A Machine Learning Approach to HII Region Kinematics

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Introduction

HII Regions

- HII regions are formed from gaseous clumps ionized by young, hot OB stars
- Characterized by strong recombination or collisional emission lines
- Tracers of different feedback mechanisms

SITELLE/SIGNALS

- Imaginig Fourier Transform Spectrograph at Canada-France-Hawai'i Telescope
- 11'x11' Field-of-View
- Spectral Resolution up to 10,000
- Star formation, Ionized Gas, and Nebular Abundances Legacy Survey

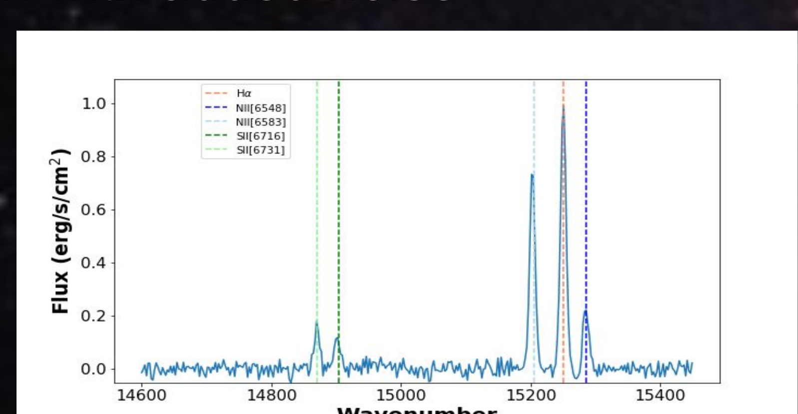
The Issue

Standard fitting procedures require a priori estimates of kinematic parameters that are often unknown initially. Our solution is to use machine learning to estimate these variables

Training

SITELLE Filter SN3 (657-685 nm)
Sincgauss function with added noise
30,000 Total

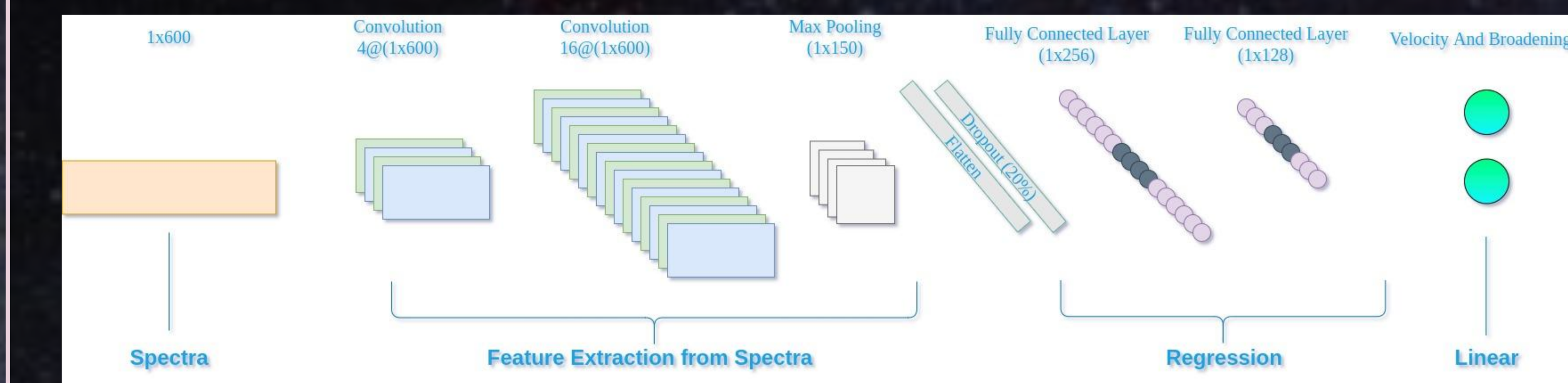
- [NII[λ6548
- [NII[λ6583
- [SII[λ6716
- [SII[λ6731
- Hα6563Å



References:

Martin et al. 2016, MNRAS, 463
Fabbro et al. 2018, MNRAS, 475
Asari et al. 2016, MNRAS, 460
Drissen et al. 2019, MNRAS, 485

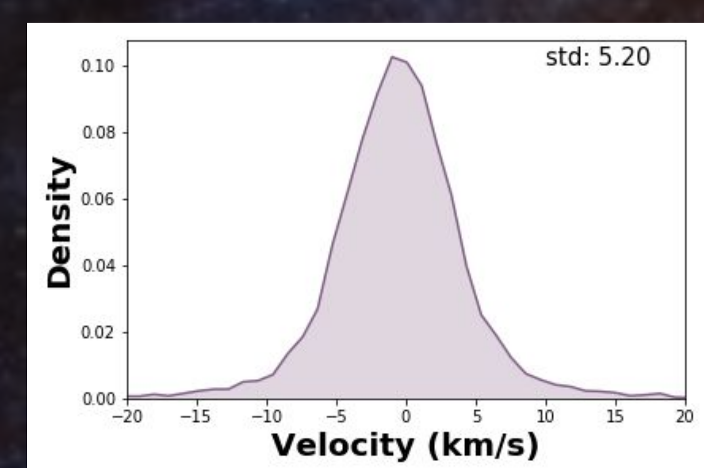
The Convolutional Neural Network

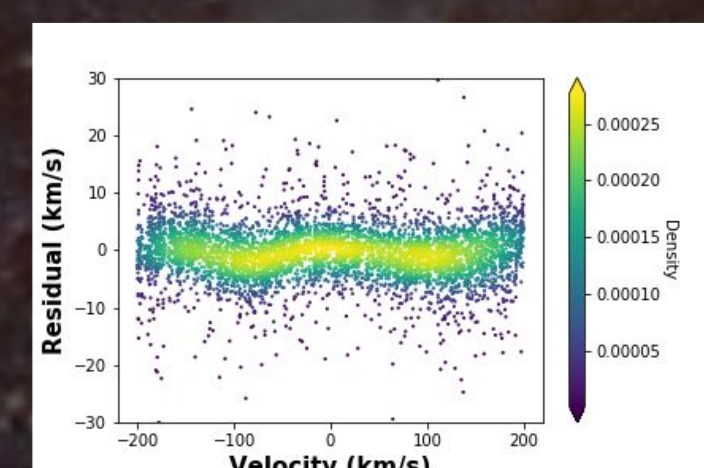


- Input: Spectrum Vector
- Activations: RELU
- Optimizer: ADAM
- Final: Linear
- Output: Velocity and Broadening in km/s

Velocity & Broadening Results

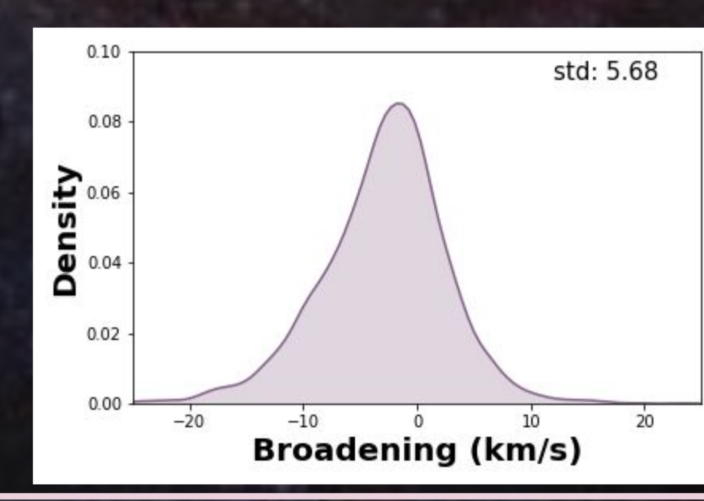
Divided Synthethic Data into Training Set (70%), Validation Set (20%), and Test Set (10%)

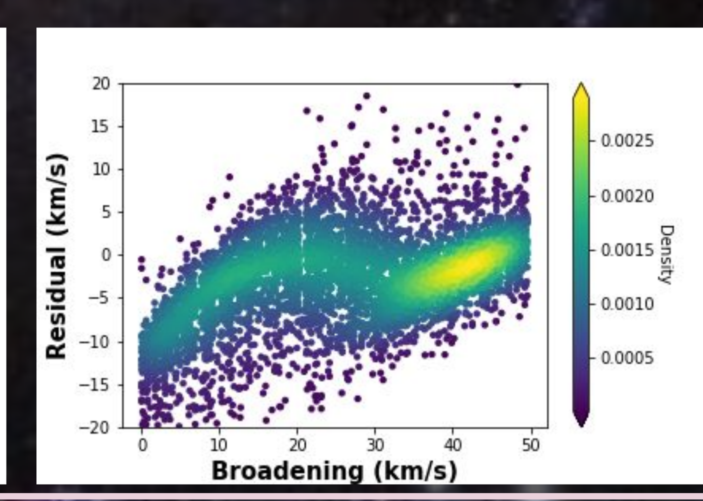




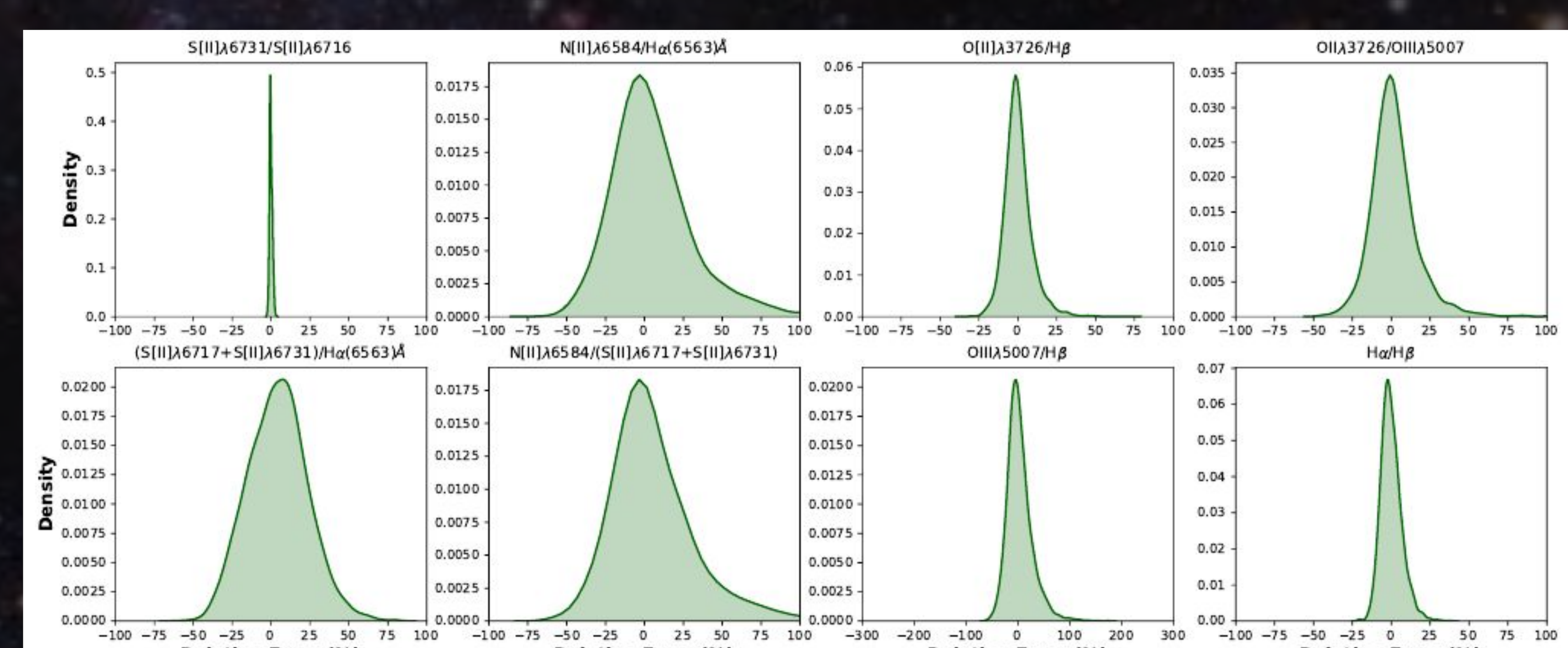
Errors are similar to those calculated using ORCS fitting software

Errors are close to the resolution limit of SITELLE



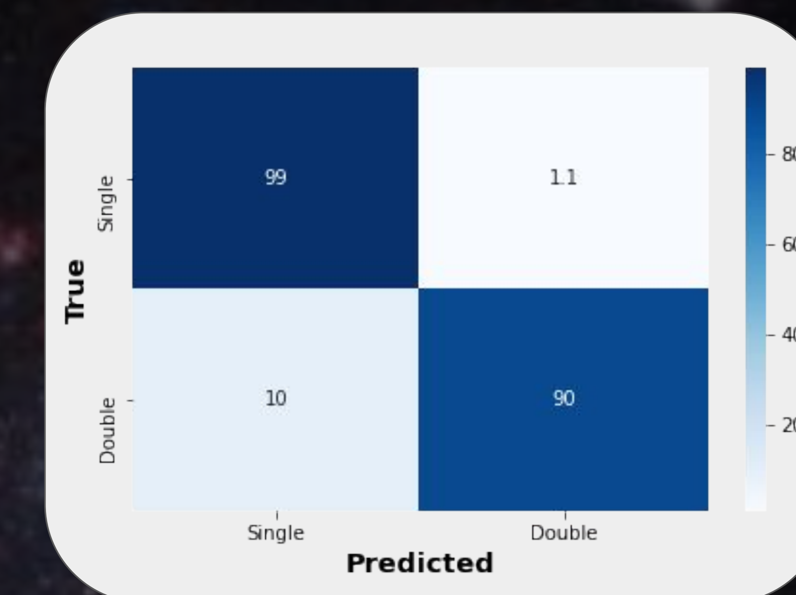


Emission Line Ratio Results



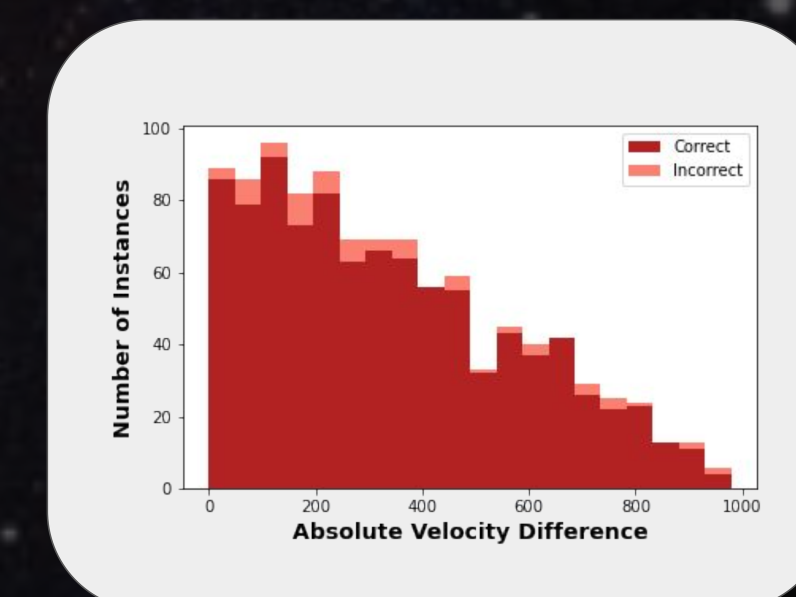
[SII]6716/[SII]6731
[SII]/[NII]
[SII]/Hα
[NII]/Hα
[OII]/[OII]
[OII]/Hβ
[OII]/Hβ
Hα/Hβ

Multiple Component Results



Confusion Matrix on the test set demonstrating the network's ability to determine the number of components

Histogram of correct/incorrect classifications as a function as the absolute velocity difference for lines with two components



Conclusions:

- ★ Machine Learning is a viable method for emission line analysis
- ★ Training set must be developed with care
- ★ Errors are similar to those achieved with traditional methods
- ★ Considerably less computationally expensive than traditional methods

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https://crhea93.github.io
https://github.com/sitelle-signals/Pamplemousse