Tidal Stream Detection in HSC-SSP with Deep Learning

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- K. Johnston (Columbia University)
- B. Robertson, R. Hausen (UCSC)

Debating the potential of machine learning in astronomical surveys
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Context: The importance of Tidal Streams

- The frequency and characteristics of low surface brightness features can be used to disentangle the different formation channels (in situ star formation versus accreted stars).

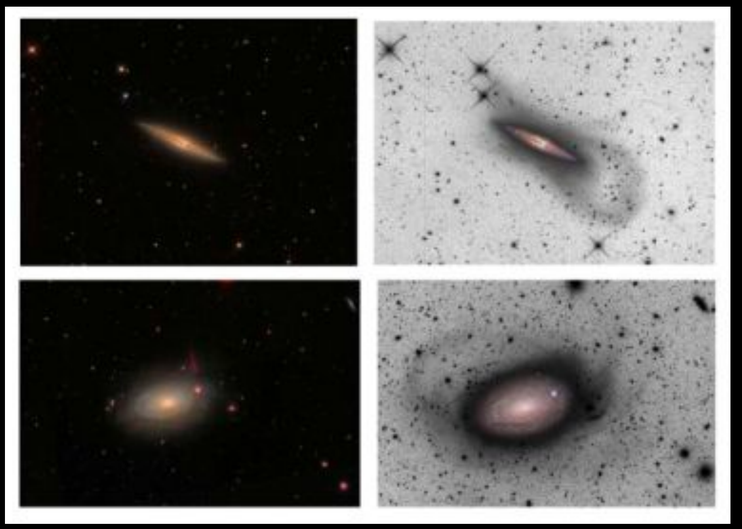
- Classical ‘cat/dog’ problem: optimal for CNN but…

- Tidal streams are difficult to detect: rare (only a few dynamical periods) and faint (imprints in the outskirts of galaxies)

- Need deep imaging and large areas! —> Small training samples available

SDSS

Martínez Delgado+2009

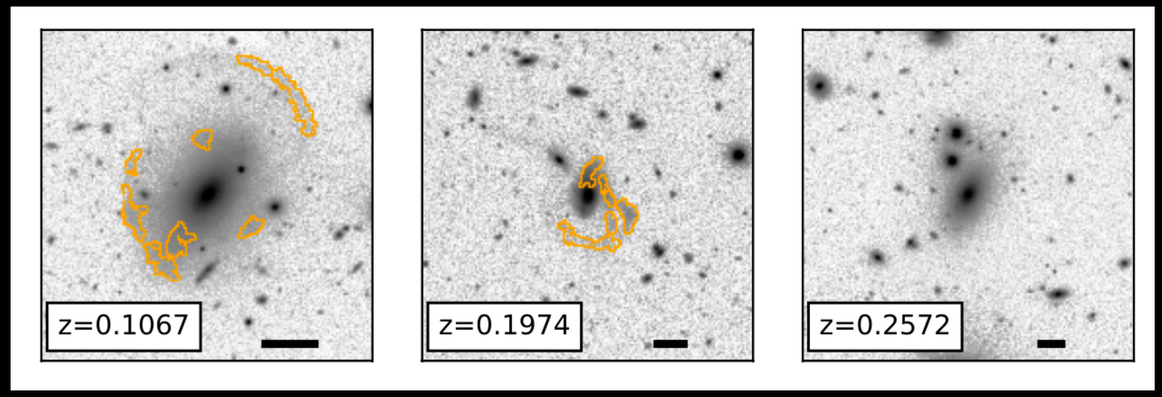


Chonis+2011

Supervised Learning: training sample

- Pioneer attempt by Walmsley+19
  - CFHTLS-Wide Survey
  - 1316 galaxies, 305 labelled as tidal streams

- HSC-SSP data (Hyper Suprime-Cam Subaru Strategic Program)
  - mi~26 mag (5σ point source), 1400 deg^2
  - 21200 galaxies at $0.05 < z < 0.45$; $mr < 17.7$
  - Filtering algorithms for high spatial frequency features + Visual inspection
  - 1200 show tidal features



Kado-Fong+18

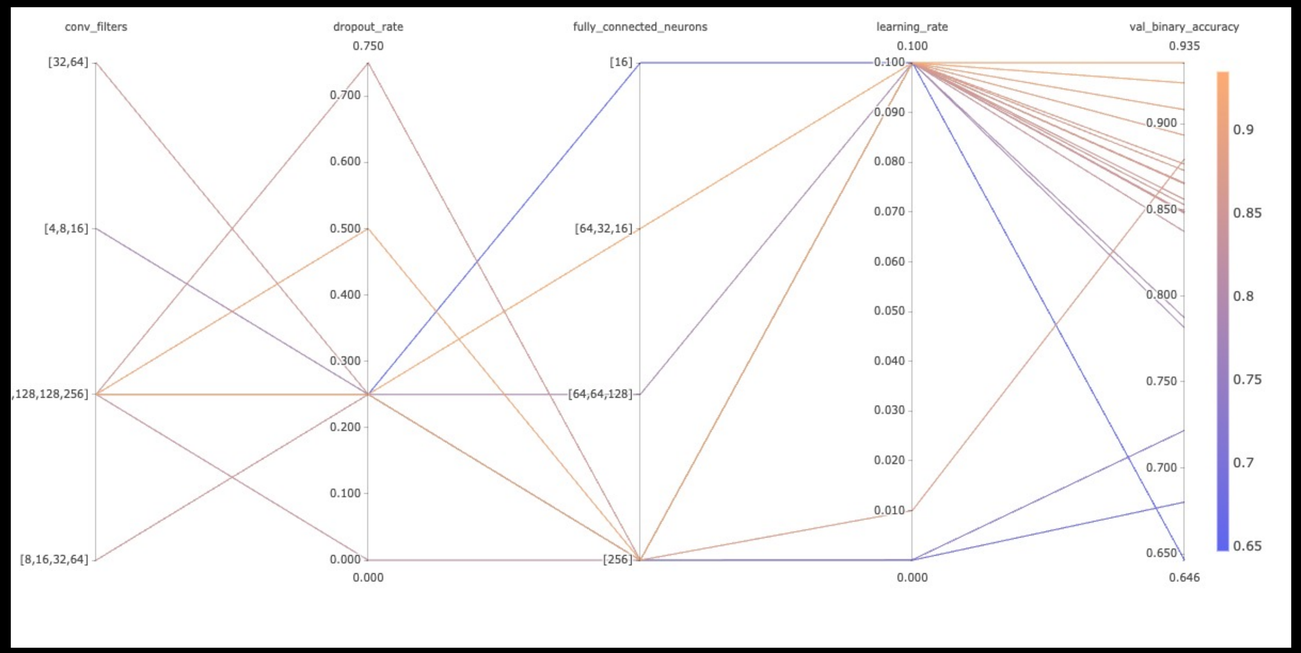
Results (preliminary)

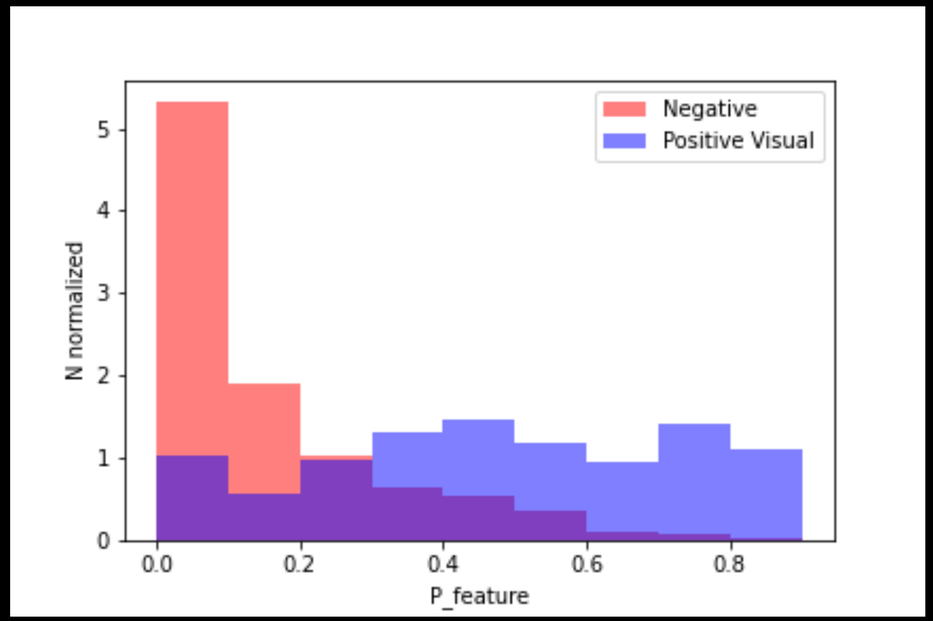
- Hyperparameter optimization
- Image pre-processing

Completness

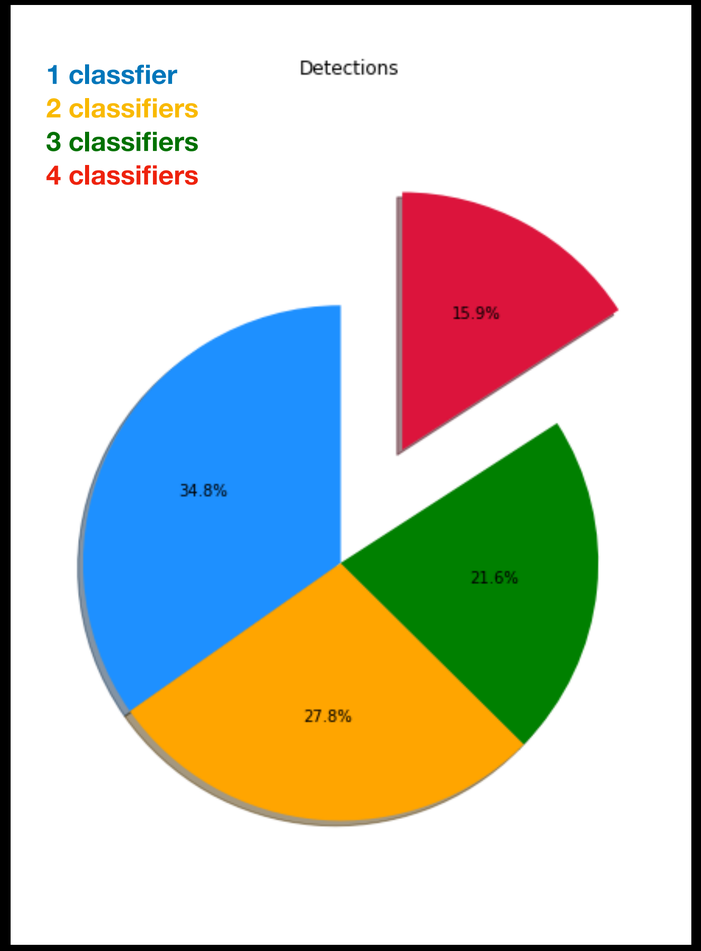
Contamination

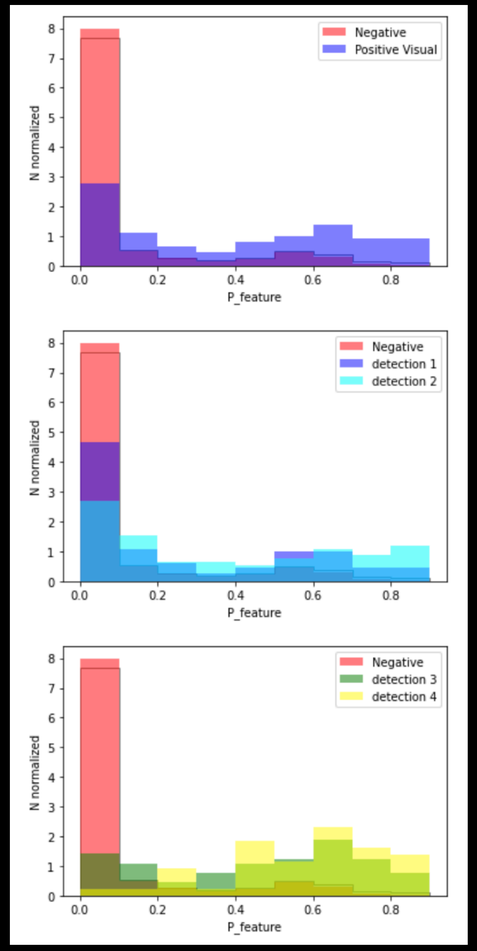
	AUC	Acc.	Recall	Prec.
Unbalanced	0.90	0.94	0.49	0.56
Balanced	0.90	0.74	0.49	0.93



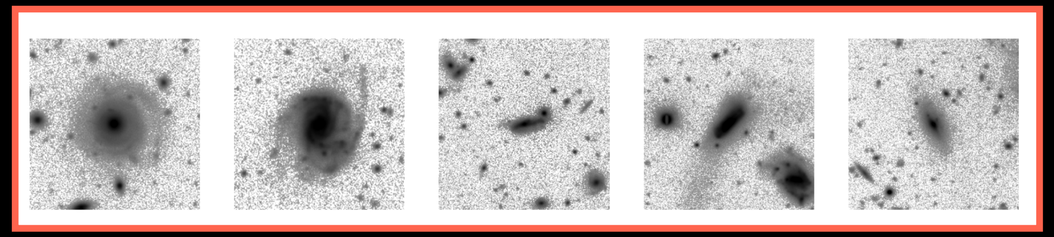


Tidal stream visual identification





- Significant disagreement between classifiers!
- Galaxies with more votes show larger Prob.
- False positives show some features.



Conclusions

Automated detection of tidal features is a challenging task due to:

- Low number of real tidal stream detections (small training samples)
- Subjectivity of the tidal stream identification (wrong labels)
- Subtleness of tidal features (low contrast and noisy images)

Future Work

- Neural Network architecture
- Transfer Learning (e.g., SDSS models)
- Combine observational datasets
- Simulations

Open to collaboration!
Contact me