Comparative Analysis of Latent Projection Resonance (LPR) against k-Nearest Neighbors in High-Dimensional Financial Anomaly Detection

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ABSTRACT

In the realm of high-dimensional financial networks, detecting anomalous topologies is severely hindered by the "Curse of Dimensionality." Traditional techniques relying on spatial proximity or density estimation experience severe performance deterioration in such environments. This study introduces a comprehensive evaluation of Latent Projection Resonance (LPR) as a superior alternative to distance-based (k-NN) paradigms. Empirical assessments conducted on five diverse datasets (Wine, Iris, Ruspini, Forest Fires, and Quakes) reveal the fundamental vulnerabilities of k-NN specifically their susceptibility to density fluctuations and distance concentration. Conversely, LPR leverages manifold learning to ensure structural integrity. Through theoretical proofs, we demonstrate that by combining a severe information bottleneck with an L1-norm loss function, LPR successfully extracts structural inconsistencies that traditional spatial metrics fail to observe. Our experiments yield a robust detection rate of roughly 35.21% for LPR, eclipsing the meager 6.85% for k-NN in complex domains. Furthermore, LPR demonstrates immense potential for real-time cybersecurity applications by scaling down the computational overhead from a quadratic $O(N^2)$ to a linear $O(d)$.

KEYWORDS: Latent Projection Resonance, k-NN, Curse of Dimensionality, Distance Concentration, Manifold Hypothesis, Structural Dissonance, Nonlinear Principal Component Extraction.