DASH: Deep Learning for the Spectral Classification of Supernovae

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INTRODUCTION

Overview

DASH is a supernova spectral classification tool that has greatly improved upon the speed and accuracy of current classification tools such as SNID and Superfit. It has employed a novel approach that does not rely on iterative template matching like previous software, but instead makes use of a deep neural network to train a matching algorithm. This has enabled DASH to be over 100 times faster than Superfit while also being just as accurate. Two user interfaces available on GitHub and PyPI have been developed: including a graphical interface for easy visual classification, and a python library for autonomous and quick classification of several spectra.

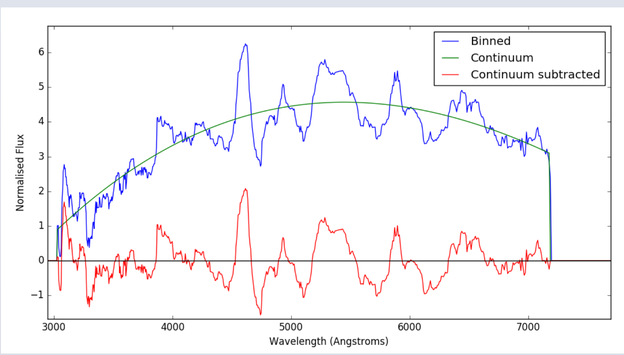
Motivation

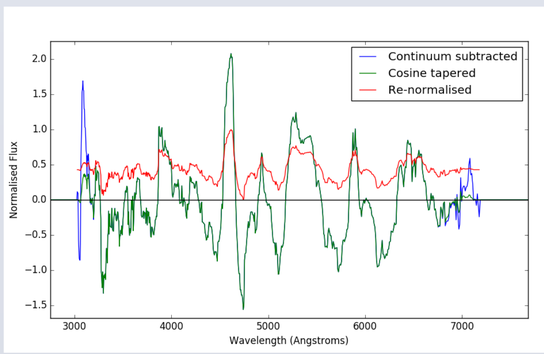
- In 2011 the Nobel Prize in Physics was awarded for the discovery that the universe is accelerating.
- Type Ia Supernovae have provided the most compelling evidence for this discovery.
- The Australian sector of a world-wide collaboration known as the Dark Energy Survey (OzDES) is observing thousands of supernovae that need to be classified.
- DASH should automate the classification process of the Type, Age, and Redshift of each supernova spectrum in the presence of host galaxy light.

TRAINING DATA

Preprocessing

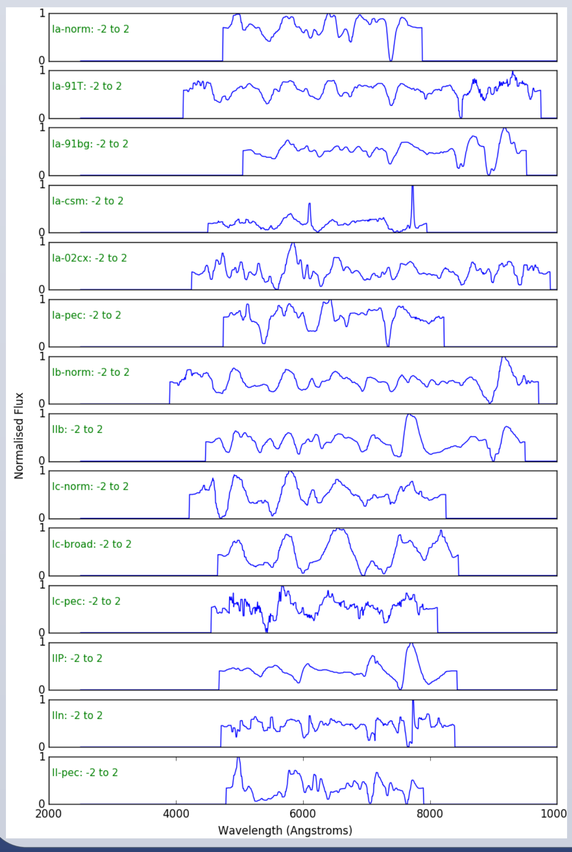
1. Filter the signal with a median low-pass filter.
2. De-redshift the signal.
3. Bin the spectrum onto a 1024-point vector on a log-wavelength scale.
4. Subtract the continuum using a spline fit.
5. Cosine taper the edges to remove discontinuities.

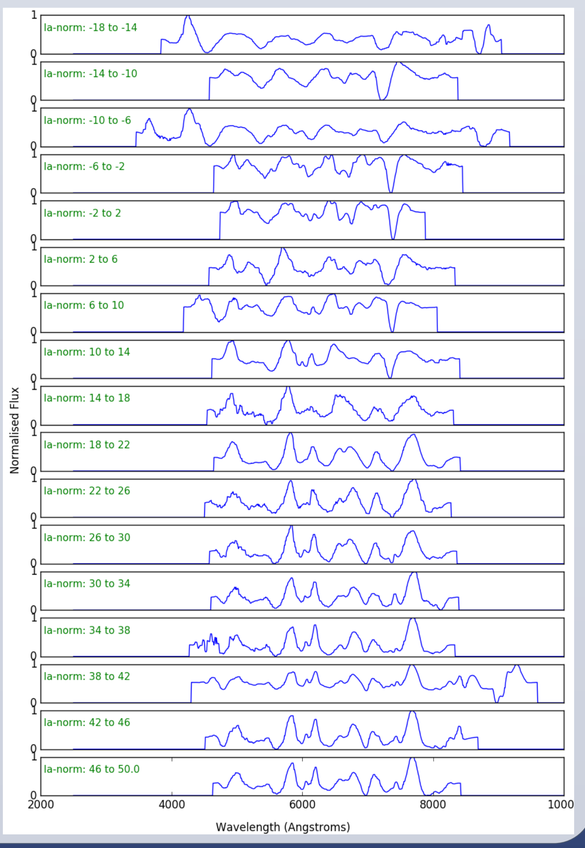




Data

- A total of 3936 templates across 515 Supernovae. Grouped into 306 different classification bins: 17 subtypes and 18 corresponding age bins.
- Samples of each of the processed subtypes (left) and samples of the different age bins of the Ia-norm subtype (right) are illustrated below.

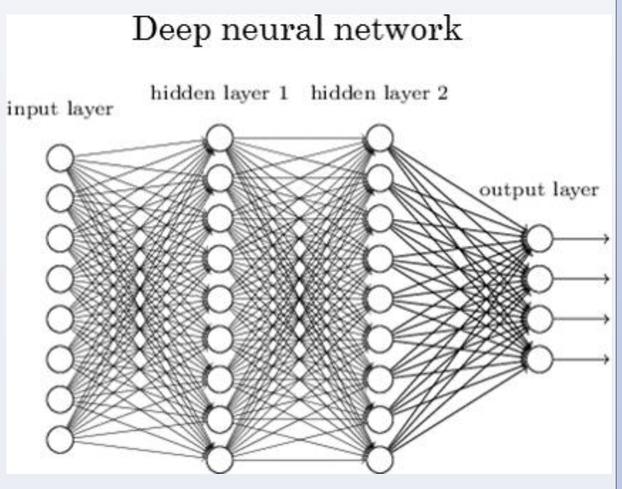


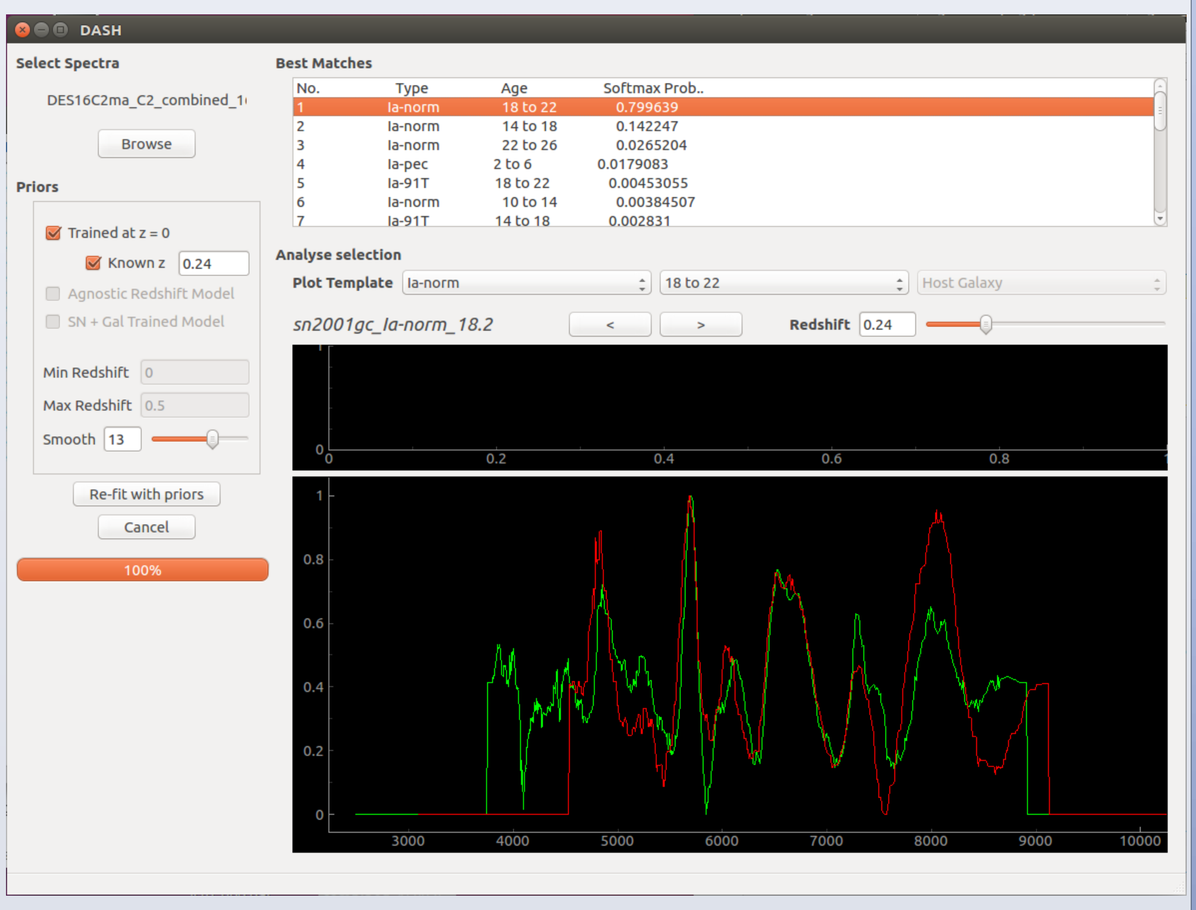


DEEP LEARNING

Developed a two-layer deep convolutional neural network using Google's *Tensorflow* Library.

- Input layer is made up of the binned 1024-point flux vector.
- Each hidden layer is built to capture a more abstract representation of the original input layer by forming linear and non-linear combinations of previous layers.
- Output layer represents 306 different classification bins representing the supernova type and age.





CONCLUSIONS

- DASH differs from previous tools by classifying based on features instead of templates.
- The GUI is user-friendly, fast, and accurate.
- The reliabilities shown in the table are based on the validation set.

Criteria	Correctly Classified
Type	100%
Subtype	93%
Type and Age	91%
Subtype and Age	87%

- Type refers to the broad type (i.e. Ia, Ib/c, II). Subtype refers to the 17 different subtypes shown in the plots on the left.
- The main improvements include:
  - Speed
  - More specific classification
  - Accuracy
  - Installation and ease of use
- Future improvements include training a more advanced redshifting model, and training a model that identifies host galaxies.
- DASH is available on GitHub (https://github.com/daniel-muthukrishna/SNClassifying_Pre-alpha) and is installable on PyPI with 'pip install DASH'.