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Dual-locality learning under neighbourhood coupling: interpretable and transferable models for structured trace data

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Local interactions, confinement and neighbourhood coupling often generate heterogeneous regimes in structured systems. Analogous effects arise in large-scale spatiotemporal trace data, where a single global hyperparameter can underfit dense regions and overfit sparse ones, and naive splits can leak spatial dependence[a].
A dual-locality, interpretable machine-learning framework is presented for functional-pattern identification from structured spatiotemporal traces. Feature-space locality is captured through prototype-specific local-k optimisation for multi-label kNN, improving over fixed-k baselines without increasing inference cost[b]. Neighbourhood locality is incorporated via Moore-adjacency influence sets for gridded activity fields (ML-proxkNN), explicitly modelling local context while preserving feature-space similarity.
On CDR-derived benchmarks in Milan and Trento, the dual-locality classifier reaches high precision and retains its advantage under spatial block cross-validation that controls for spatial autocorrelation[c]. Complementary experiments on trajectory-derived mobility features from geolocated social traces detect cross-border home–work commuting with high accuracy and reproduce official flow directionality through zero-shot transfer across multiple European border regions[d]. Overall, the contribution emphasises relevant design principles: encode neighbourhood structure, adapt model complexity locally, validate under non-leaky splits, and use explanations to assess descriptor portability across domains.

References:

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