ALeRCE.science

Deep learning in Astronomy and its application to transient detection within the **ALeRCE** system

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ALeRCE
Automatic Learning for the
Rapid Classification of Events

ALeRCE in a nutshell

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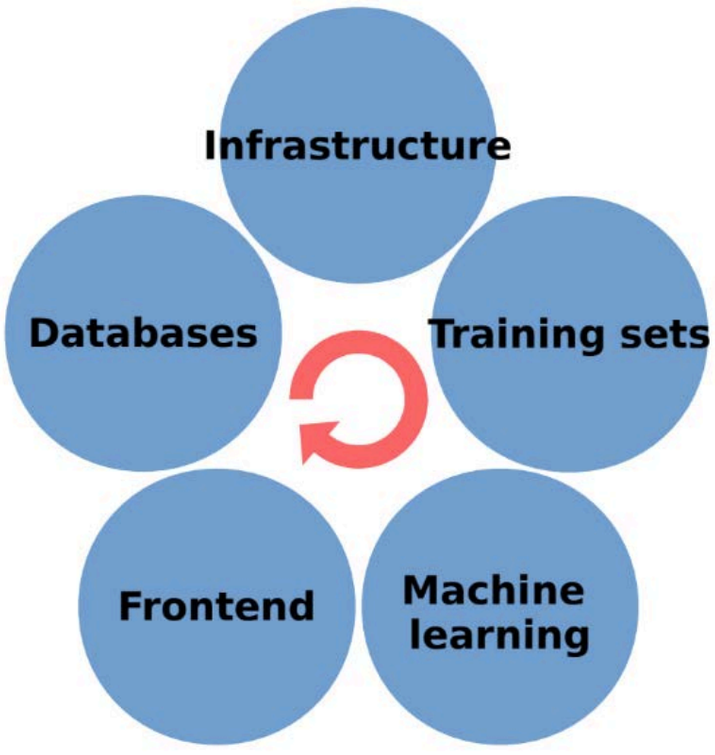
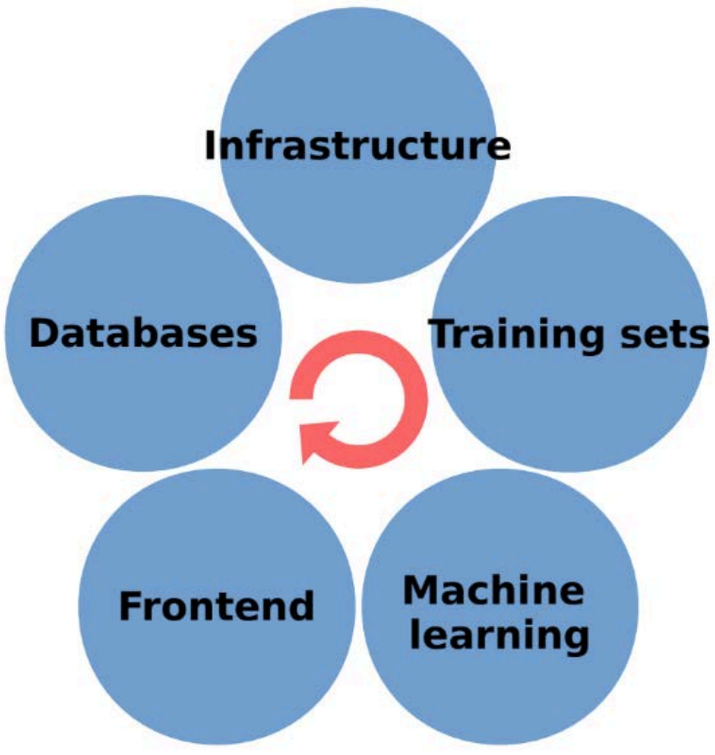
- Alert life cycle

Five interdisciplinary teams



Five interdisciplinary teams



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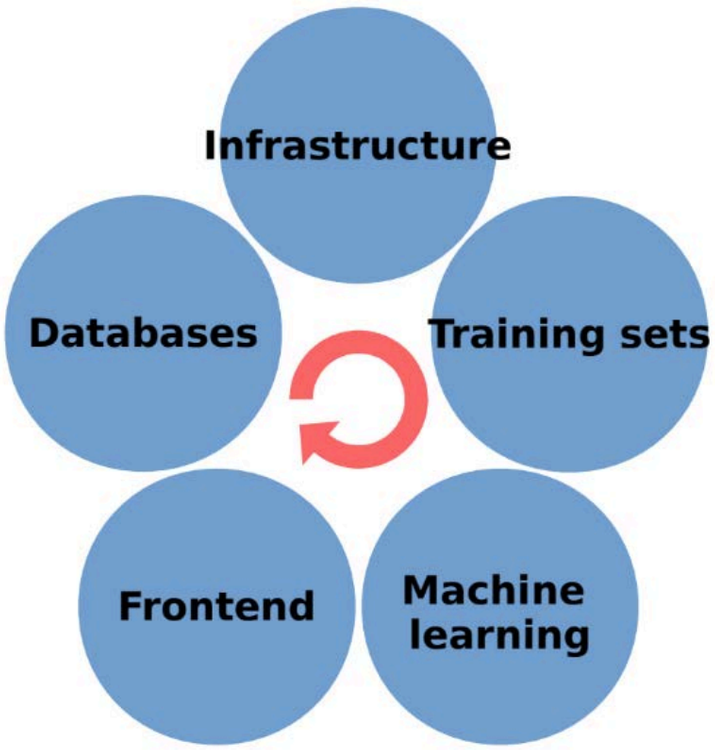

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Rosario Molina (UCh)
Diego Mesa (UdeC)
Francisco Muñoz (UCh)
Arturo Lira (UCh)
Manuel Pérez (UdeC)
Esteban Reyes (UCh)
Ignacio Reyes (UCh)

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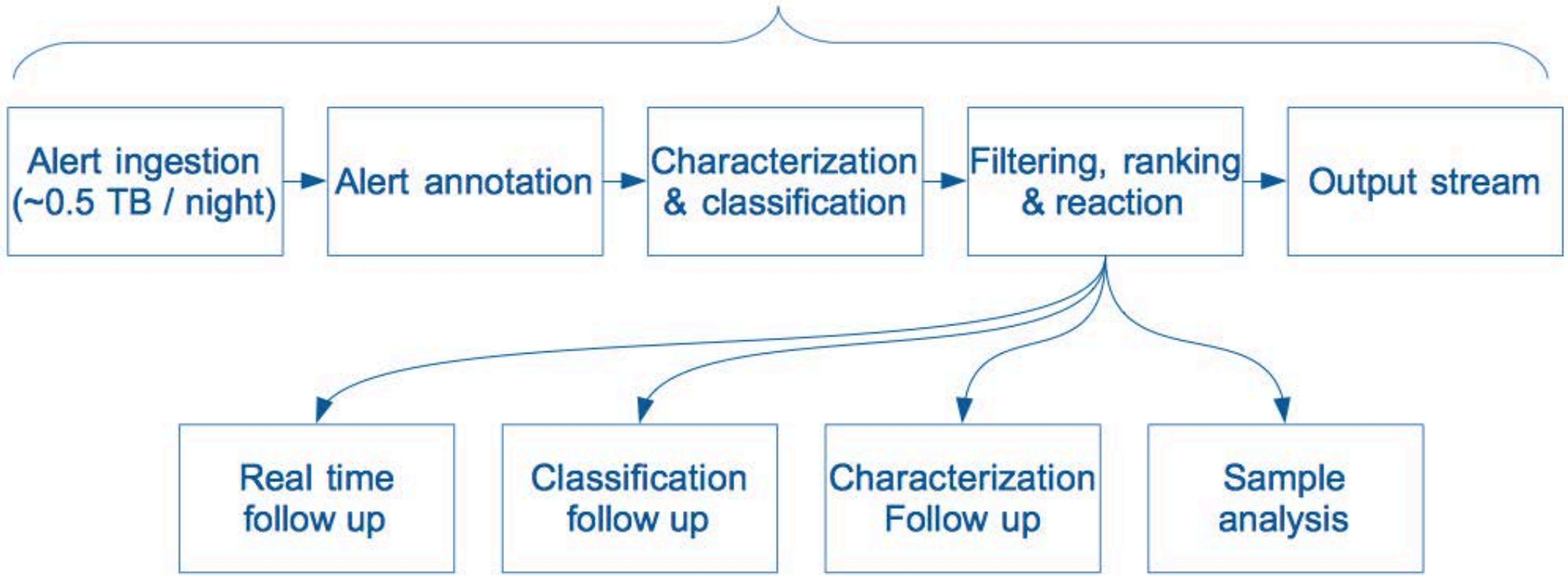
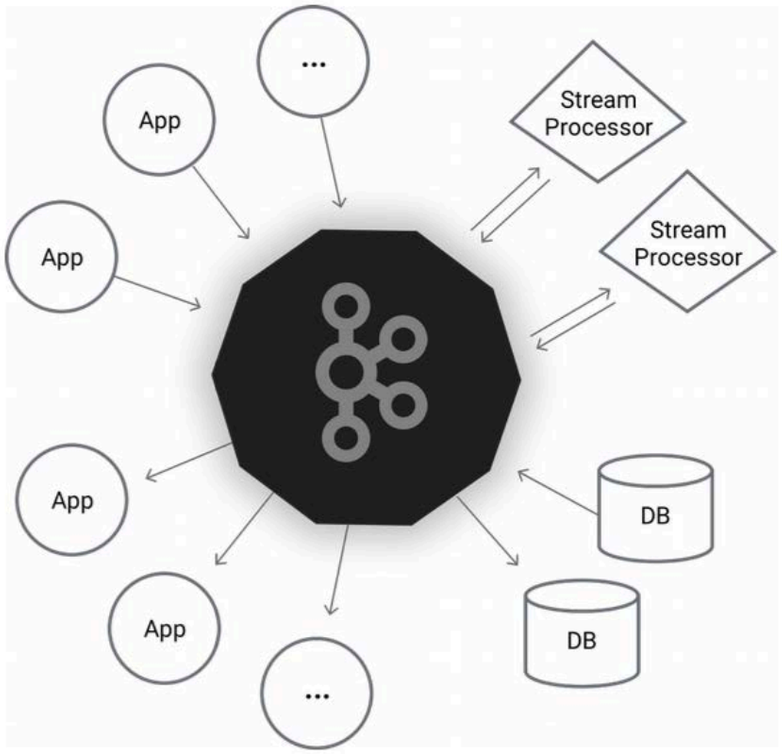
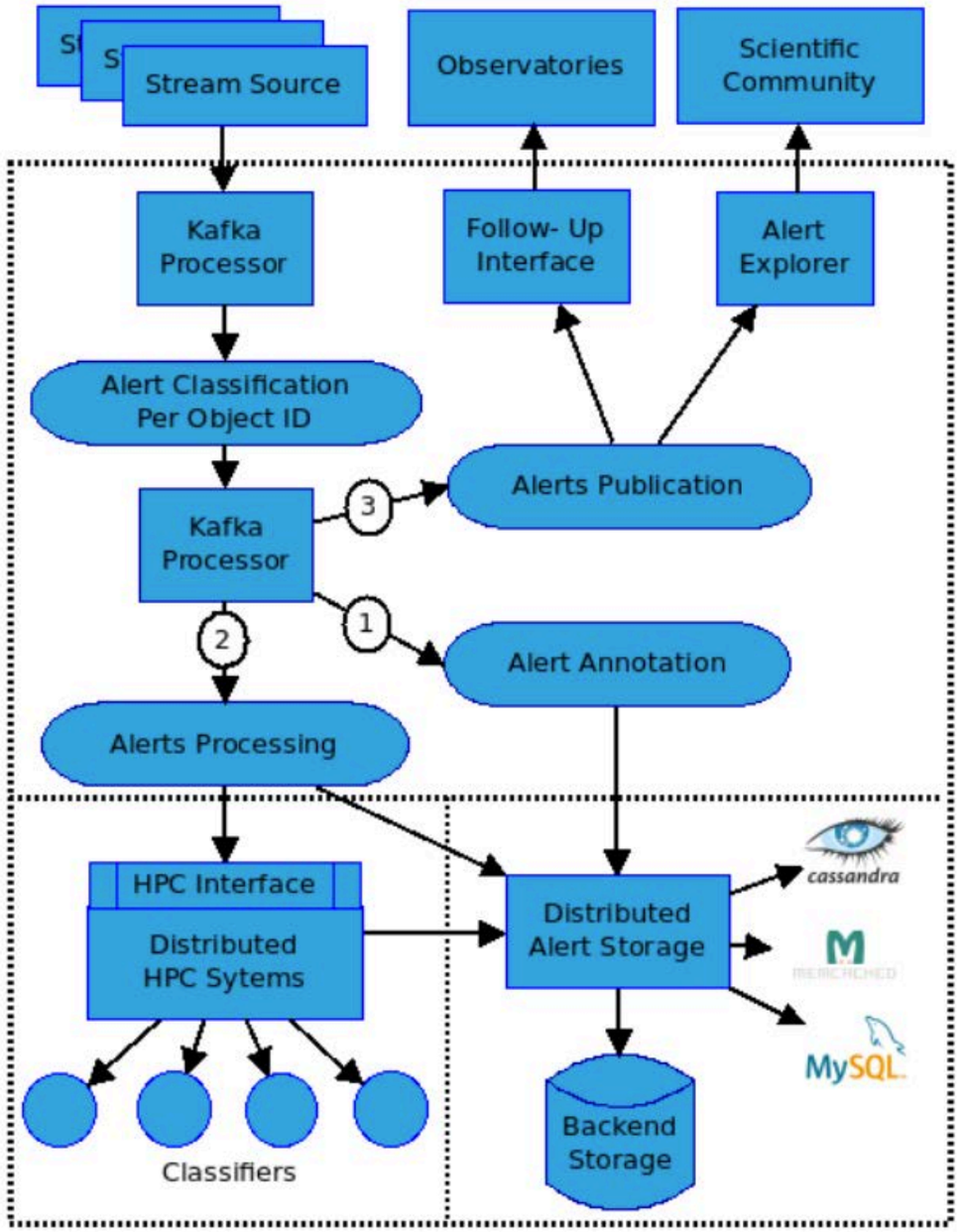
Astrophysics + high performance computing + signal processing
+ databases + machine learning + statistics



Alert life cycle





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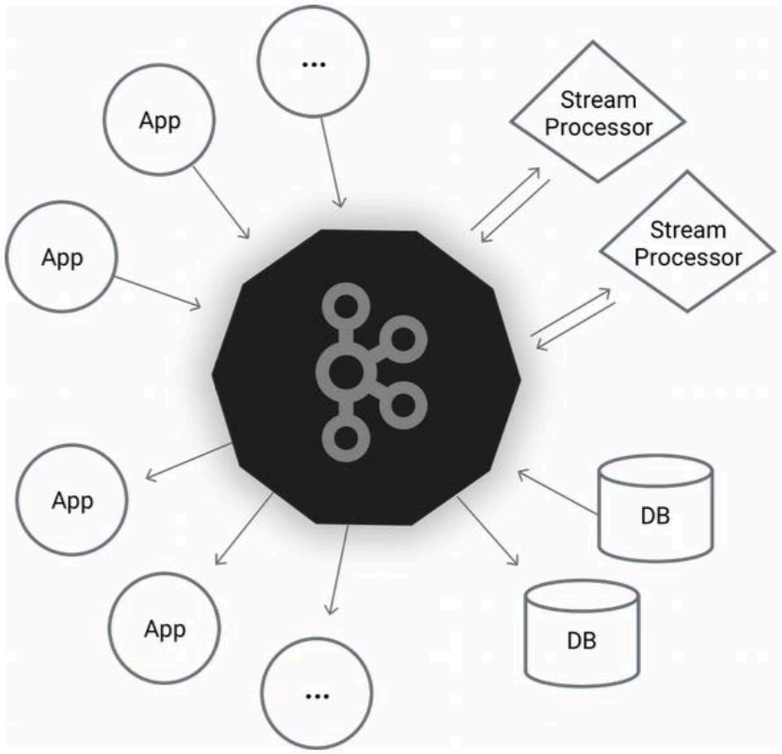

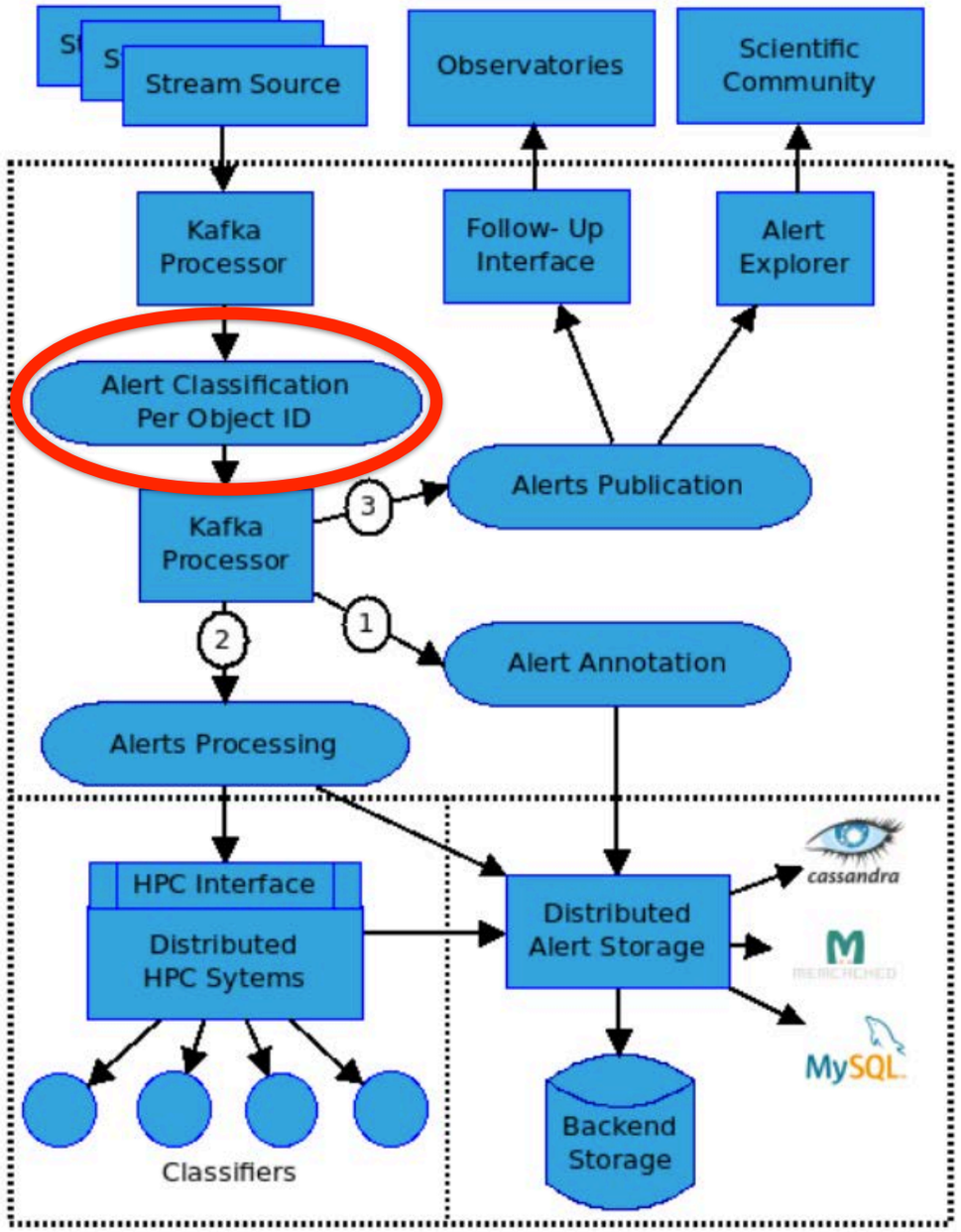

Deep Learning & ALeRCE

Deep Learning

- Model data through multiple levels of abstraction using a hierarchical set of layers

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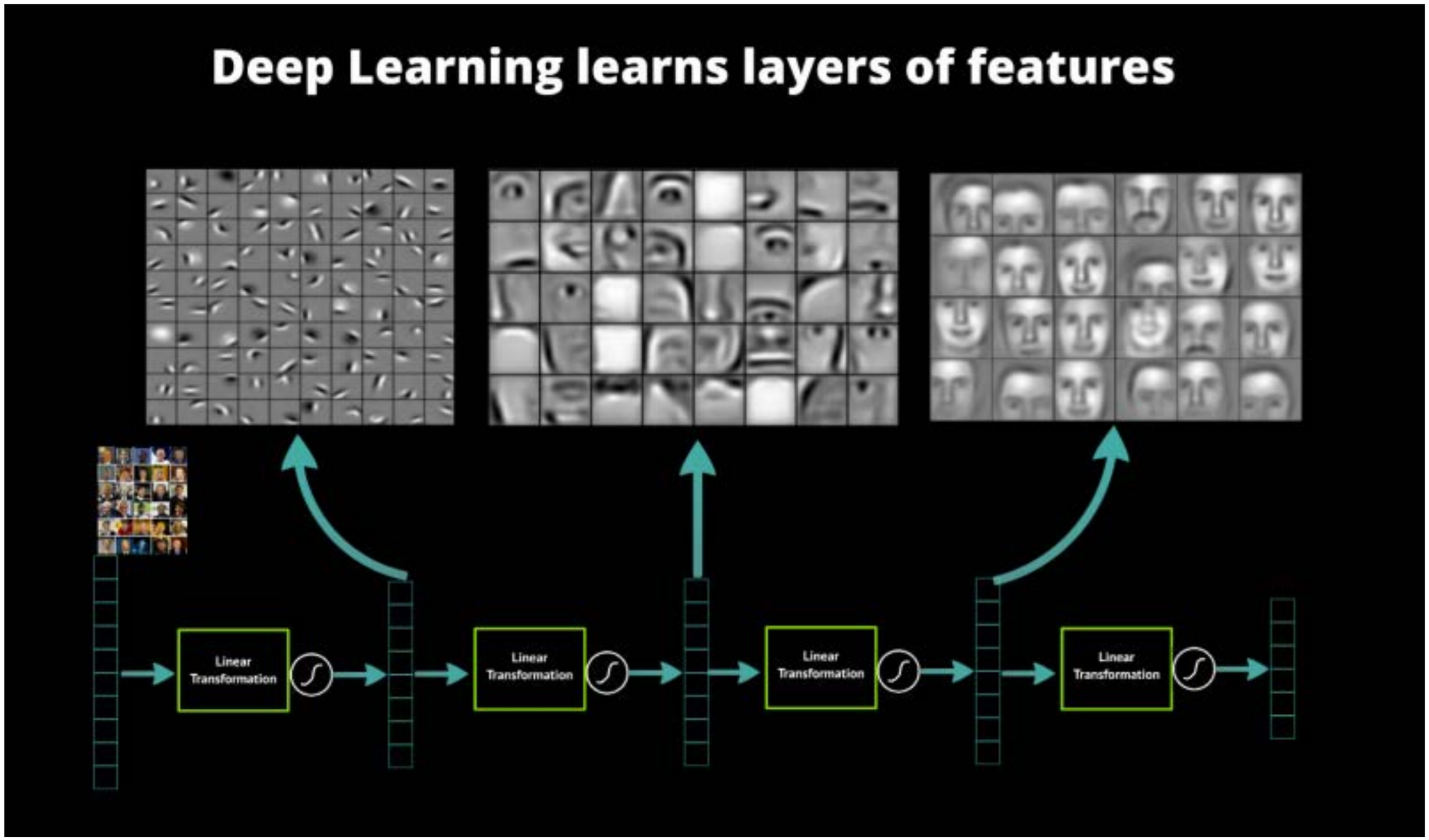
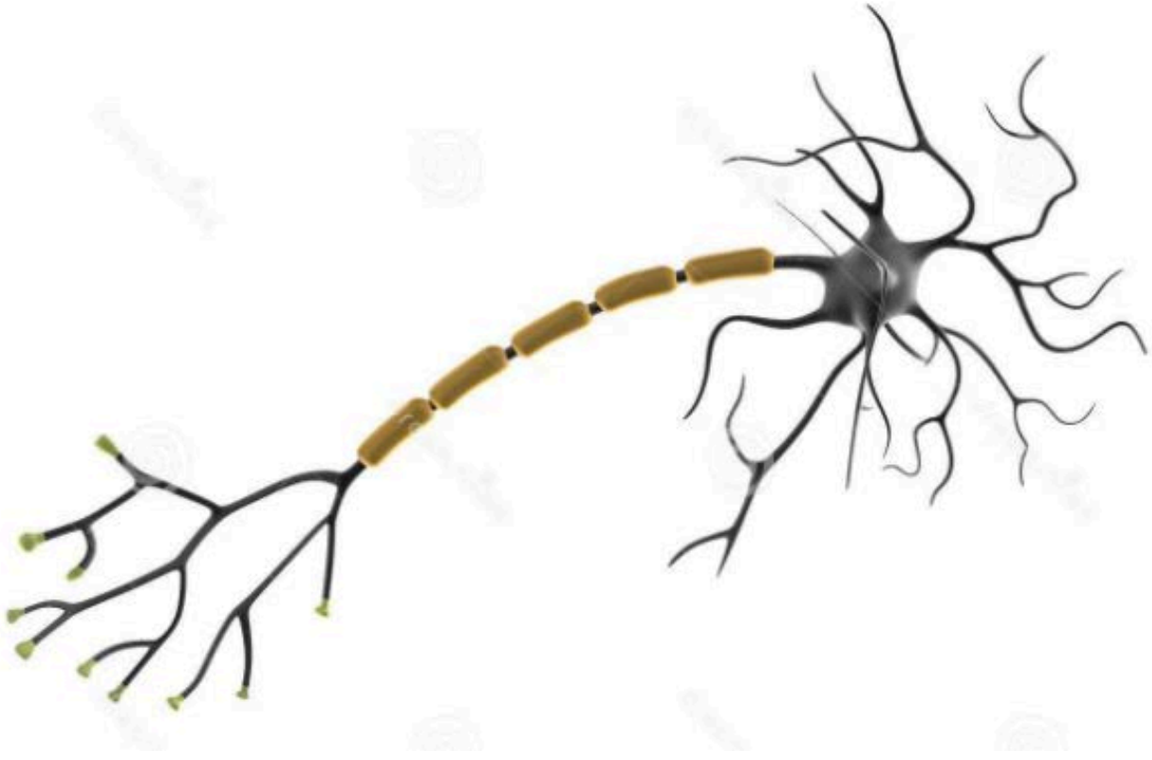


http://www.datarobot.com/blog/a-primer-on-deep-learning/

Feed-forward Neural Networks

- inspired by biological neural networks
- set of interconnected "neurons"



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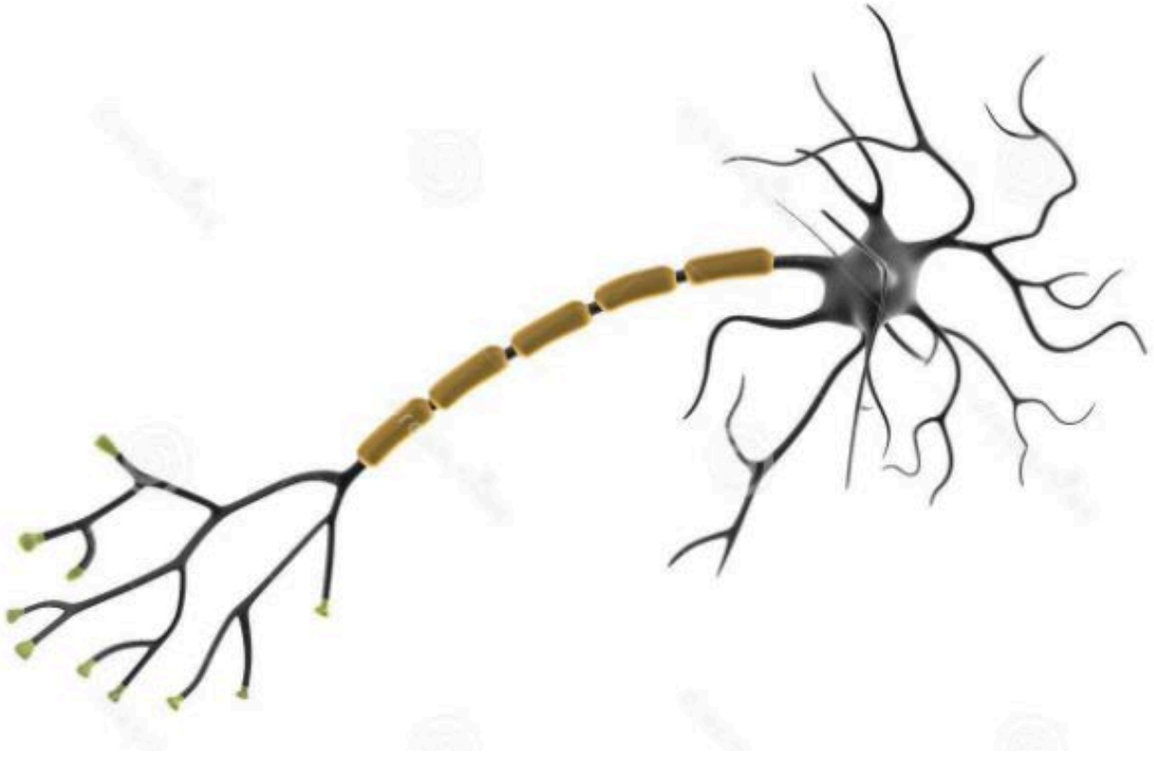

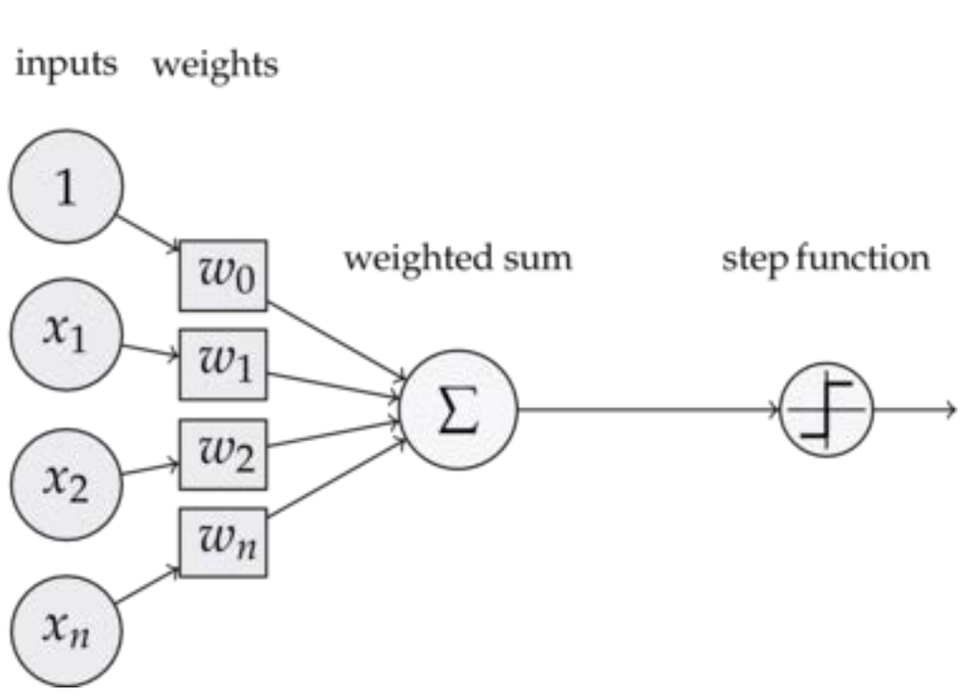

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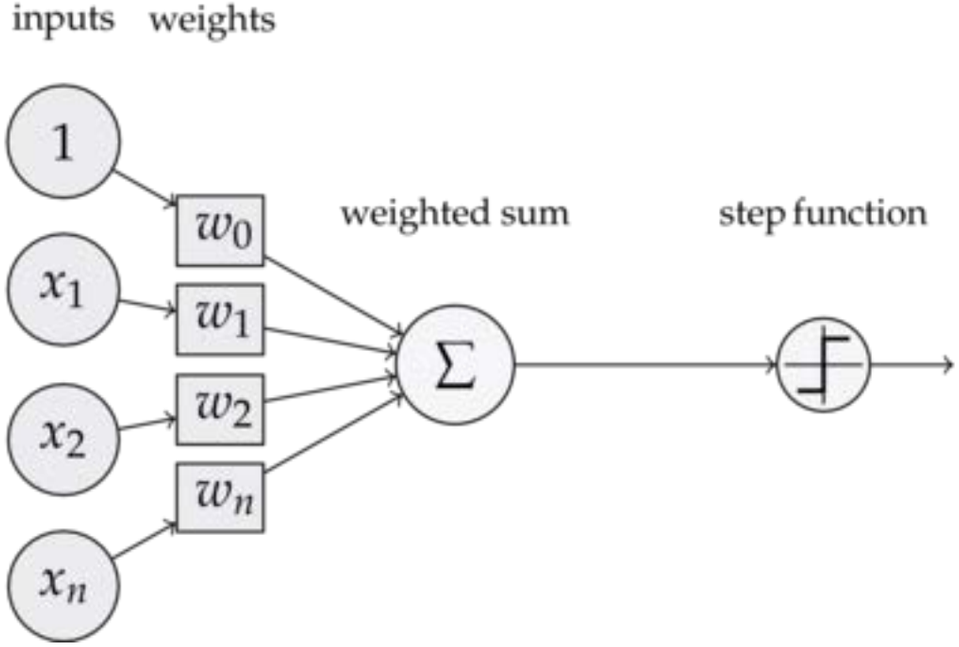

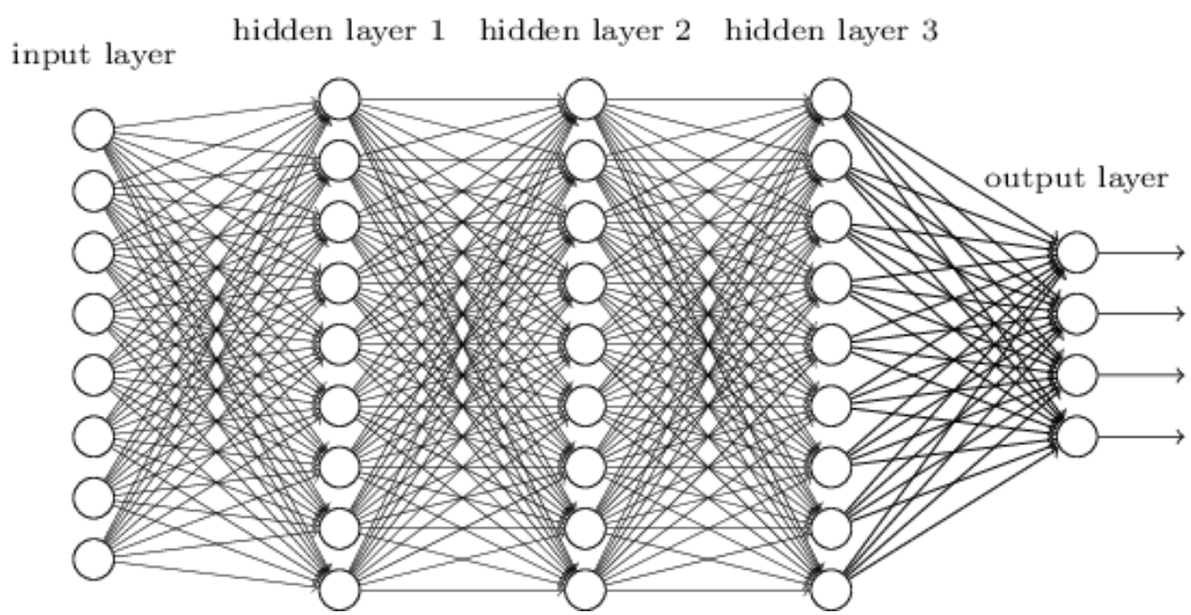

Deep Learning Architectures

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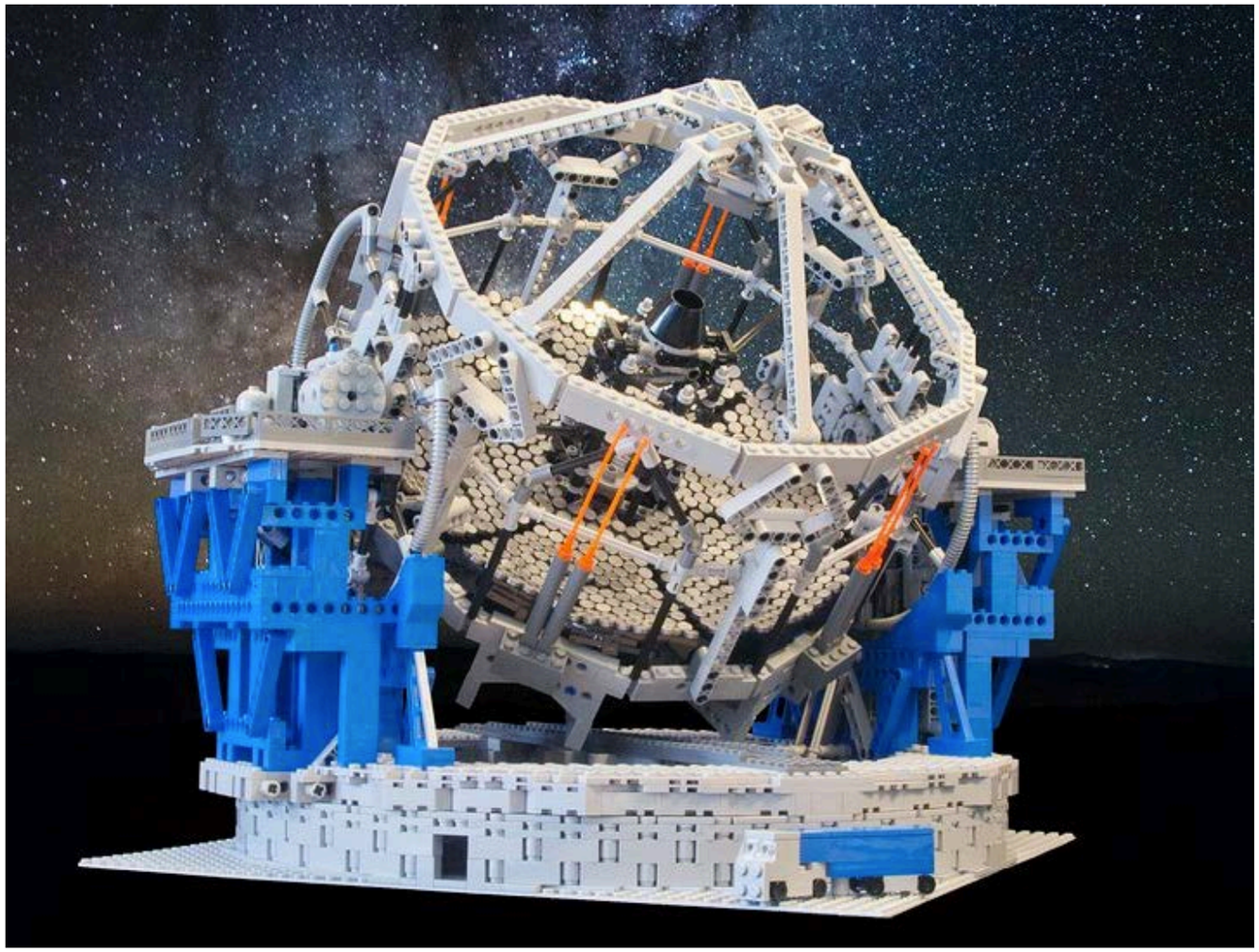

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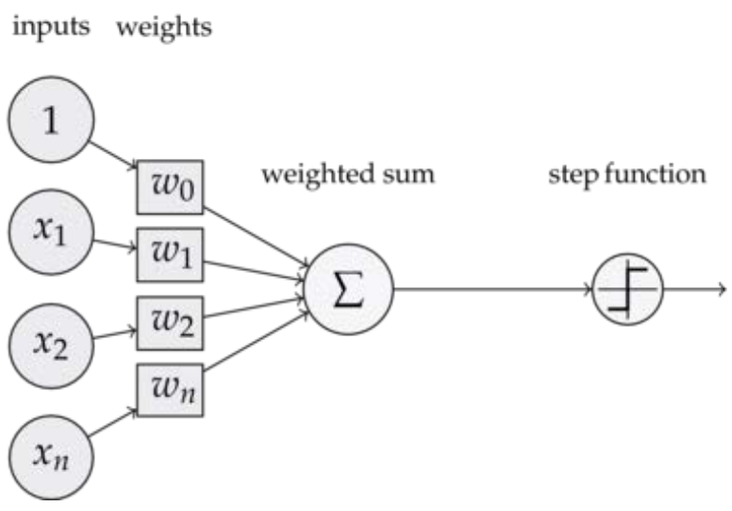

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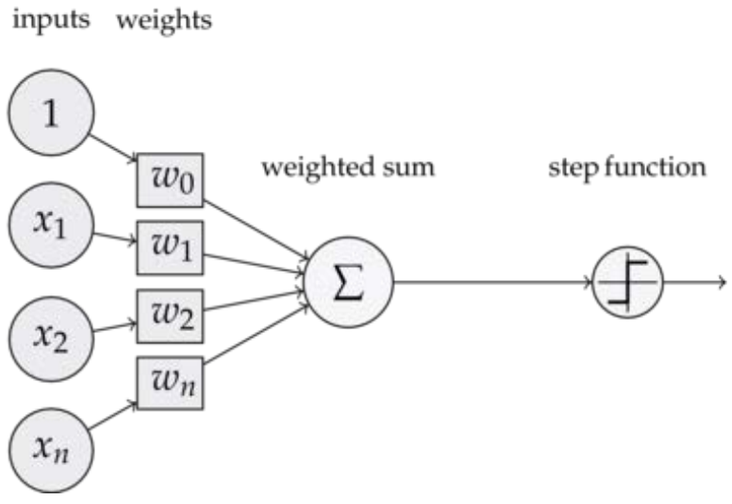

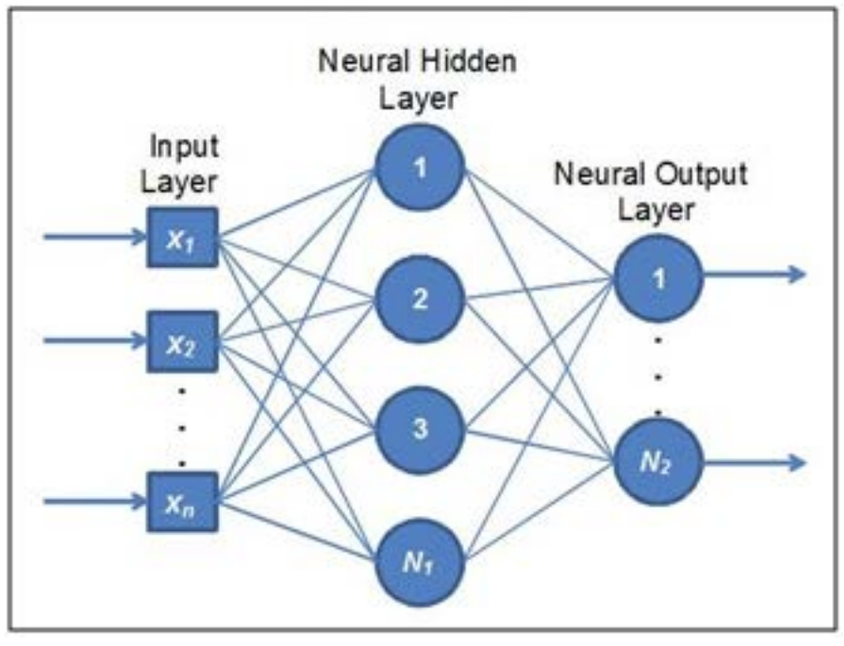

http://engineering.electrical-equipment.org/

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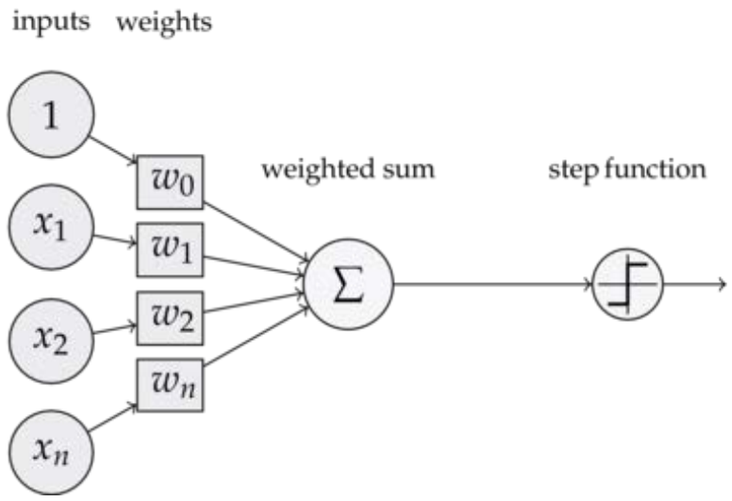
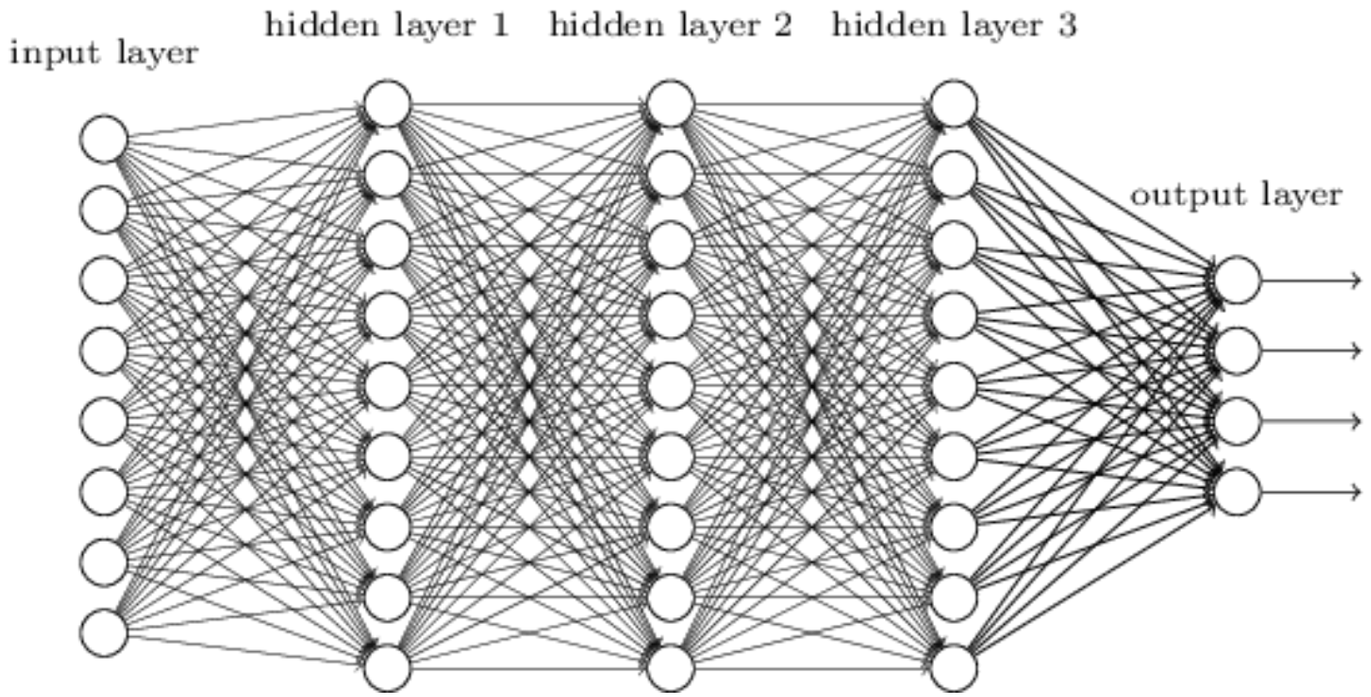
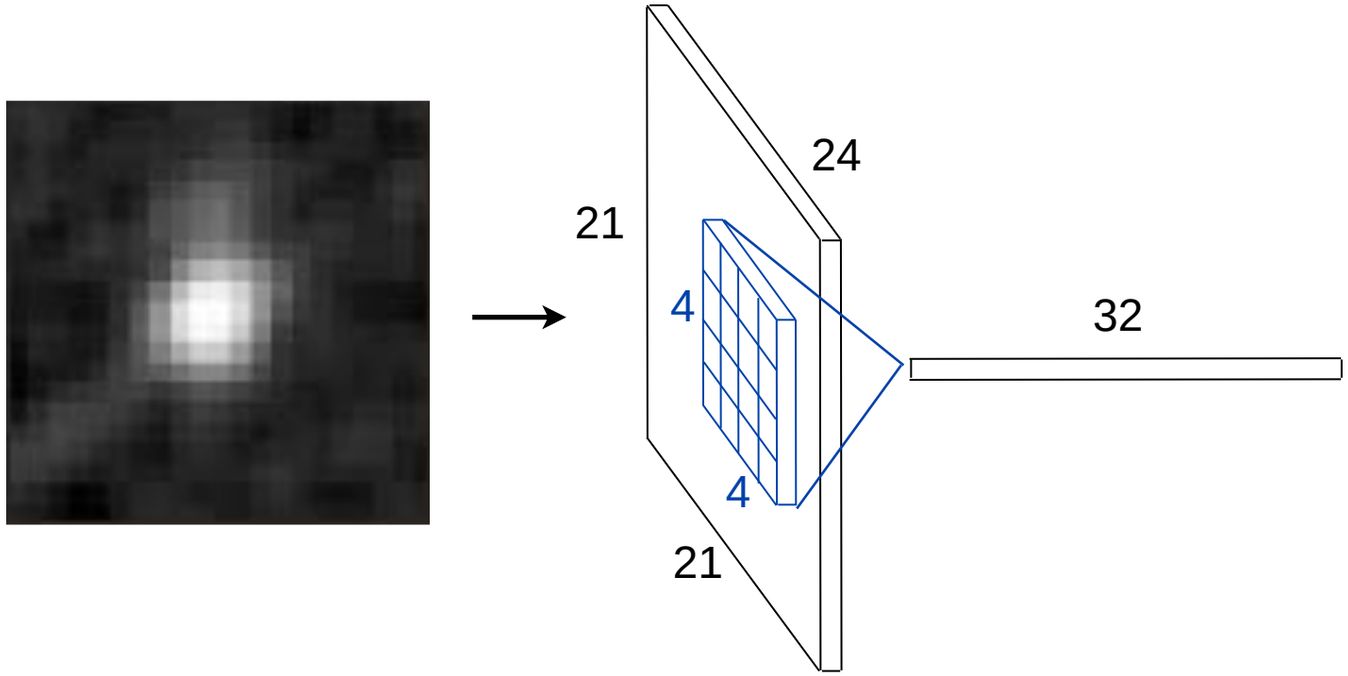
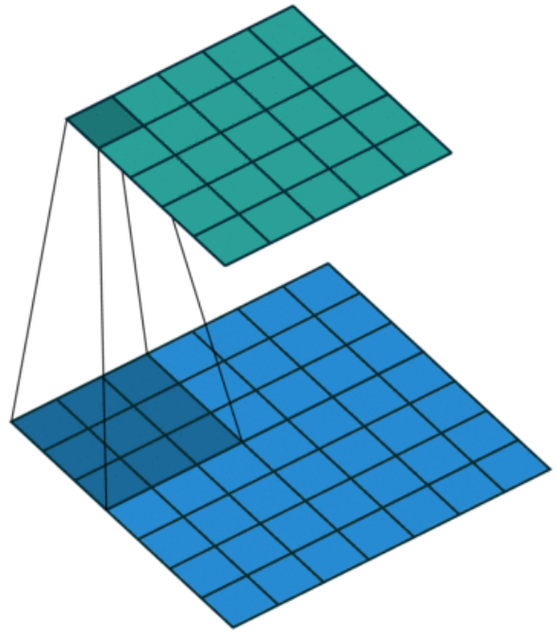




Convolutional Neural Networks





http://iamaaditya.github.io/

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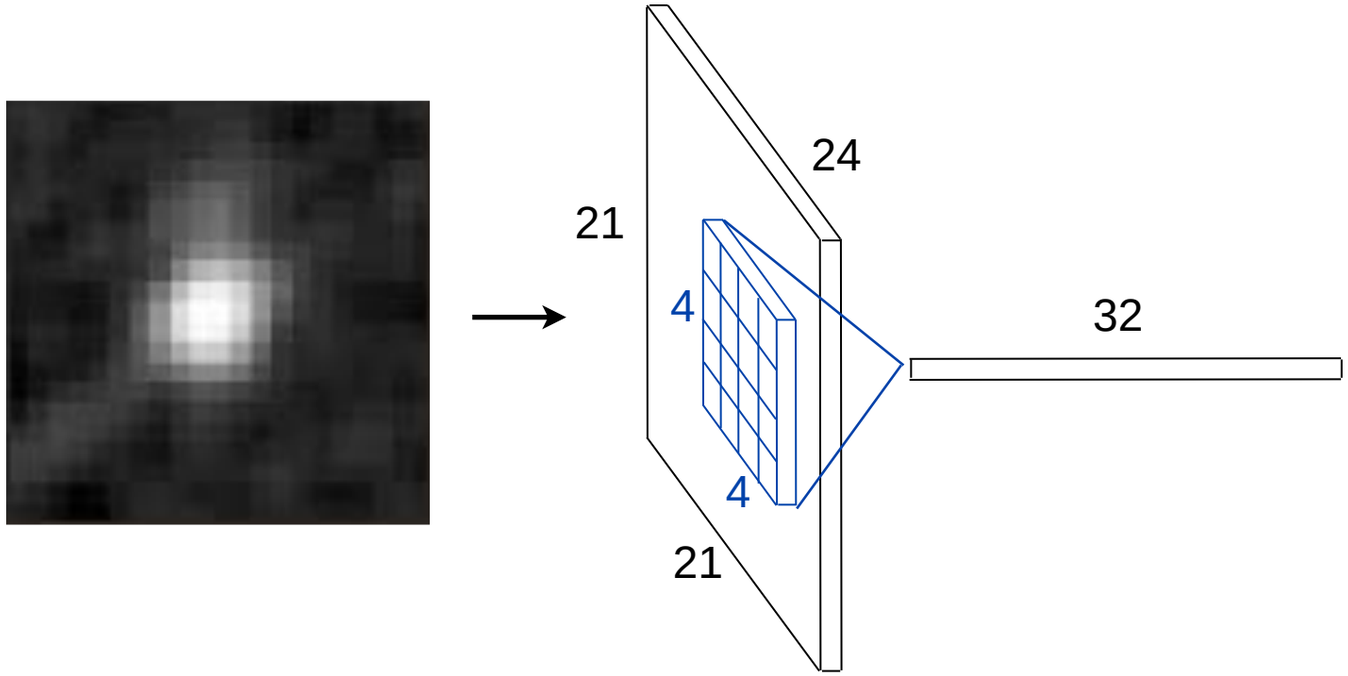

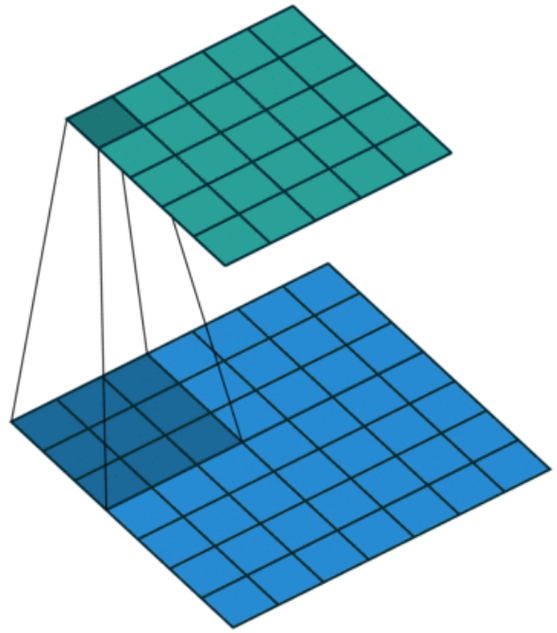

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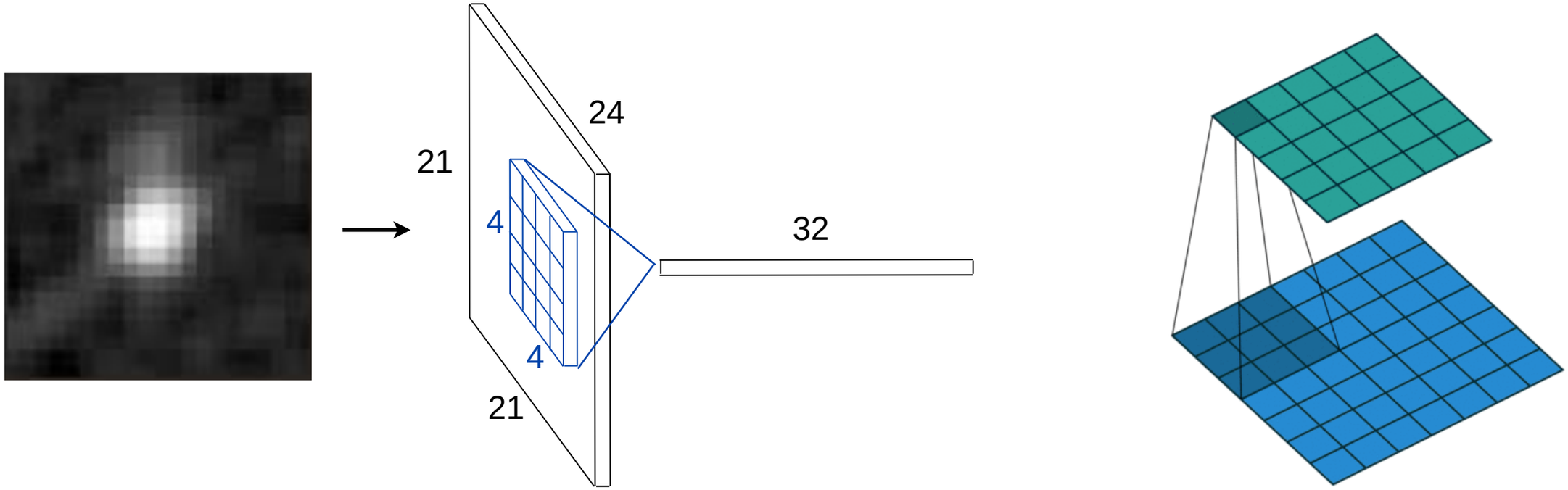
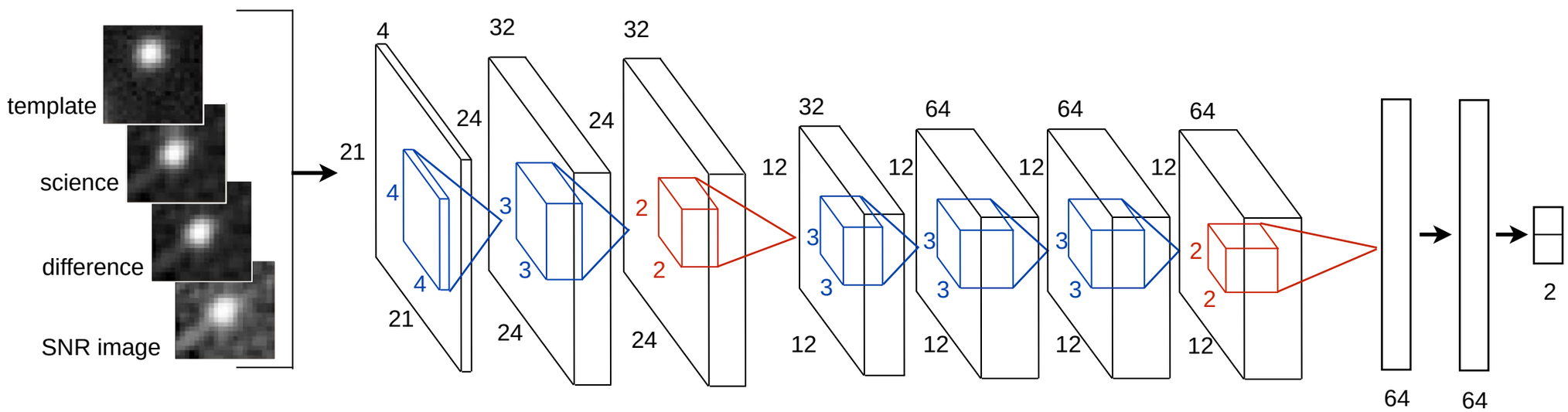
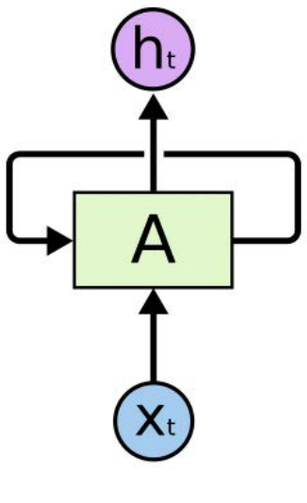




Recurrent Neural Networks



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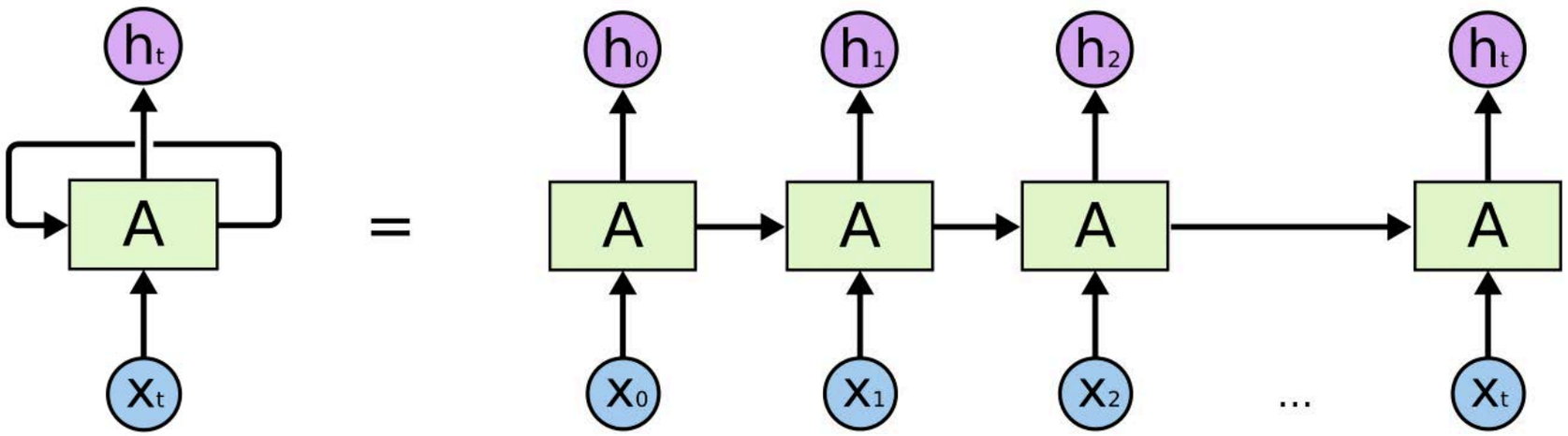

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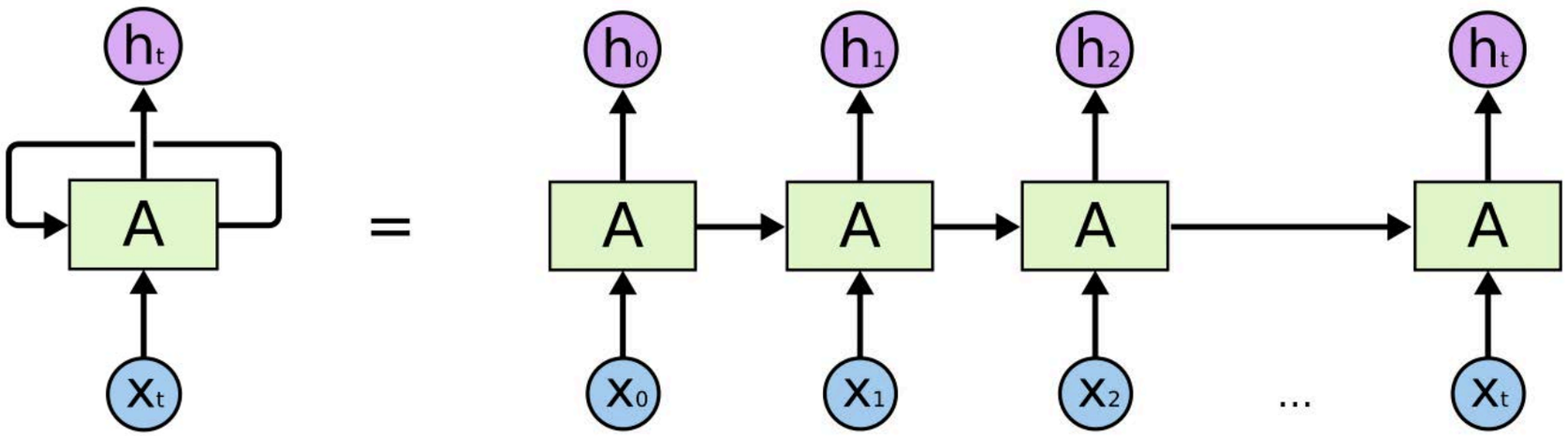
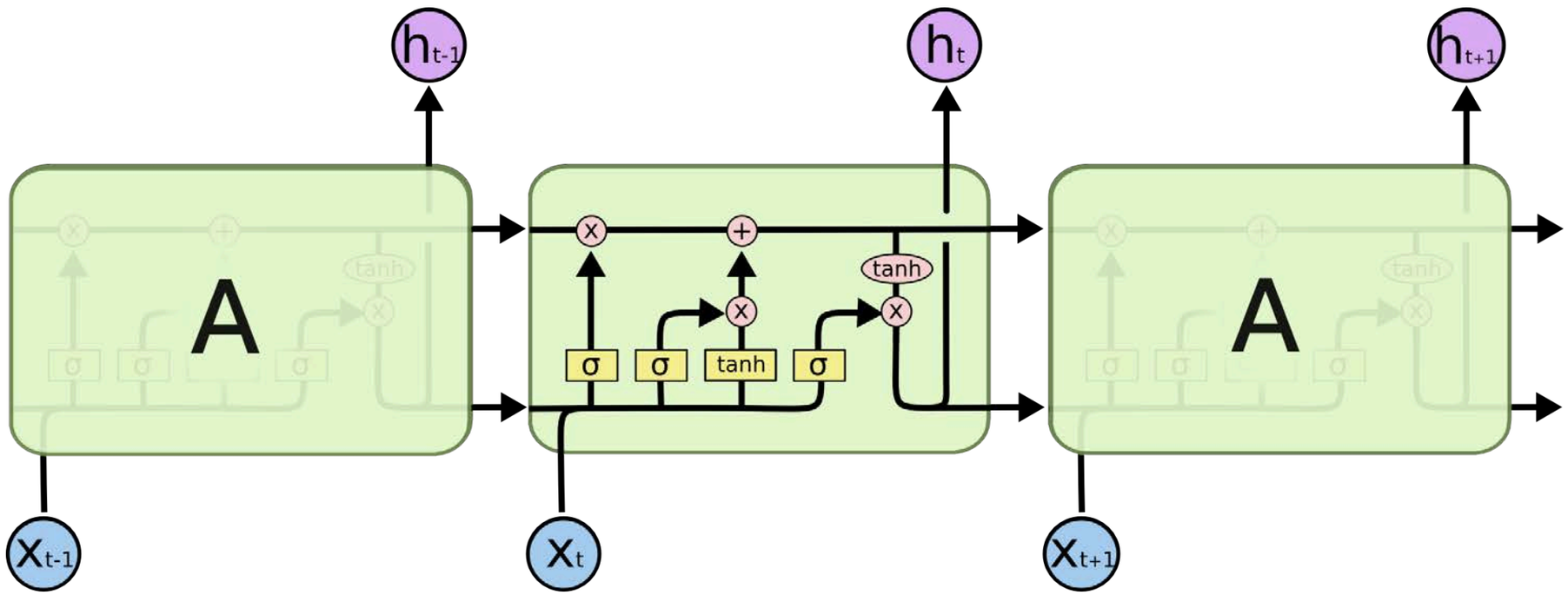
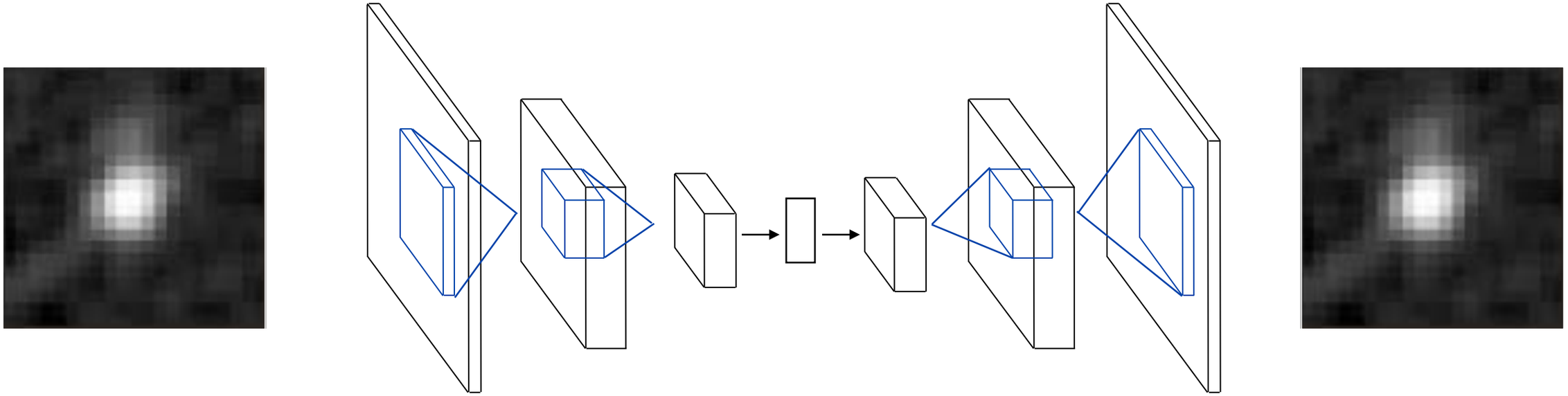




http://colah.github.io/

Variational Autoencoders



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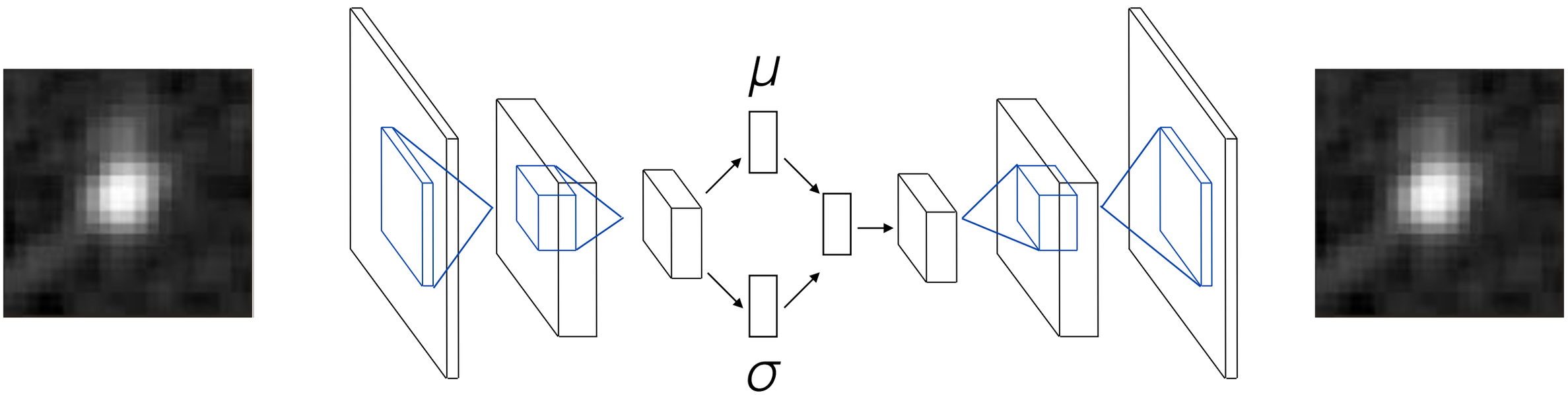
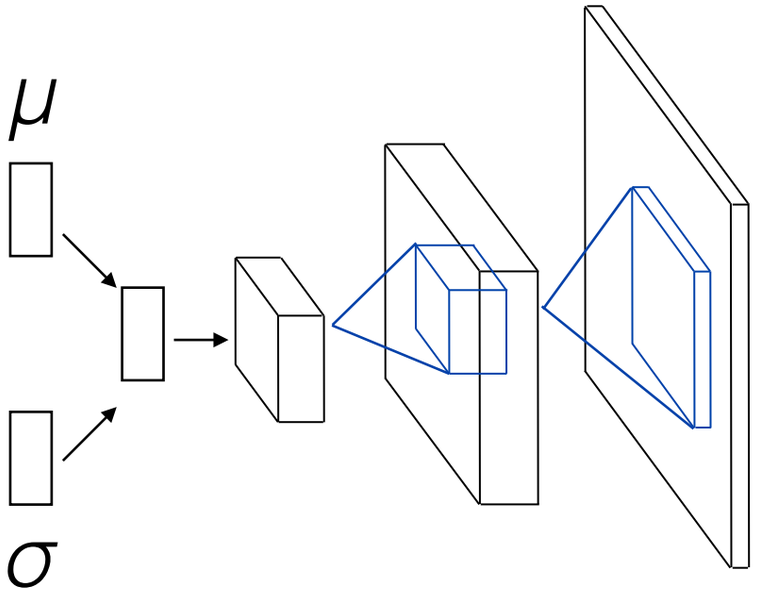
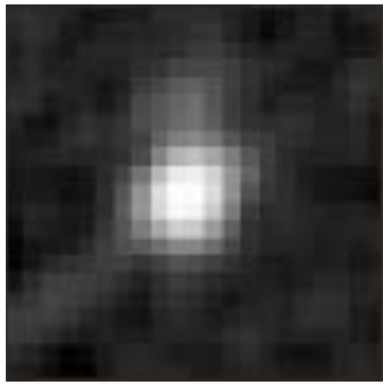


Variational Autoencoders

It works as a generative model





Astronomy

Applications

CNN: Galaxy Morphologies

- Galaxy Zoo Challenge (2014)

- Top solutions used CNNs

- Winner: Rotation-invariant convolutional Neural Networks (Dieleman et.al., MNRAS, 2015)

https://www.kaggle.com/c/galaxy-zoo-the-galaxy-challenge

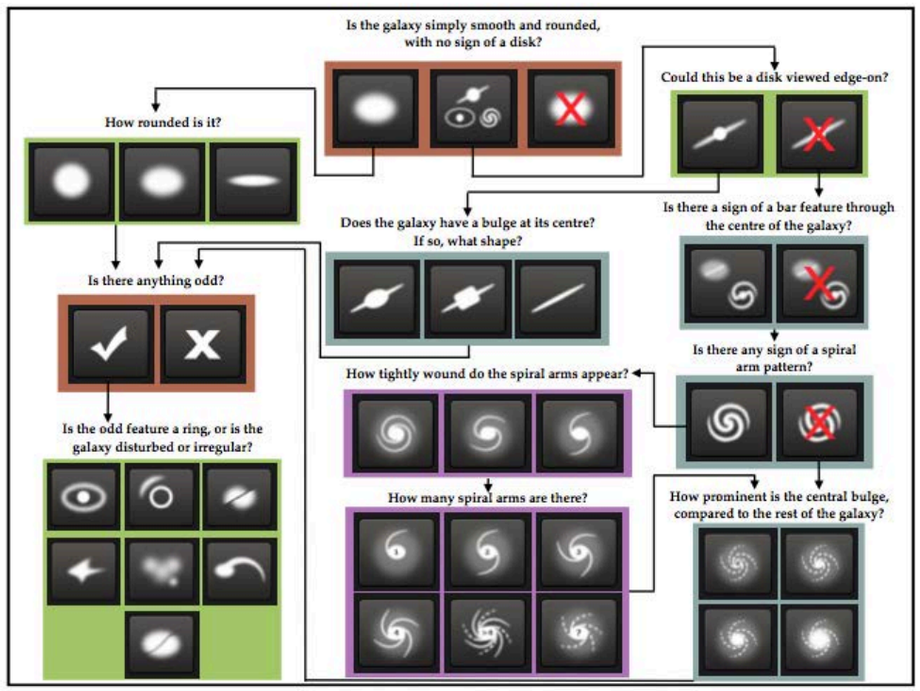


Figure 1. Flowchart of the classification tasks for GZ2, beginning at the top centre. Tasks are colour-coded by their relative depths in the decision tree. Tasks outlined in brown are asked of every galaxy. Tasks outlined in green, blue, and purple are (respectively) one, two or three steps below branching points in the decision tree. Table 2 describes the responses that correspond to the icons in this diagram.

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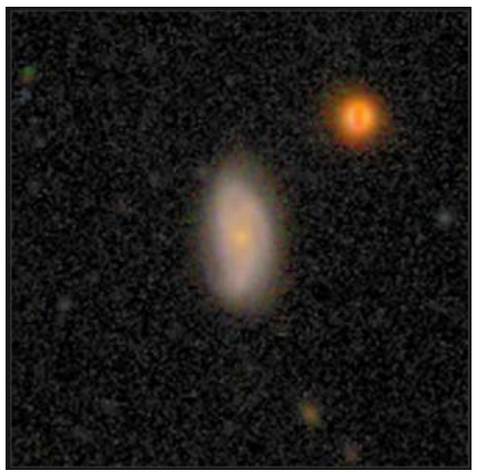

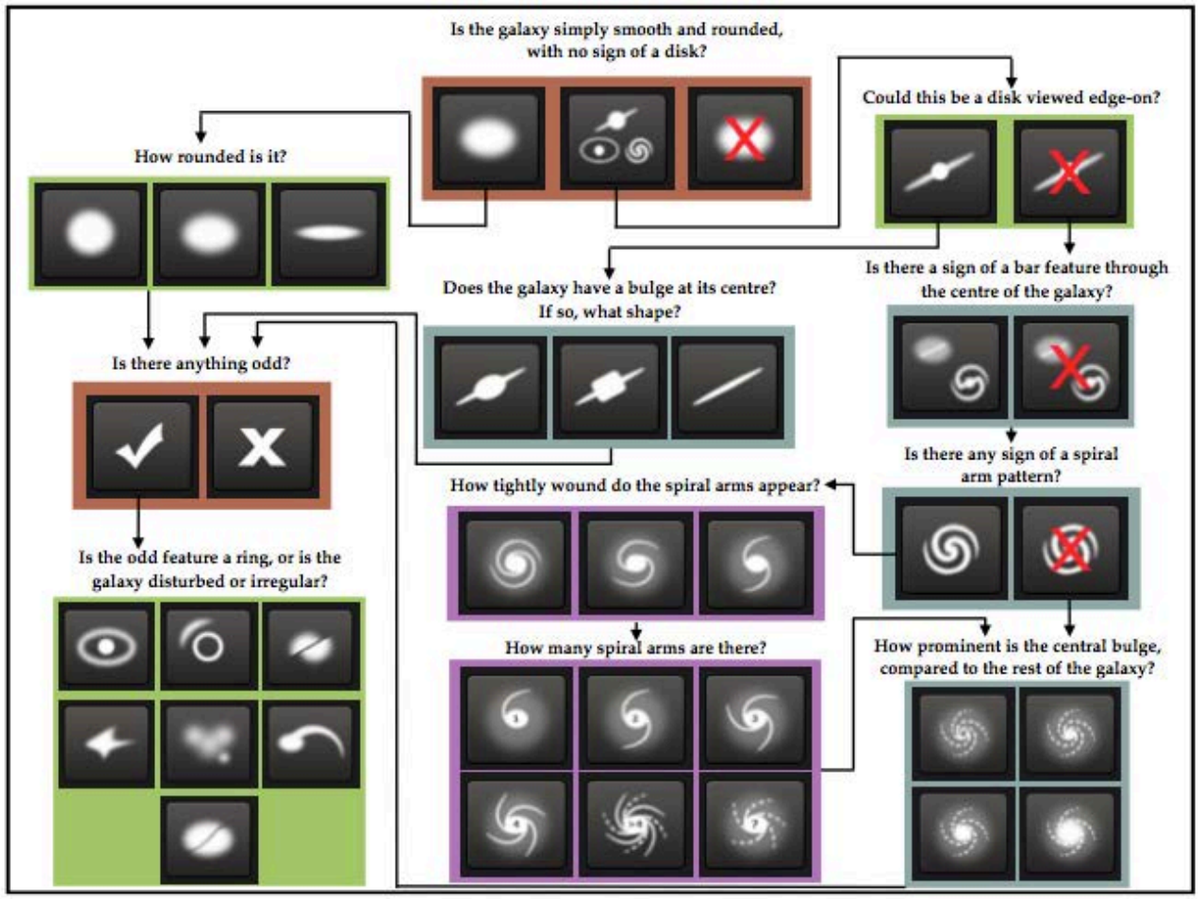

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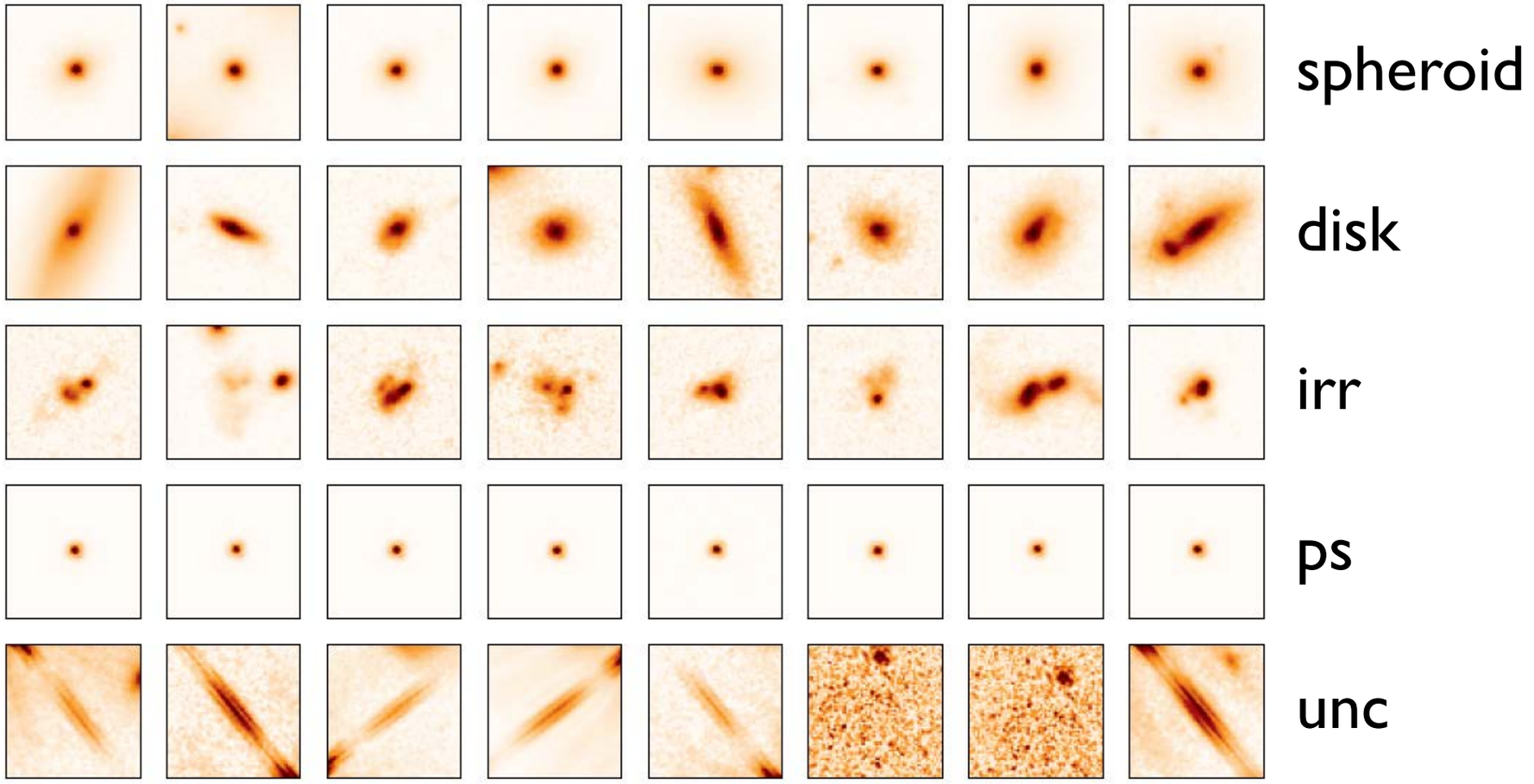
  - CANDELS: Huertas-Company et.al. ApJS, 2015



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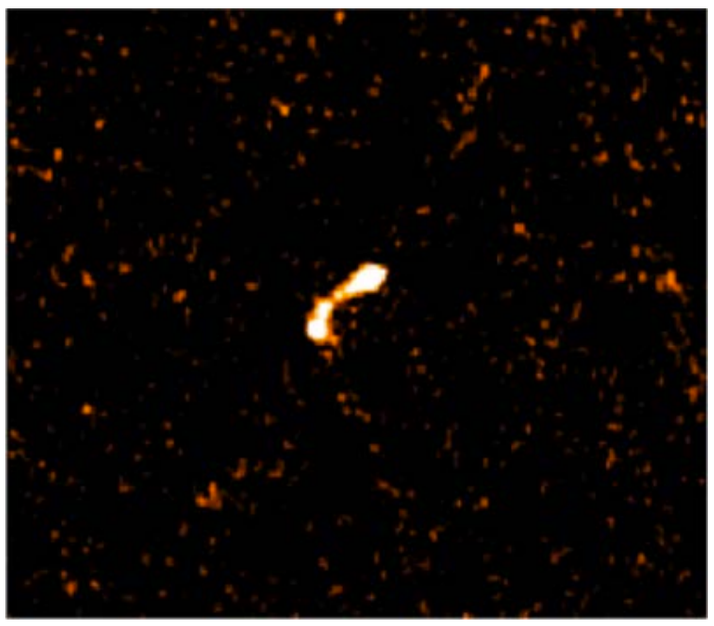
  - CANDELS: Huertas-Company et.al. ApJS, 2015
  - Radio: Aniyan & Thorat, APJS, 2017

FRI



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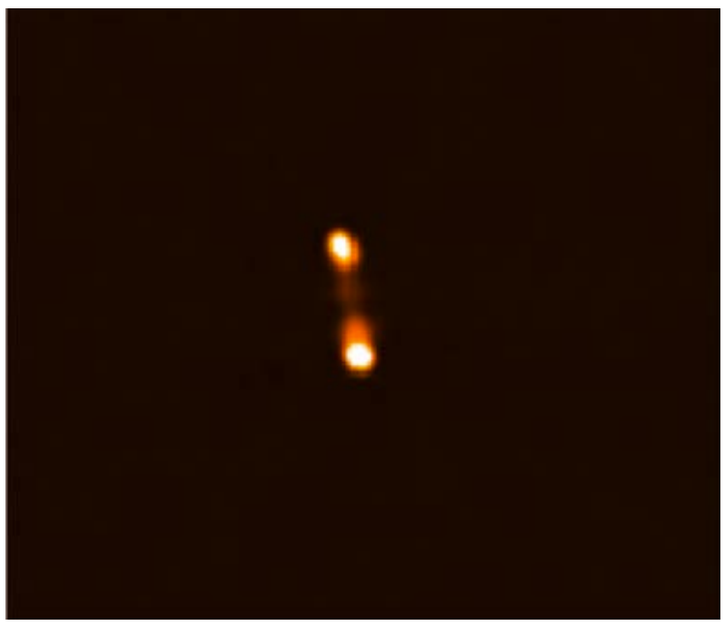
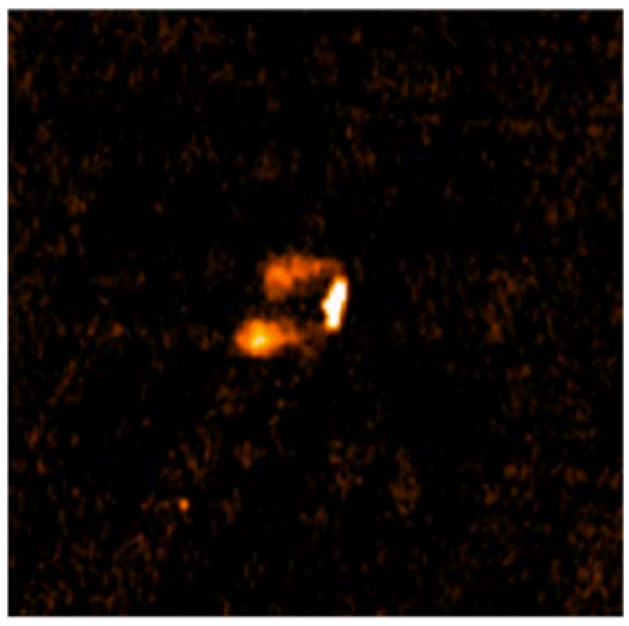


bent-tail



Astronomy Applications

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- **Transient Detection and Classification**

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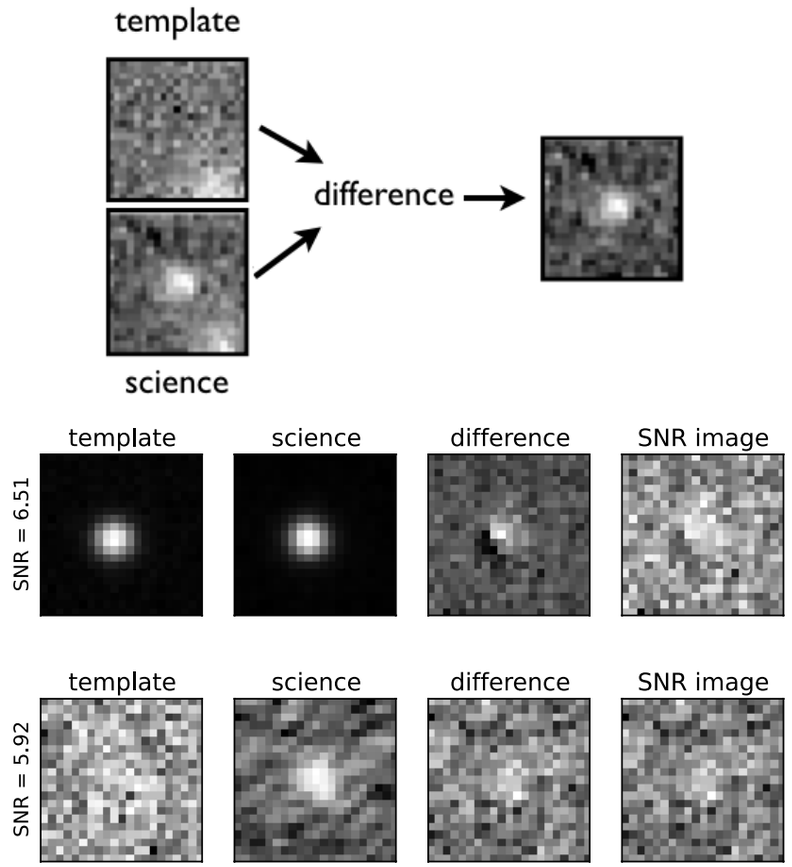
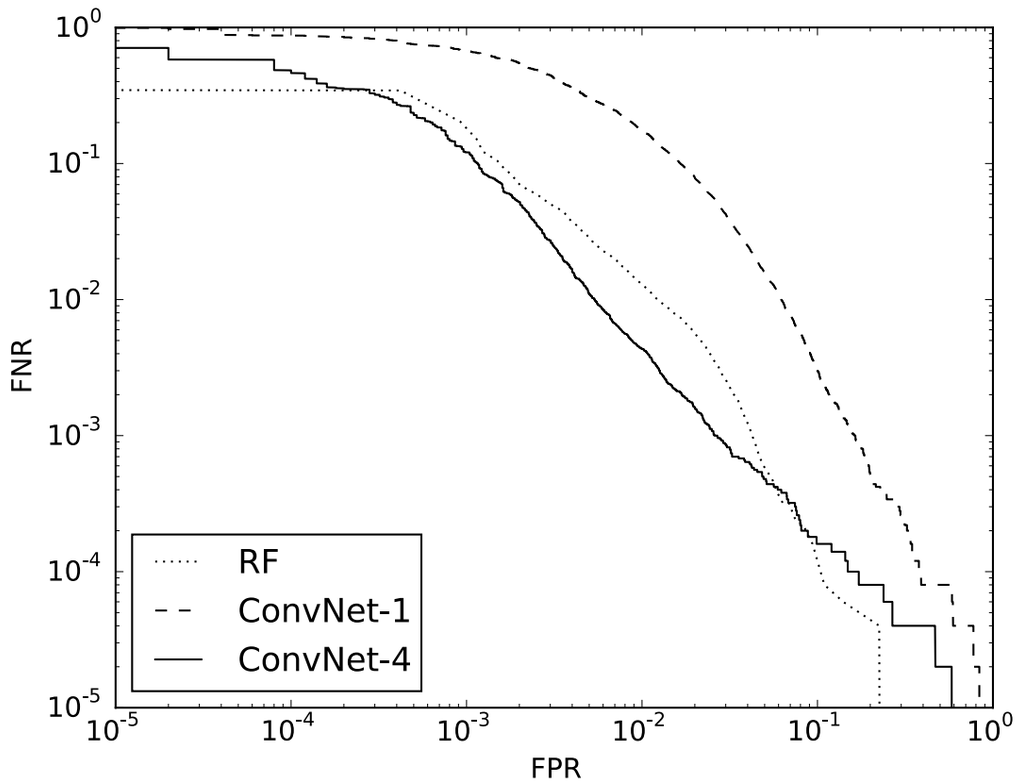
  - Supernovae detection using CNN: Cabrera-Vives et.al., IJCNN, 2016





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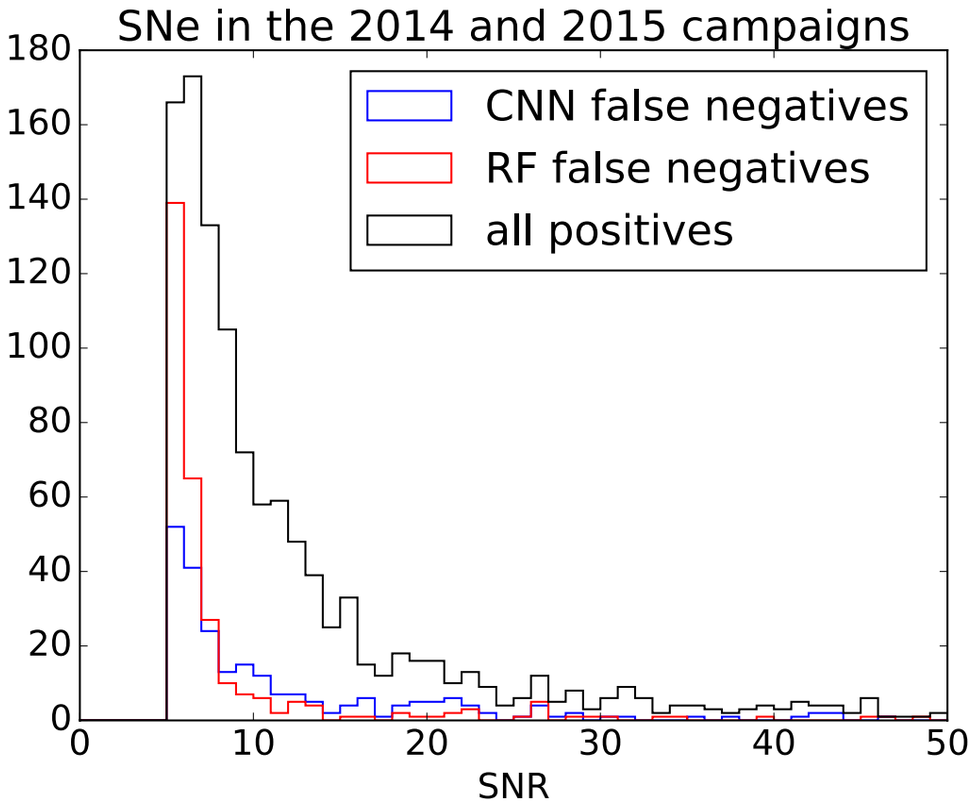

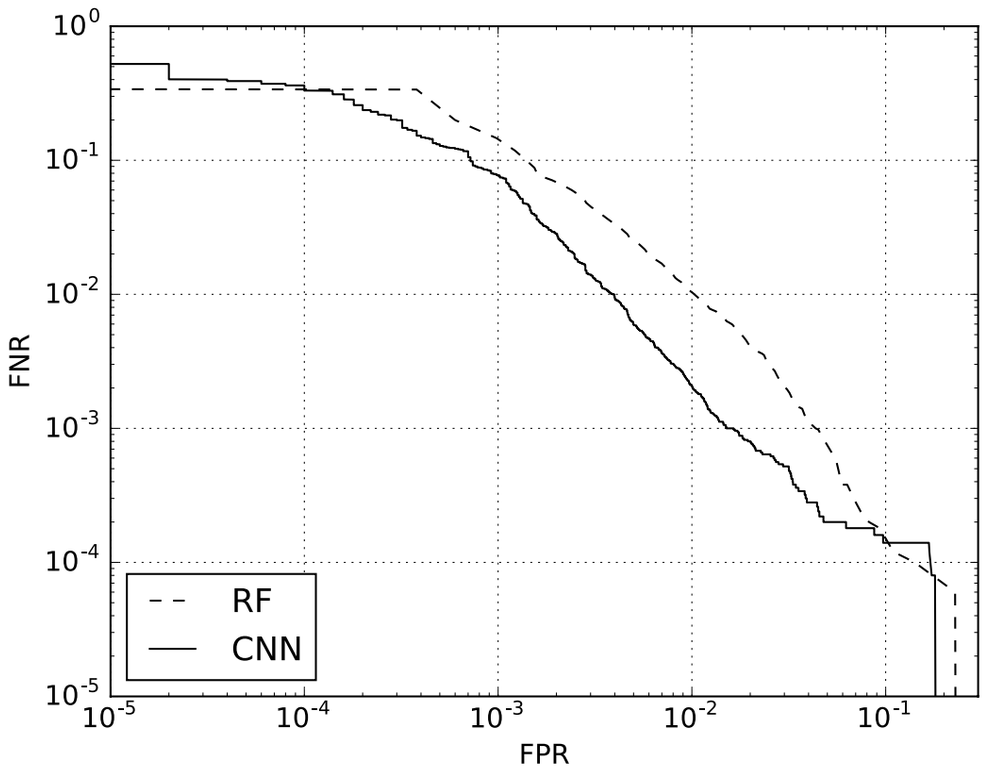

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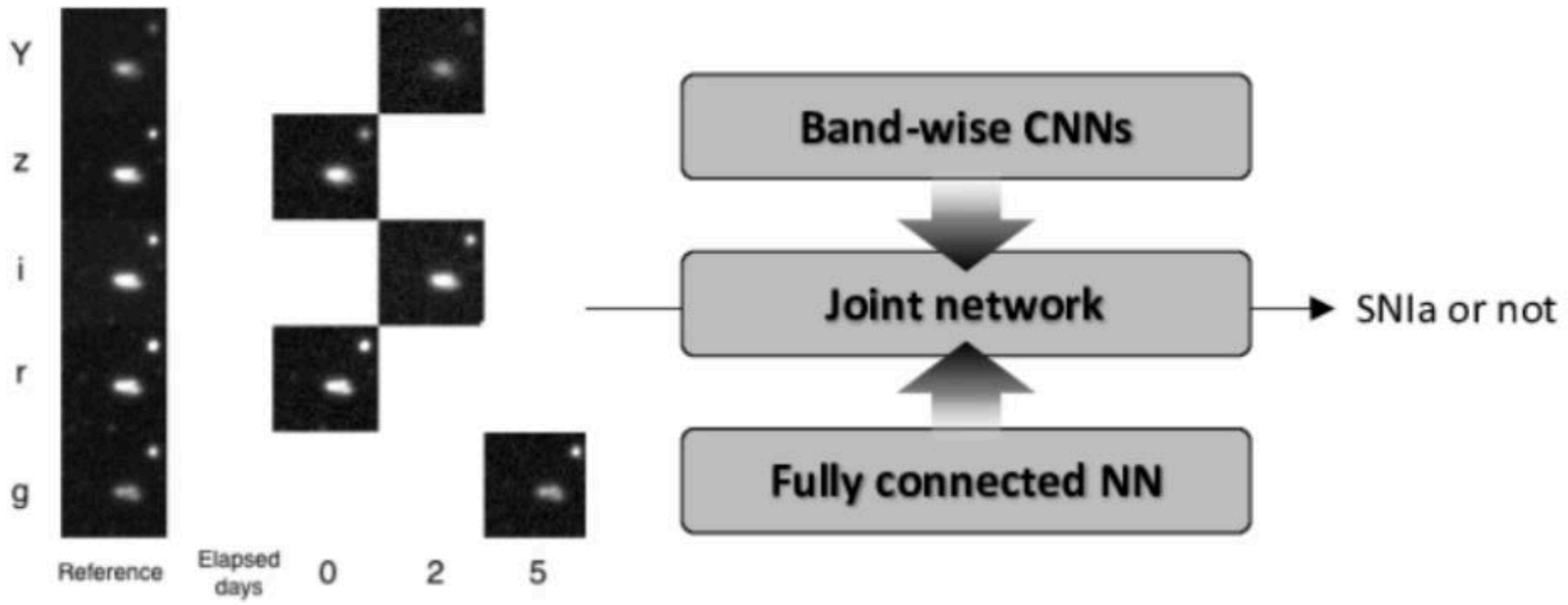

Astronomy Applications

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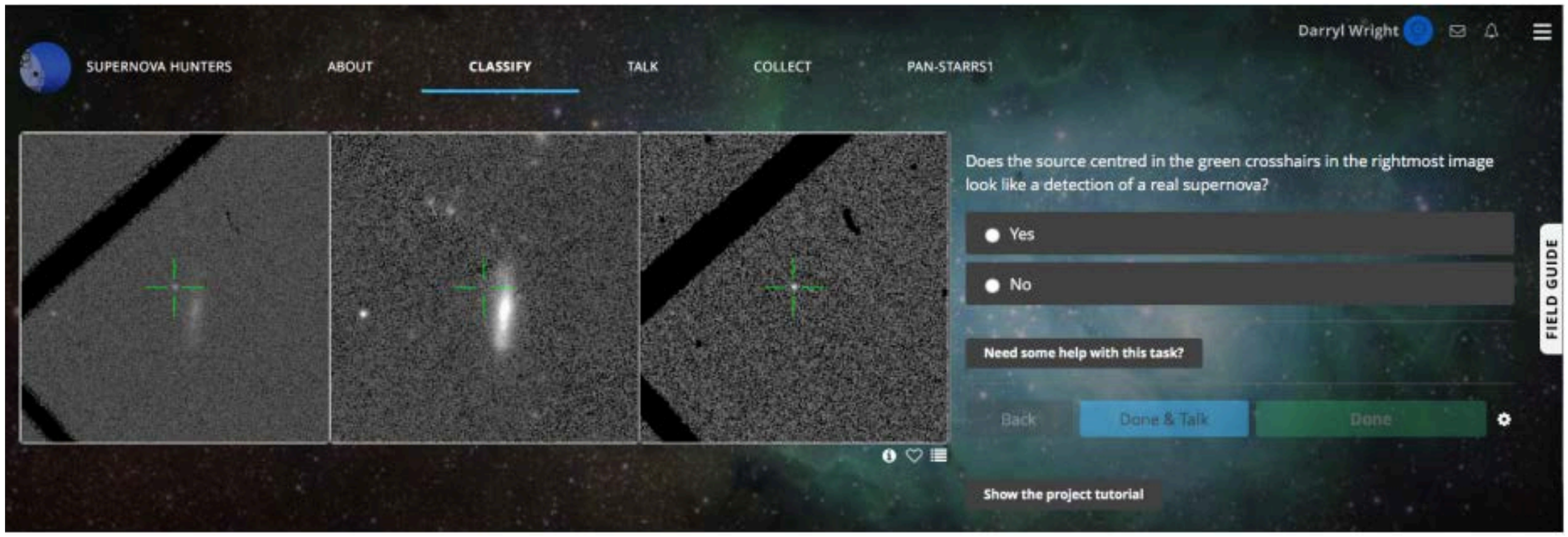

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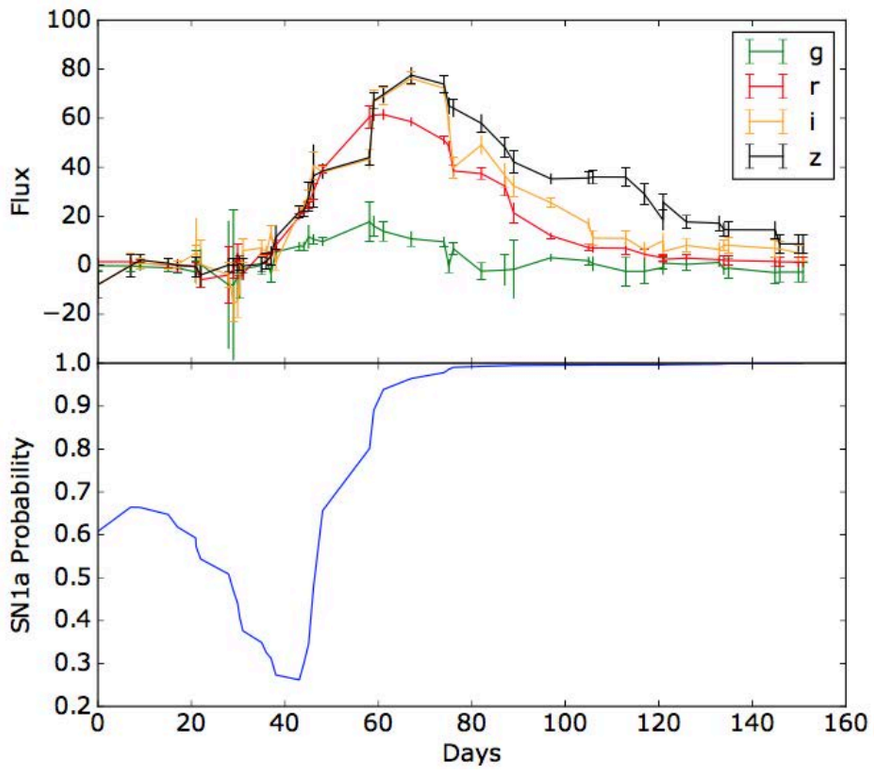

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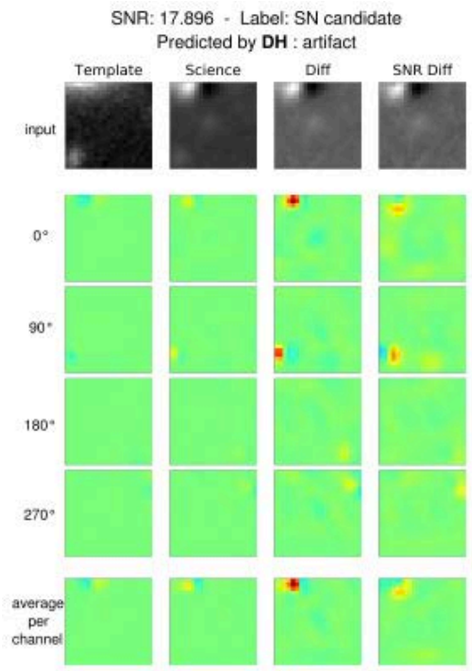

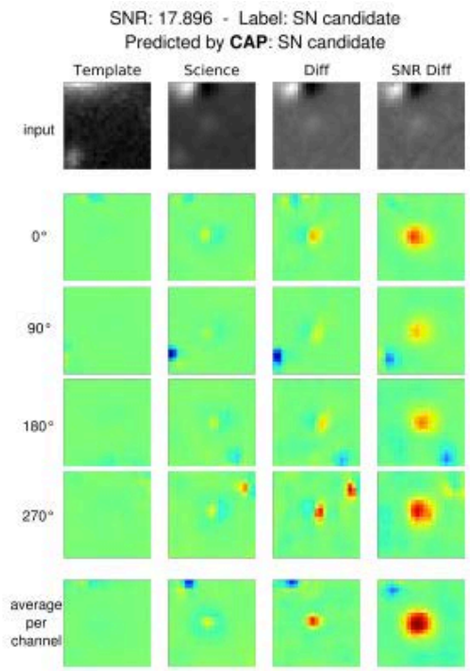

Astronomy Applications

Astronomy Applications

- **Gravitational Waves**
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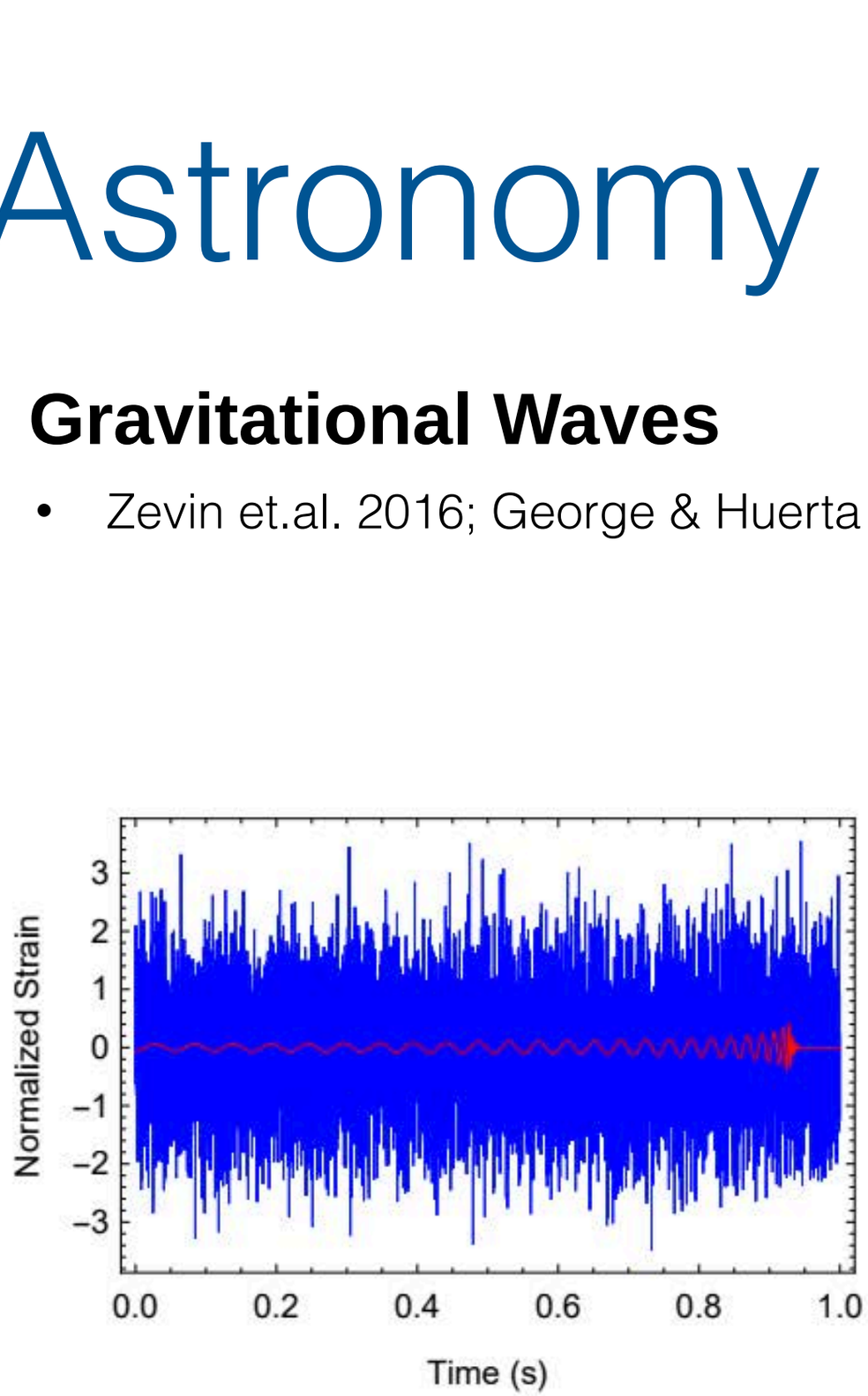

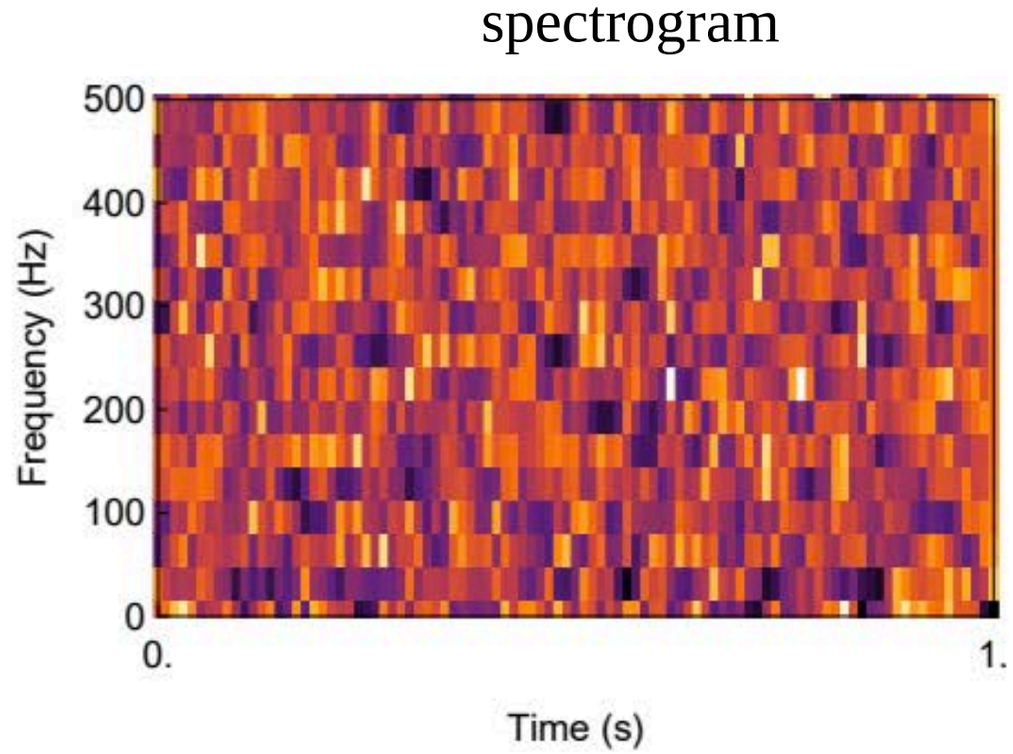

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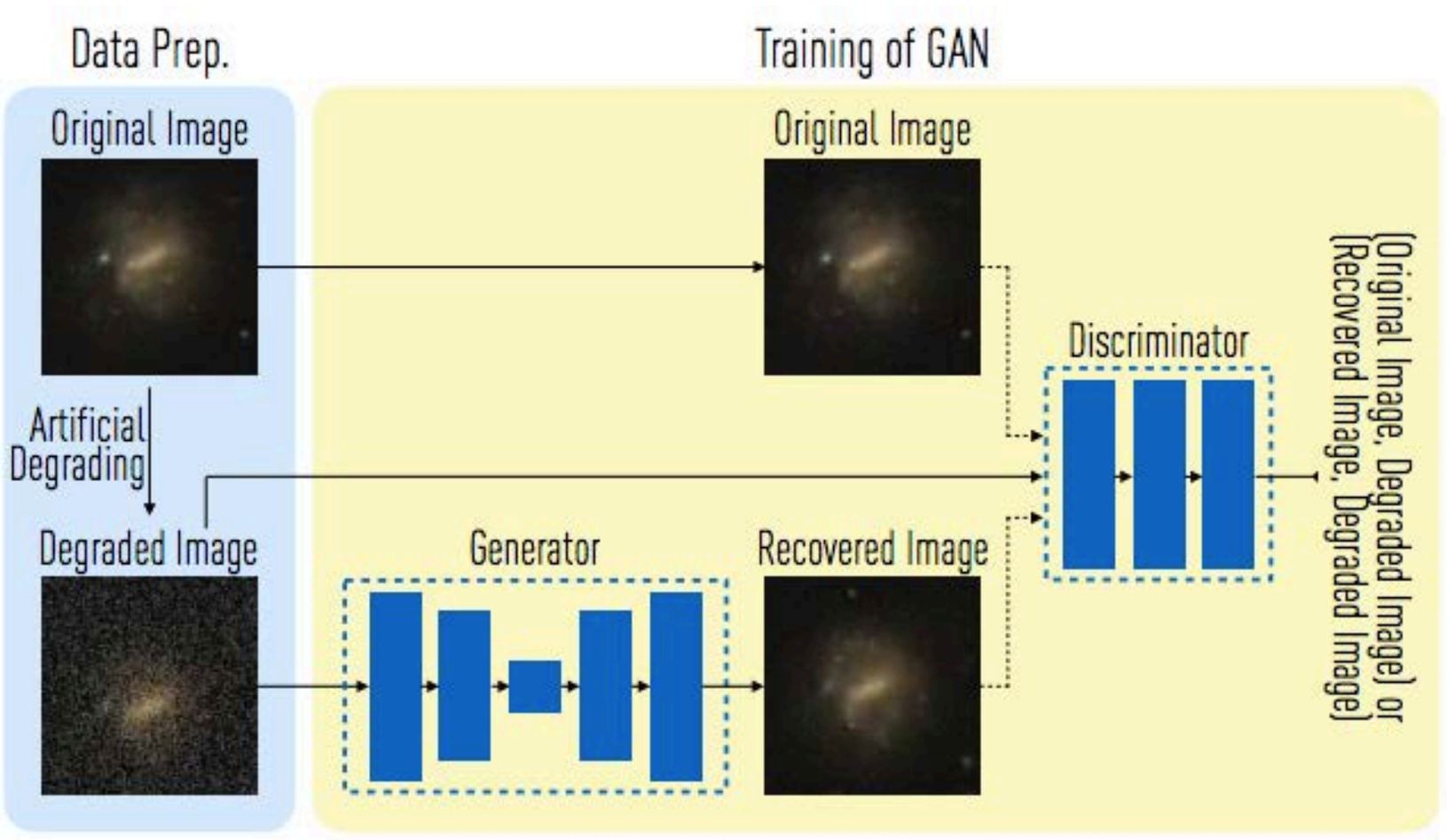

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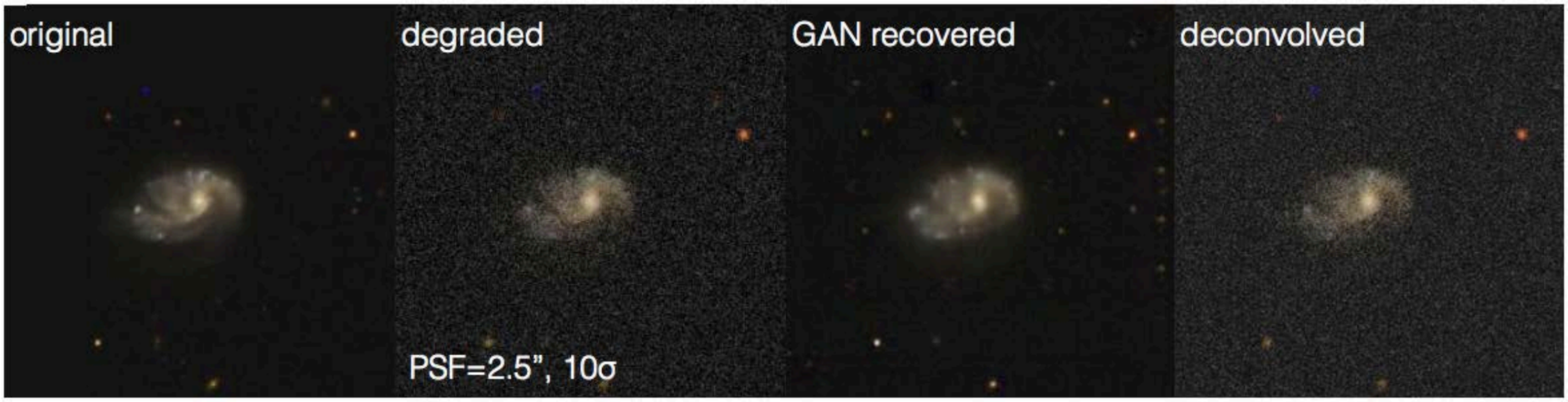

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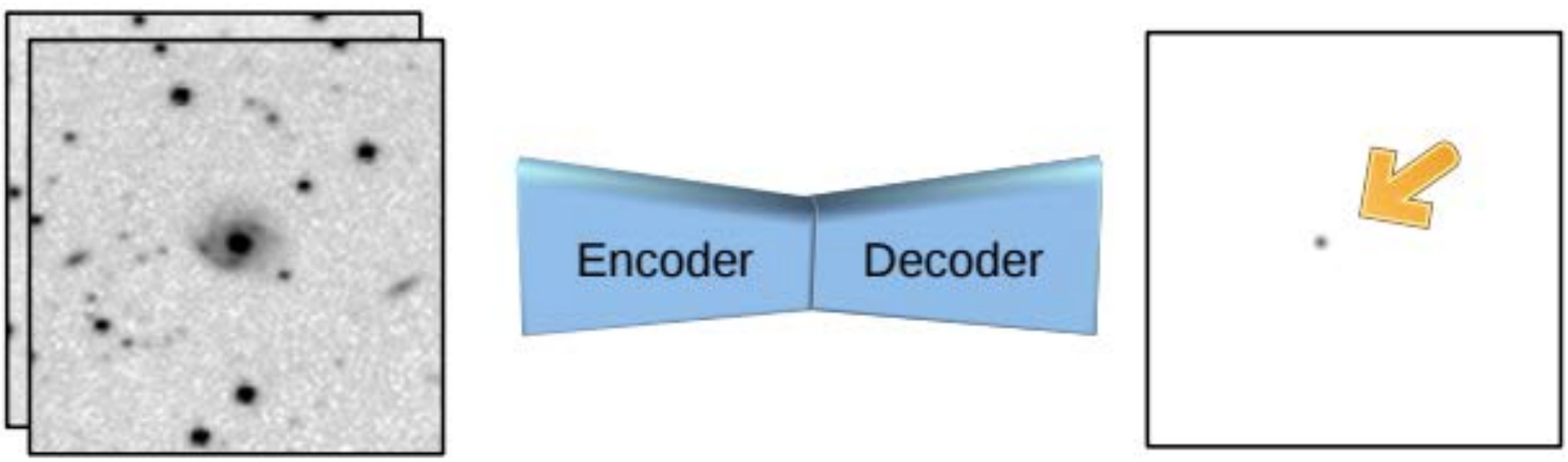


Deep Learning @ ALeRCE

The Present

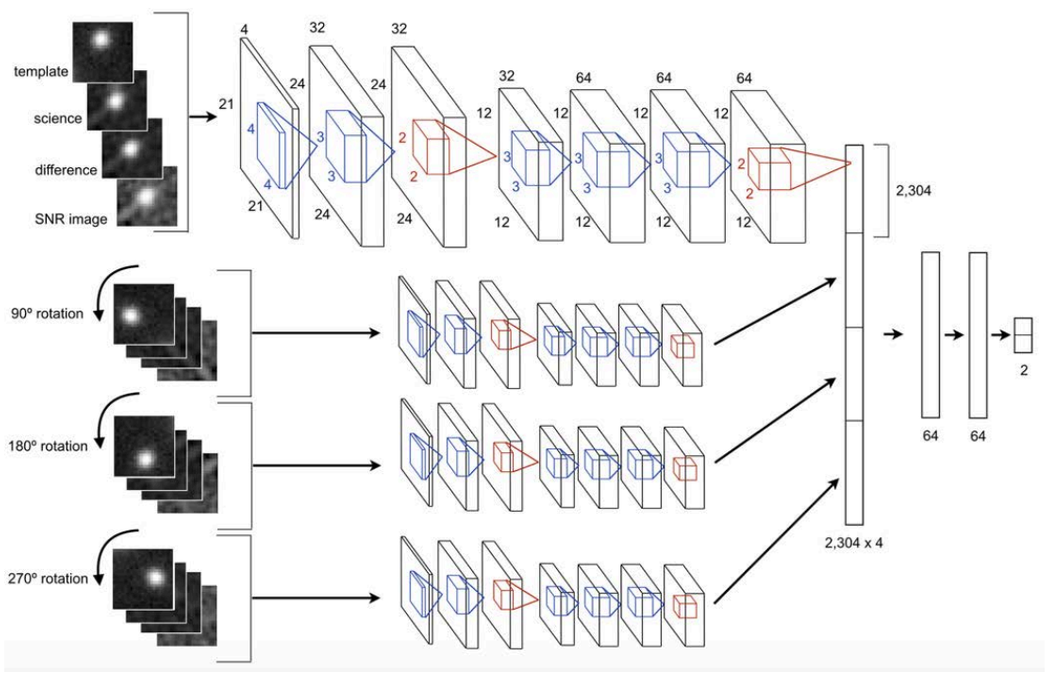
details in Pablo Estevez talk

Transient detection

Transient detection

Deep-HiTS

rotation invariant CNN



Cabrera-Vives et.al. 2016 & 2017

Transient detection

Deep-HiTS

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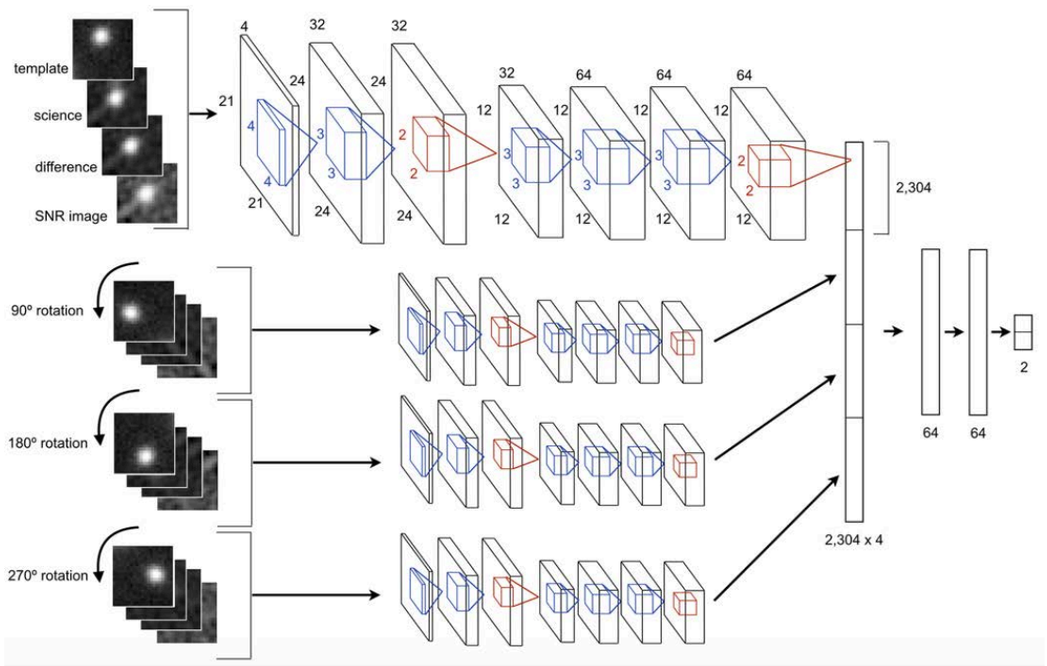
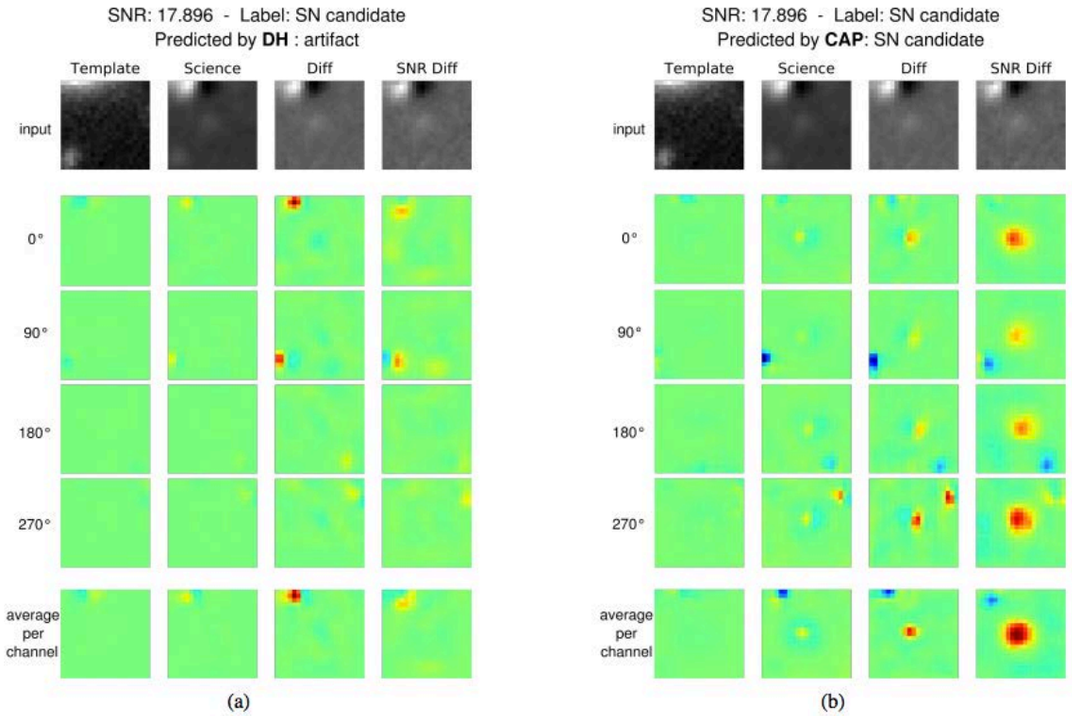


Cabrera-Vives et.al. 2016 & 2017

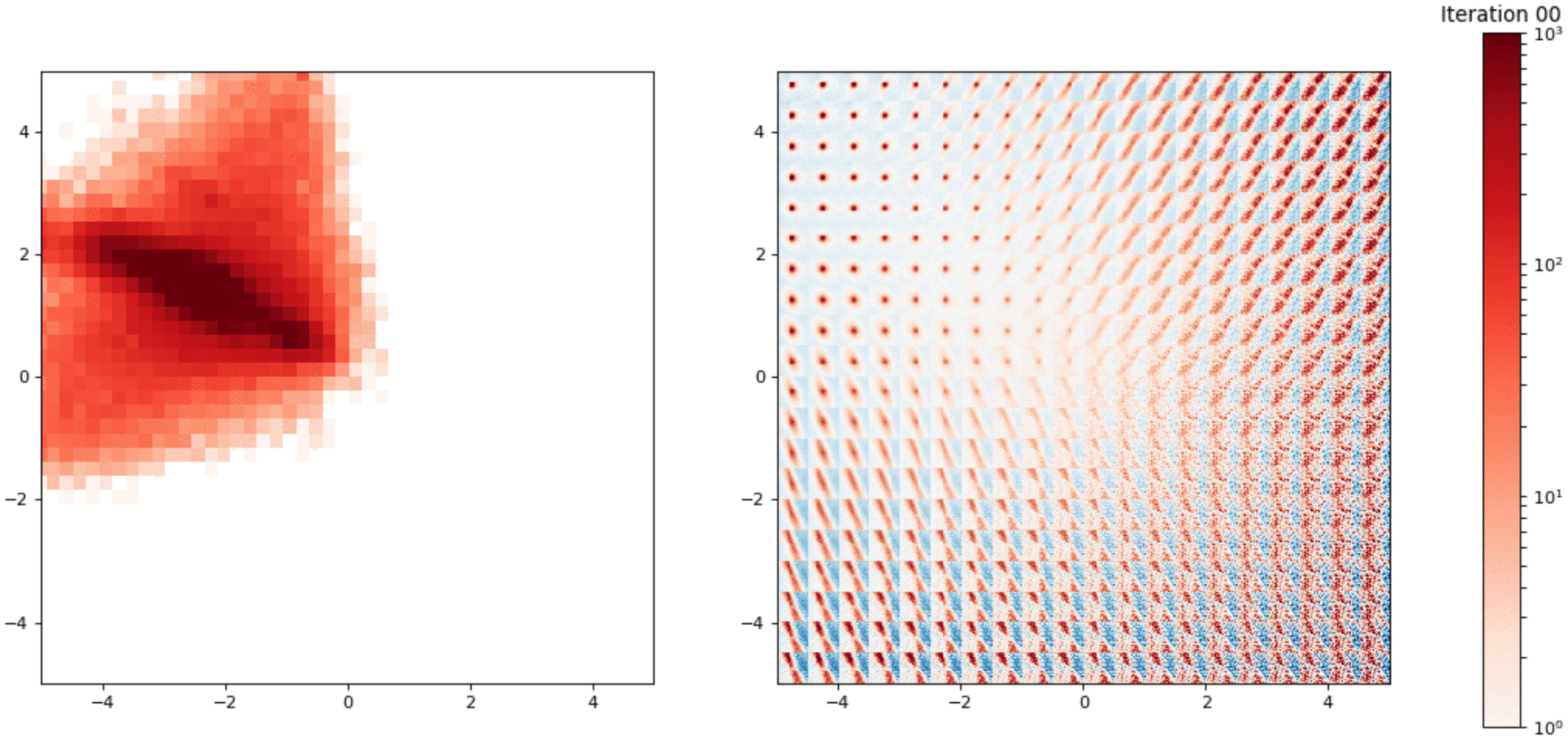
Enhanced Deep-HiTS

cyclic pooling layer



Reyes et.al. 2018

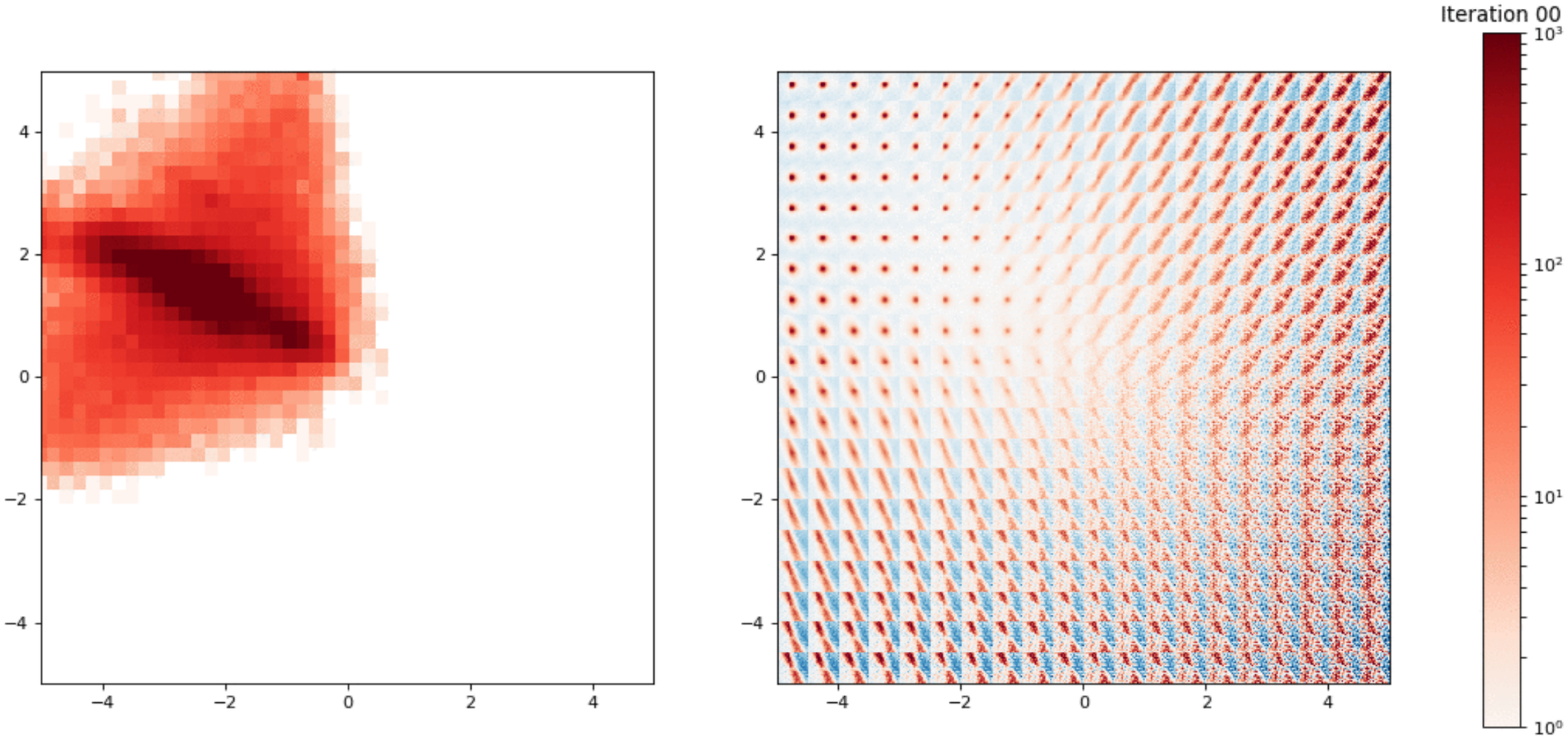
Latent variable models



Huijse et.al. 2018

Astorga et.al. 2018

Latent variable models



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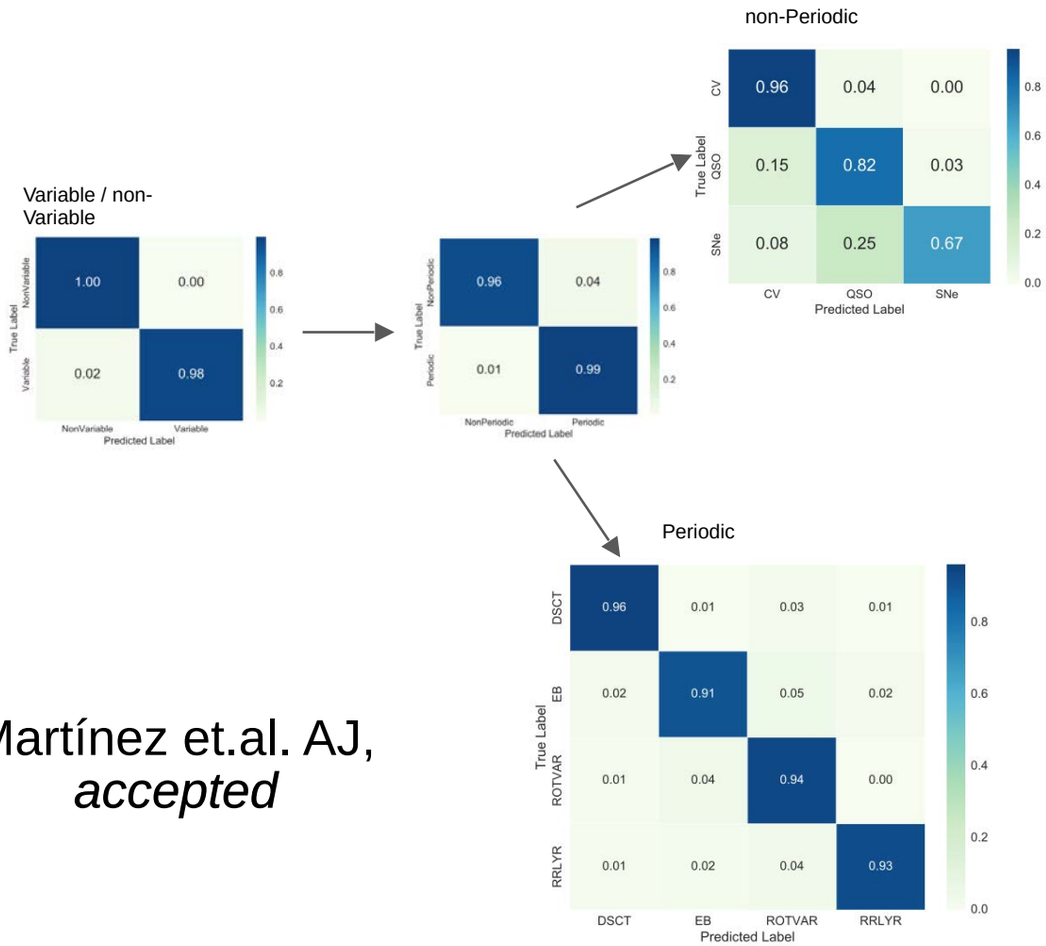
Light curves

Light curves

HiTS light-curve catalogue

Features + Random Forest



Martínez et.al. AJ, *accepted*

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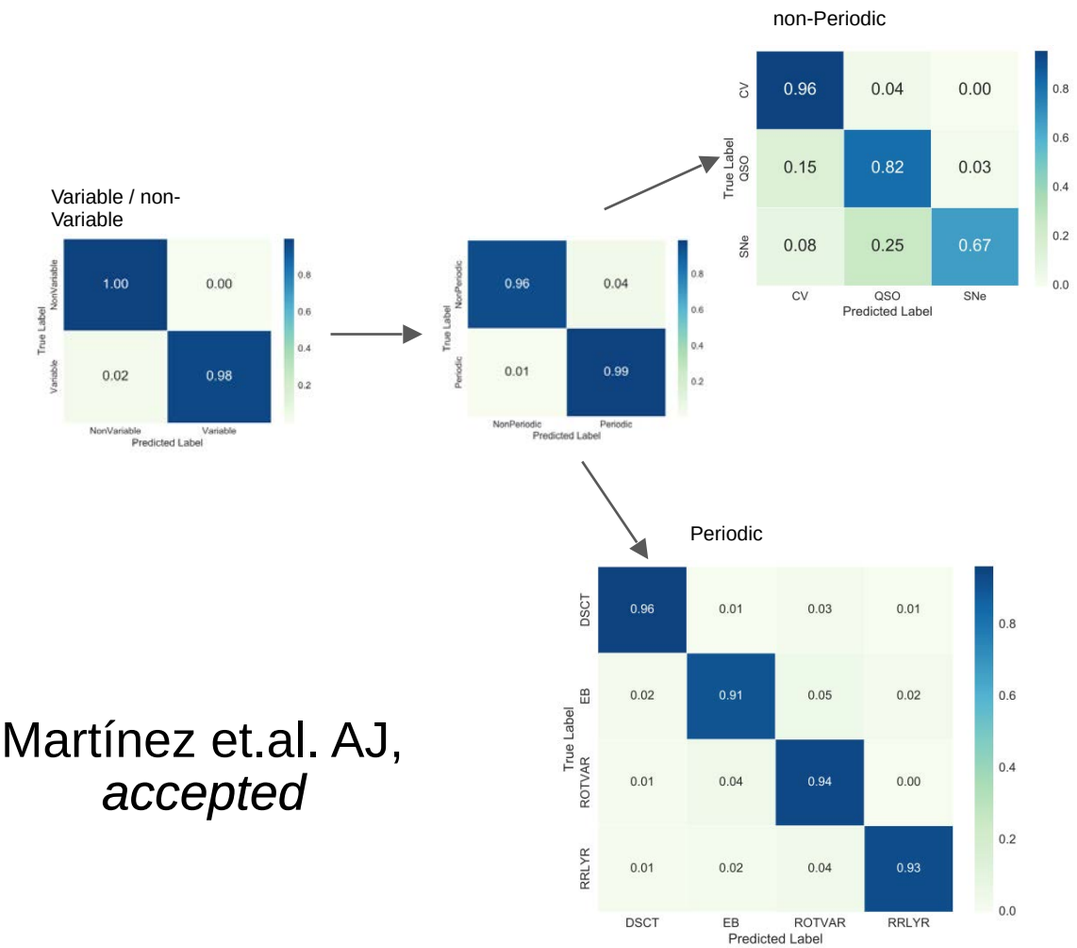

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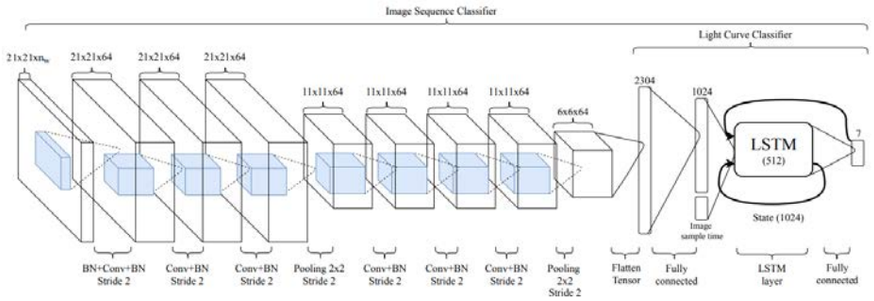
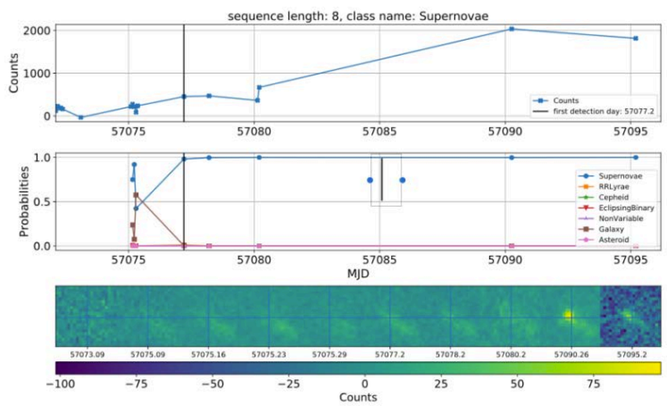
Image sequences

Convolutional recurrent NN





Carrasco-Davis et.al. *submitted*

The future

The future

- Transfer learning

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- Tailored models for irregularly sampled light curves

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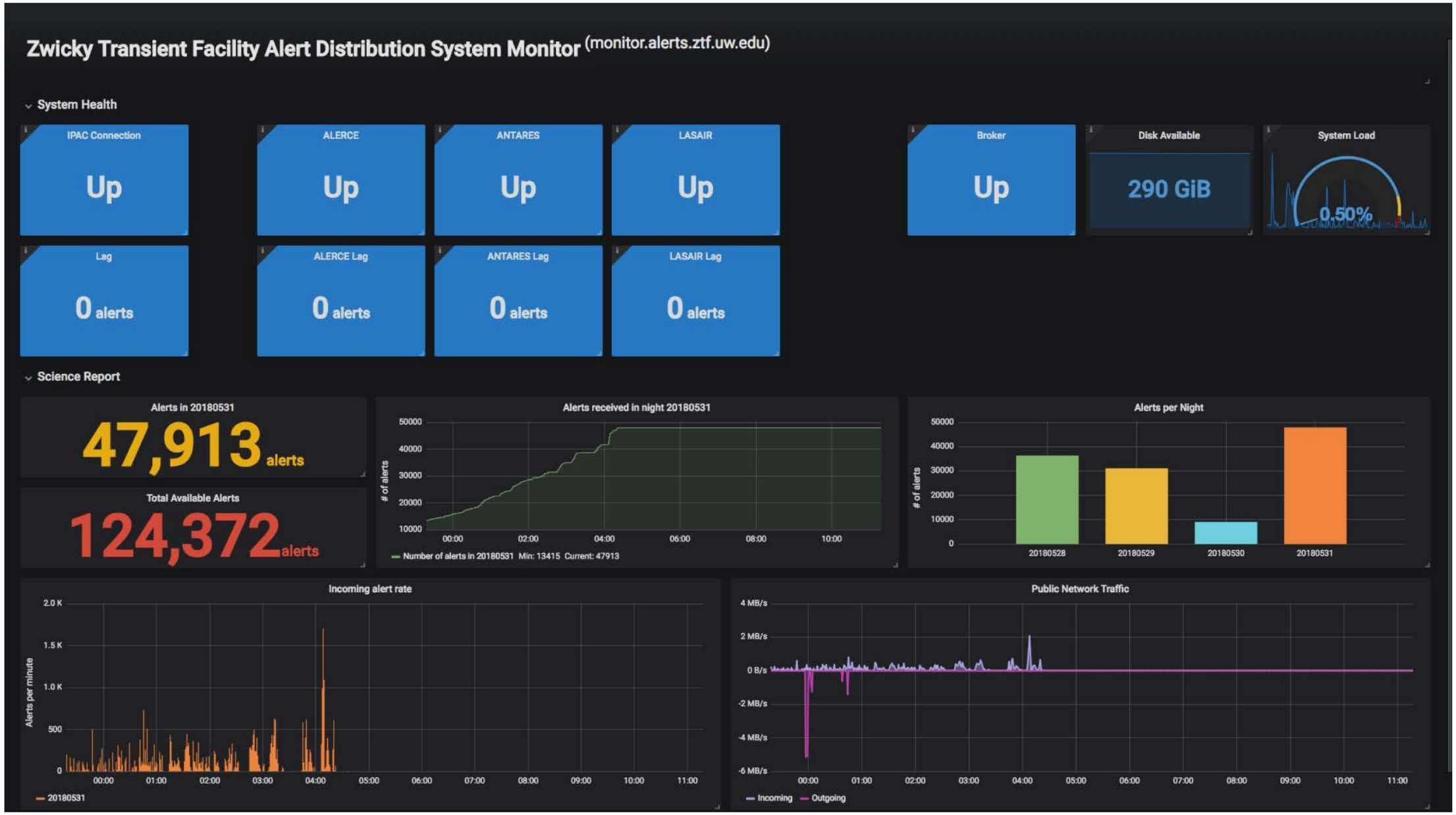
The future is NOW



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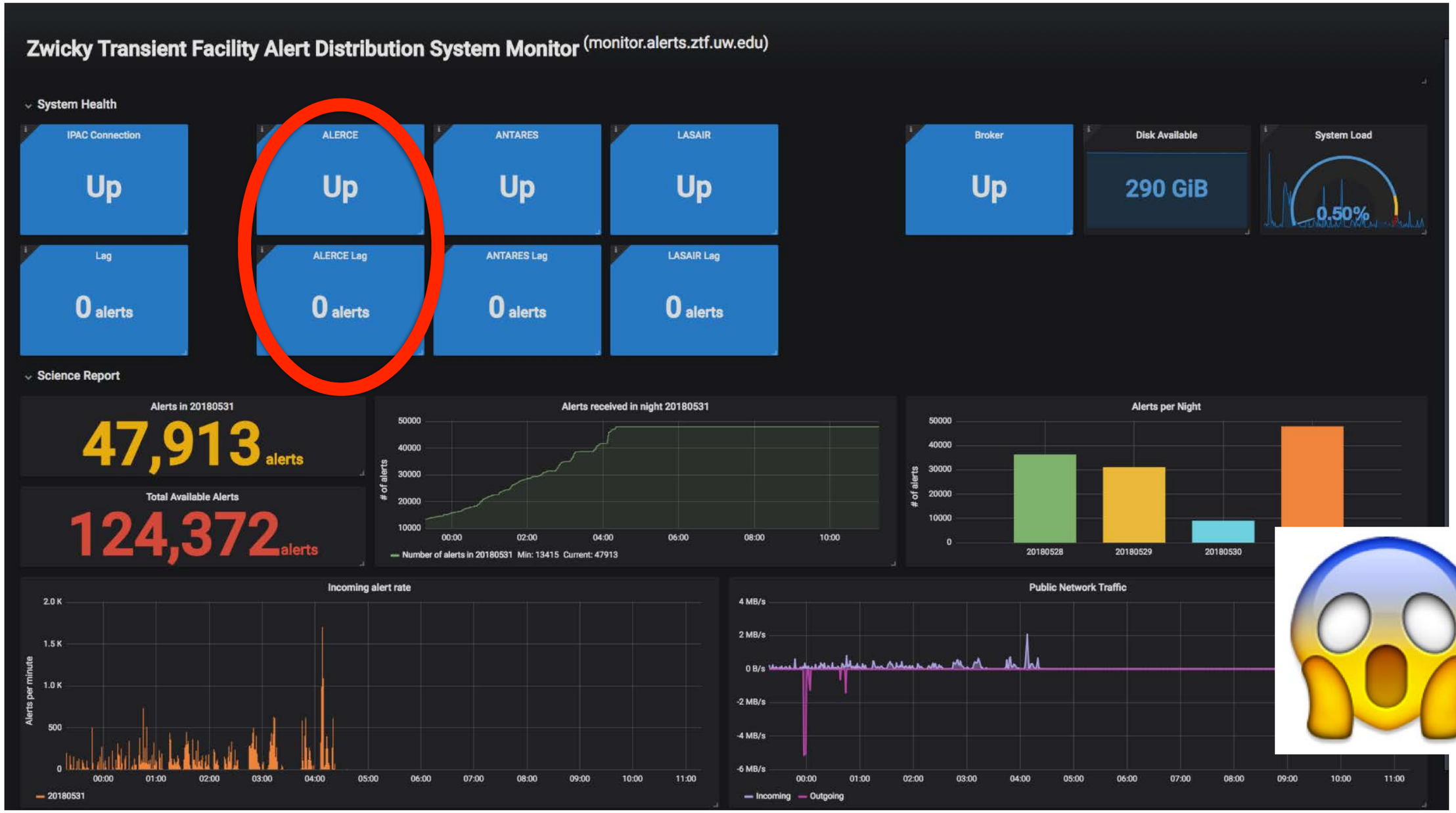
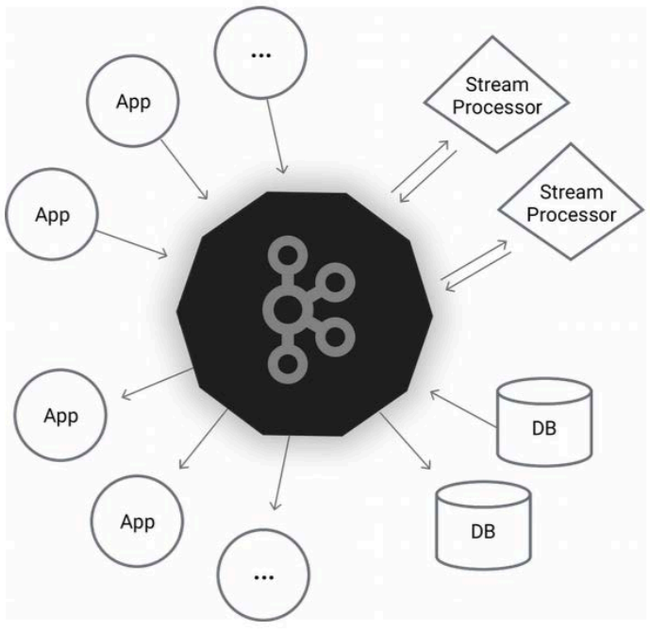


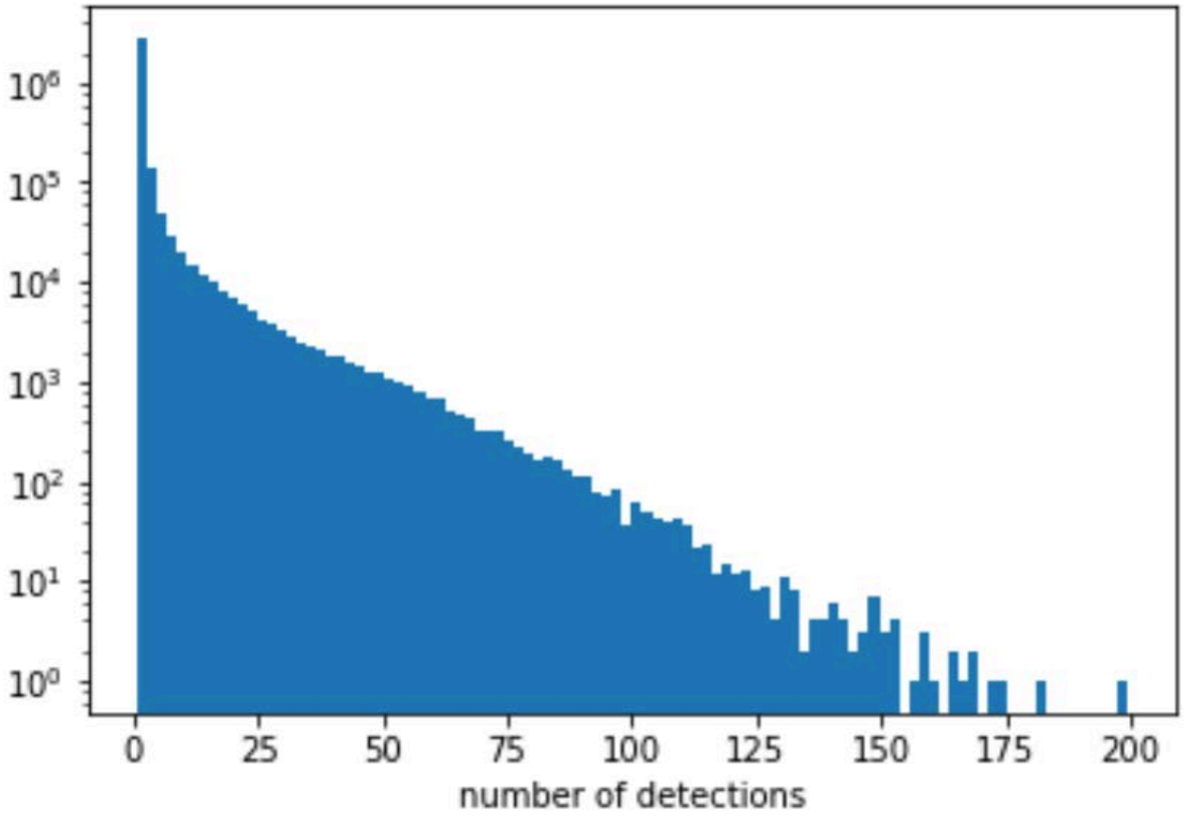
ZTF alerts: ALeRCE is ready to distribute!

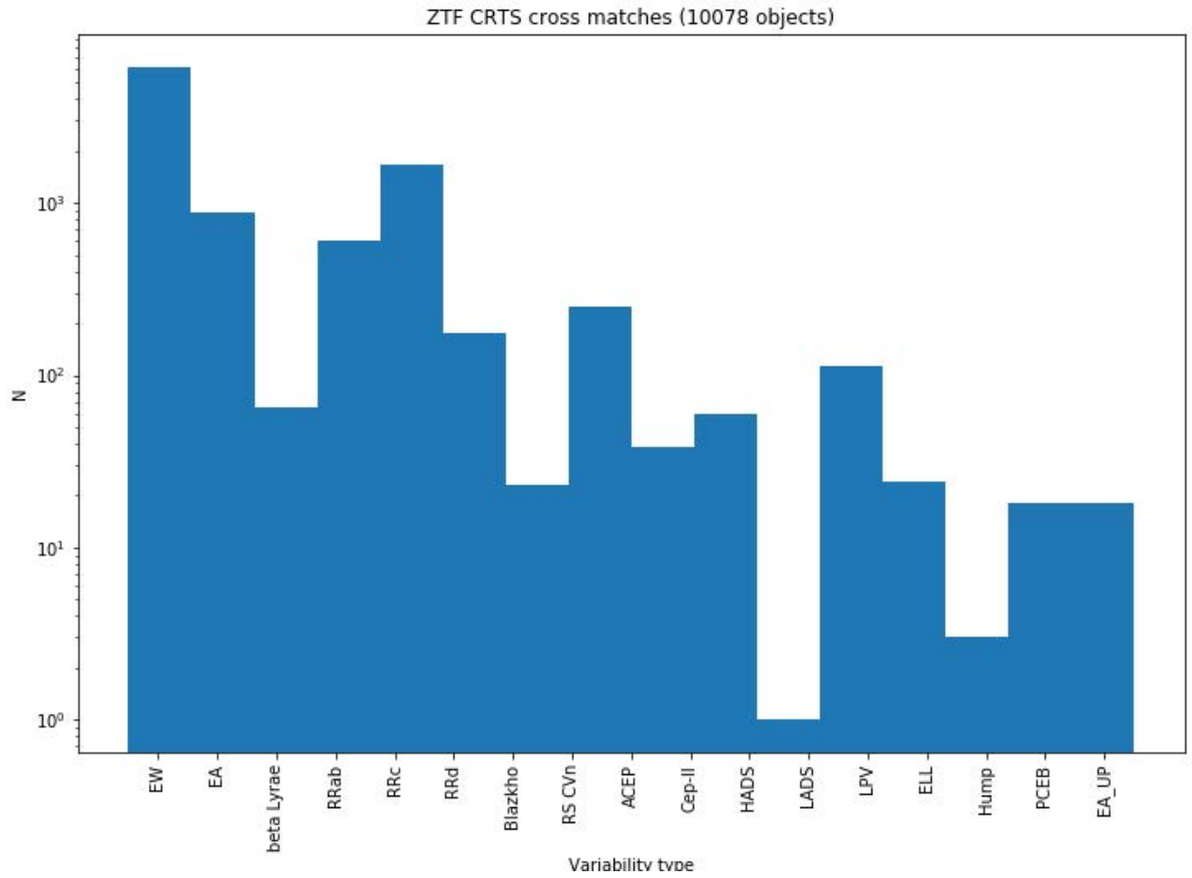


APACHE kafka
A distributed streaming platform

ALeRCE
Automatic Learning for the Rapid Classification of Events

ZTF alerts: we got data!





ALeRCE
Automatic Learning for the
Rapid Classification of Events

We are hiring!

- Full time engineer to work for the AleRCE project needed
- Funded by the Millennium Institute for Astrophysics and Center for Mathematical Modeling
- Experience in architecting, integrating, deploying, testing and maintaining computational systems
- Advanced knowledge of Linux system administration, proficiency in scripting languages such as python, good understanding in compiling software libraries, and skills in integration of software via scripting interfaces are required.

See http://alerce.science for more details

Summary

ALeRCE.science

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ALeRCE.science

- **ALeRCE**: real-time classification of alert streams (e.g. ZTF, HATPI, LSST)

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ALeRCE.science

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ALeRCE.science

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- We are currently able to redistribute alerts
- Coming soon: distribution of labeled alerts

ALeRCE.science

Deep learning in Astronomy and its application to transient detection within the **ALeRCE** system

THANK YOU

Guillermo Cabrera-Vives
guillecabrera@inf.udec.cl

Andrew Connolly, Pablo Estévez, Susana Eyheramendi, Francisco Förster, Matthew Graham, Pablo Huijse, Ashish Mahabal, Juan Carlos Maureira, Karim Pichara, Giuliano Pignata, Pavlos Protopapas, Andrea Rodríguez