Early Classification of Explosive Transients using Deep Learning

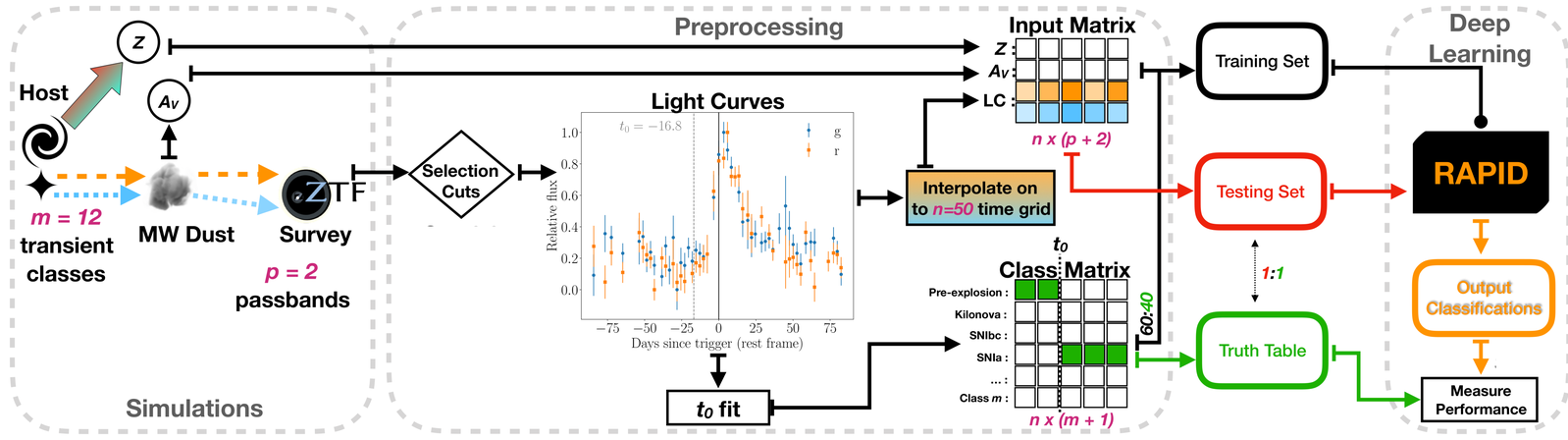
Daniel Muthukrishna[1]*, Gautham Narayan[2], Kaisey Mandel[1,3], Rahul Biswas[4], Renee Hložek[5]
[1]Institute of Astronomy, University of Cambridge. [2]Space Telescope Science Institute, Baltimore. [3]StatsLab, DPMMS, University of Cambridge.
[4]The Oskar Klein Centre for CosmoParticle Physics, Department of Physics, Stockholm University.
[5]Department of Astronomy and Astrophysics & Dunlap Institute, University of Toronto.

*daniel.muthukrishna@ast.cam.ac.uk

Paper submitted to PASP. Go to `https://www.ast.cam.ac.uk/~djm241/rapid` for an audio description of this poster and for figure animations.

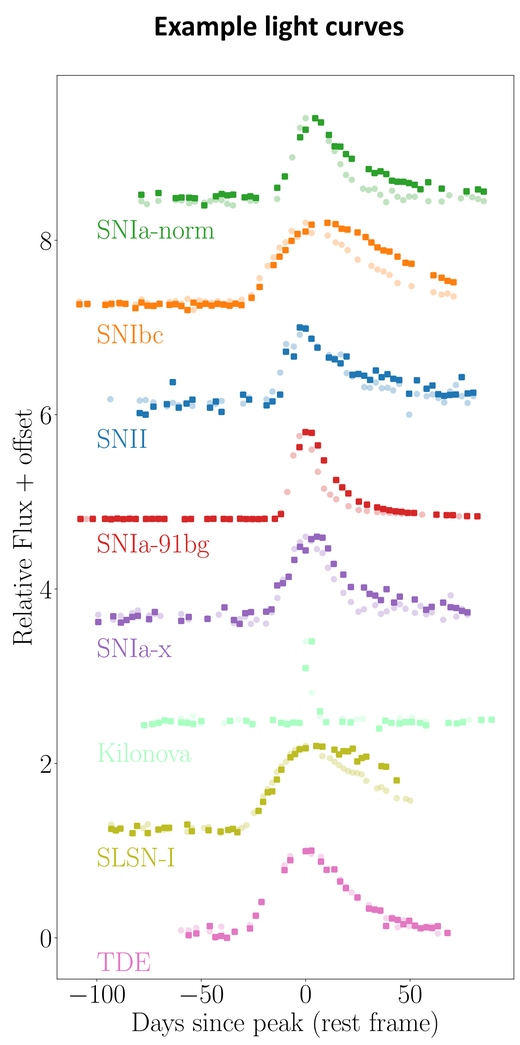
Introduction

- The Zwicky Transient Facility (ZTF) and the Large Synoptic Survey Telescope (LSST) are expected to observe millions of new transients as multi-wavelength time series light curves.
- To meet this demand, we present `RAPID` (Real-time Automated Photometric IDentification), a novel time-series classification tool capable of automatically identifying transients from within a day of the initial alert, to the full lifetime of a light curve.



Data

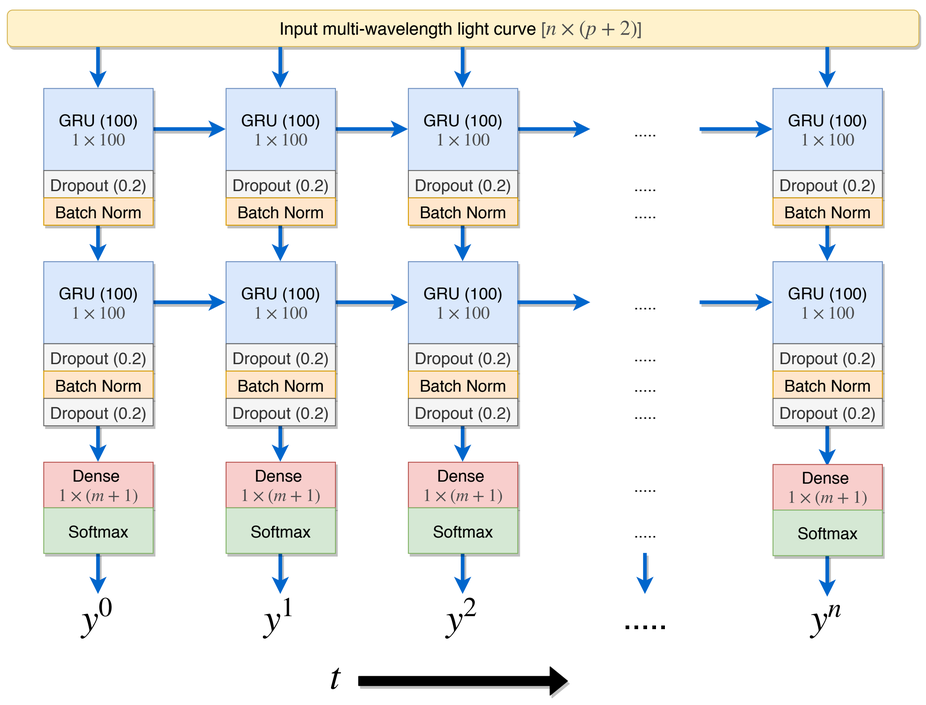
- The dataset consists of 48029 transient light curves split between twelve different astrophysical types that have been simulated with the observing properties of the ZTF astronomical survey.
- We fit a quadratic to the pre-maximum part of each light curve in each passband. We obtain an estimate for the explosion time, t_0, by optimizing the model's fit in all passbands simultaneously.
- The data at each epoch along the light curve is labelled as *Pre-explosion* for $t < t_0$ and as the corresponding transient class at $t \geq t_0$. These time-dependent labels are fed into the supervised RNN, and are what enable classifications as a function of time.



Recurrent Neural Network

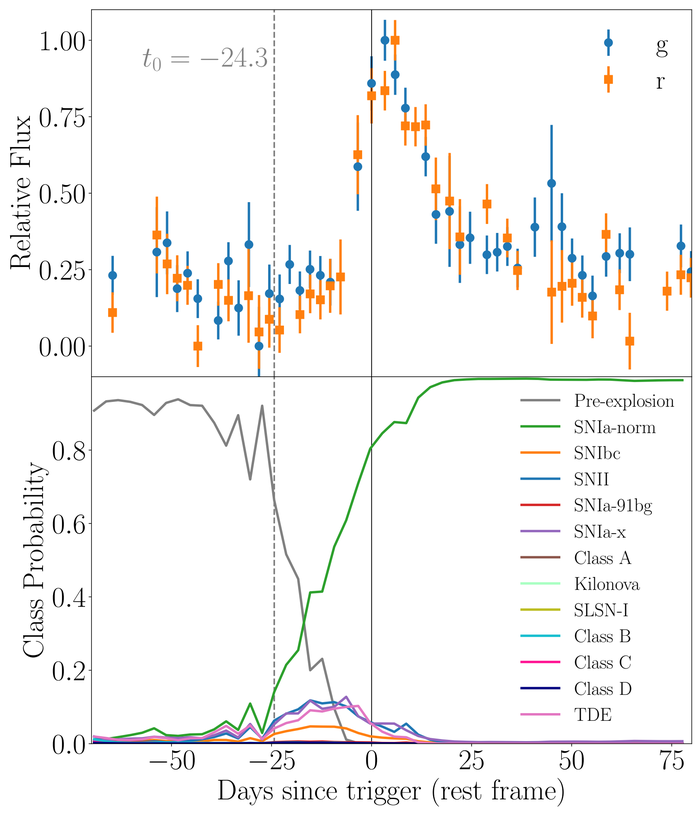
Using a deep recurrent neural network (RNN) with two Gated Recurrent Unit (GRU) layers, we can capture an internal memory of sparse multi-passband light curves. We build upon the work developed in Charnock & Moss (2017) [arXiv:1606.07442].

The input layer consists of the redshift, Milky Way reddening, and the *r* and *g* band flux at each time step along the light curve. The output at each time step is a vector containing the classification probabilities of each transient type.

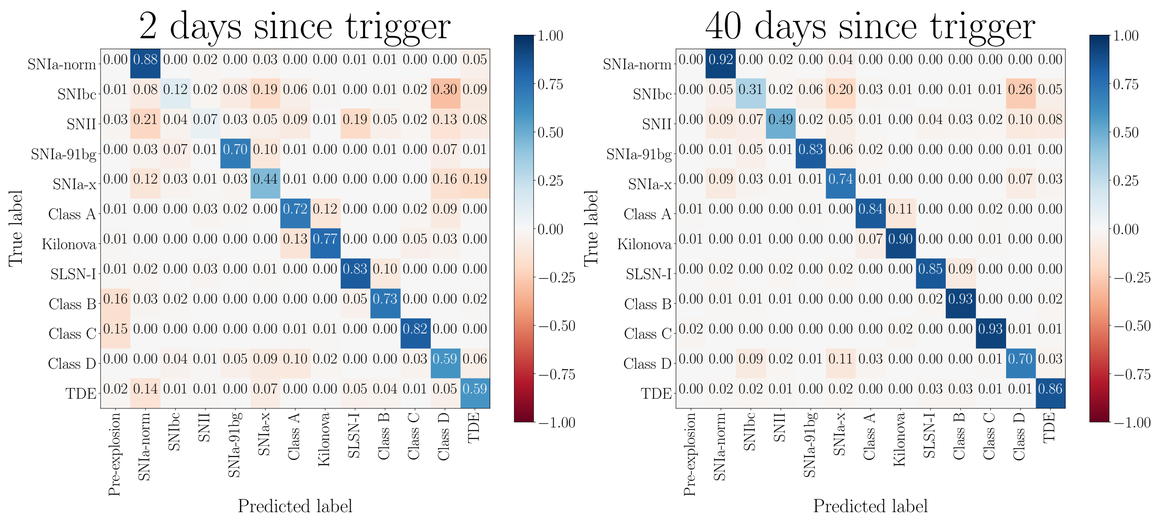


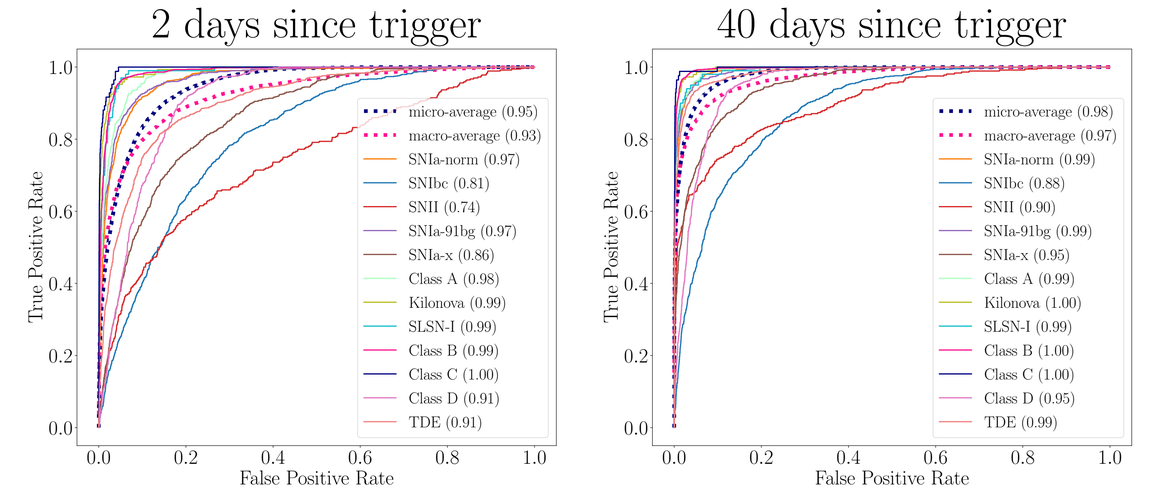
Performance

The RNN is trained on 60% of the dataset and is validated on the remaining 40%. The classification accuracy of an example transient is plotted below. The correct type is predicted within a few days of the transient explosion.



The performance of the classifier on the validation set at an early and late time in the light curve is shown in the confusion matrices and ROC curves below. Some transient classes are embargoed for the PLAsTiCC science challenge.





`RAPID` is currently being integrated into the ANTARES transient broker pipeline (`https://antares.noao.edu`). See session 214.05 for more details.