ALeRCE
Automatic Learning for the Rapid Classification of Events

DeLight

DELIGHT: Deep Learning Identification of Galaxy Hosts of Transients using Multiresolution Images

Förster, Francisco; Muñoz Arancibia, Alejandra M.; Reyes-Jainaga, Ignacio; Gagliano, Alexander; **Britt, Dylan; Cuellar-Carrillo, Sara; Figueroa-Tapia, Felipe; Polzin, Ava; Yousef, Yara**; Arredondo, Javier; Rodríguez-Mancini, Diego ; Correa-Orellana, Javier; Bayo, Amelia; Bauer, Franz E.; Catelan, Márcio; Cabrera-Vives, Guillermo; Dastidar, Raya; Estévez, Pablo A.; Pignata, Giuliano; Hernández-García, Lorena; Huijse, Pablo; Reyes, Esteban; Sánchez-Sáez, Paula; Ramírez, Mauricio ; Grandón, Daniela ; Pineda-García, Jonathan; Chabour-Barra, Francisca; Silva-Farfán, Javier; **2022, AJ, 164, 195.**
+ Diego León & Benjamín Bustos (HiPS server).

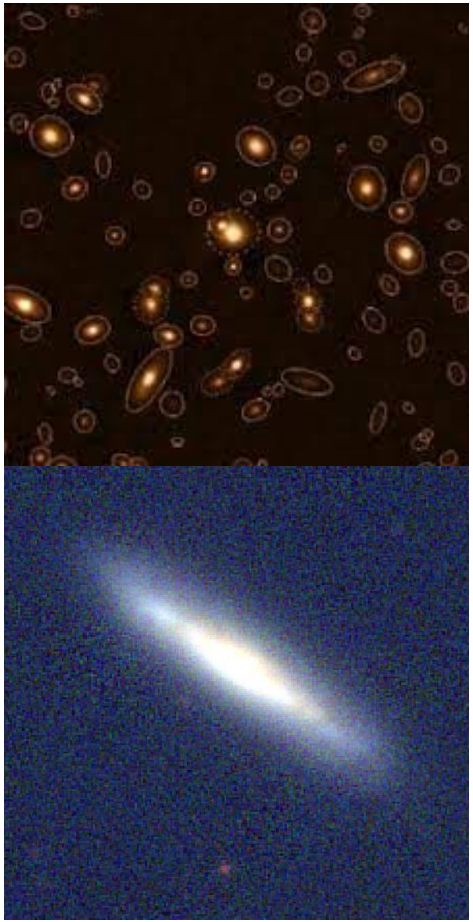
Automatic host association

Real-time alert classification methods require **real-time host galaxy identification** methods to be reliable.

Two main ways to identify host galaxies:

1. from a **catalogue** of galaxies around the position of an object (e.g. smallest normalized distance)

2. Identifying the host galaxy directly from the **images**, e.g., visual selection or convolutional neural network (CNN)

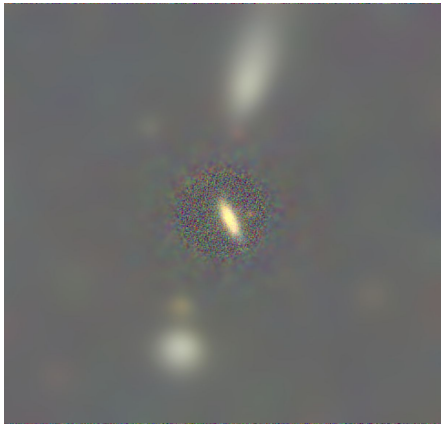


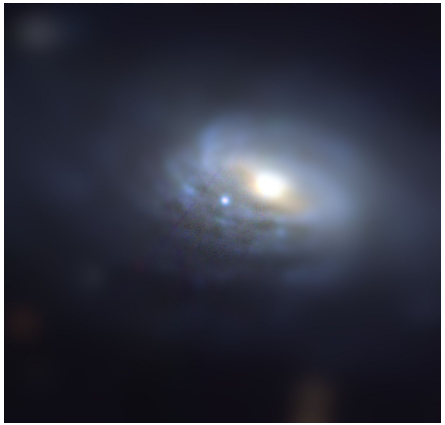
Input images: multi resolution?

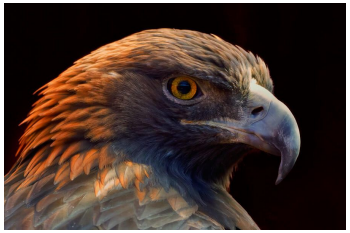
When using images, we would like the following to be satisfied:

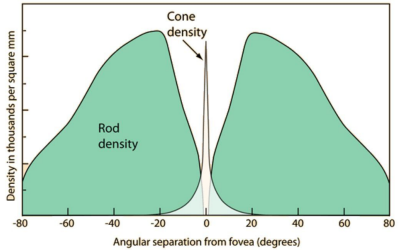
1. Span a **large area** to identify large nearby host galaxies.
2. Have **good central resolution** to identify small distant host galaxies.
3. Are **lightweight** to be acquired and streamed rapidly.

We look for inspiration from animal vision, where high resolution is only needed near the central regions of the visual system.





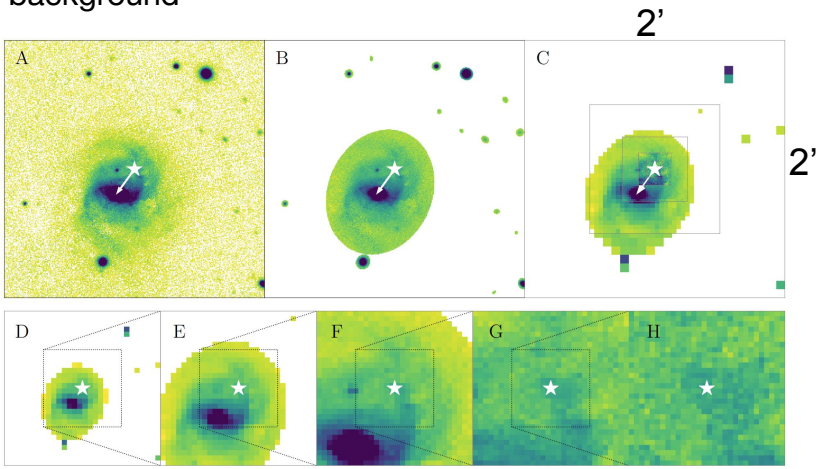




DELIGHT: Host galaxy identification

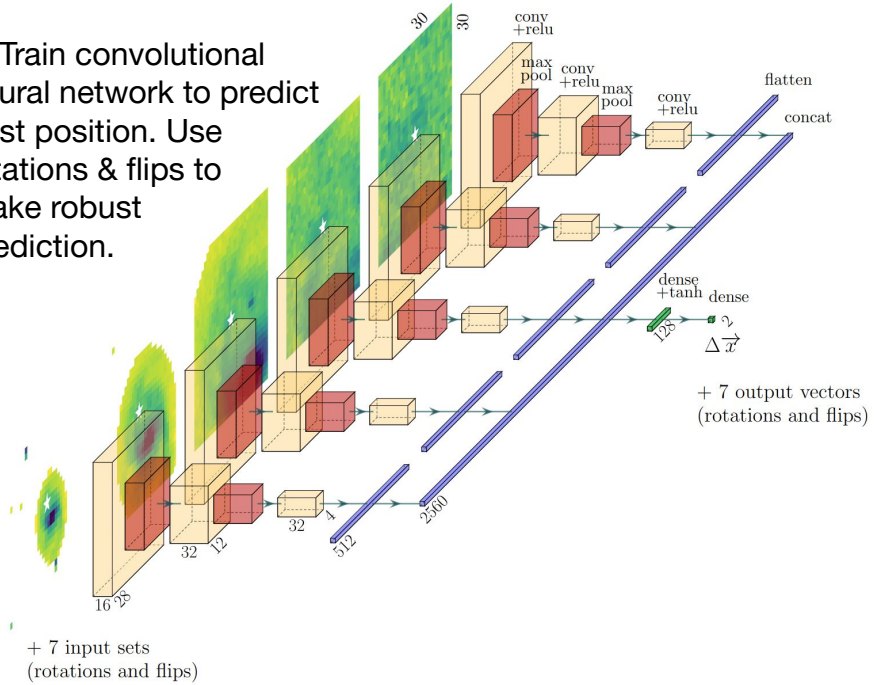
1. Start with 2'x2' r band PanSTARRS images centered at the position of the transient.

2. Use sep (Barbary+2016) to remove stars and background



3. transform 2'x2' images into multi resolution images with 5 levels.

4. Train convolutional neural network to predict host position. Use rotations & flips to make robust prediction.



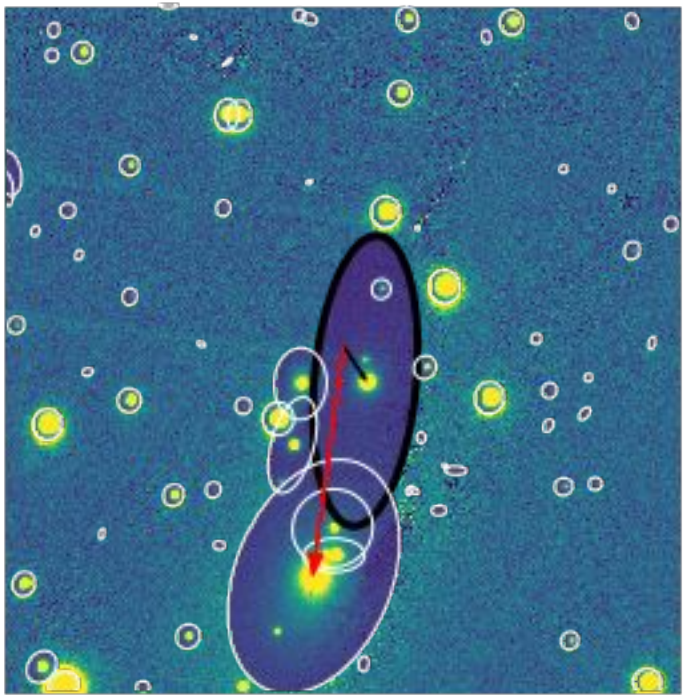

```
pip install astro-delight
```

Förster et al. 2022

Comparison with other host association methods

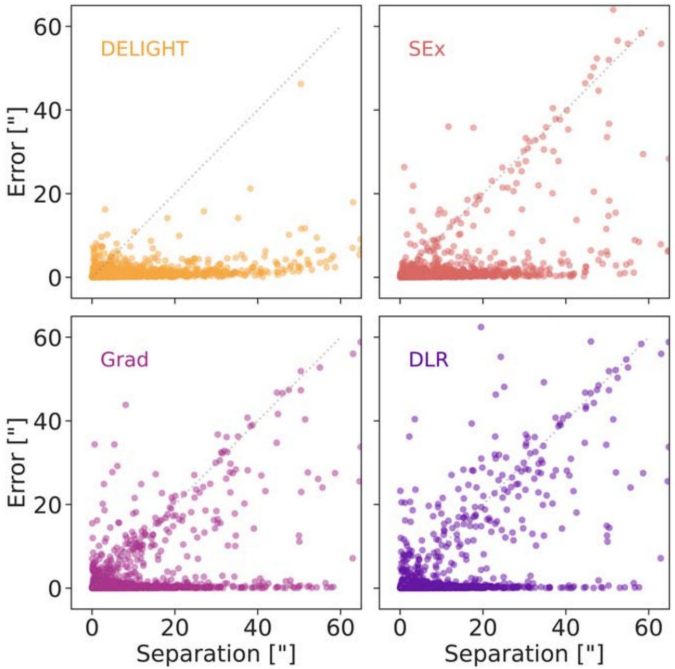
We compare several methods in ~5 k sample test set.

1. ***True* position**: visually selected host (from NED, Simbad or SDSS DR16).
2. **Closest match (1-NN):** closest absolute distance.
3. **Sextractor predicted (SEx)**: closest normalized distance using Sextractor ellipses.
4. **Directional light radius (DLR, Gupta+2016)**: closest normalized distance using source moments.
5. **Gradient ascent (Grad, Gagliano+21)**: start from source and ascend light profile.
6. **Deep Learning Identification of Galaxy Hosts in Transients (DELIGHT, this work)**: CNN prediction based on multi resolution image.

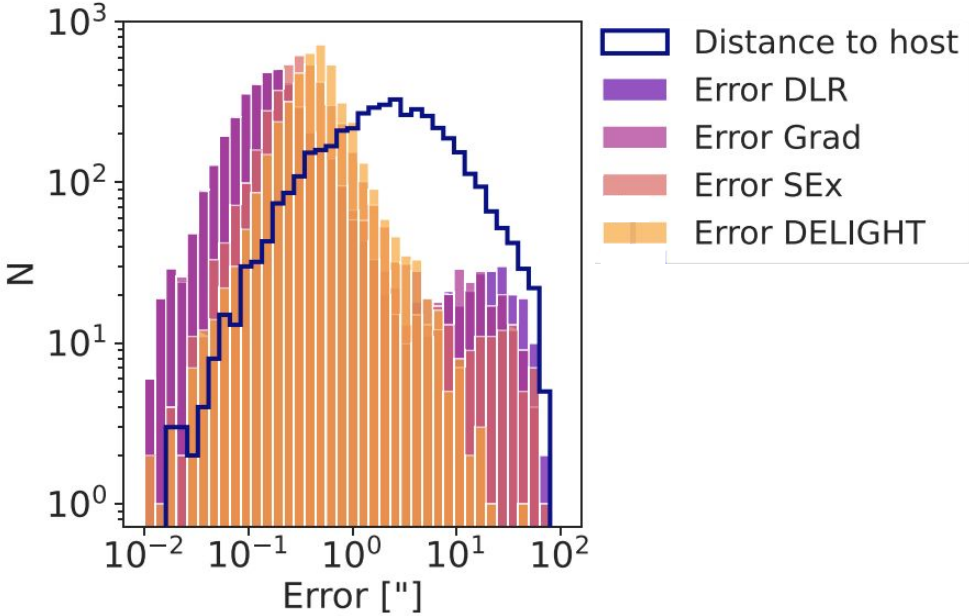


Error distribution

Errors as a function of separation



Error distribution



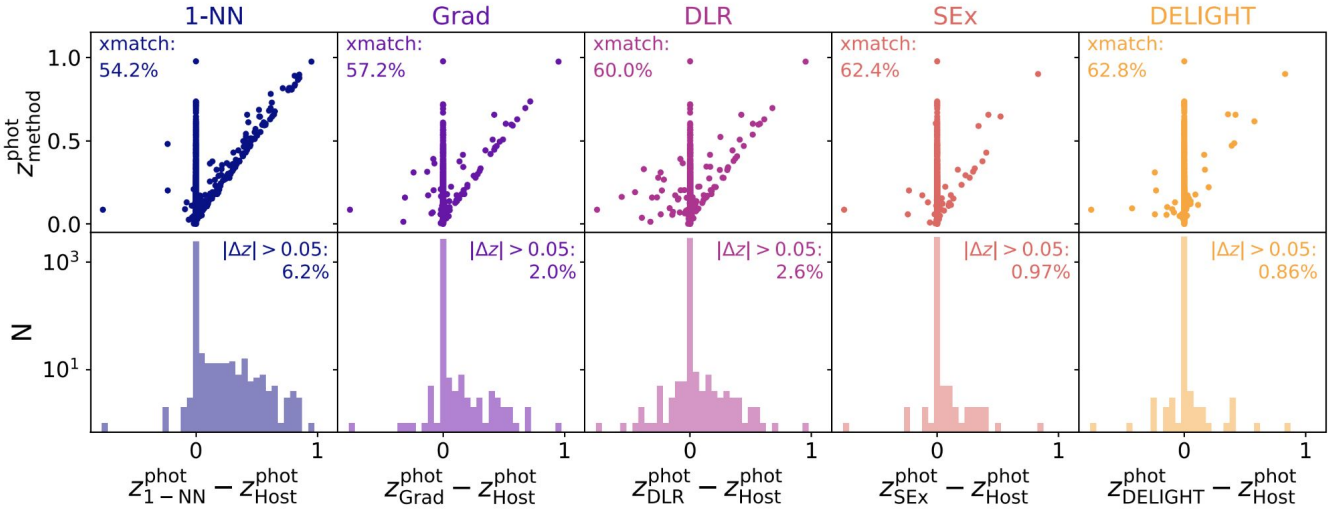
DELIGHT is slightly less precise than other methods (<1”), but it **is the most robust method**!

Redshift crossmatches

Redshift cross matches

Method	% true spec-z	% true photo-z
True position	100.0	100.0
DELIGHT	**98.5**	**99.3**
SEx	96.5	98.9
DLR	91.6	95.3
Grad	87.1	90.8
1-NN	68.2	87.6

Redshift error distribution



DELIGHT spectroscopic crossmatches are more **complete** and **pure** than other methods!

Can we run DELIGHT for **all** Rubin alerts?

Times to obtain single band, multi resolution images of 5 levels and 2' x 2' centered at the position of the candidate using different methods.

HiPS (Hierarchical Progressive Surveys) server populated with PanSTARRS r band images.

Work done by computer science B.Sc. student Diego León.

Method	Time [ms]
Pantamps (single to multi res.)	5,468
Fitscut.cgi (single to multi res.)	3,047
Own HiPS server (single to multi res.)	215
Own HiPS server (multi res.)	38
Own HiPS server (10 parallel jobs, multi res.)	**4**

10,000 alerts / 40 s

It is possible to generate input images at a rate comparable to the Rubin stream!

Summary

1. DELIGHT is a **host galaxy identification algorithm** that uses **multi resolution PanSTARRS images** as input (it could be trained with Rubin data).
2. The ALeRCE broker uses DELIGHT to associate hosts in **TNS** candidates everyday.
3. A comparison with other methods suggests that DELIGHT:
   a. is slightly less precise than other methods, but with typical **<1" precision**.
   b. is the **most robust** host association method, with fewer catastrophic errors.
   c. leads to more **complete** and more **pure** redshift crossmatches (spec & photo).
4. Using our own HiPS server we conclude that **DELIGHT could be run in real time for all the Rubin stream.**
5. DELIGHT is available via pypi (`pip install astro-delight`).