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Data-Driven Discovery: Machine Learning for the Detection and Characterization of X-ray Transients

Recent serendipitous discoveries in X-ray astronomy such as extragalactic fast X-ray transients, Quasi-periodic eruptions, exoplanetary transits, and other rare short-duration phenomena in the X-ray sky highlight the importance of a systematic search for such events in X-ray archives. Variable-length time series data in form of X-ray eventfiles present a challenge for the identification of characteristic features of these time-domain anomalies with machine learning applications. Novel equal-length data representations of X-ray eventfiles capturing both time and energy information are introduced. We use these eventfile representations as features for an unsupervised X-ray transient detection pipeline involving principal component analysis or autoencoder feature learning followed by dimensionality reduction and clustering. The association of these clusters with previously identified transients produces a new set of X-ray transient candidates. Supervised regression and classification models are trained to characterize and predict the time-domain and spectral properties of X-ray eventfiles. We find 8956 X-ray transient candidates in the Chandra archive including a confirmed eclipsing low-mass X-ray binary system and a potential accretion-powered X-ray pulsar. The developed data science tools and catalog of X-ray transient candidates are made publicly available for the advancement of data-driven discoveries in the X-ray astronomy community.

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