Innovative Machine Learning Approaches for Exoplanet Detection and Anomaly Identification: Applying Computational Techniques to Uncover Hidden Patterns in TESS Data

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Accurately detecting exoplanets is essential for understanding planetary system formation and dynamics. Anomaly detection is an essential part of exoplanet studies, especially when analyzing light curve data. Exoplanet candidates can sometimes be hidden in this data, and traditional detection methods might miss them. Anomaly detection techniques help identify unusual patterns or outliers in the data that could indicate the presence of an exoplanet. This study is a novel, hybrid approach combining machine learning methodologies for supervised exoplanet detection and unsupervised anomaly identification utilizing data from the NASA Exoplanet Archive and Transiting Exoplanet Survey Satellite (TESS). The machine learning techniques-K-Nearest Neighbors (KNN), Random Forest, and Multilayer Perceptron-were tested with KNN achieving an accuracy of 95%. KNN was then deployed on TESS Sector 70 data, effectively distinguishing between exoplanets and non-exoplanet light curves. These classifications were grouped into high-confidence and low-confidence predictions. The autoencoder, trained on high-confidence data, learned to recognize typical transit patterns, while DBSCAN (Density-Based Spatial Clustering of Applications with Noise) further refined detections, revealing potential outliers. This method successfully identified three distinct anomalies within the low-confidence predictions: TIC 14333593, TIC 58720396, and TIC 145750919, each showcasing unique characteristics suggesting unrecognized planetary systems. The results emphasize the effectiveness of combining supervised and unsupervised learning strategies, potentially unveiling hidden phenomena within large astronomical datasets, laying the groundwork for future applications in missions like the James Webb Space Telescope.

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