Improving the Feature Extraction for RESSPECT

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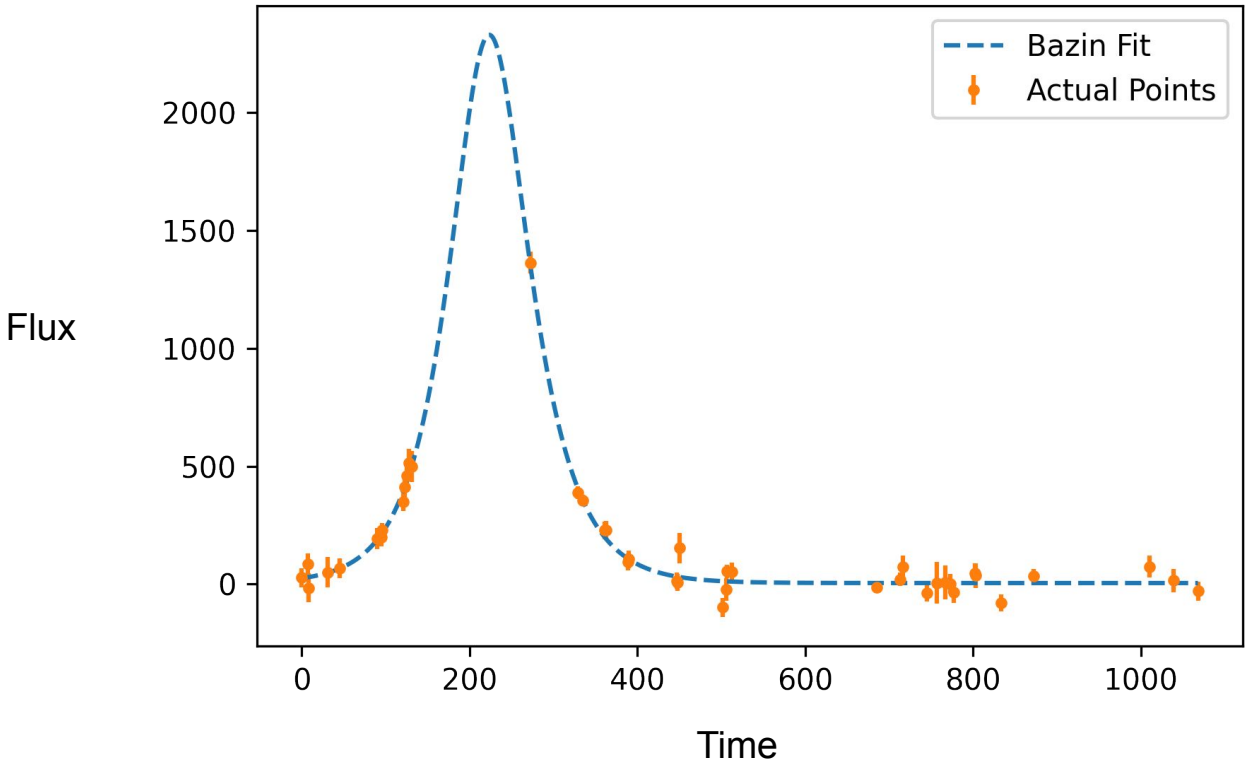
A little about myself

- Final year MS student at the Indian Institute of Science Education and Research (IISER), Bhopal, India.
- Working with Johann as a summer intern.
- We’re looking at methods to improve RESSPECT’s feature extraction methods.

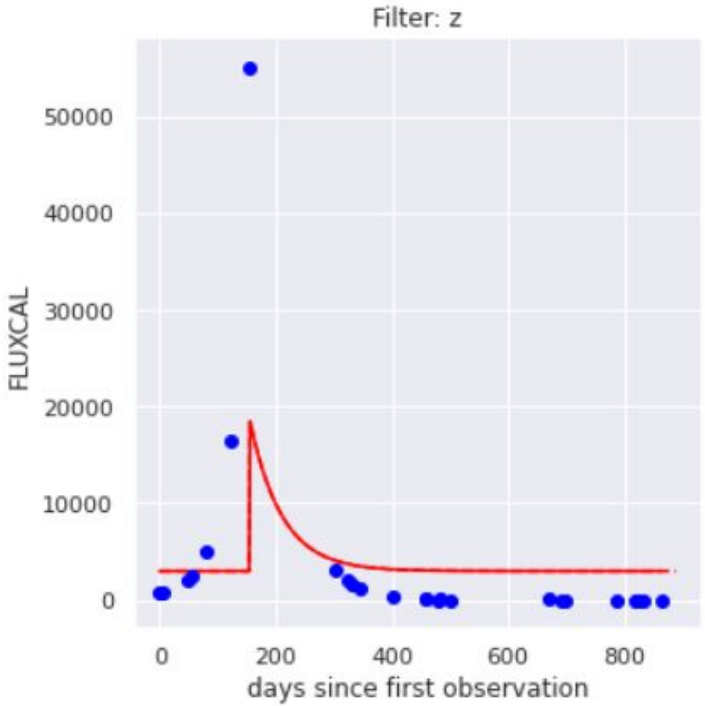
A review of current features: Bazin

- Extract features by fitting a function to each light-curve
- The function has 5 free parameters:
    - a: Normalization parameter
    - b: Shift parameter
    - t0: Time of maximum
    - tfall: Characteristic decline time
    - trise: Characteristic raise time

An example of the fit:

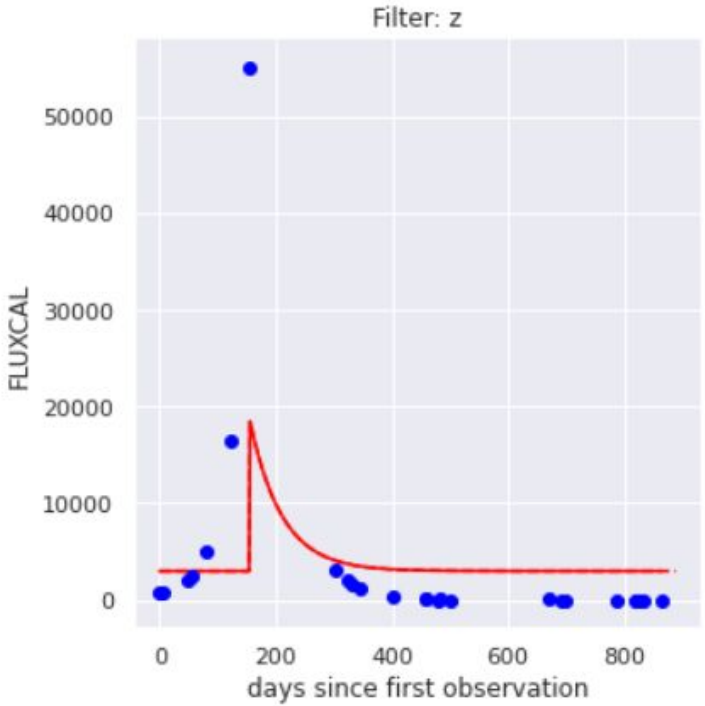


Fixing some cases of a failed fit:

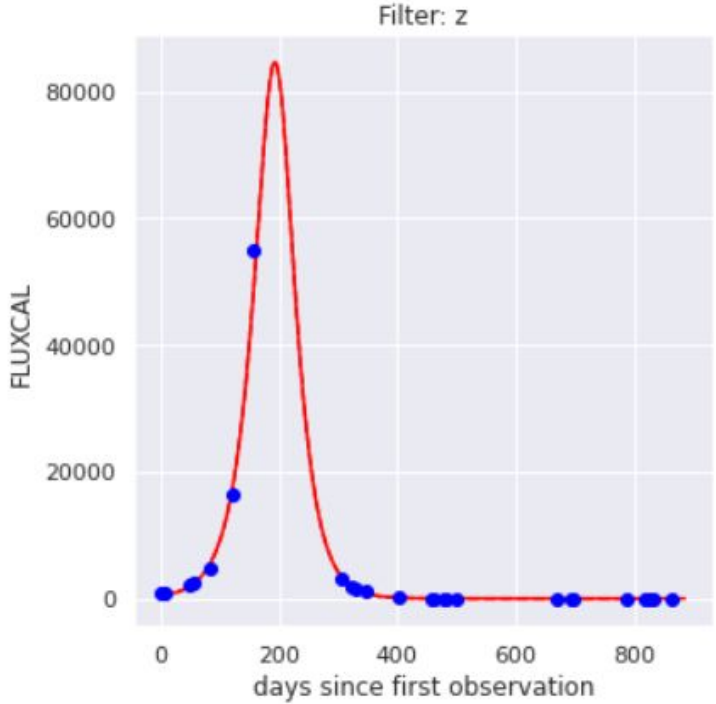


- Here, it is fitting tfall and trise separately.
- But, we know that tfall > trise (Dai et. al. (2017))
- So, reparameterize from (tfall,trise) → (tfall, r) and enforce r > 1

Fixing some cases of a failed fit:



OLD



NEW

Comparing Different Parameterisations

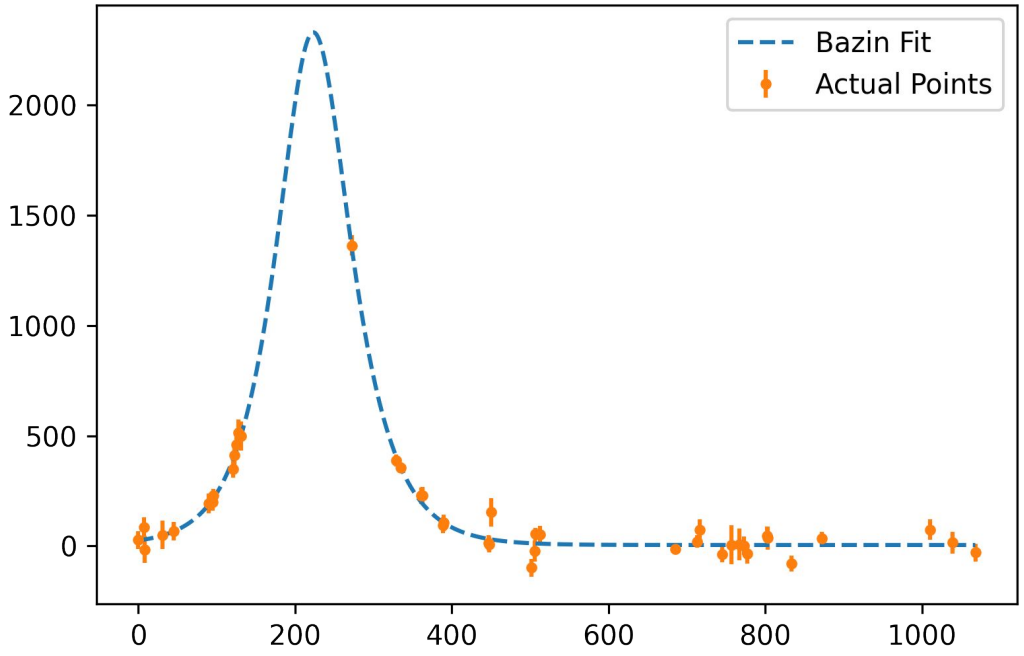
Name	# Params	Comparative Score	Time Taken	Failed Fits	Authors
Bazin	5	56 ± 2 %	30 ms	2.29%	Bazin et. al. (2009)
ALERCE v1	6	50 ± 2 %	37 ms	2.08%	Sanchez-Saez et. al. (2020)
ALERCE v2	6	47 ± 2 %	78 ms	2.08%	Sanchez-Saez et. al. (2020)
FRED	5	47 ± 2 %	45 ms	11.25%	Peng et. al. (2010)

Note: All numbers are comparative only.

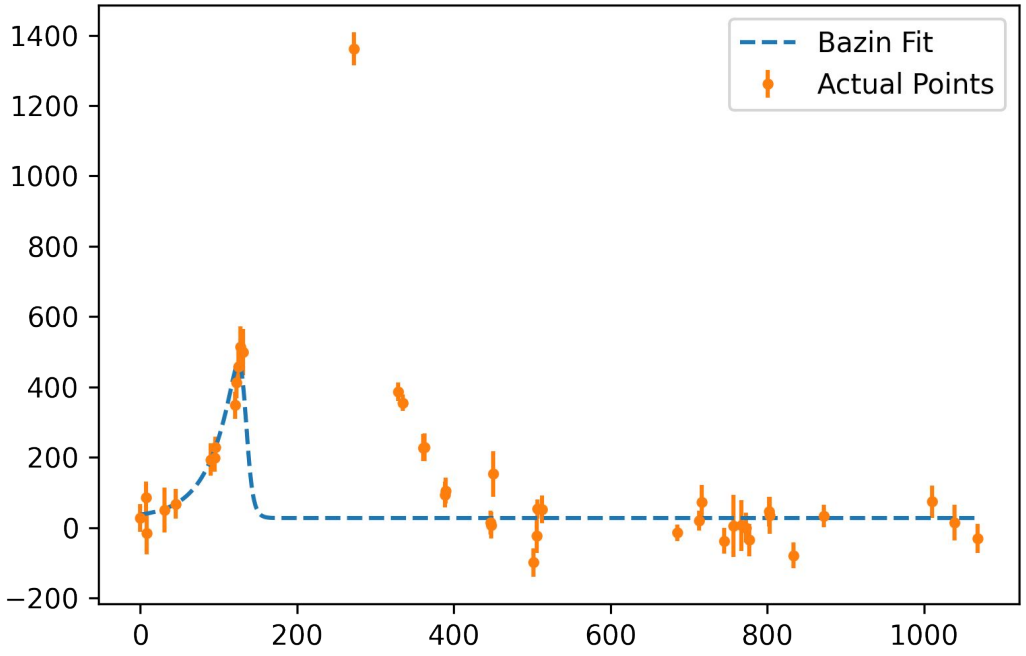
Limitations:

- Slow - Fitting a function
- Greedy - Needs 5 points per light-curve per passband
- Each passband is treated as independent
- Not very robust - Designed for SNIa & SNII

Considering all points:



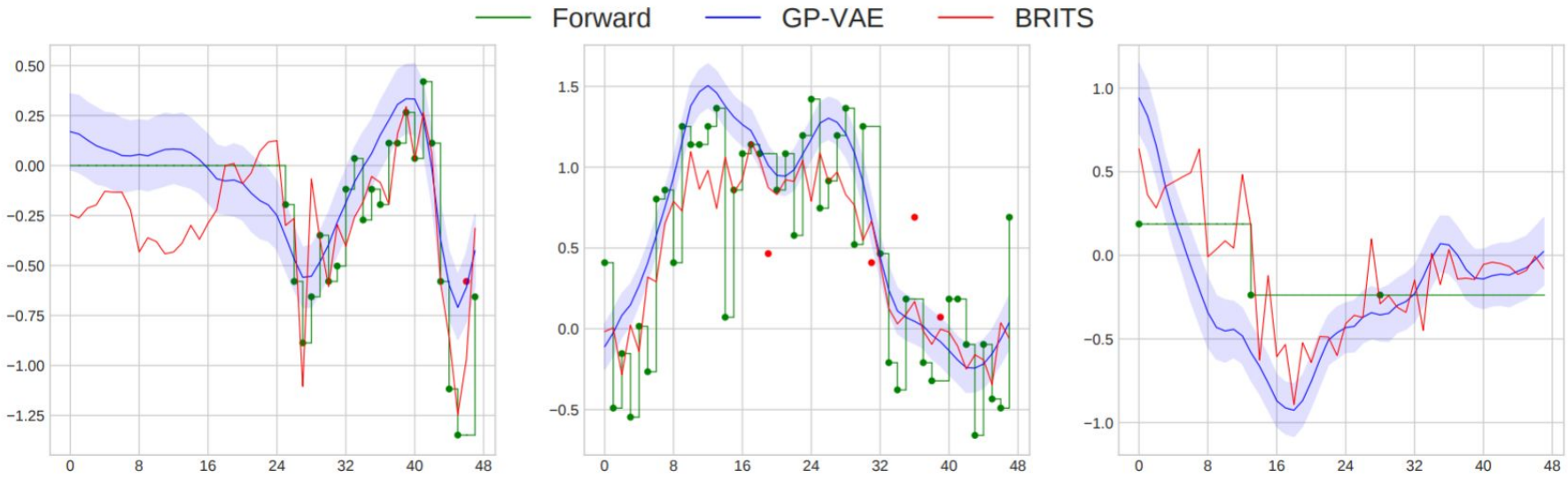
Considering only first 6 points:



Looking at more modern methods:

- Deep learning approaches are available which fix the previous issues.
- Fortuin et. al. (2019) have worked times series imputation using Gaussian-Process Variational Autoencoder (GP-VAE).
- Demonstrated it for multivariate medical data.
- We’re looking at using the latent space of such a model for light curve parameterisation.

Example of GP-VAE for Time Series Imputation:



From Fortuin et. al. (2019)

Thank You.

$$t_{\mathrm{max}} = t_0 + t_{\mathrm{rise}} \ln(\frac{t_{\mathrm{fall}}}{t_{\mathrm{rise}}} - 1)$$

Bazin (old):

$$f(t) = A\frac{e^{-(t-t_0)/\tau_f}}{1+e^{(t-t_0)/\tau_r}} + B$$

FRED:

$$F(t) = F_m \left(\frac{t+t_0}{t_m+t_0}\right)^r \left[\frac{d}{d+r} + \frac{r}{d+r}\left(\frac{t+t_0}{t_m+t_0}\right)^{(r+1)}\right]^{-\frac{r+d}{r+1}}$$

ALERCE v1:

$$F = \begin{cases} \dfrac{A\left(1-\beta'\frac{t-t_0}{t_1-t_0}\right)}{1+\exp\left(-\frac{t-t_0}{\tau_{\text{rise}}}\right)} & \text{if } t < t_1 \\ \dfrac{A(1-\beta')\exp\left(-\frac{t-t_1}{\tau_{\text{fall}}}\right)}{1+\exp\left(-\frac{t-t_0}{\tau_{\text{rise}}}\right)} & \text{if } t \geq t_1, \end{cases}$$

ALERCE v2:

$$F = \frac{A\left(1-\beta'\frac{t-t_0}{t_1-t_0}\right)}{1+\exp\left(-\frac{t-t_0}{\tau_{\text{rise}}}\right)}\cdot\left[1-\sigma\left(\frac{t-t_1}{3}\right)\right]+\frac{A(1-\beta')\exp\left(-\frac{t-t_1}{\tau_{\text{fall}}}\right)}{1+\exp\left(-\frac{t-t_0}{\tau_{\text{rise}}}\right)}\cdot\left[\sigma\left(\frac{t-t_1}{3}\right)\right]$$