Problems

1. Matrix/Tensor Factorization

- **Techniques:** Matrix Factorization (SVD, NMF), Tensor Factorization (CP, TUCKER)

- **Applications to Problems:**
  - **Anomaly Detection**: Identifying unusual patterns in network traffic using latent factors. [6]
  - **Recommendation Systems**: predicting user preferences. [1]
  - **Time series analysis:** Weather forecasting [14]
  - **High-dimensional data:** application in Hyperspectral image processing [19]

2. Matrix/Tensor Completion

- **Techniques:** Low-Rank Approximation

- **Applications to Problems:**
  - **Signal Denoising**: Completing missing or corrupted values in signal matrices. [2]
  - **Recommendation Systems**: Predicting missing user-item interactions. [1]

3. Regularized Regression

- **Techniques:** Lasso Regression (L1 Regularization), Ridge Regression (L2 Regularization), Elastic Net Regression

- **Applications to Problems:**
  - **Image Classification**: Enhancing feature selection in high-dimensional image datasets. [3]

4. Proximal Gradient Methods

- **Techniques:** Forward-Backward Splitting, Accelerated Proximal Gradient Descent

- **Applications to Problems:**
  - **Compressed Sensing**: Solving L1-regularized recovery problems. [11], [13]
  - **Overfitting**: Incorporating regularization to improve model generalization [7].

5. Higher-Order Methods

- **Techniques:** Newton's Method, Quasi-Newton Methods (BFGS, L-BFGS), Trust-region

- **Applications to Problems:**
  - **Compressed Sensing**: Accelerating convergence for high-dimensional recovery tasks.
  - **Time Series Analysis**: Efficient parameter estimation for autoregressive models.

6. Sparse PCA

- **Techniques:** Robust PCA
- **Applications to Problems:**
  - **Anomaly Detection**: Identifying outliers in network traffic or sensor data. [12]

7. Dimensionality Reduction

- **Techniques:** Linear Methods (PCA, ICA), Non-Linear Methods (t-SNE, UMAP)

- **Applications to Problems:**
  - **Image Classification**: Feature extraction from high-dimensional pixel data. [15]

8. Sparse Representation

- **Techniques:** Basis Pursuit, Orthogonal Matching Pursuit, Dictionary learning [22]

- **Applications to Problems:**
  - **Signal Denoising**: Using sparse coding to remove noise from audio or images [5]
  - **Compressed Sensing**: Reconstructing signals with fewer measurements. [11]

9. Distributed Optimization

- **Techniques:** ADMM, Federated Learning Optimization

- **Applications to Problems:**
  - **Time Series Analysis**: Parallel processing for forecasting models.
  - **Recommendation Systems**: Collaborative optimization across decentralized datasets. [4]

10. Non-Convex Optimization

- **Metaheuristic Algorithms:** Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization (PSO)
- **Learning based optimization:** LISTA [18], Algorithm unrolling [8]

- **Applications to Problems:**
  - **Recommendation Systems**: Optimizing latent factor models for user-item matrices.
  - **Time Series Analysis**: Handling non-convex cost functions in forecasting.

11. Control problems

- **Techniques:** Linear quadratic programming

- **Applications to Problems:**
  - **Convex optimization control policy** [16].
  - **Model predictive control** [17]

Papers

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18. Gregor, Karol, and Yann LeCun. "Learning fast approximations of sparse coding." Proceedings of the 27th international conference on international conference on machine learning. 2010.
19. Peng, Jiangtao, et al. "Low-rank and sparse representation for hyperspectral image processing: A review." IEEE Geoscience and Remote Sensing Magazine 10.1 (2021): 10-43.
20. Tošić, Ivana, and Pascal Frossard. "Dictionary learning." IEEE Signal Processing Magazine (2011).

Libraries

https://github.com/tensorly/tensorly

https://github.com/scipy/scipy/tree/main/scipy/signal

https://www.cvxpy.org/index.html

https://github.com/PyLops/pyproximal

https://scikit-learn.org

https://github.com/jettify/pytorch-optimizer

https://github.com/sktime/sktime

https://www.tensorflow.org/

https://pytorch.org/

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Data sources

https://paperswithcode.com/datasets

https://www.tensorflow.org/datasets

https://archive.ics.uci.edu/datasets

https://en.wikipedia.org/wiki/List_of_datasets_for_machine-learning_research