Detecting Stellar Streams Through Deep Learning

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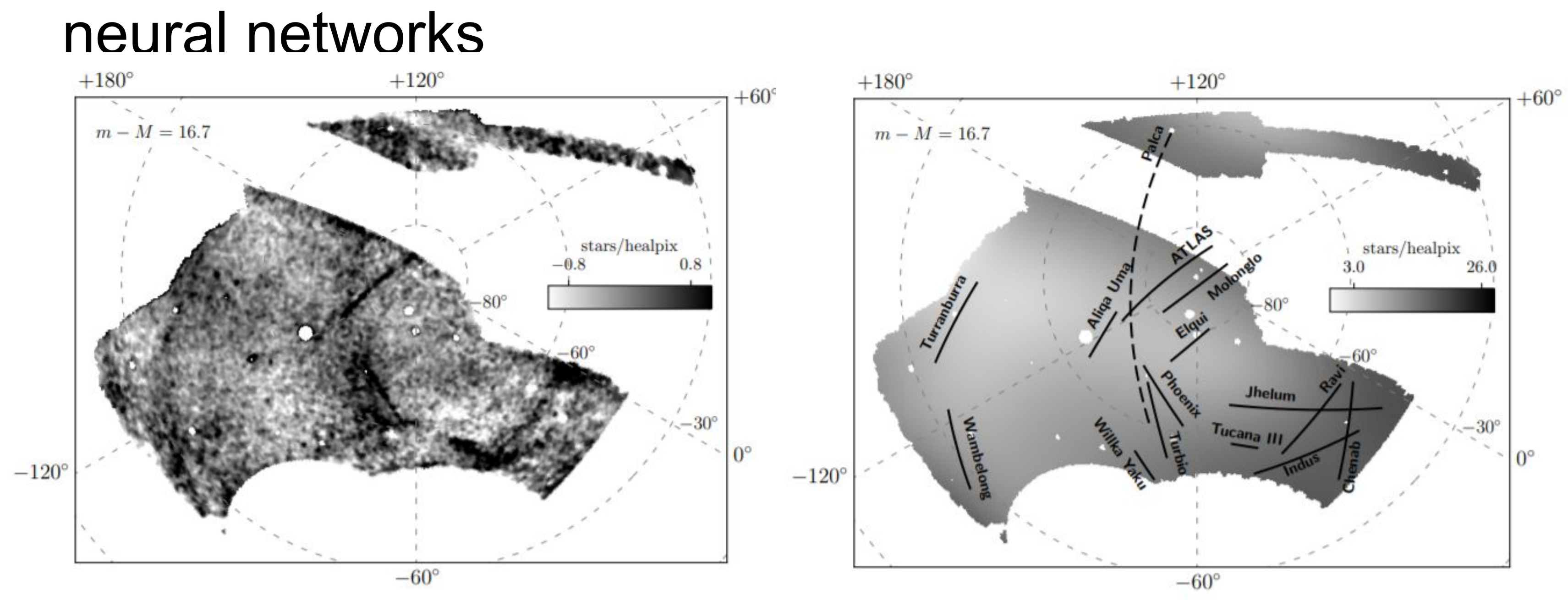
Background and Motivation

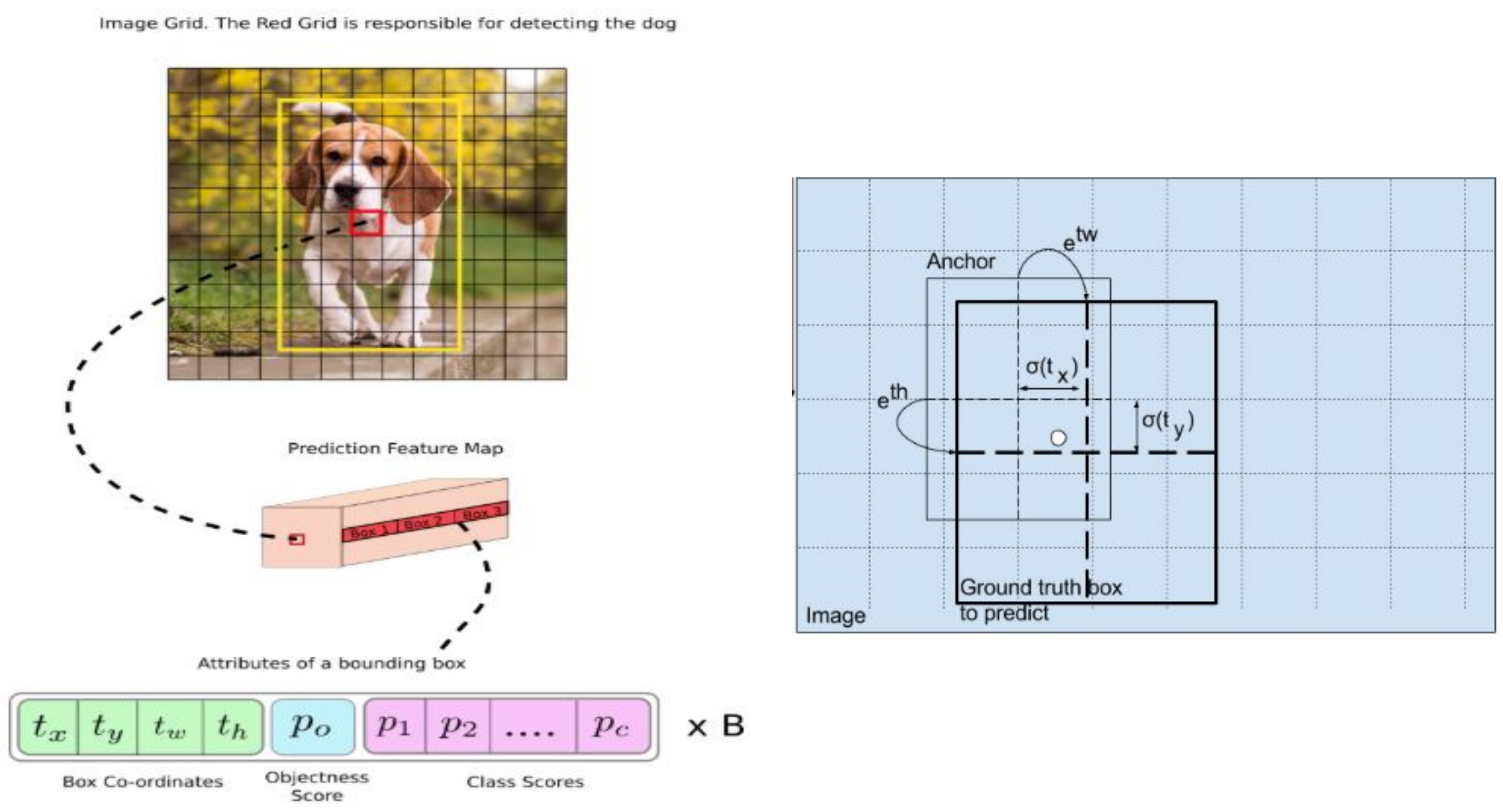
- Stellar streams help us measure the gravitational potential of our galaxy and may reveal the existence of dark matter substructures
- The goal of this project was to implement a way to detect and localize stellar streams in a given skymap through neural networks



Stellar stream data from DES (Ref: Shipp, et. al. arXiv:1801.03097)

Approach

OBJECT DETECTION - Convolutional Neural Networks (CNN) identify objects in images by having different layers of the network learn different features of the objects. Because we were interested in both detecting and localizing streams, the neural network thought best for the task was **YOLO,** a modified CNN that predicts bounding boxes for the objects in the images.

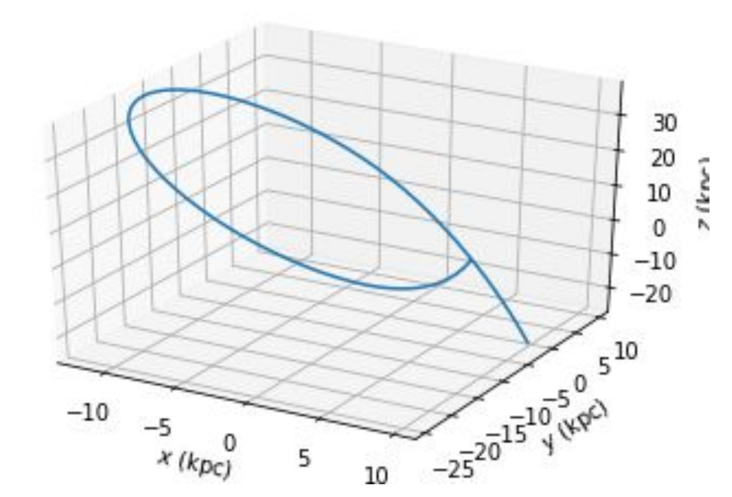


YOLO detection mechanism (Ref: Karol Majek)

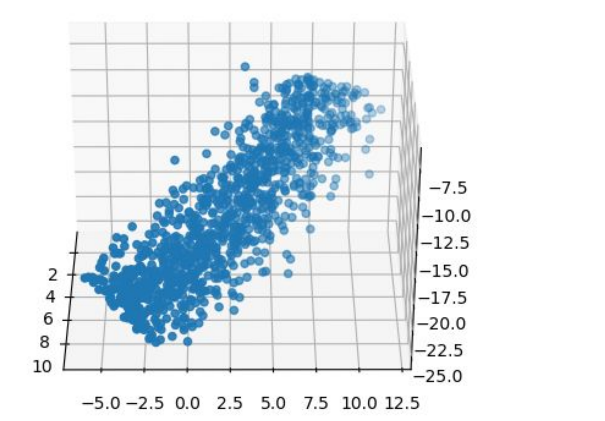
Methodology

STEP 1 - Constructing simulated stream data

- Phase 1 - Identify viable progenitors using the Galpy Python package and populate a section of their orbit with stars
- Phase 2 - Construct a healpixelized map of the background and stream with isochrone selection cuts, and convert that to an image
- Phase 3 - Box the streams in the image



Simulated orbit of a progenitor star

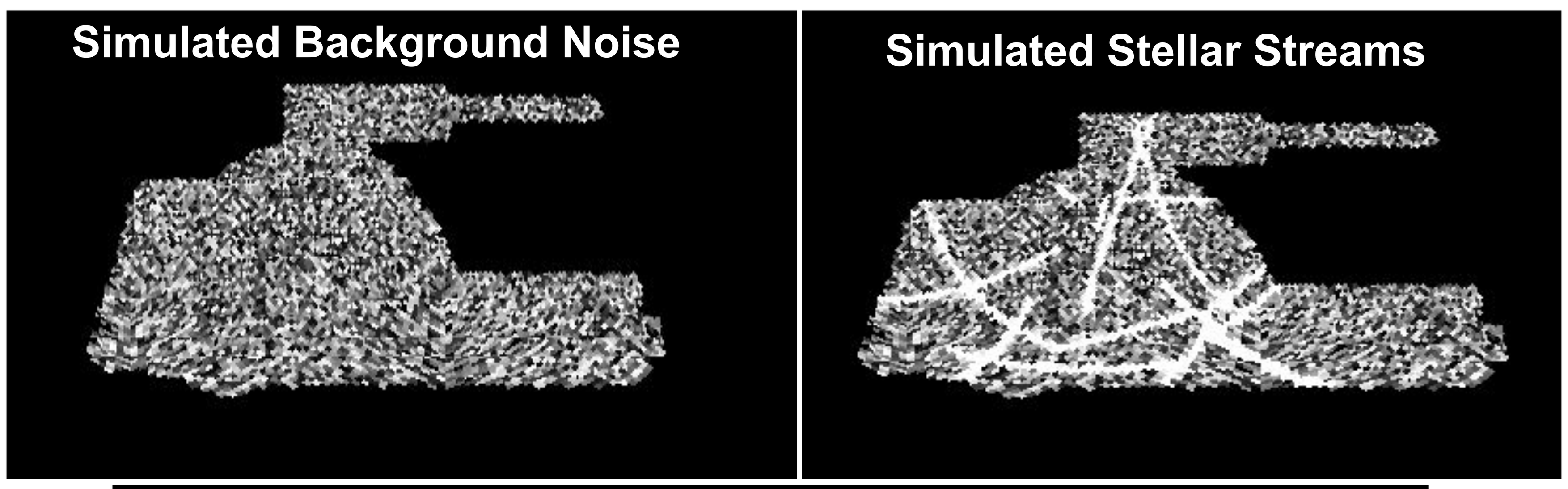


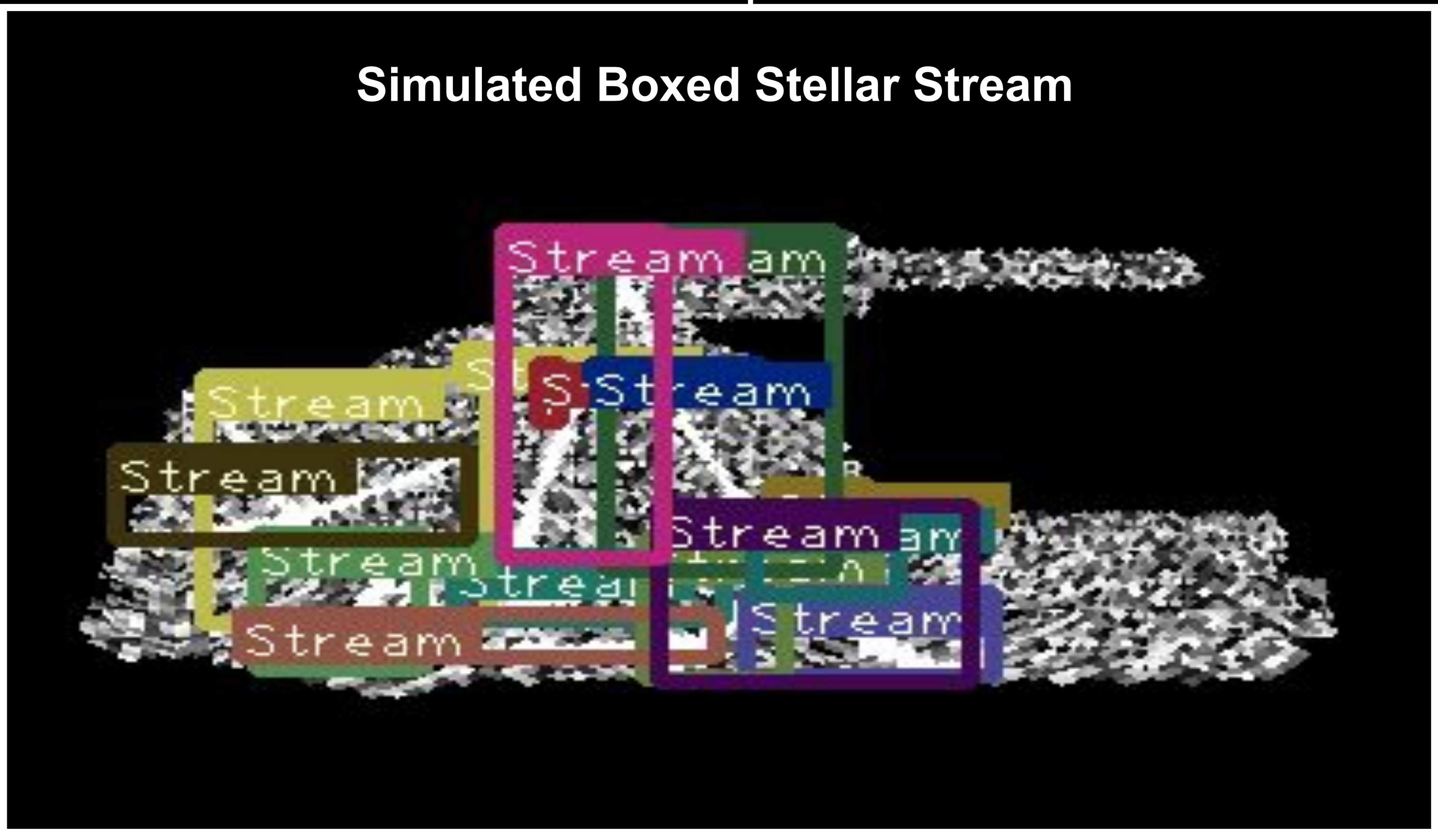
Simulated stream along such a orbit

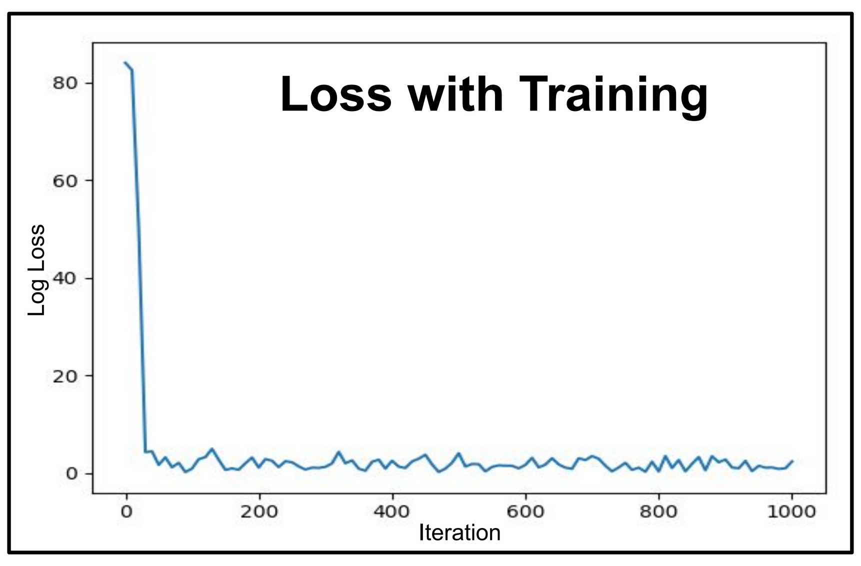
STEP 2 - Training the YOLO detection algorithm on the data

- Train and test the NN with the images from step 1
- Adjust hyperparameters and training parameters for the best performance

Preliminary Results







Conclusion and Future Steps

CURRENT STATUS - Trained the network effectively, still working to test it

FUTURE STEPS

- Test the performance and adjust hyperparameters
- Test the performance of the network on real data and adjust the simulation accordingly

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