Dissertation Title	Ensemble Deep Learning for Real-bogus Classification with Sky Survey Images
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ABSTRACT

The detection of astronomical transient events—short-lived phenomena such as supernovae, gamma-ray bursts, and stellar flares—has become a major focus in contemporary astrophysical research. These events are often linked to extreme cosmic processes and provide essential insights into stellar evolution and the dynamic nature of the universe. However, identifying such events within the vast and rapidly expanding datasets generated by modern sky surveys presents significant challenges, especially as manual inspection becomes infeasible. The Gravitational-wave Optical Transient Observer (GOTO) project exemplifies this complexity. Designed to detect optical counterparts to gravitational-wave sources, GOTO produces hundreds of sky survey images per night, with each image containing tens of thousands of celestial objects. The scale and frequency of this data render traditional analysis methods—such as manual feature extraction and visual inspection—insufficient and inefficient, leading to missed opportunities in capturing rapidly fading events. This research proposes the use of Deep Learning techniques, particularly Convolutional Neural Networks (CNNs), to enhance the classification of transient objects. Unlike traditional methods, CNNs can automatically learn discriminative features directly from raw image data, making them well-suited for large-scale, high-dimensional image classification tasks. To improve model performance and robustness, the study employs Transfer Learning and Fine-Tuning strategies using pre-trained models on ImageNet, adapting them to the specific characteristics of astronomical imagery. It also integrates various Data Augmentation techniques—including image rotation, flipping, and noise injection—to increase data diversity. Additionally, the research investigates the role of Dropout in preventing

overfitting and evaluates the effect of varying Batch Sizes on model training and generalization.

To further enhance classification performance, the study incorporates Ensemble Learning techniques such as Soft Voting and Weighted Voting, combining multiple CNN models to produce more reliable predictions. The results demonstrate that this integrated approach significantly improves the accuracy and reliability of transient classification within large-scale datasets, offering a practical and scalable solution for real-time astronomical event detection in projects like GOTO.

Keywords: Astronomical Transients, Convolutional Neural Networks (CNNs), Transfer Learning, Fine-Tuning, Data Augmentation, Batch Size, Ensemble Learning, Sky Survey, Optical Transient Detection, Ensemble Deep Learning