UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

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Covariance Cleaning with Neural Networks in Non-stationary Settings

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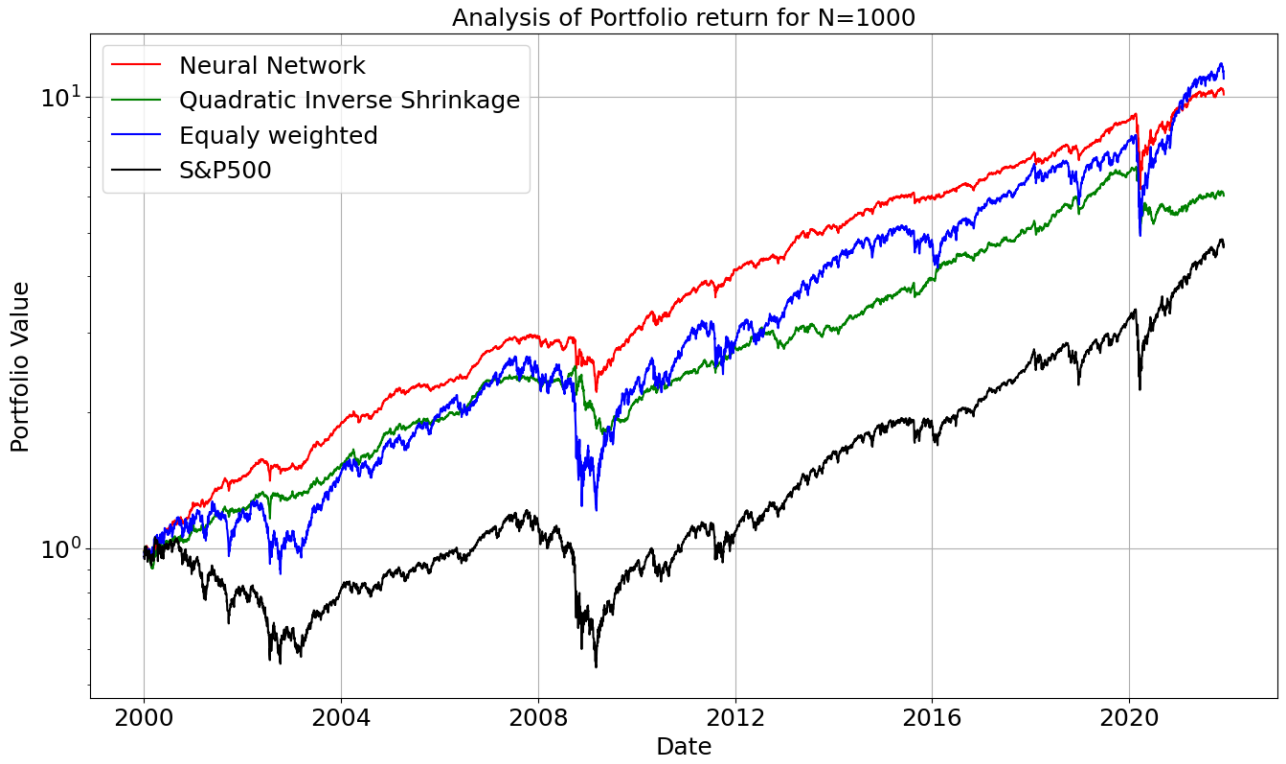

We introduce a physics-based neural network (NN) for covariance matrix cleaning, tailored for applications like portfolio optimization. Our NN architecture encodes problem-specific symmetries of the eigenvalues by leveraging the well-known Coulomb gas analogy, which models eigenvalue interactions as stochastic particle dynamics with Coulomb-like repulsion in a complex energy landscape. This is achieved with a long short-term memory (LSTM) network by interpreting the eigenvalue rank as a temporal sequence, mapping nearest-neighbor interactions to short-term memory channels, and approximating global interactions through long-term memory as a mean field. This approach allows precise inverse covariance estimation, which is essential for determining asset weights that minimize portfolio risk. Applied to portfolio optimization, our method outperforms traditional optimal methods even when high-dimensional limit conditions are not satisfied.