Low-latency Forecasts of Kilonova Light Curves for Rubin and ZTF

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Motivation

- Developing an ML tool to help discover and follow-up kilonova (KN) candidates identified by ZTF and Rubin.

Background

- KN discovery is challenging: their fast-evolving and faint signals require tools to support candidate analysis and follow-up planning.

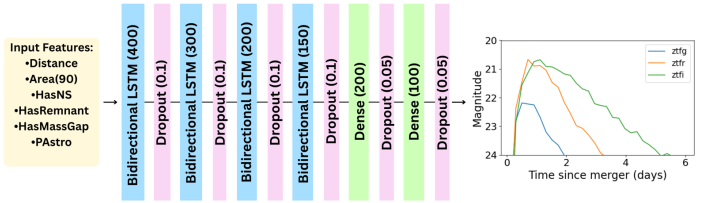
Training Data

- ZTF filters: 8,080 BNS and 92 NSBH simulated light curves.
- Rubin filters: 4,223 BNS and 82 NSBH simulated light curves.
- Input features: Distance, area enclosed of 90% probability density, HasNS, HasRemnant, HasMassGap, and PAstro.

Methods

- Convert low latency data from IGWN to light curves in ZTF/Rubin filters using an LSTM network.

Long Short-Term Memory



Results for ZTF Filters

Obtain MSE of 0.19 and R^2 of 0.82 for our test data across all 3 filters.

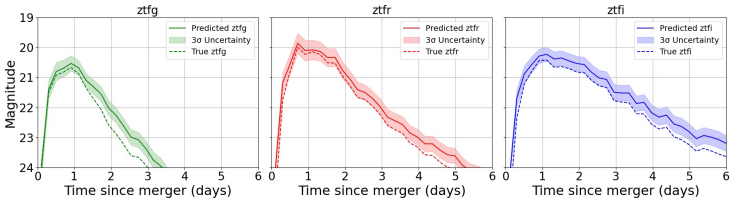


Fig.2: Predicted (solid lines) and truth (dashed lines) light curves in ZTF filters using our trained model for a random KN in our test set. Shaded regions show 3-σ uncertainties.

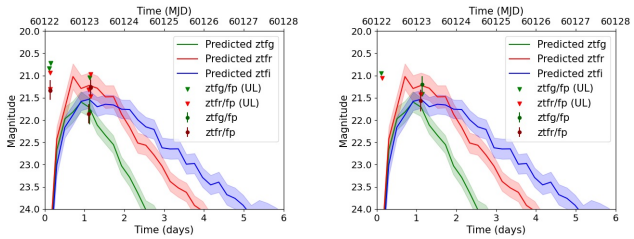


Fig.3: Predicted mean (solid lines) and 3-σ uncertainities (shaded regions) of KN light curves associated with S240627c using low latency alert data.

Results for Rubin Filters

Obtain MSE of 0.22 and R^2 of 0.68 for our test data across all 6 filters.

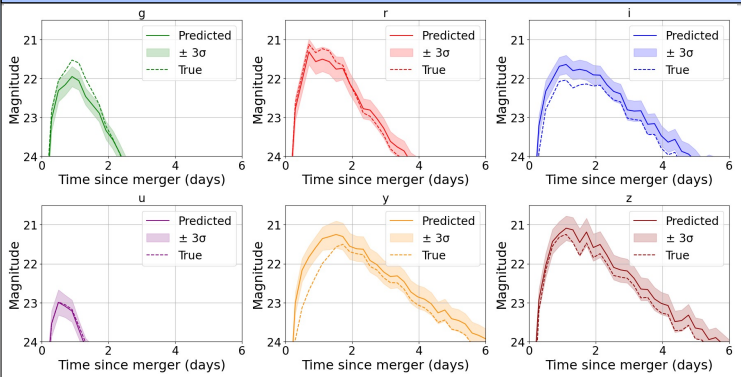


Fig.4: Predicted (solid lines) and ground truth (dashed lines) light curves in Rubin filters.

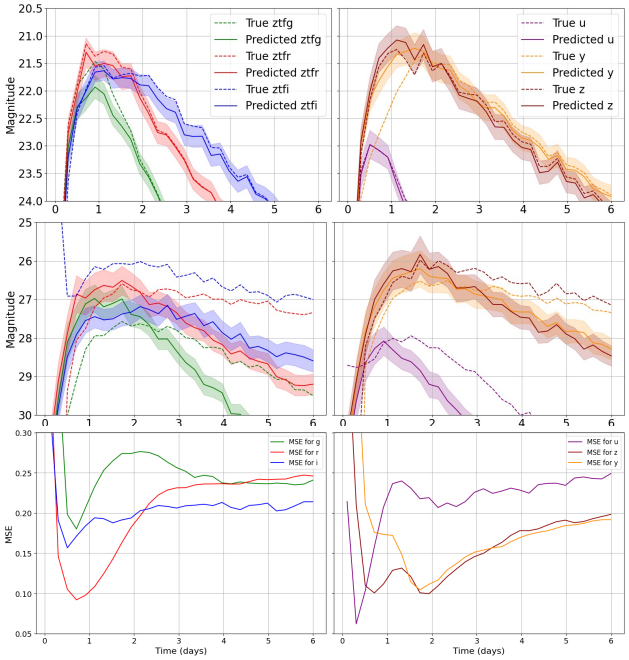


Fig.5: The best-predicted light curve with an MSE of 0.017 is on the top. The worst predicted light curve, with an MSE of 4 in the middle. MSE as a function of KN time is on the bottom.

Future work

We are developing a reinforcement learning agent to optimize follow-up observations. It accounts for survey randomness and evaluates full light curves to make the best use of limited resources.

References

Kiendrebeogo et al. "Updated observing scenarios and multi-messenger implications for the International Gravitational-wave Network's O4 and O5". In: arXiv e-prints, arXiv:2306.09234 (June 2023), arXiv:2306.09234. doi: 10.48550/arXiv.2306.09234. arXiv: