ASTErIsM

python AStronomical Tools for clustERIng-baSed detection and Morphometry

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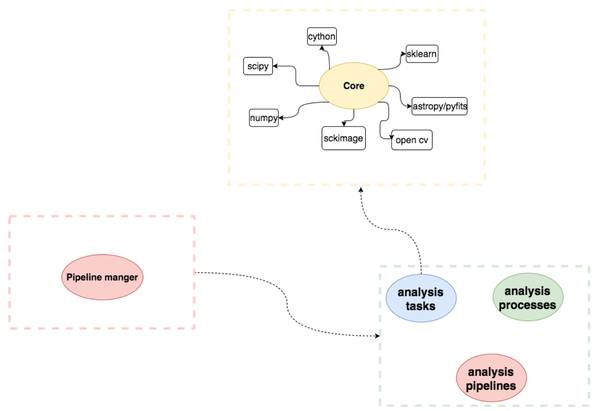
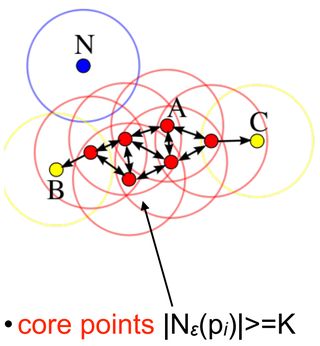
Abstract

ASTErIsM is a ptyhon-based framework for detection of astronomical sources, and extraction of morphometric features. The detection and features extraction are based mainly on density clustering algorithms (DBSCAN and DENCLUE). ASTErIsM also offers tools for machine learning supervised classification, based on the scikit-learn framework. The kernel computation in the DENCLUE algorithm has been written in Cython to speed up the computational time. **Both the DBSCAN and DENCLUE algorithms have been modified in order to work with digital images and γ-ray photon lists**. ASTErIsM implements also the possibility to design flexible user-oriented pipelines, by the use of its pipeline manager sub-package, that allows to combine together different task, with the possibility to configure parameters through configuration files.

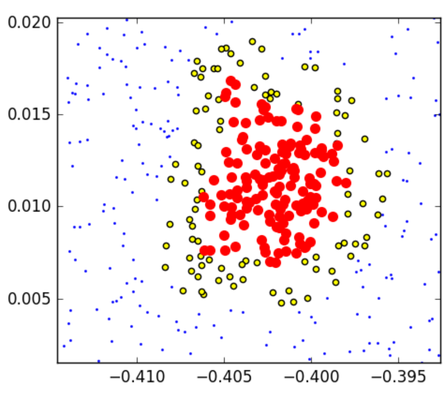


clustering methods: DBSCAN

A cluster is a set of density connected points

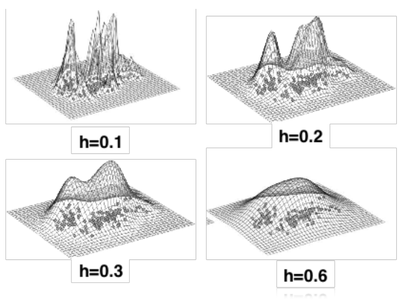


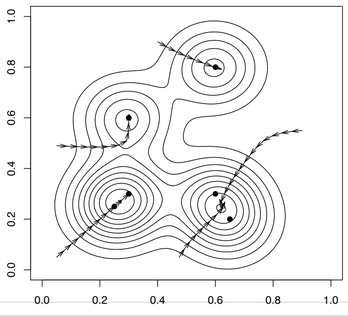
K ~ Noise level
ε ~ PSF



- core points $|N_\varepsilon(p_i)|>=K$
- density connected are points connected through a chain of core points
- we use geodetic distance

clustering methods: DENCLUE





parent cluster

chose a kernel with width h
influence function

iterative update of the postion of each point weigthed on the influence function
stop when dr<d*

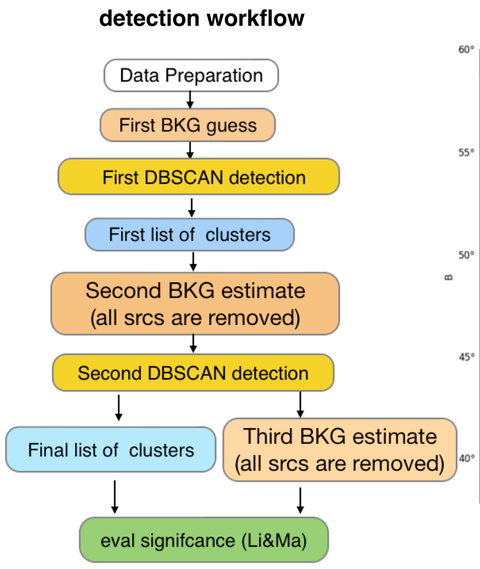
clustering of attractors to partition the parent cluster

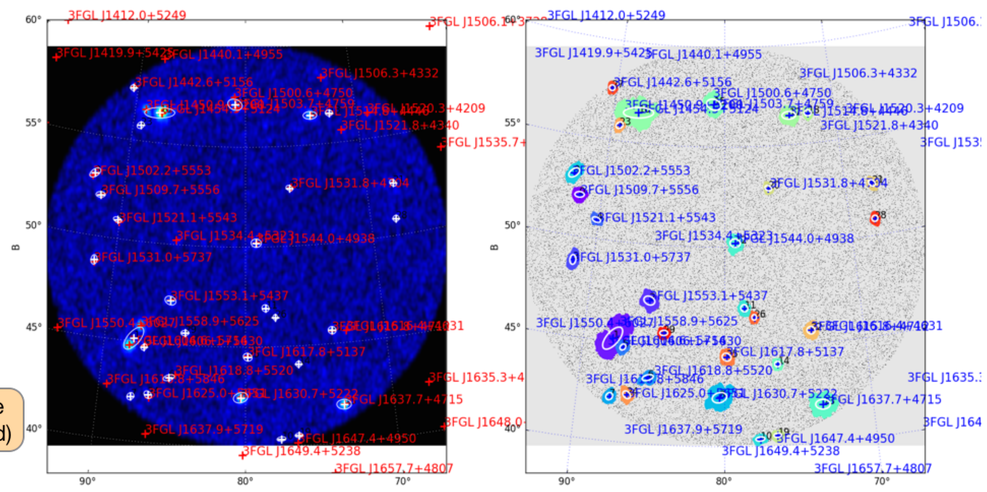
references - doc - code

Tramacere&Vecchio 2013 A&A…549A.138T
Tramacere et al 2016 MNRAS.463.2939T

code: https://gitlab.com/andreatramacere/asterism (still beta, please contact andrea.tramacere@gmail.com)
doc: http://isdc.unige.ch/~tramacer/asterism_doc/html/index.html

γ-ray detection (DBSCAN)

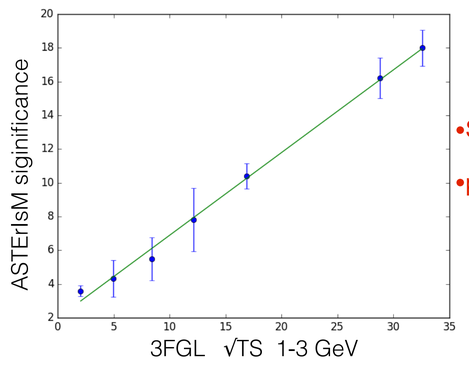




Application to Fermi data, using the same 3FGL time span, and the P8R2 calib. E>1 GeV, and the DBSCAN is applied with the following configuration ε=0.2 deg, K=5 (*Left* Fermi counts map. *Right*, ASTErIsM photon map, white ellipses show 98% PCA confinement of the cluster, coloured large dots actual clusters points, black small dots the background classified events)

γ-ray significance of the detection

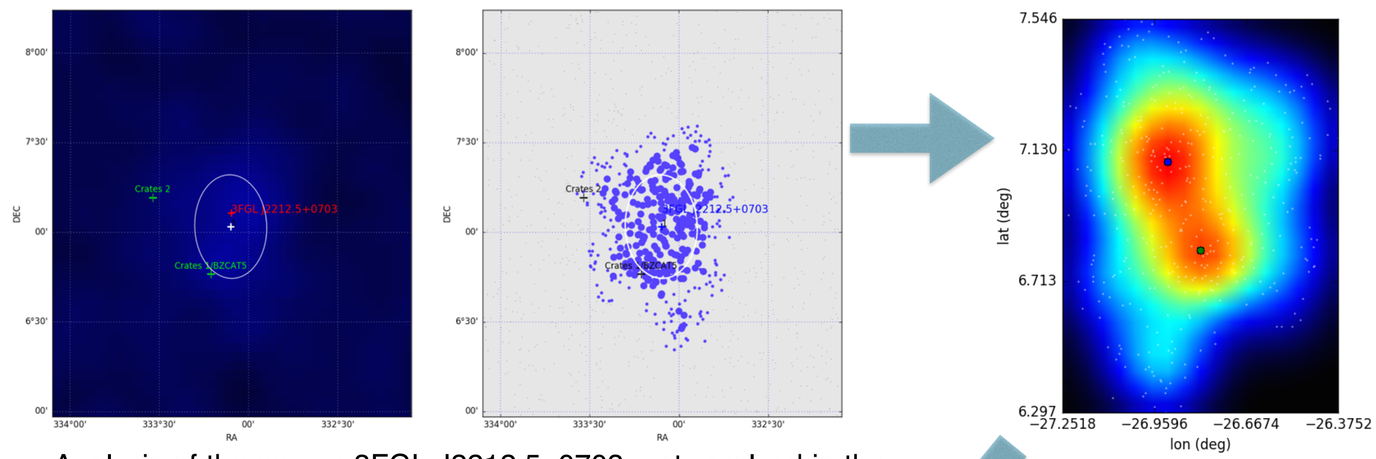
3FGL time span,~80 sources binned inTS, L>15



- Significance ~0.5 √TS 3FGL
- pos err ~ 3FGL poss err

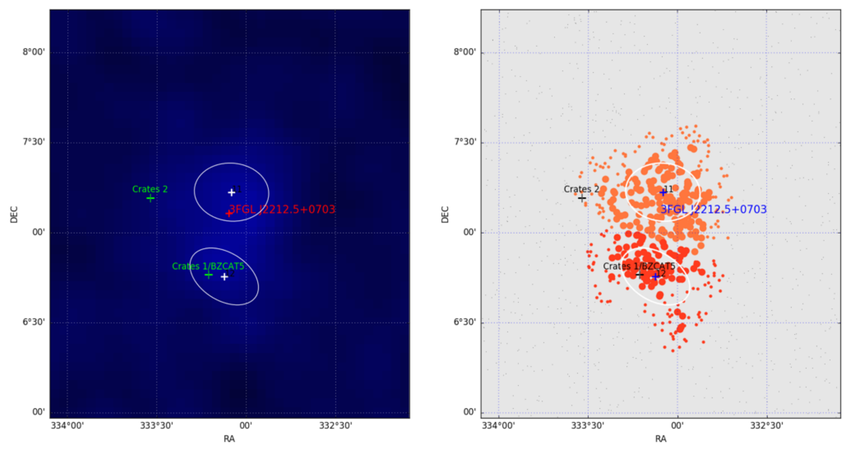
A comparison between the significance of the detection obtained with ASTErIsM, and that reported in the 3FGL, for the energy range closest to that of the presented analysis. The sources are those detected and shown in the panel above.The significance is evaluated basing on the Li&Ma algorithm.

γ-ray deblending of confused sources (DENCLUE)



Analysis of the source 3FGL J2212.5+0703, not resolved in the 3FGL catalog. The application of the DBSCAN gives a similar result (*Left* Fermi counts map. *Right*, ASTErIsM photon map, white ellipses show 98% PCA confinement of the cluster, coloured large dots actual clusters points, black small dots the background classified events)

Application of the DENCLUE algorithm to the same source show in the left panels. A Gaussian kernel is used. The algorithm identifies two sub-clusters.



The two resolved sources. Note how both the separated sub clusters are positionally coincident with an astrophysical counterpart, the 3FGL J2212.5+0703 source and a blazar reported in the BZCAT5, respectively.