GLORIA is funded by the European Union 7th Framework Programme (FP7/2007-2013) under grant agreement n° 283783

GLObal Robotic telescopes Intelligent Array for e-Science

Web components and documentation for programming on-line experiments

CODE: DEL-033

VERSION: 01

DATE: October 22nd, 2012

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Change Control

Issue	Date	Section	Page	Change Description
01	22/10/2012	All	All	Creation

Reference Documents

Nº	Document Name	Code	Version
R.1	D8.2-Web components and documentation for programming off-line experiments	DEL-034	01
R.2	D8.3-Web components and documentation for preparing community-wide experiments	DEL-039	01
R.3	D3.10-Report for standard methodology for online experimentation and the choice of the on-line experiments	DEL-023	01
R.4	D8.1-Web components and documentation for programming on-line experiments	DEL-033	01

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1. Introduction

Providing a suite of open-source tools, written in common web languages (particularly HTML, CSS, Javascript) will provide the GLORIA community with a base from which to develop their own data collection and analysis tools. These tools will be used to interact with data from the GLORIA telescopes; in this deliverable, we focus on the development of tools and workflows for online experiments only. Online experiments are defined as those which require access to the GLORIA telescope network, in contrast to experiments conducted by users that simply do not require live telescope access (standard offline experiments), detailed in Deliverable 8.2 (R.2), and 'community experiments' that use GLORIA data in a crowdsourced, structured fashion, which are covered in Deliverable 8.3 (R.2).

The tools outlined in section 2 of this document are make up the web components for online experiments. These can be embedded as iFrame modules in GLORIA's Liferay CMS, or in many cases could be repurposed if necessary in the native Java language.

In the following section we outline a list of possible online experiments and the web components required to create them.

2. Example Online Experiments

Our approach has been to consider example online experiments gathered through discussion with scientists and with the GLORIA collaboration partners. For each of these example workflows we have identified the necessary components as being high priorities for incorporation into the GLORIA software. In contrast to offline experiments, the examples given in this section combines both complete experiments with necessary steps for many experiments.

2.1. Search Coordinates Before Submitting:

2.1.1. Steps taken by users:

- Request observations of coordinates.
- Search SIMBAD for previous studies at this location.
- Search GLORIA network for previous studies.
- Modify list and submit observation to system.

2.1.2. Web components required:

- Search SIMBAD
- Search GLORIA database

2.2. Planetarium View:

2.2.1. Steps taken by user:

- Input a data and time and see local 'planetarium' view (e.g. using LCOGT Virtual Sky)
- Change locations to any of telescopes on the network and see what regions of the sky are observable at their location.
- See the locations of current/previous targets of telescopes in the GLORIA network.

2.2.2. Web components required:

- Virtual planetarium that can centred around any location/time.
- All-sky map showing live data from multiple sources.

2.3. Calculating Wolf Number by Solar Observation (see also R.3)

The Wolf Number is a measure of solar activity, calculated by observing the number of individual sunspots and sunspot groups present in a visible light image of the Sun. Historical records of Wolf Number dating back more than a century provide an unbroken accurate record of changes in solar activity. This fundamental part of solar observation can also provide the precursor activities for more complicated measurements, for example of differential rotation, as the network and the sophistication of our userbase grows.

2.3.1. Steps taken by user:

- User selects a telescope to observe the Sun
- User records image(s) of the Sun or loads local/pre-recorded image
- User counts sunspots and sunspot groups
- User calculate Wolf Number

2.3.2. Web components required:

- Telescope selector
- Image viewer/loader
- Sun image display (possibly with ability to mark sunspots and groups).
- Wolf Number calculator widget
- Plotting and analysis component (we intend to use the open source optimise.js library at http://dan.iel.fm/optimize.js/examples/gaussfit/)

3. Web Components Under Development

The Liferay CMS allows the creation of iFrame modules. These iFrame modules can be hosted either on the same GLORIA servers by the collaboration - or on cheaper solutions such as Amazon S3 by users. They can be user-hosted and developed by members of the GLORIA network, as well as embedded within other sites. This gives them a clear advantage and a good compatibility with the GLORIA project's ethos.

Much of this content is shared with Deliverable 8.1(R.4), as the web components for online and offline experiments are very similar.

3.1. Coordinate Conversion

As an example we have built a simple coordinate conversion tool as an iFrame module. This tool converts from Equatorial Coordinates (FK5) to Galactic Latitude and Longitude. Below you can see a set of screenshots showing this web component in action in the Liferay framework.

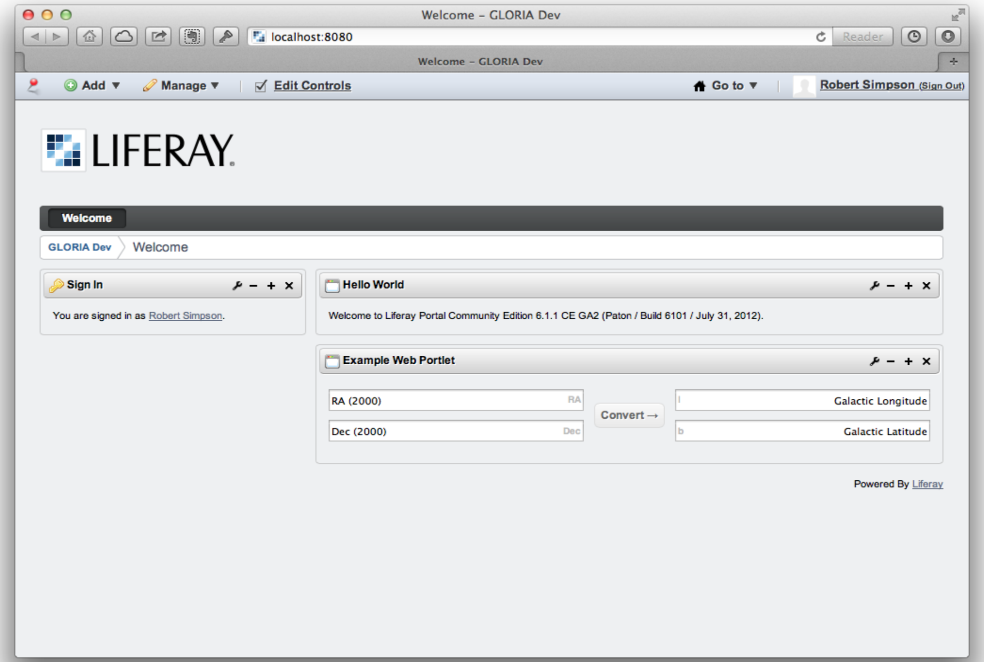


Figure 1: Coordinate Conversion Component Screenshot

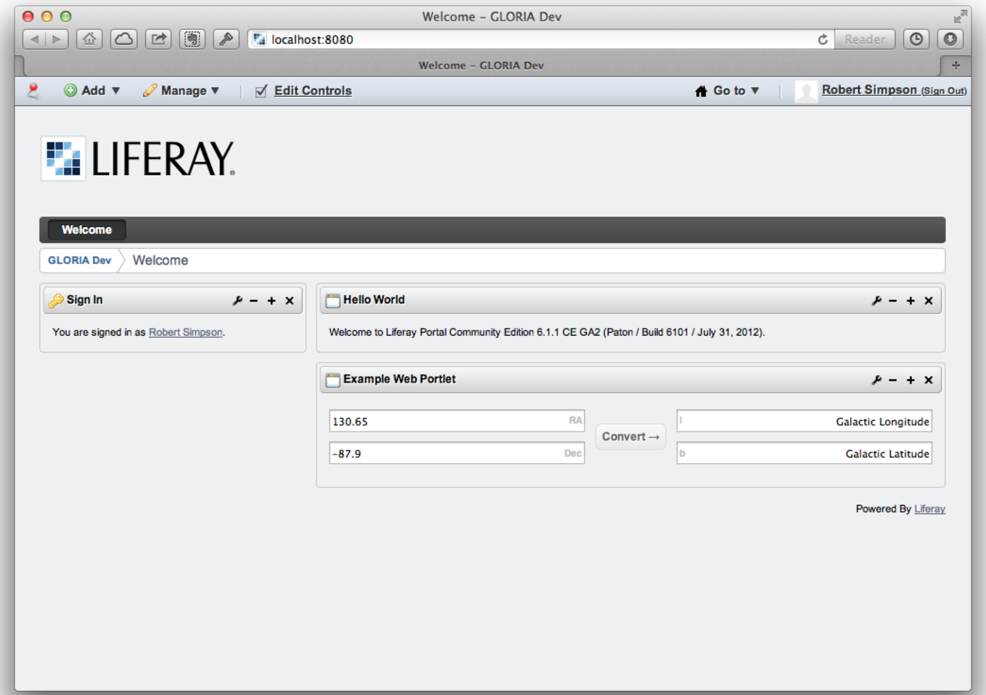


Figure 2: Coordinate Conversion Component Screenshot

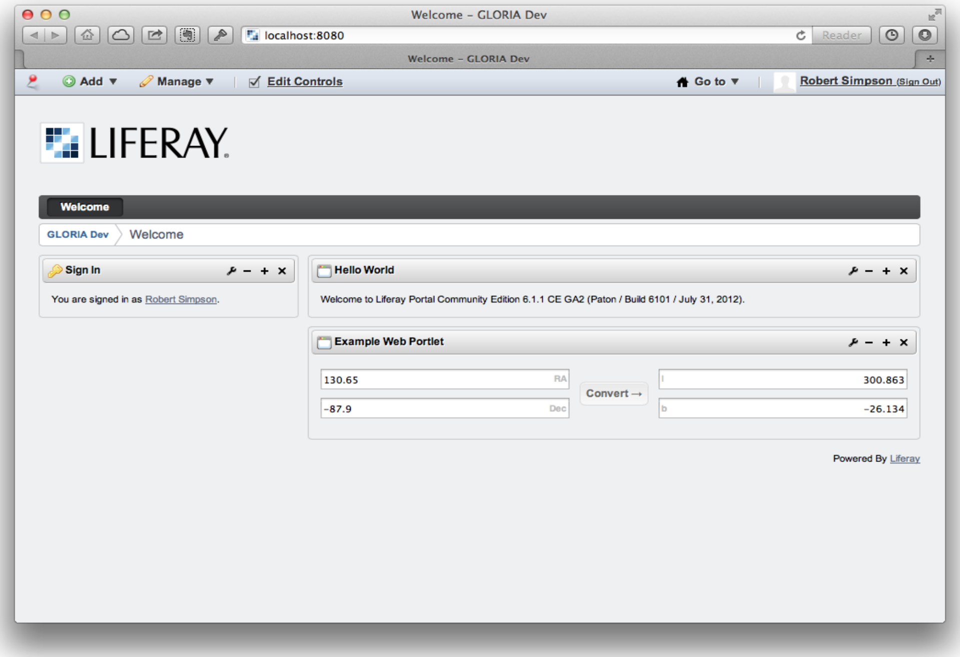


Figure 3: Coordinate Conversion Component Screenshot

It converts in either direction and all the code is open to the user. Using Javascript means using the users own CPU, and so the only burden of hosting in on delivering the content to the browser. This does not require a server and the code can be run locally or offline, once download is complete.

3.2. Flora: FITS in a Web Browser

Astronomers often use Flexible Image Transport System (FITS) files to store and share data. For GLORIA to truly be useful in astronomical research we need to be able to to read and manipulated FITS files, and these are the desired outputs from the GLORIA telescopes.

FITS can now be handled very well by the open source javascript library AstroJS (https://github.com/astrojs), within which we represent the leading the development group. Here (http://ubret.s3.amazonaws.com/dotastro4/index.html) you will find Flora, a project developed at .Astronomy 4 (http://dotastronomy.com), which uses AstroJS. The same techniques can be applied to any iFrame and as such we can support the use of FITS files in the browser within GLORIA.

Opening and viewing FITS files is possible, and in the future more advanced tasks such as aperture photometry.

3.3. IVO Standards in Action: Spectral Energy Distribution

The International Virtual Observatory (IVO) has developed a set of useful standards for the exploration of their data archives. Their Table Access Protocol (TAP) can be used to explore the databases defined in various centralised XML catalogues.

To explore how easily TAP can be utilised by GLORIA we developed a tool for creating Spectral Energy Distributions (SEDs) from just coordinates. The process involves querying several online catalogues for data at all available wavebands and returning the results as a collection of single SED charts, showing the energy profiles of objects within a predefined radius of those coordinates.

SED profiles are another essential tool for many astronomers. The prototype tool is available at http://ubret.s3.amazonaws.com/sed/index.html and screenshots of an example search are provided below.

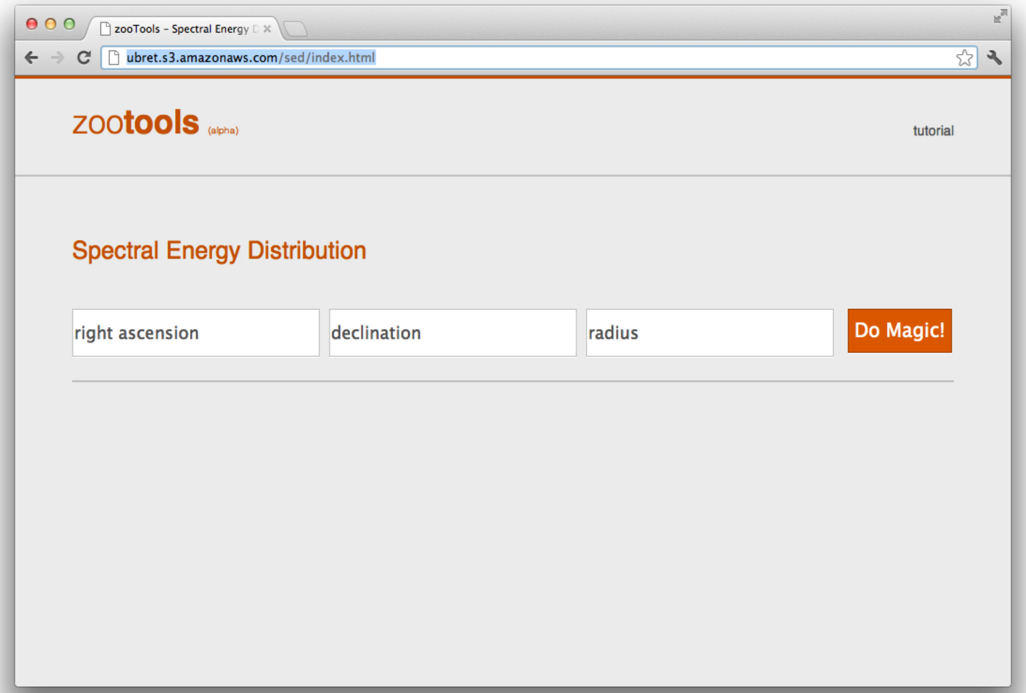


Figure 4: SED Tool Screenshot

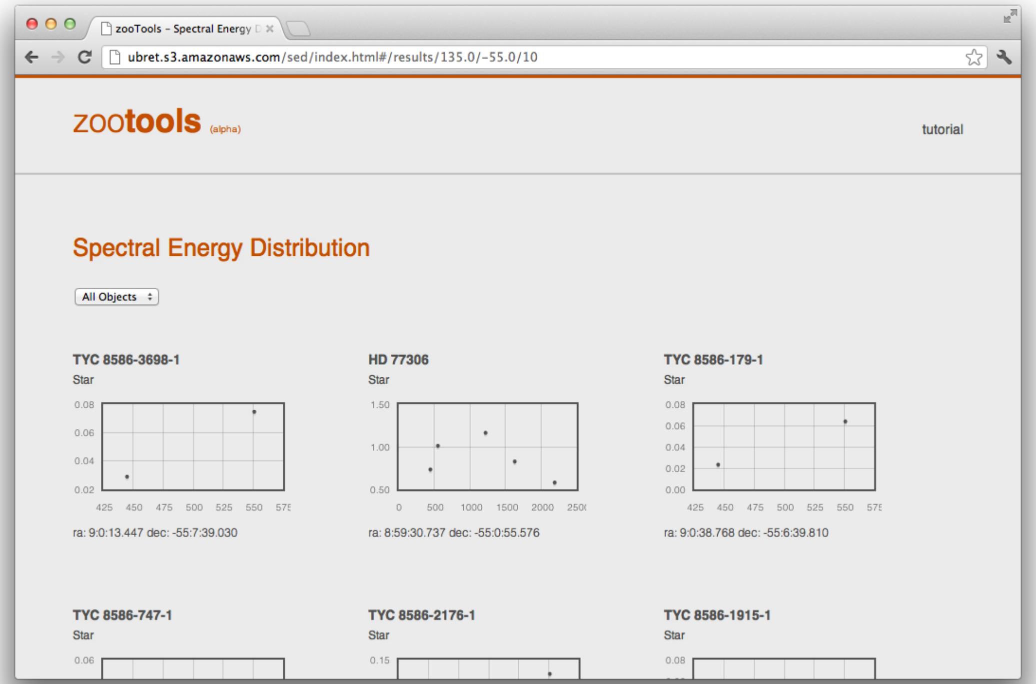


Figure 5: SED Tool Screenshot

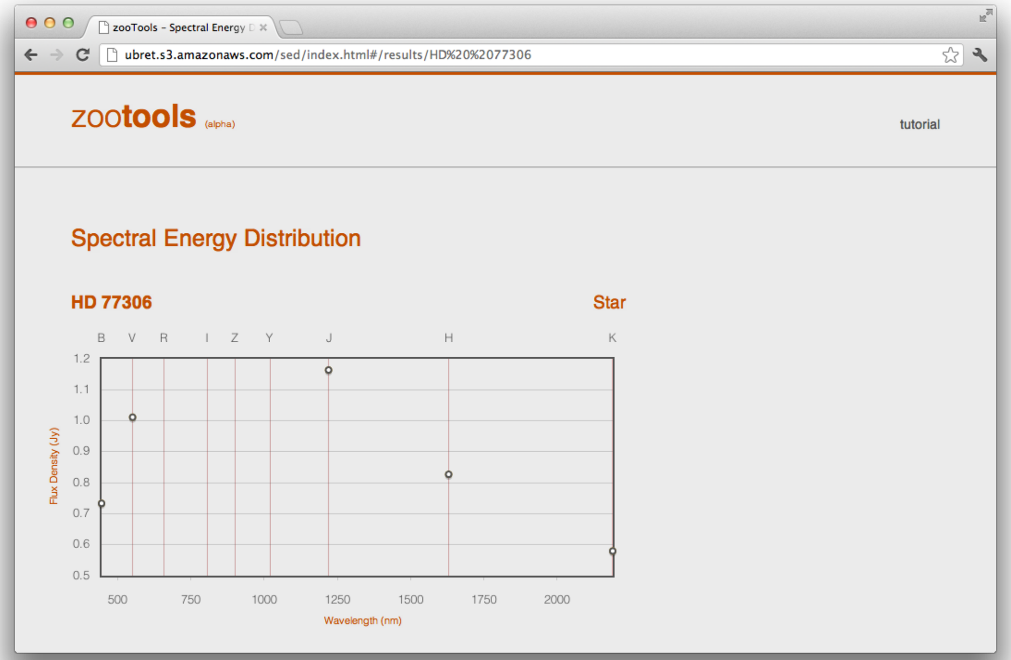


Figure 6: SED Tool Screenshot

This example shows how IVO protocols can now be implemented in a web browser and hence within GLORIA. Such tools would normally require large amounts of processing power - which do not scale well when the network is experiencing heavy traffic. By offloading the processing to the user and to the cloud - in this case the various IVO data servers - the user experience is vastly improved and thus such utilities are possible.

3.4. SIMBAD Search and Display

We have created web browser tools for searching and displaying data from CDS's SIMBAD service, an excellent repository of astronomical objects from the literature. For this web component, we decided to test the robustness of the implementation, which depends heavily on external APIs with the Zooniverse's Milky Way Project (http://milkywayproject.org) as a testbed. The Milky Way Project has already been successful in attracting a large audience of citizen scientists engaged in research; this audience is a good match to that we would like to attract to GLORIA and this therefore represnets a chance for user interface testing as well as API evaluation.

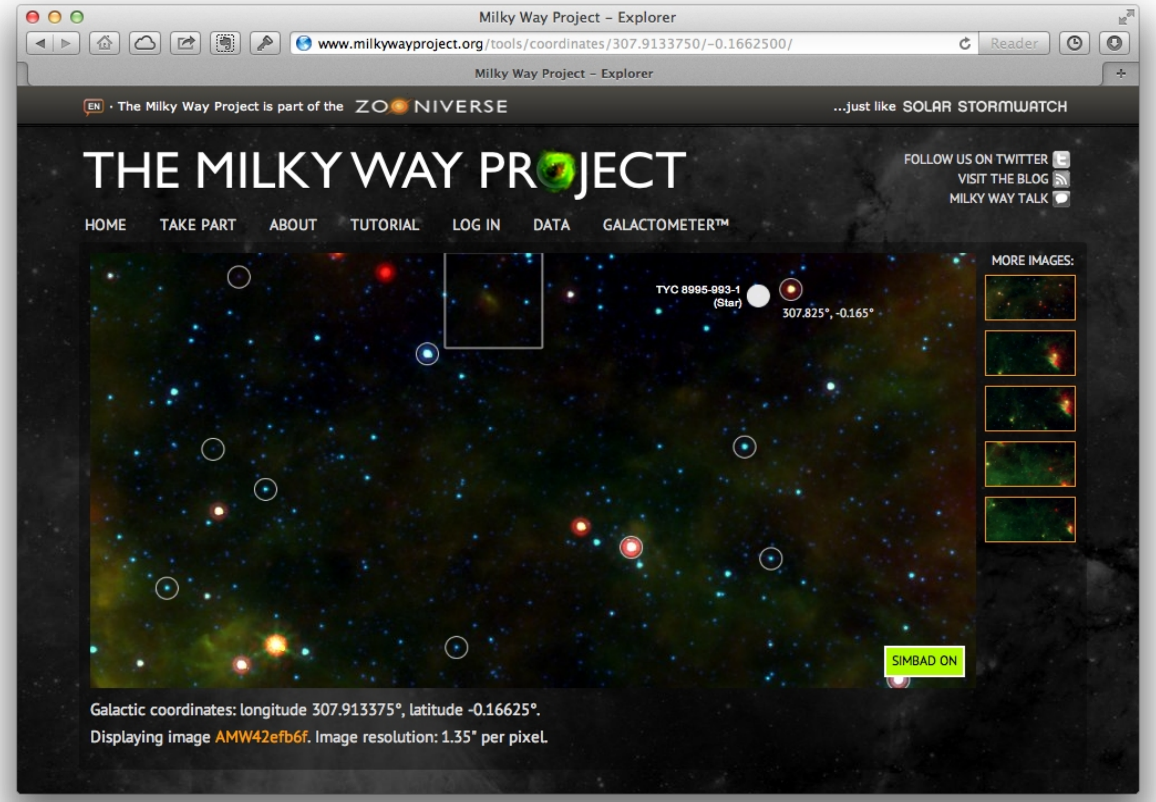


Figure 7: SIMBAD Search in Javascript on the Milky Way Project

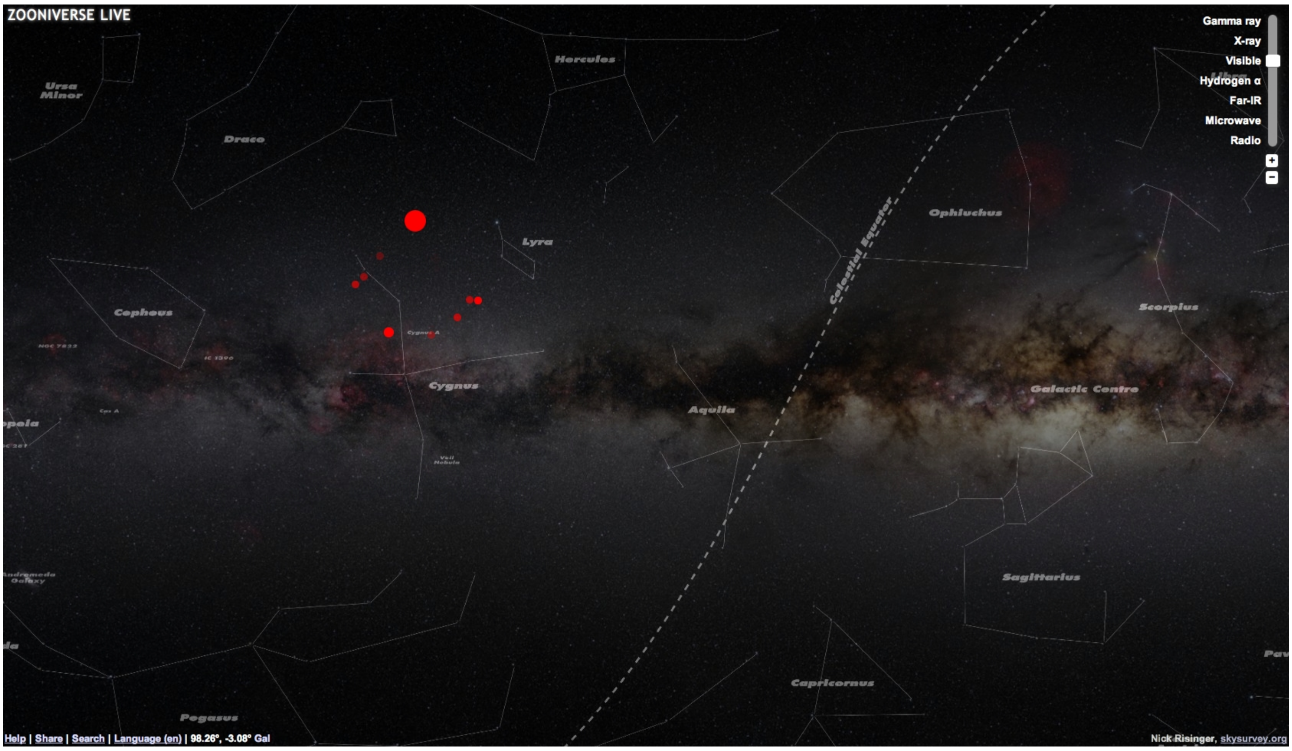
For this prototype we created a tool that displays any Milky Way Project data set (images from the Spitzer Galactic plane survey, GLIMPSE) for a given pair of coordinates. Users can explore the images and perform a SIMBAD search to see what objects have already been identified by the astronomical literature. In the example screenshots provided below, we show how a user who spots a possible galaxy in the field, can do a quick check that the object has not already been reported.

You can replicate this experience by visiting http://www.milkywayproject.org/tools/coordinates/307.9133750/-0.1662500/

The source code from this project can be easily deployed in GLORIA online and offline experiments, either as a standalone iFrame tool, or within a more complex component. SIMBAD (and eventually Vizier) search should become an important tool for GLORIA users interested in making discoveries and doing independent research.

3.5. Live All-Sky Data

A protoype tool has been built displaying live Zooniverse data on an exploreable all-sky image. It can be seen at http://live.zooniverse.org. The has been developed using the open source Chromoscope package (available at https://github.com/slowe/Chromoscope) and currently shows live positions of Galaxy Zoo and Planet Hunter's classifications.



4. Development of a data analysis framework: Luiza

One of the challenges we have to face in designing an environment for GLORIA experiments is dealing with huge amounts of disparate data, alongside a variety of analysis tasks which will change as the scientific requirements of the network's users evolve. We therefore need an analysis framework which would be both very efficient and very flexible. This combination of efficiency alongside flexibility produces requirements which are new to astronomy. However, one possible lead is to adopt strategies already employed by high energy physics experiments, including experiments at the LHC collider at CERN, which deal with volumes of data greatly larger than that expected from even a vastly expanded GLORIA network, enabling the performance of complicated analysis tasks.

The MARLIN framework has been developed for efficient data reconstruction (the task which most closely corresponds to image reduction in astronomy) and analysis for the proposed International Linear Collider (ILC) project. As it turned out to be very efficient and flexible, and is widely used by the ILC community, we decided to use the same concept in development of the framework for GLORIA, known as LUIZA.

The main advantage of LUIZA is its flexibility. The idea is to develop a large number of processing routines, capable of performing many different tasks, so that a user is always able to find a set which matches their needs. They will then able to define the whole analysis chain at run time, by specifying list of active processors (read by LUIZA from an XML steering file), without the need for any changes in the software. Dedicated web interfaces will assist GLORIA users in setting up the analysis task or tasks where they are not already uniquely defined for any given off-line experiment. More advanced users will be able to use dedicated LuizaGUI (Graphic User Interface, which will be based on QT4 library) to define their analysis chain and set the required processor parameters.

As with the development of web components, we have implemented a set of example processes designed to demonstrate LUIZA's capabilities, and to provide basic functionality ready for the incorporation of telescopes into the network.

4.1. Implementation of FITS image processing in LUIZA

Basic image processing tasks implemented as processors in LUIZA include:

- simple geometry operations: image cropping, flipping and rotations
- image stacking or averaging
- image normalization: dark/bias subtraction and flat correction
- image viewer based on CERN ROOT package

4.1.1. Implementation and tests of algorithms for star position and brightness determination

Data reduction is a necessary step in all automatic data analysis, and a prerequisaite for many of the WP8 and WP6 deliverables. The image of the sky, which is just the array of pixel values, has to be converted into the list of objects observed on the sky giving (in the simplest case) their position and brightness. Only on this level data from different telescopes can be combined. The first step of the data reduction is the 'photometry', which identifies objects on the image and calculates their brightness, although at this stage working only in telescope-specific units (object position on CCD is given in pixels, brightness as a sum of pixel values in ADC units). Two simple object finding processors were developed so far: one based on the particle identification algorithm developed for silicon pixel detectors in particle physics (the task turns out to be very similar) and another one based on Python library Mahotas, originally developed for image processing. Both codes were tested on the GLORIA data samples and turned out to be quite effective in object identification. Unfortunately, such simple algorithms do not give very precise results for object brightness. Therefore, it is planned to implement also additional algorithms, based on aperture as well as on profile photometry, which would be useful for analysis of selected objects (eg. variable stars).

4.1.2. Implementation of the astrometry.net algorithms in Luiza

Astrometry - the identification and measurement of position - is the second indispensable step in the automatic astronomical image analysis. We decided to use algorithms implemented in the Astrometry.net package, which is available under GNU General Public License. These algorithms have been tested on a wide range of astronomical and astrophysical data with positive results. The algorithms, which make use of the identification of catalogued 'starmarks' - recognisable patterns of stars - capable of producing precise astrometry results for a wide range of telescope field of views, from 2 arcminutes to 33 degrees. Fields of view of the telescopes in the GLORIA network span from about 10 arcminutes to 20 degrees, so, importantly, this single procedure can be used for collected data.

An astrometry processor based on the astrometry.net package has been implemented in Luiza. First tests were successful, but more work is needed to optimize the performance, as the task is in general case very time consuming preventing its use for online experiments as currently implemented.

4.2. Luiza Documentation

Up-to-date documentation for Luiza can be found online at http://hep.fuw.edu.pl/u/zarnecki/gloria/luiza/doc/html/

5. Future Work

Work on Luiza will continue and provide the basis for submitting proposal requests via the GLORIA system and for analyzing the results. At present, web components under development do not involve retrieving data from the network or network database. When these facilities become available we intend to utilise the new API to build components that allow web users to request and manipulate data via Luiza.

6. Relevant Proceedings

Development of GLORIA/Zooniverse user-tools reaches alpha stage. Various tools released as open-source libraries.

A. Kapadia et al.i, AstroJS: Astronomy with Javascript, 4th .ASTRONOMY CONFERENCE (Heidelberg, Germany, 7-10 July 2012)

Release of the first public version of complete Luiza framework. Concept of the framework and results of first data analysis were presented at conferences (articles submitted for publication in conference proceedings).

A.F.Zarneck et al.i, Luiza: Analysis Framework for GLORIA, 9th INTEGRAL/BART Workshop (Karlovy Vary, 22 - 24 April 2012)

A.F Zarnecki et al., Analysis framework for GLORIA, XXXth IEEE-SPIE Joint Symposium on Photonics, Web Engineering, Electronics for Astronomy and High Energy Physics Experiments (Wilga, Poland, 31.05.2012)

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