CARPYNCHO

The VVV band-merged catalogue and data mining/machine learning facility

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Introduction

We present a first version of Carpyncho, a data mining facility in development which we hope will be utilized to search for and characterize time variable data of the ~ PiB size VVV survey.

The project is designed to provide a simple to use small language set (~4 functions) to filter data, train machine learning models, execute experiments in a VVV server, and provide access to refined data and the model parameter downloadable to a local computer.

The Backend

A data mining facility for the VVV is being developed for the detection and classification of periodic and non-periodic (or transient variables). For this purpose the stacked pawprint data from the VDFS CASU v1.3 catalogues have been crossed matched with the VDFS CASU v1.3 tile catalogues into a PostgreSql data-base. The Carpyncho infraestructure http://carpyncho.jbcabral.org/ is being developed entirely in python on top of a Custom-Framework for data processing and a Django web-framework (for the webapp). The PostgreSql database layer was chosen since its performance is adequate for large databases (~1 PetaByte) and because PostgreSql is open-source, thua ensuring support with evolving versatility.

For calculation purposes Carpyncho is layered on-top of a scientific- python library stack that includes:

- Numpy & Scipy: for Numerical calculations
- Astropy: for Processing of Fits tables, astrometric and photometric calculations
- PyAstronomy: for GLS, PDM and time conversion algorithms
- AstroML & Scikit-learn: for machine learning algorithms
- SKLL: for machine learning automation.

CQL - Carpyncho Query Language

All the interaction to the backend (including the Web Interface) are made by a small Domain Specific Language that provide (at this moment) four functions to:

- Make a Simple Cone Search (SCS) on the Ks-band data.
- Sort and slice the result
- Filter the SCS by attributes
- Train a model with the selected learner (RandomForestClassifier, DecisionTreeClassifier, SVC or MultinomialNB)
- Download the data and model generated in the server

Note: The first 3 and last item are already functional and available in the demo.

CQL is created above the Python Object Model and compiled to a JSON format client-side with Brython (http://brython.info/) to avoid the execution of untrusted code on the server side.

The syntax can be summarized as:

```
search(
    <CONE SEARCH PARAM>[, SLICE, COLUMN SELECTOR AND ORDER]
).filter(
    <FILTER_0 [, FILTER_1, ...]>
)
```

Where:

- **search()** are the cone search and the creator of the query
- **filter()** are the optional filters by attributes.

For example if you want to make only a SCN around some position you can write:

```
search(271.906250005, -40.1668833333, 1)
```

If you want to make the same query as before but ordering by the **source.ra_k** attribute and only select the **first 100** sources starting from the source number **23** and only get the columns **tile.name**, **source.id**, **source.ra_k** and **source.dec_k** the query will be like:

```
search(
    271.906250005, -40.1668833333, 1, orderby=source.ra_k,
    offset=23, limit=100,
    columns=[tile.name, source.id, source.ra_k and  source.dec_k])
```

The query functionality is independent, for example the SCS is not mandatory and filtering for all stars from a particular tile is obviously possible as in:

```
search(
    offset=23, limit=100,
    columns=[tile.name, source.id, source.ra_k and  source.dec_k]
).filter((tile.name == "b201") | (tile.name == "d001"))
```

Aside of the the classics boolean operators **==**, **<=**, **>=**, **<** and **>** CQL supports more complex logic operators like **.belongs** which returns true when the field value belongs to the specified set

```
search().filter(tile.name.belongs(["b201", "d001"]))
```

like and **ilike** that you can use to match strings (ilike ignore if the letters are upper or lower cases)

```
# all the sources from the bulge
search().filter(tile.name.ilike("B%"))
```

"OR", **|**, conjunction **&** and negation **~**

```
# all the sources from the bulge
search().filter(
    (tile.id >= 23) |
    ~((source.ra_k > 274) & (source.ra_j < 275))
)
```

Also the download feature is implemented as function with the signature:

```
# csv is actually the only supported format
export(search(...).filter(...), fmt="csv")
```

CQL - Machine Learning

The current state of Carpyncho can process the data from VVV and store all the features into a relational database that we explore and export through CQL functions.

Our aim is to extend CQL to create a platform for data mining & machine learning on the VVV dataset.

Currently we have implemented a simple function called **Learn** with signature:

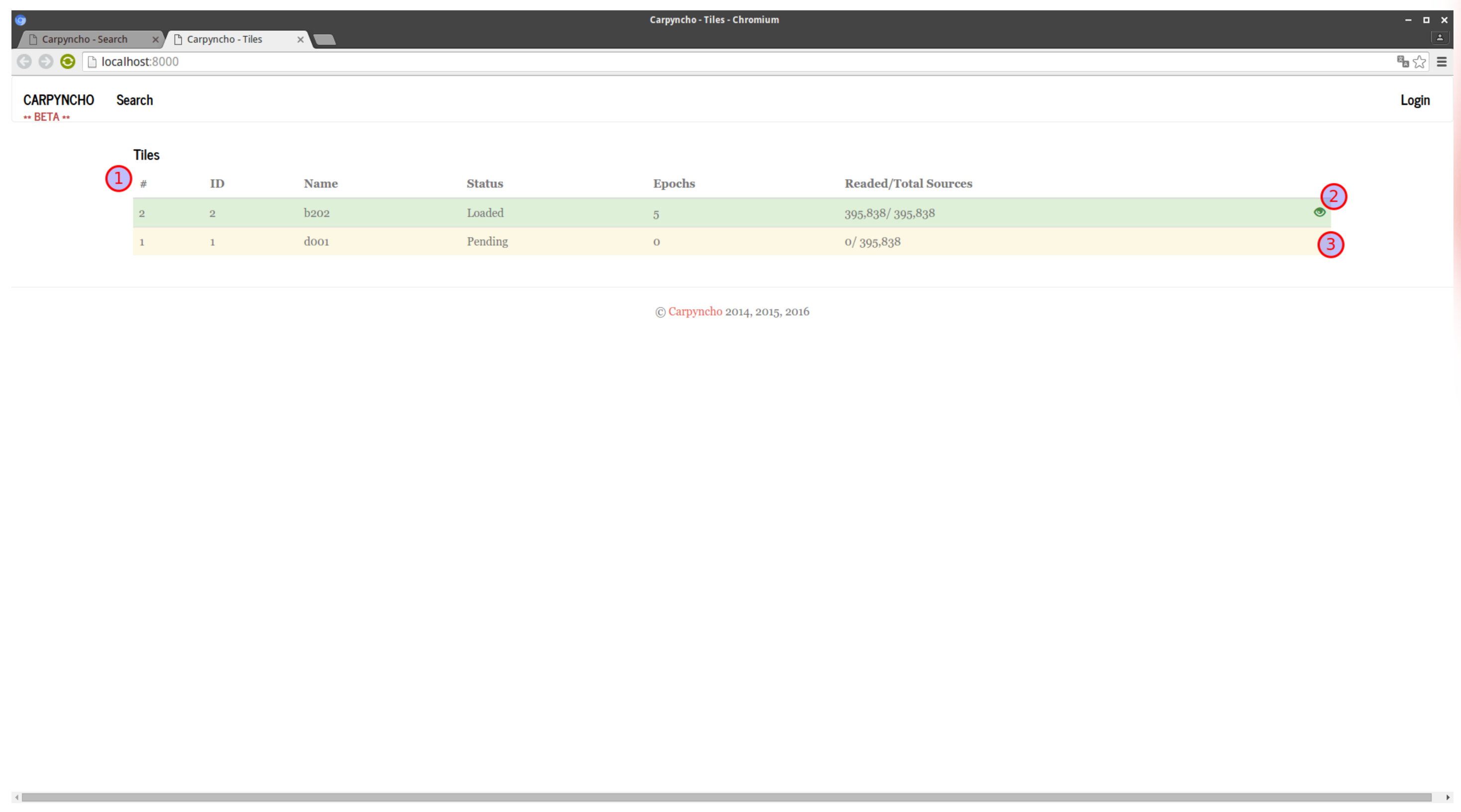
```
Learn(
    "my_custom_learner", search(..).filter(..), PARAMS)
```

where **my_custom_learner** is a name of your model (a model is only visible to the creator) and **PARAMS** is a set of parameter to configure a machine learning experiment. Because "Learn" takes time, when the training is ready an email is sent to the user to inform them that the model is ready for te user to check quality measures for example ROC Curves or Spearman.

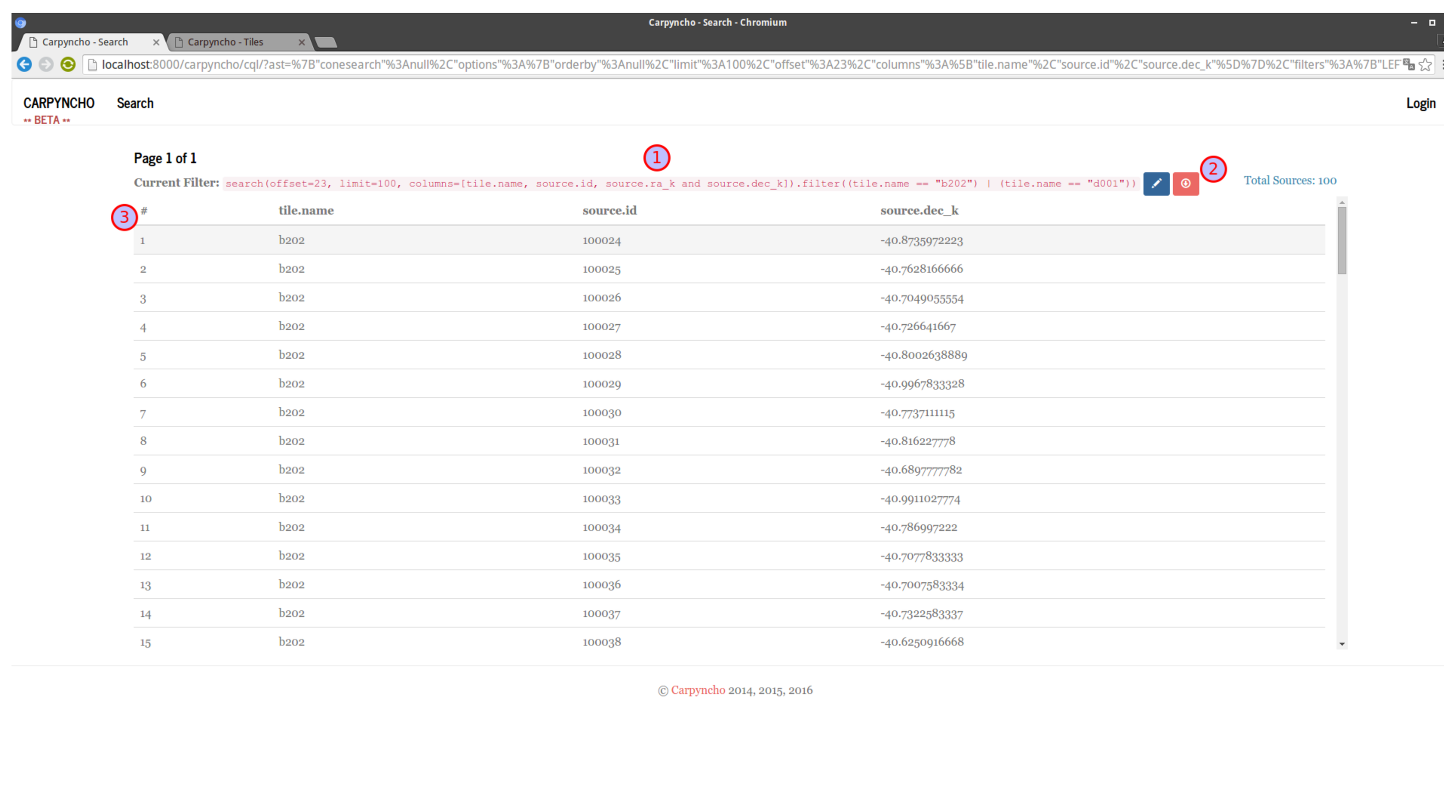
Webapp

Because all the Carpyncho webapp are implemented over CQL we have 2 main pages:

- The index that shows the current status of the pipeline (like pending processing) that in addition serves as a "welcome" screen
- and the CQL where all results of CQL are showed.



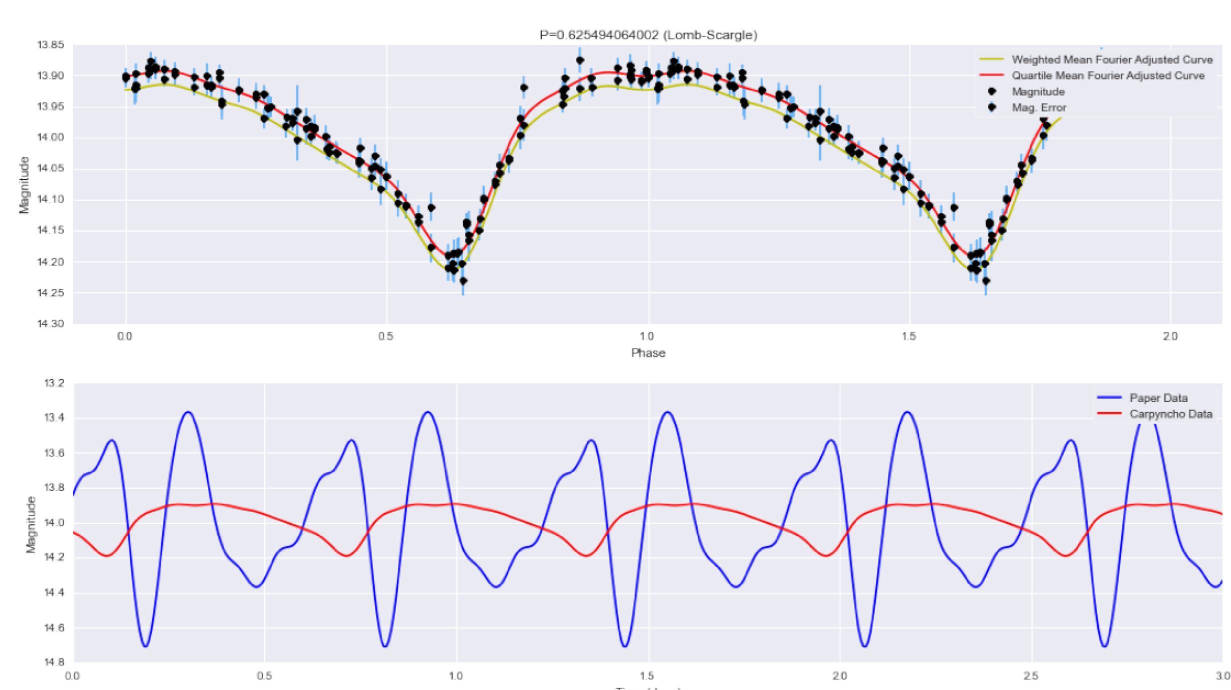
Index Page. 1-The list of tiles in the Carpyncho DB. 2-The Tile b202 are in green (ready to use) if you click over the "eye" in the right side of the green rows this execute a CQL to show all the sources of the given tile. 3-The tile d001 still need some more processing to be useful.



CQL Page. 1-The current query. 2-Tools: the blue button with the pencil allow the user to edit the current CQL and the pink one with the down arrow execute a query to download the current results as CSV

Results

In the current state of the database and with some external tools as plotting libraries we already reproduced the RRLyrae analysis for tile b201 and revised the Fourier components the work of Gran, et al 2015 [1].



***Top:** Reproduction of the RRLyrae AB from the work of Gran, et al 2015 [1]. **Bottom:** the simulated light curves with the original Fourier Components (blue) and the revised ones (red)*

	type	ls_period	lsmc_period	mc_period	src_id	std_period
0	FGran RRab	44136.683102	0.003059	44136.680043	1076808	0.000002
1	FGran RRab	39757.310977	0.006103	39757.304874	1078902	0.000002
2	FGran RRab	55547.822051	0.018935	55547.803117	1125368	0.000003
3	FGran RRab	54042.687130	0.026372	54042.713502	1139241	0.000003
4	FGran RRab	58582.099782	0.006148	58582.105930	1155733	0.000002
...						
35	FGran RRc	24636.642633	0.012707	24636.629926	1311038	0.000001
36	FGran RRc	22711.490498	15174.190748	37885.681247	1033079	0.260742
37	FGran RRc	26149.481227	0.002520	26149.483747	1039777	0.000001

Stability of the periods calculated from Carpyncho data throughout 100,000 Montecarlo simulations

Future Works

In the short term we plan to complete the analysis on the RRL sample as our test-bed.

You can require access to our demo: http://carpyncho.jbcabral.org/

1(1, 2) Gran, F. et al. Bulge RR Lyrae stars in the VVV tile b201. Astronomy & Astrophysics 575, A114 (2015).

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