BTSbot: A Multi-input CNN to Automate and Expedite Bright Transient Identification for ZTF

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1. Background

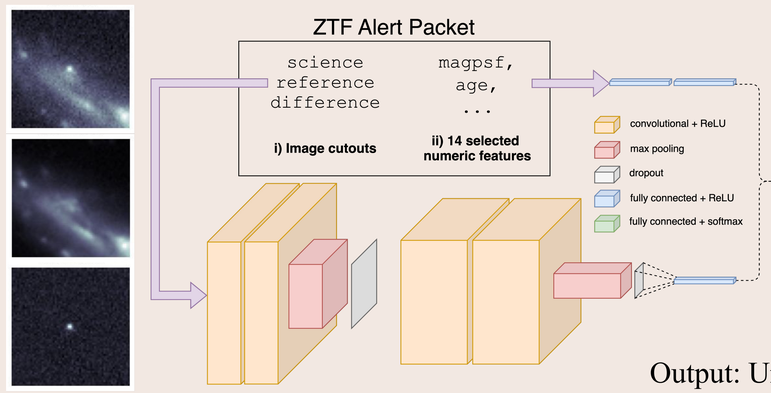
The Zwicky Transient Facility (ZTF)[1]
- Optical time-domain survey with 47 deg^2 field-of-view

The Bright Transient Survey (BTS)[2,3]
- Spectroscopically classify all extragalactic transients with $m < 18.5$ mag from ZTF
- "Scanning": Manual inspection of candidate bright transients

Project Goals
Automate identification of bright transients to
i. Streamline BTS workflow
ii. Collect very early supernovae spectra

2. BTSbot scope & architecture

Identify ~7 real bright transients from ~50 candidates / night
Candidates include dim transients, AGN, CVs, variable stars

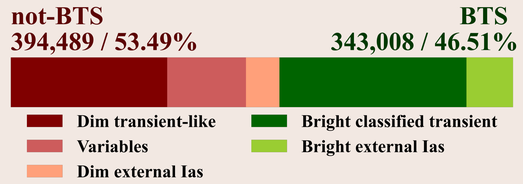


Binary classification
bright extragalactic transient
vs.
not bright extragalactic transient

Input: Single ZTF alert packet
i. Image cutouts
ii. Alert metadata
No time-series information

Output: Unit interval bright transient score

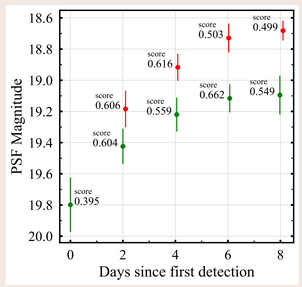
3. Training set



Drawing from ZTF archive (2018–Present)
Labels thanks to years of effort by BTS

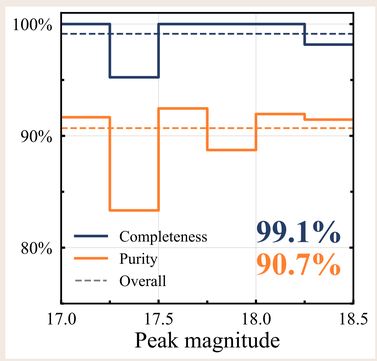
Prevent overfitting
1. Data augmentation
2. Thinning alerts
3. Class weights

4. BTSbot performance

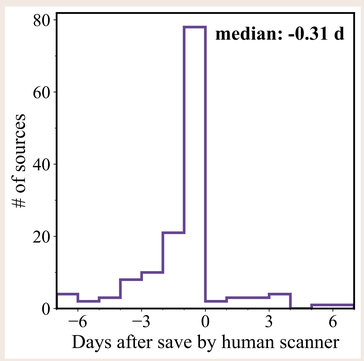


"Policy": Map sequence of alert-based scores to source-based classification

`gt1`: Classify source as bright transient when ≥ 1 alert with score ≥ 0.5



Properties of mock BTS sample when following `BTSbot` with `gt1`



Identifying sources 0.31 days quicker than human scanners

7.4 hours ≈ 1 night
↳ 24-hour speed-up

Outperforming human scanners in completeness (99.1% to 95.2%) and speed (7.4 hours quicker)

5. SN2023ixf and extremely rapid follow-up

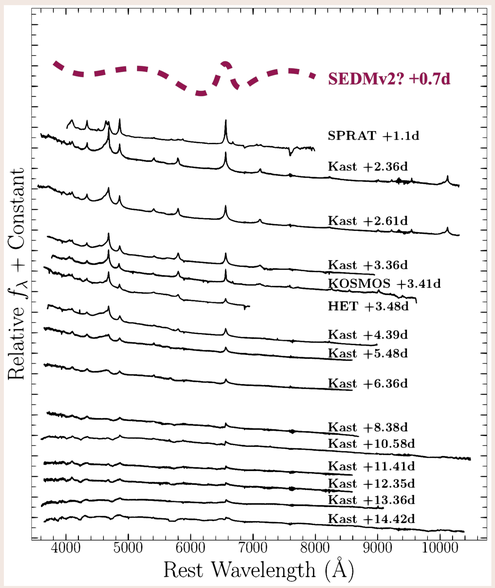


Figure adapted from [6]

`autoscan`
Check for new policy-passing sources during night
Immediately save and request follow-up

SN2023ixf discovery and follow-up
May 19th, 2023 (PDT)
- 14:42: First TNS report[4]
- 15:23: First spectrum[5]
- 00:45: ZTF detection
  - `BTSbot` score=0.840
- 01:00: Seen by `autoscan`
  - Pass `gt1`, save source to BTS
  - Request spectrum from robotic spectrograph
- 05:00: End of observing

Earliest spectrum then 0.4 days earlier
Probe physics that is otherwise inaccessible

References
[1] Bellm, E. C. et al. 2019
[2] Fremling, C. et al. 2020
[3] Perley, D. et al. 2020
[4] Itagaki, 2023
[5] Perley et al. 2023
[6] Jacobson-Galán, W. V. et al. 2023

Codebase available at github.com/nabeelre/BTSbot