Centro Brasileiro de Pesquisas Físicas
Brazilian Center For Research in Physics

Galaxy Morphology in the DECam Local Volume Exploration Survey: first results and perspectives

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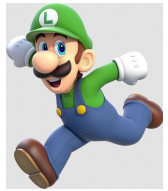
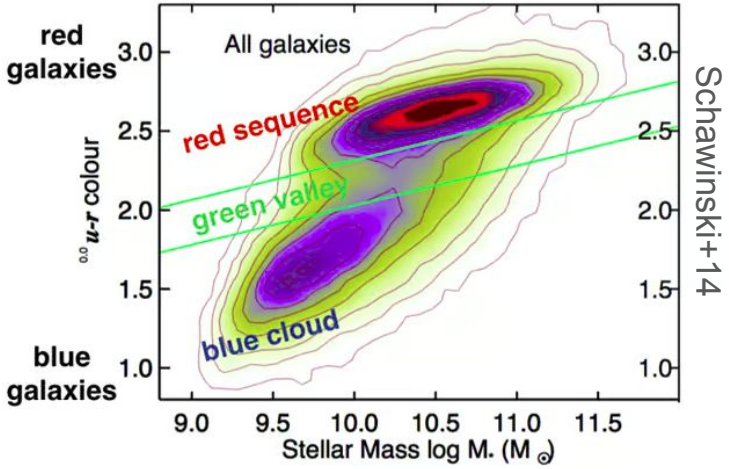
On behalf of the DELVE Collaboration

20-23 May 2024 | Tucson, AZ, USA
RARE GEMS in BIG DATA

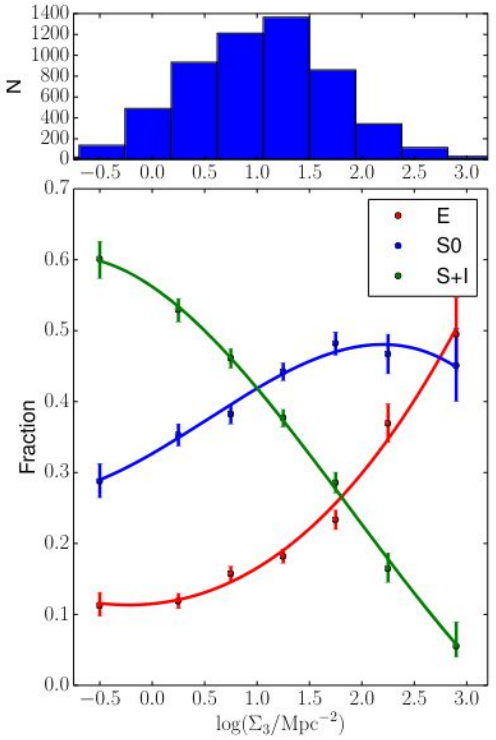


Galaxy Morphology: why we care?

- Morphology is strongly correlated to galaxy properties.
- Colors, Star-formation, stellar mass..
- Morphology-Density relation (Dressler, 1989).



Schawinski+14



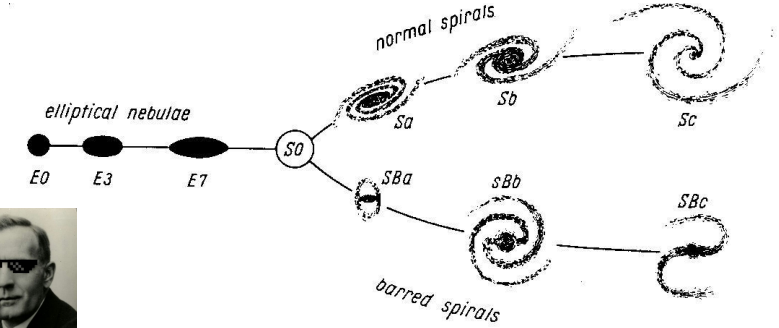
Hougthon+15

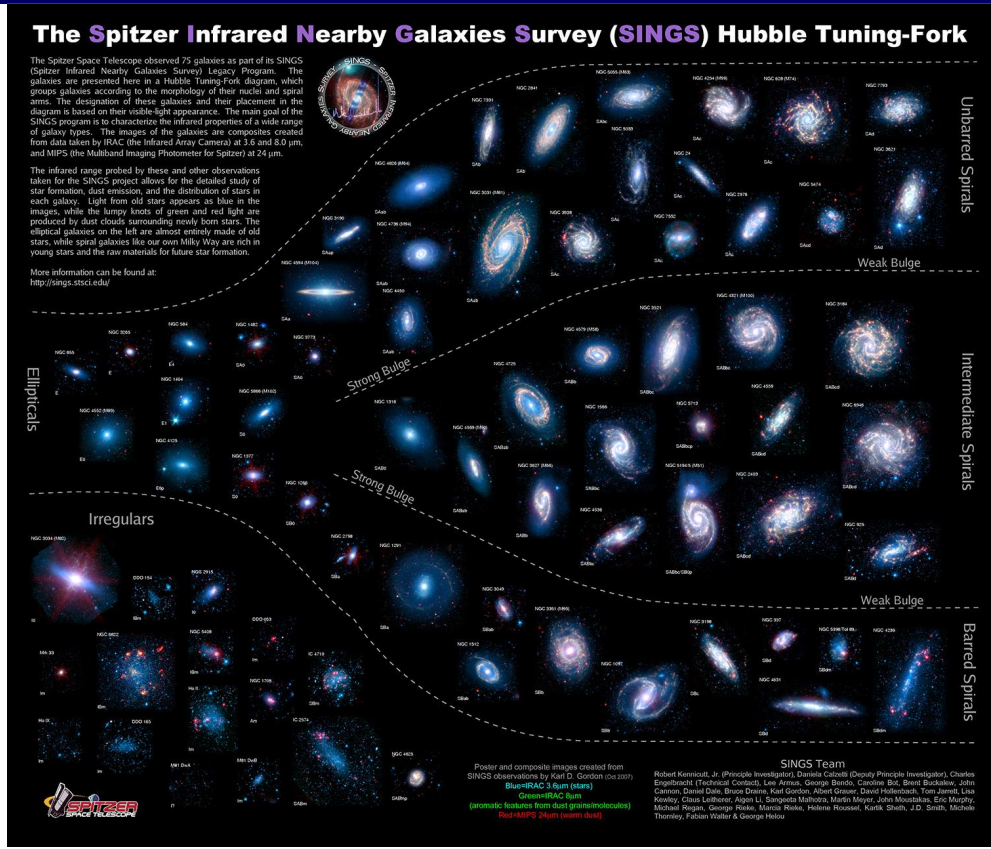
How to classify galaxies?

- Visual Classification.
- ETG & LTG.
- Time consuming in the scale of surveys such as DELVE, DES, DESI……..

Alternative Methods

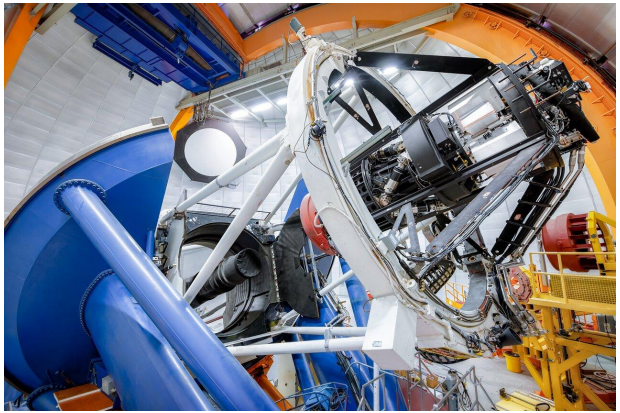
- Galaxy Zoo (Lintott+08,+11).
- Machine Learning (Clarke+20,Barchi+20..).
- Deep Learning and Deep Neural Networks (.....Bom+21)



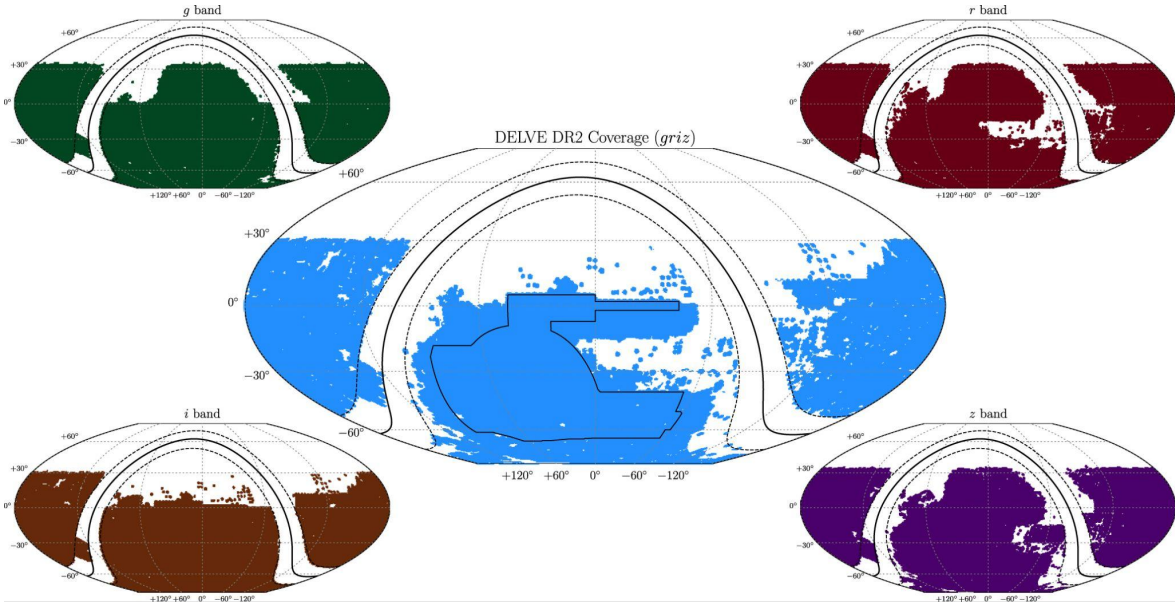


DECam Local Volume Exploration Survey (DELVE)

- 4 filters (g,r,i,z).
- Dark Energy Camera, Blanco Telescope, 0.26 arcsec/pixel.
- 17000 deg² (~23.5 mag).
- ~ 3 billion unique objects.



Credits: NOIRlab



Drlica-Wagner & DELVE collaboration +21,22

DECam Local Volume Exploration Survey (DELVE)

May 22:
Searching for the Universe's Faintest Galaxies in our Galactic Neighborhood (William Cerny).

Lightning IV:
A measurement of the Hubble constant using dark sirens from the first four LIGO/Virgo observing runs with galaxy information from DELVE and DESI Legacy Survey (Viviane Alfradique)

Satellites of dwarf galaxies with the MADCASH+DELVE survey
(Amandine Doliva-Dolinsky)

Galaxy Morphology on DELVE

Main Goals:

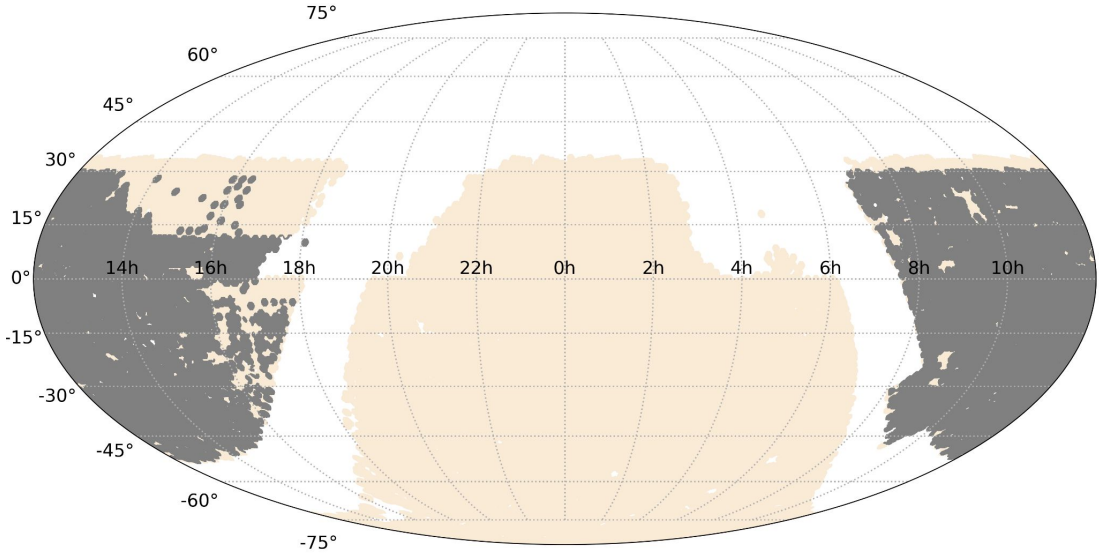
- Provide reliable morphological classification for galaxies observed by DELVE down to magnitude 22 (g-band), and S/N > 5.
- Model I: Disk and Spheroids.
- Model II: Disturbed, Round-Smooth, Barred Spiral, Unbarred Spiral, Edge-on galaxies (work in progress).
- Investigate galaxy morphology across different environments and redshifts.

Santana-Silva (in prep.)

Galaxy Morphology on DELVE

Selection:

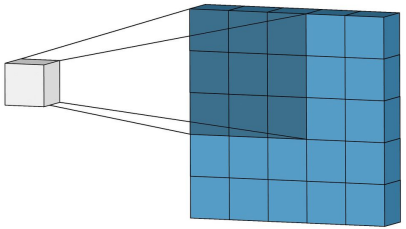
- Main catalog: g < 22.5, b > 0 , *Extendend_Class* = 3, images (*g,r,i,z*), Flags =0.
- Main catalog: ~ 20 million galaxies (~ 20 Tb of cutout data).
- Logistics: stamp production (DES machines), Training models (Scimind - CBPF).

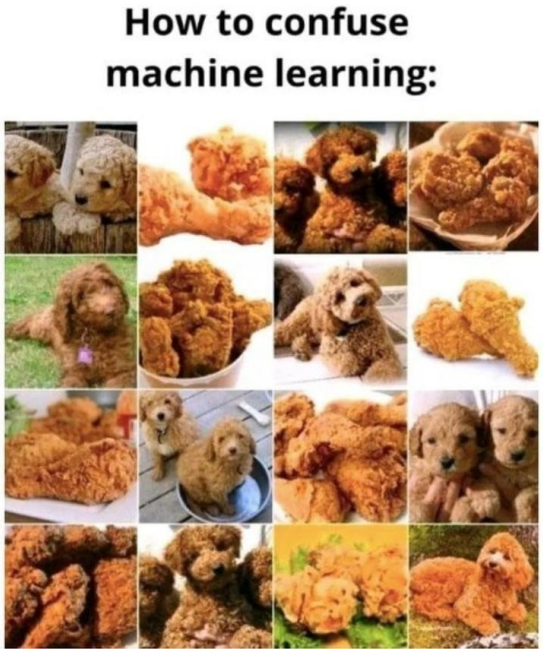


Santana-Silva (in prep.)

Convolutional Neural Networks (CNN)

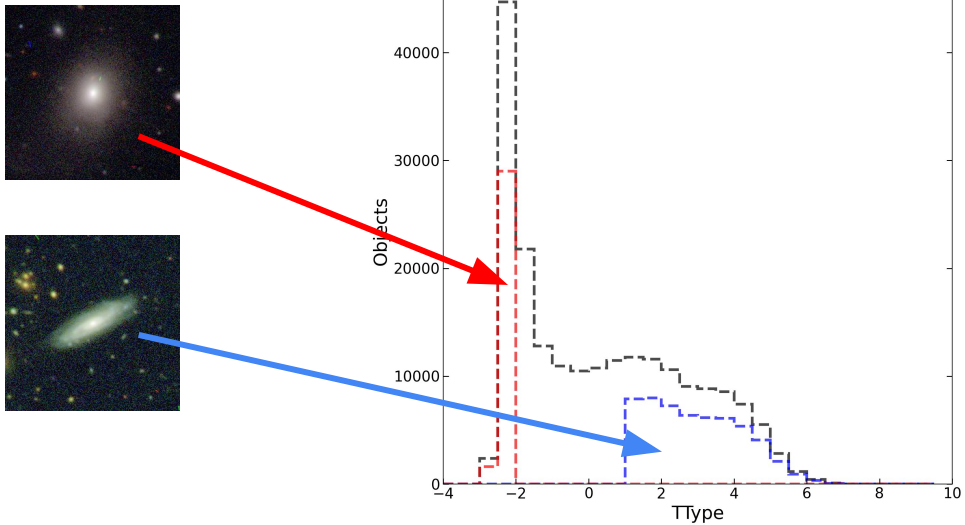
- It learn features by using filter (kernel) applications.
- Widely used in image recognition problems.
- Need a good training sample.

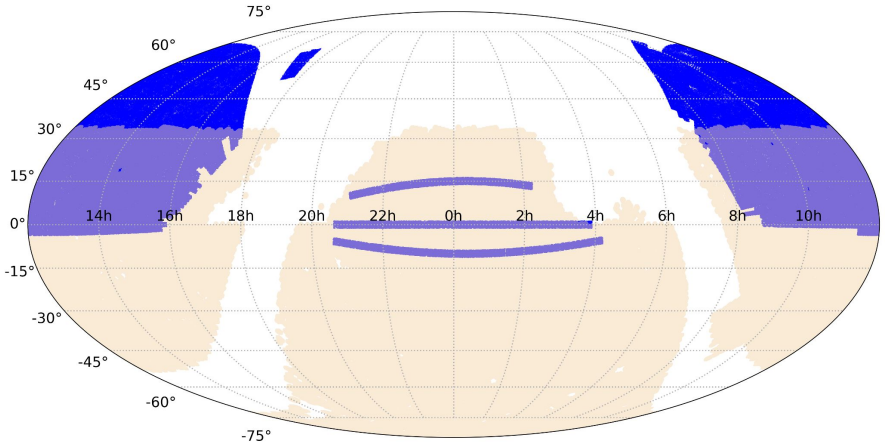




Galaxy Selection to training

- Training sample: Dominguez+18 (TType selection)
- Overlap with 200k objects available at Dominguez+18.



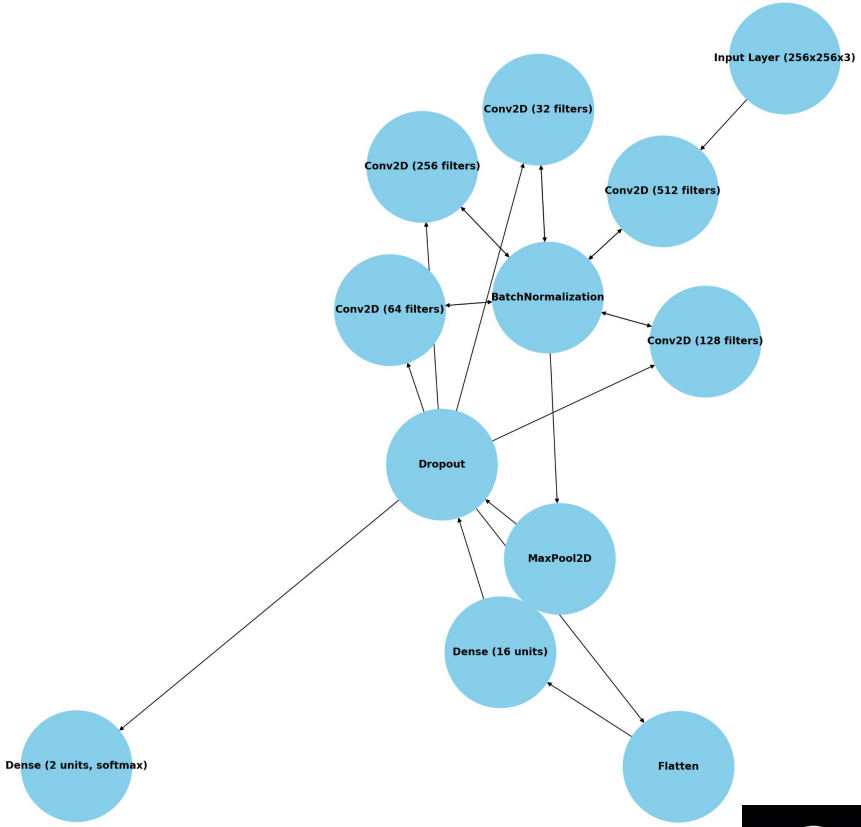


Santana-Silva (in prep.)

CNN applied to morphology classification

- 60000 galaxies.
- Binary classification: Disk and Spheroids.
- 70% (train), 20% (validation), 10% (test).
- Hardware: 8 GPUs (Nvidia A5000)

SCI.MIND-CBPF



Santana-Silva (.in prep)

CNN Results

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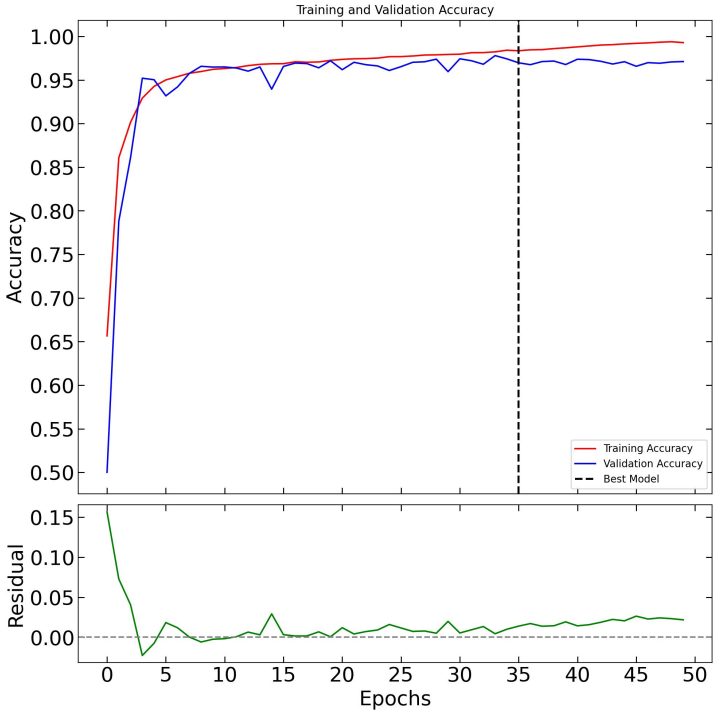
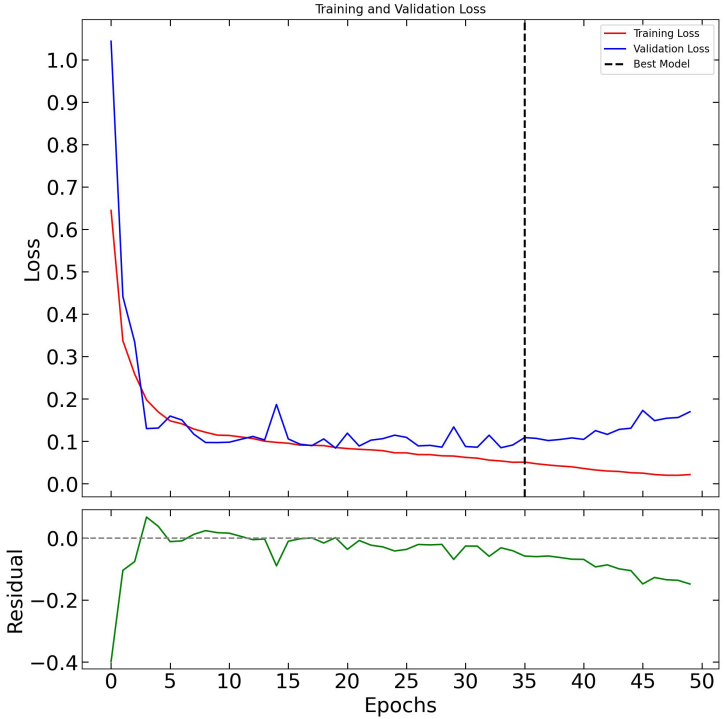
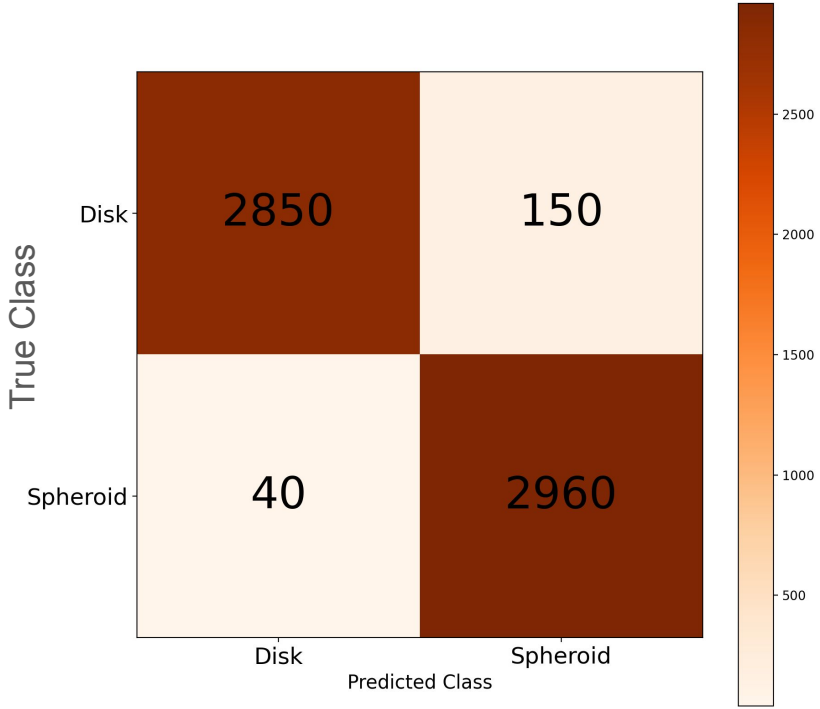


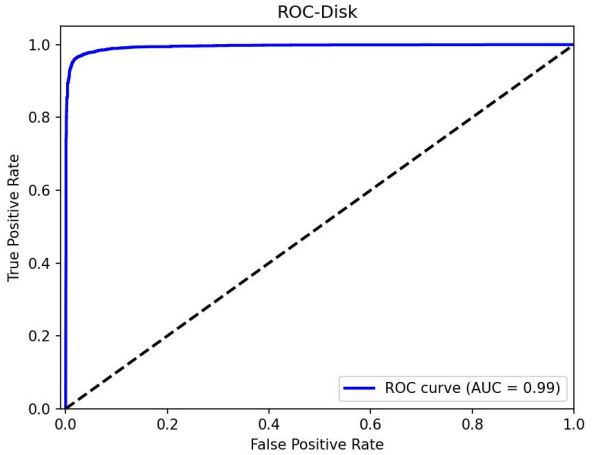


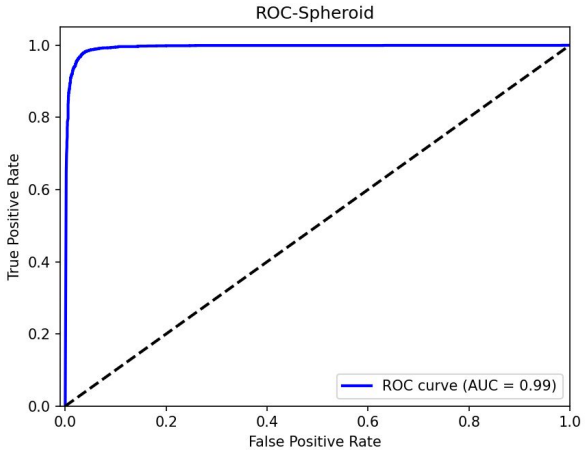
Santana-Silva (.in prep)

CNN Results

- Binary classification: Disk and Spheroids.
- 6000 for testing.
- Precision = 98,67 , Recall = 95,18



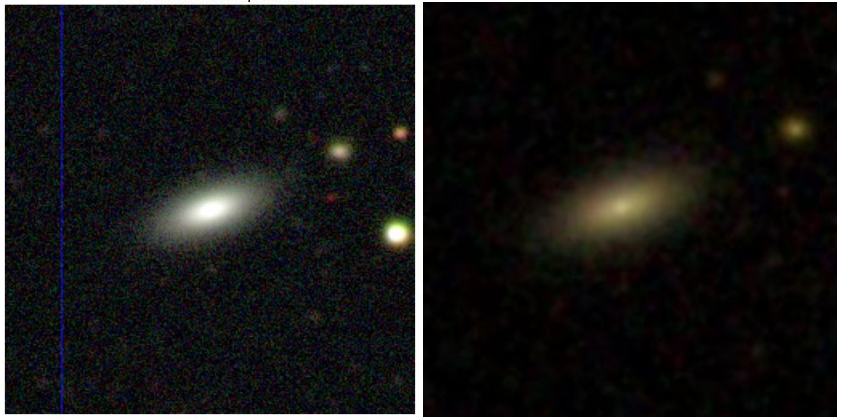




Santana-Silva (.in prep)

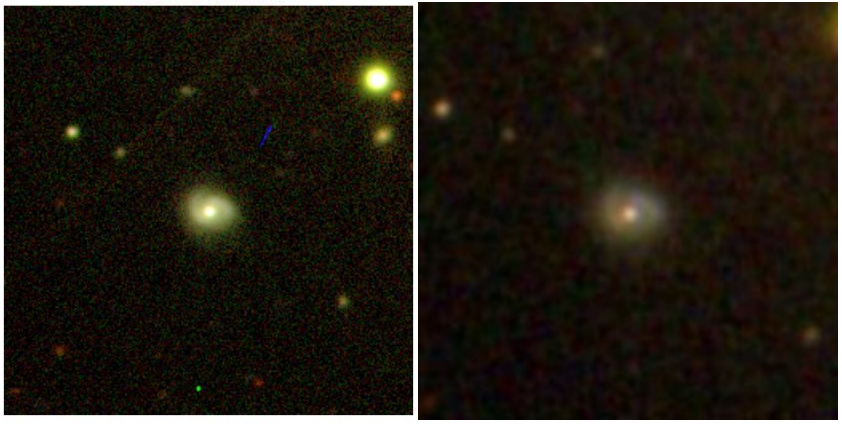
CNN (wrong classifications)

QUICK_OBJECT_ID: 10305200037838
Class: disk
Predicted Class: spheroid



QUICK_OBJECT_ID: 10369100065202
Class: spheroid
Predicted Class: disk

QUICK_OBJECT_ID: 10397500055712
Class: spheroid
Predicted Class: disk



QUICK_OBJECT_ID: 10526600166629
Class: spheroid
Predicted Class: disk

Summary

- Galaxy morphology plays an important role to understand galaxy formation and evolution.
- The amount of data in modern astronomy turns infeasible the classification using visual inspection.
- The model is efficient to classify galaxies observed on DELVE with precision ~ 98%.
- 4 million galaxies already done.

- *Release the morphology catalog with the binary classification.*
- *Implement the model with more complex classification.*
- *Connect the morphology classification with the photoz measurements in order to investigate the environment.*

For now, that’s all folks!!!

Special Thanks to:

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UNIDADE DE PESQUISA DO MCTI

Fermilab

DELVE

AI LITCOMP