rendering;
- Object server: enable the visualisation clients to display data without penalising user interactivity. It offloads computations from the client-side to the server (albeit generically important, this is especially important for web-based visualisations and for visualisation in low power devices). It also lowers the need of data transfers from the server to the clients, and thus bandwidth requirements on the server (and client) side;
- Data mining algorithm interface.

Through the usage of gUSE's remote api it's possible to execute workflows on different DCI.

The access to the knowledge base DB is possible through SQL and TAP Queries. This enables the application also to access the VO catalogues.

5. Visual Analytic Front-end v1

5.1. Visual Query

A sort of visual selection of the region of interest has been developed and it is used as starting screen of the visual analytics client, in order to allow the users to easily query and retrieve from the search&cutout service [AD1] (fig.1).

The *visual query* services has been implemented as a customization of openlayers[1] framework.

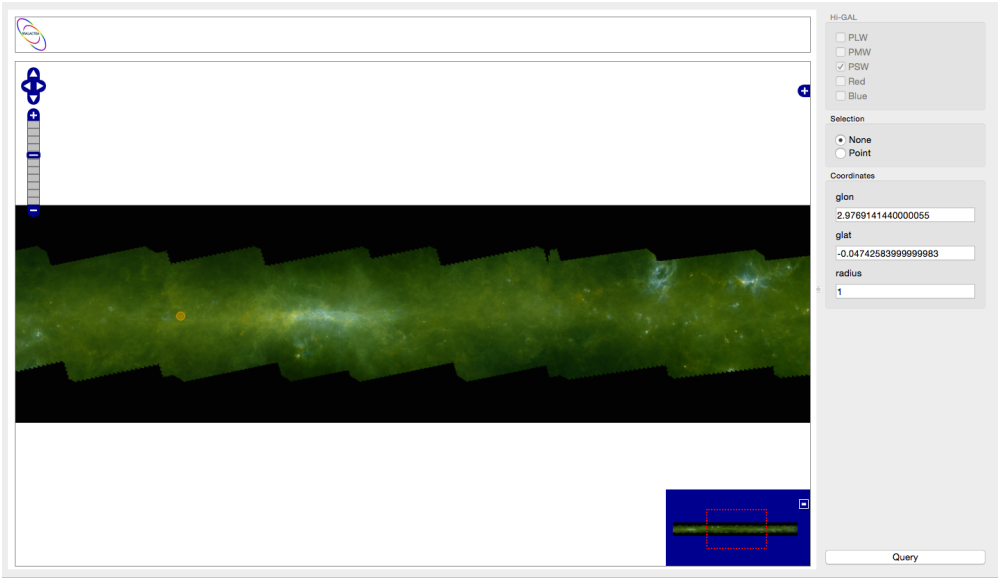

Figure 1. Visual query services user interface

The image shown within the window, provided by IAPS, is a tiff image of galactic plane from -60° to + 60°. This original image has been converted to jpeg and divided into smaller tiles using GDAL2Tiles[2]. This utility generates small tiles and a simple web page with viewer based on OpenLayers.

This web based approach (files are locally stored and embedded in visual analytic client) allows the user to comfortably explore, with zoom and pan functionality, galactic plane maps. Moreover that this is also useful for dissemination purposes (e.g. on the project website).

The selection of the region of interest is, up to now, performed by choosing a point on the map and specifying the radius of selection in the dedicated box on the right part of the window. The maximum radius accepted by the *search & cutout* is 2 degrees.

The service returns a fits image containing the user selected region that is used as starting point for visual analytics.

[1] http://openlayers.org

[2] http://www.gdal.org/gdal2tiles.html

5.2. **Compact sources**

Starting from the fits image, the user can display compact sources overlapped to the fits image. Compact sources dataset can be loaded from a local file or obtained from the VLKB.

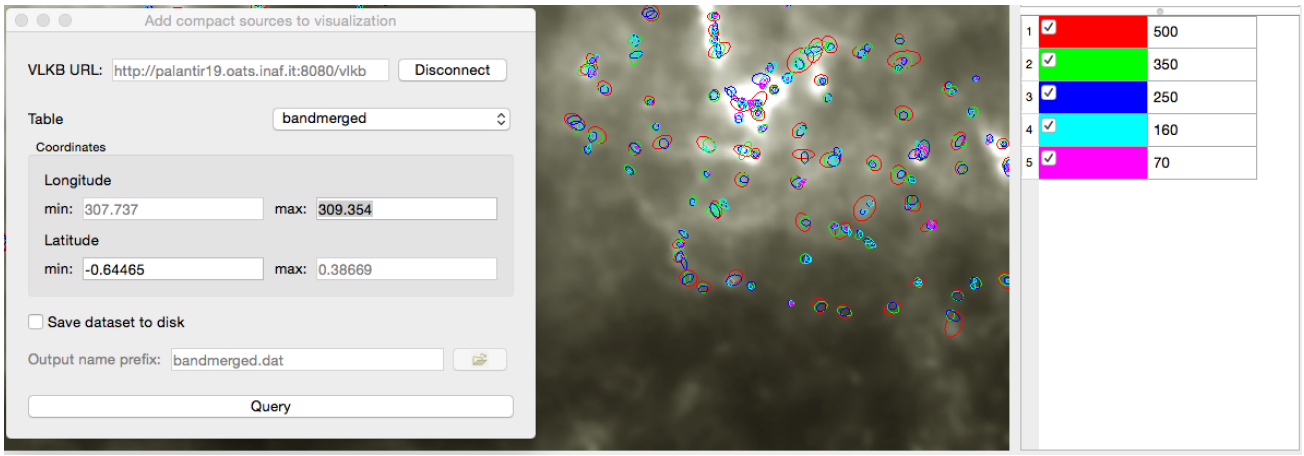

Figure 2. Adding compact sources from VLKB to visualization screen

If the user decides to retrieve compact sources dataset from the VLKB he/she can make a rectangular selection of the region of interest on the visualized image. The tool, extracting coordinates from the selection made by the user, queries the project database and automatically display compact sources on top of the fits image on which the user is doing the analytic operations (see fig.2).

Selecting one or more of the visualized clumps the user can choose to visualize the SED plot.

In case the SED presents multiple associations the user can choise to sum the fluxes of counterparts obtaining the SED with a cumulative flux. In figure 3 the SED drawn in red line is the collapsed one while the dashed lines are the original SEDs.

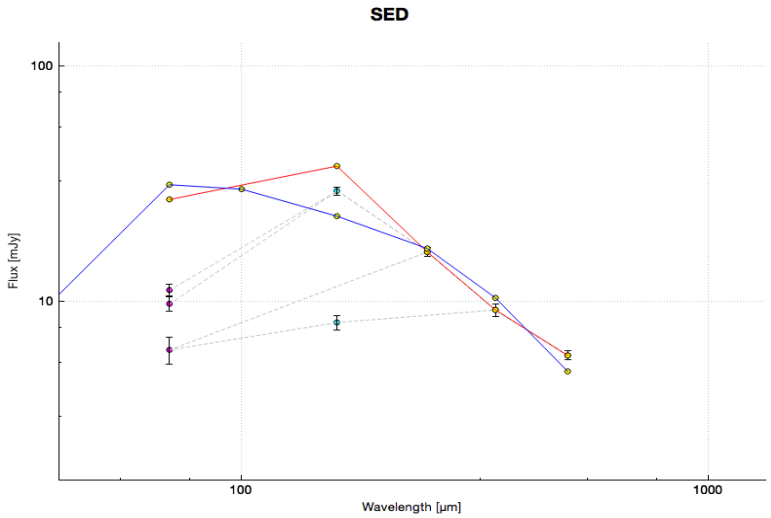

Figure 3. SED plot: in blue the theoretical SED that fit the collapsed one drawn in red

There are three different kind of fitting operations available, one for the fit with the theoretical models and two for the analytical fit.

Fit operations are performed through the use of IDL[3] routines developed by IAPS and integrated, in a transparent way for the user, within the client of the visual analytics tool.

5.3. **Datacube visualization**

Selecting a point on the fits image the user can query the search & cutout services in order to get and visualize radiocubes.

The visual analytics client provides two different ways to query the services:

- *Generic query*. The service is queried using the galactic coordinates of the selected point on the map and specifying values for the radius and the speed in the case of circular selection (default value are proposed). The user obtain a list of surveys contained in the RDB that contain data for the selected area, and can therefore choose to display the associated datacube.
- *Specific query*. In addition to the galactic coordinates and the radius the user specify survey, species and transition he/she wants. The service is queried looking for a specific datacube and if exists on RDB it automatically displayed.

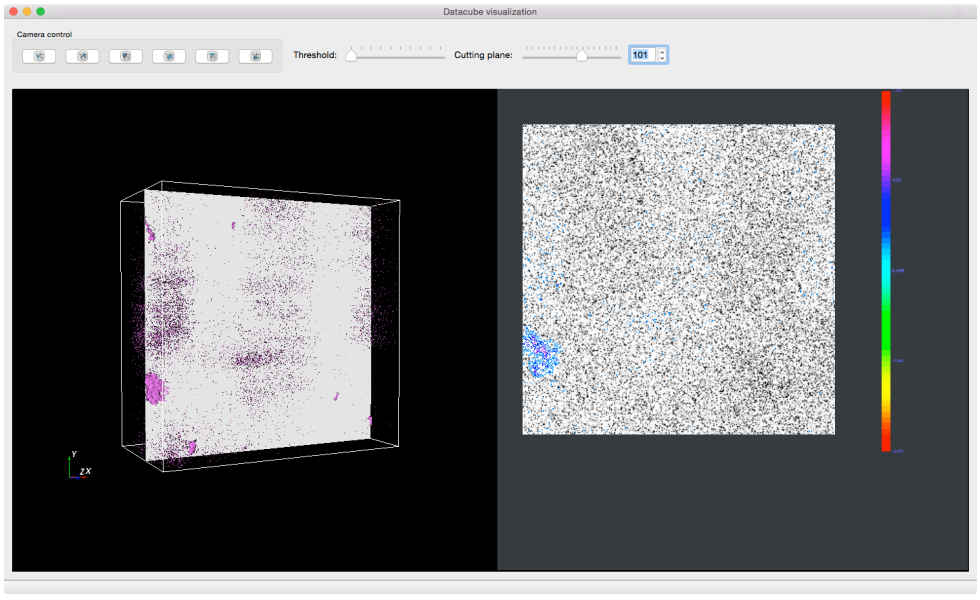

Figure 4. 3D datacube ad isocontours visualization

The 3D visualization of the datacube (see fig. 4) is implemented using isosurfaces algorithm with thresholds that the user can change in real-time using the slider located in the top of visualization.

With the cutting plane slider, the user can select one of the slice of the cube and display it with isocontours in the right pane of the window.

[3] http://www.exelisvis.com/ProductsServices/IDL.aspx

5.4. **3D Visualization for sources on galactic plane**

The user can select a region of interest within the fits image in order to query the VLKB obtaining a 3D visualization of compact sources on the galactic plane in that region (see fig5.).

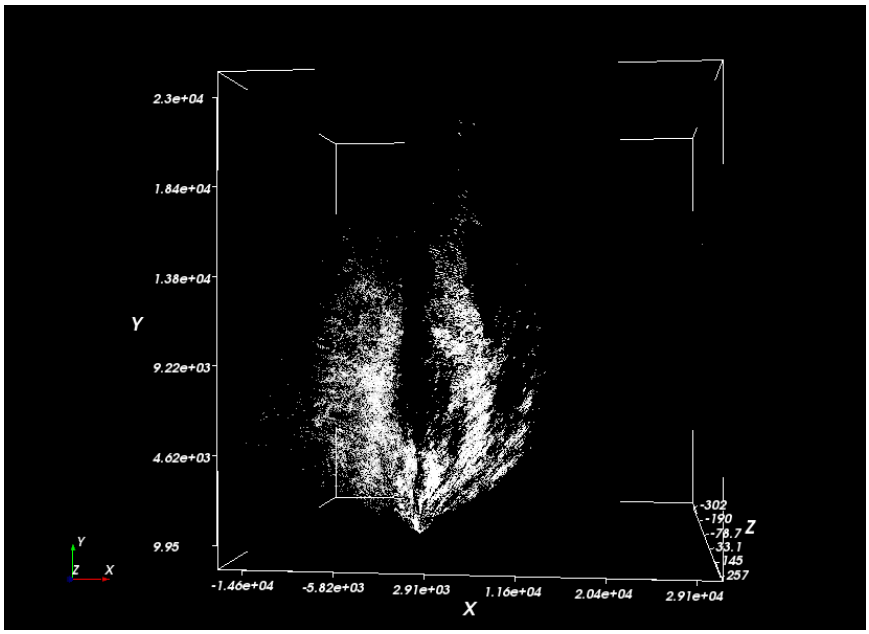

Figure 5. 3D Visualization of sources on galactic plane

Users can make a selection in the 3D visualization in order to extract the sources of interest. This selection is currently implemented as rectangular selection; the freehand selection is being under bug fixing.

6. **Visual Analytics portlets v1**

During last year of the project visual analytics portlets will be designed and implemented.

Visual analytics portlets will allow the users to run, in an easy and intuitive way, workflows developed through the science gateway by a workflow developer.

It has already decided to implement two portlets one for Q-FULLTREE [AD3] and one for mosaic creation.