Supernova Photometric Lightcurve Classification

Tayeb Zaidi, Gautham Narayan

Macalester College, National Optical Astronomy Observatory (NOAO)

Supernova Classification

This project proposes a method for producing a non-parametric representation of the light curve data, and applying a Random Forest classifier algorithm to distinguish between supernovae types. We examine the impact of Principal Component Analysis to reduce the dimensionality of the dataset, for future classification work. The classification code will be used in a stage of the ANTARES pipeline, created for use on the Large Synoptic Survey Telescope (LSST) alert data and other wide-field surveys.

Project and Methodology

- A non-parametric representation was created using a linear spline fit each light curve
- The data was shifted into a common reference frame using the r-band maximum as the reference point
- Goodness-of-Fit metric used in combination with Nelder-Meade optimizer to produce better spline-fits to the data

\[
(1-q) \frac{1}{N} \sum_{i=1}^{N} \left( \frac{y_i - f(t_i)}{\sigma_i} \right)^2 + q \sum_{i=3}^{N} (f''(t_i))^2
\]

Equation 1: Goodness-of-Fit metric used in Nelder-Meade optimizer

Classification Performance

- Random Forest Classifier used from the scikit-learn package implemented in Python
- 80% of data selected randomly for training, 20% used for testing (drawn from SNPhotCC data)
- The final figure-of-merit for the DES data in just the 'r' band was 60% for binary classification (Type I vs II)
- Dimensionality reduction has not yet been implemented in tandem with the classification for the SNPhotCC data
- Future work: multiple passbands, using PCA eigenvectors, incorporating catalog, and host-galaxy information, sparse lightcurves

Training Sets

SNPhotCC (simulated data):  
- Challenge in 2011 to determine good classification algorithms using photometric observations of supernovae  
- The data consist of 18,000 simulated supernovae (Type I/II) from the DES (Dark Energy Survey)

Various high-z + Harvard Low-z:  
- REAL OBSERVATIONAL DATA
- Approximately 500 k-corrected light curves of Type Ia supernovae provided by GN
- Includes Type II & other core-collapse supernovae
- Provided data for initial testing before larger DES dataset

References:

Cui, Z, and the University of Iowa, Two New Alternative Smoothing Methods in Equating: The Cubic B-spline
Presmoothing Method and the Direct Presmoothing Method, 2006, 20

We thank the National Science Foundation for support of the NOAO REU program