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A PHYSICS-INSPIRED FRAMEWORK FOR AGN CLASSIFICATION IN TIME-DOMAIN SURVEYS

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The classification of active galactic nuclei (AGNs) in large-scale optical time-domain surveys is challenged by irregular sampling and diverse variability behavior. Traditional methods often focus on direct time-series statistics and/or spectral features, overlooking the dynamical structure of lightcurves. We propose a novel deep learning pipeline that employs physically inspired representations of variability: the first derivative, characterizing the rate of flux variation, and the second derivative, describing the temporal acceleration of variability.

Using high-quality light curves from a highly imbalanced dataset of ∼ 40,000 AGNs from the Zwicky Transient Facility (ZTF) Data Release 6 (DR6), we construct 2D maps of these variability derivatives—encoding both smooth modulations and rapid transitions in observed magnitudes. These dynamic feature maps are used as input to a ResNet-based convolutional neural network (CNN) trained to classify AGN sources as core-dominated Type-1 AGNs (Q ∼ 20,000), Type-1 AGNs with X-ray emission (QX ∼ 4,000), and Type-1 AGNs with radio emission (QR ∼ 2,000). The pilot results from this master's thesis show that this dual-derivative approach improves classification accuracy of AGN subclasses, providing a scalable, physically motivated basis for light curve classification in current (ZTF) and upcoming Vera C. Rubin Observatory Legacy Survey of Space and Time.

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