

Interpretable Feature Extraction by Supervised Dictionary Learning for Identification of Cancer-Associated Gene Clusters

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(GitHub : <https://github.com/ljw9510/SDL>)



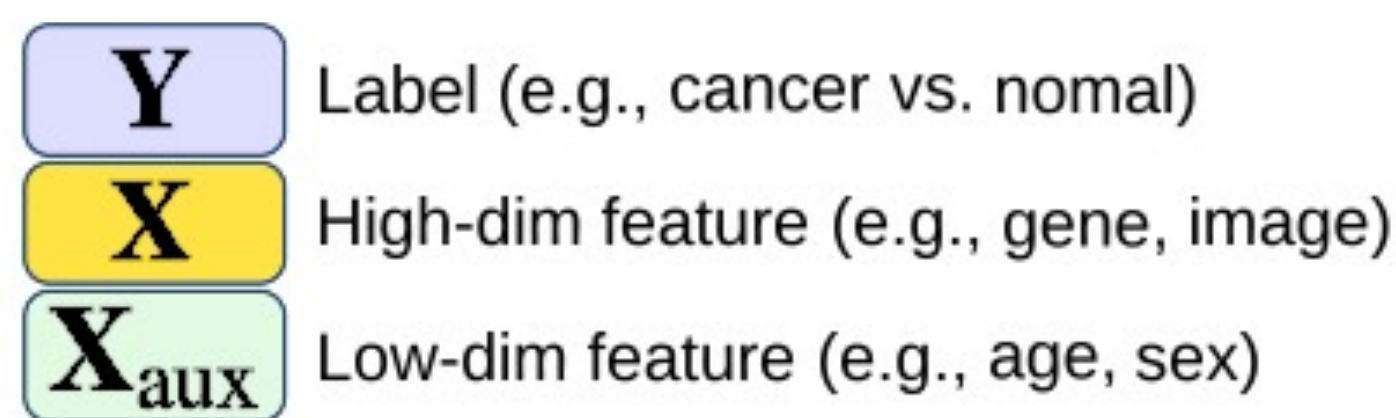
Introduction

Supervised Dictionary Learning (SDL)

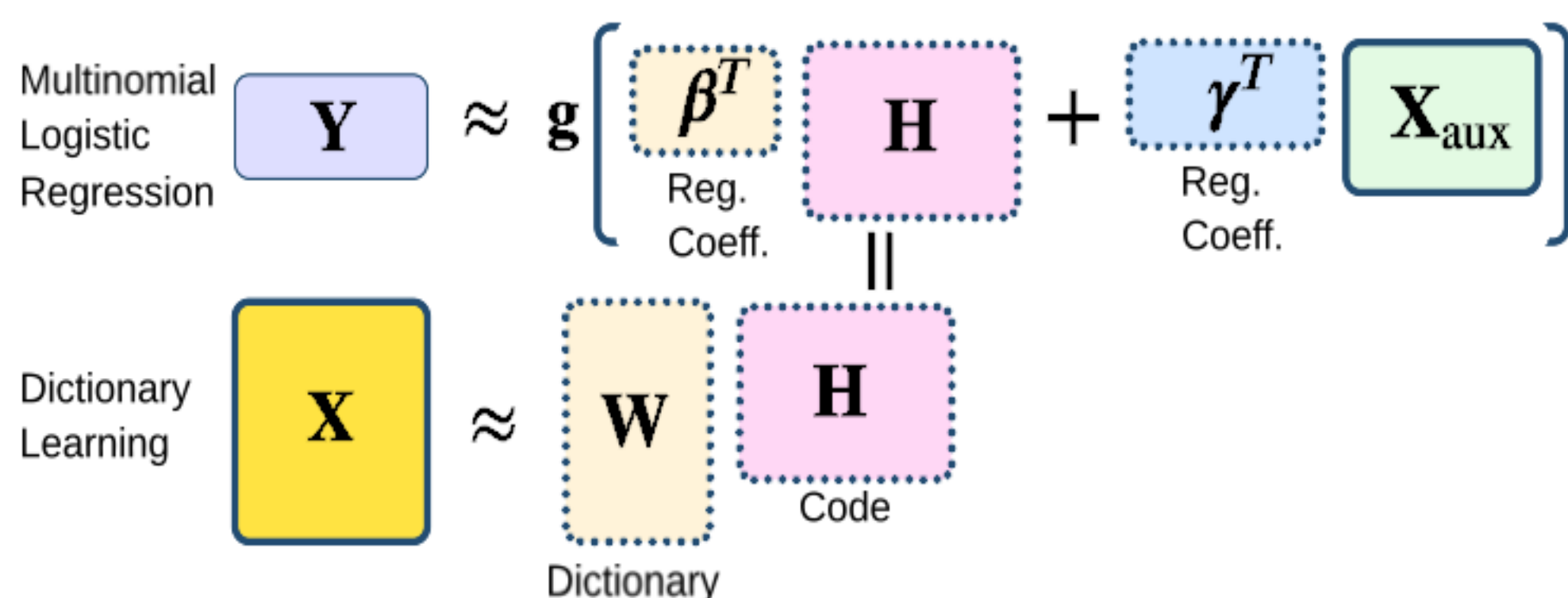
- Perform the tasks of feature extraction and classification simultaneously for interpretability.
- Learn a class-discriminative dictionary that can well-explain both the features as well as labels of observed data.
- [Perform supervised learning in the framework of dictionary learning.](#)

Method

Input

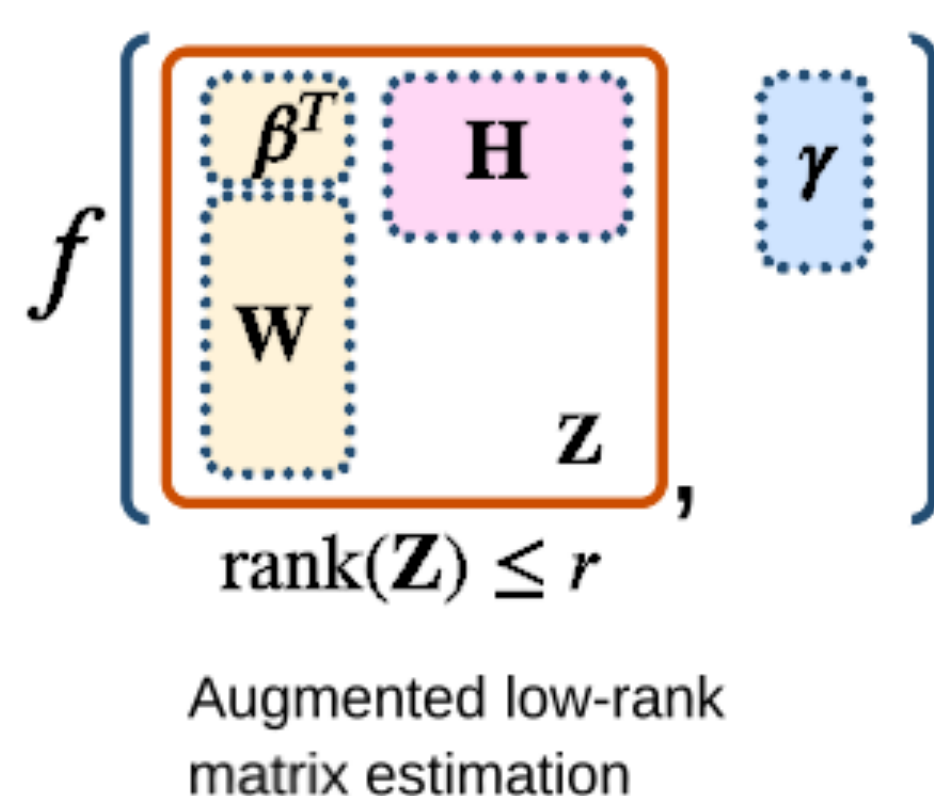


Model



- Designed for multi-class classification by combining low-dimensional informative features X_{aux} (such as age and sex) and high-dimensional features X (such as genes) that may not all be informative or easily interpretable.

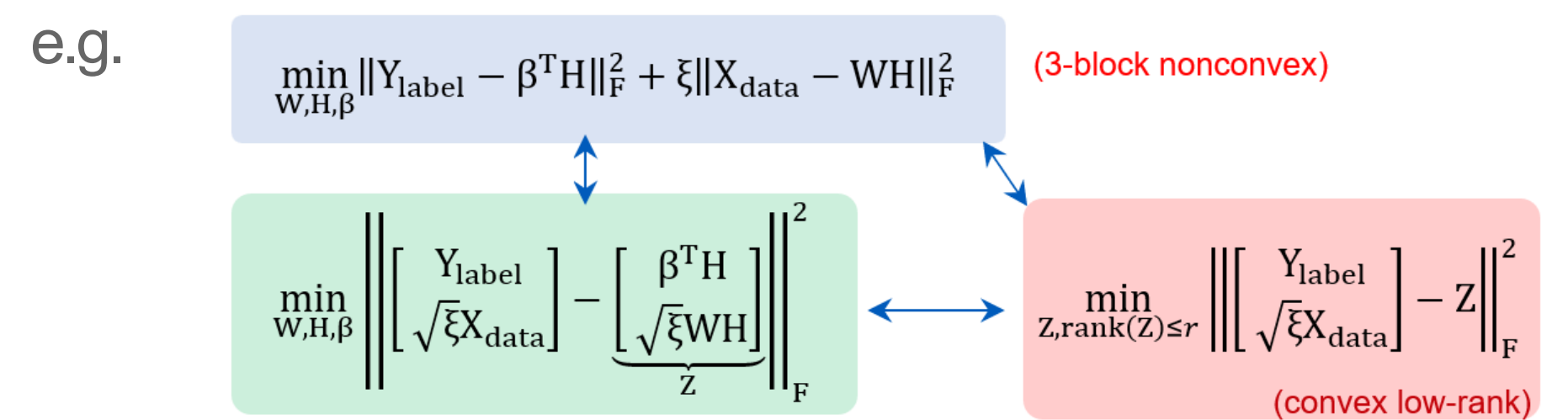
Training



- Combines the loss functions of logistic regression and matrix factorization \Rightarrow [Nonconvex optimization problem with 4 blocks.](#)
- Computationally challenging to solve exactly.

Sketch of algorithm

- Convert SDL problem into a low-rank matrix estimation problem.



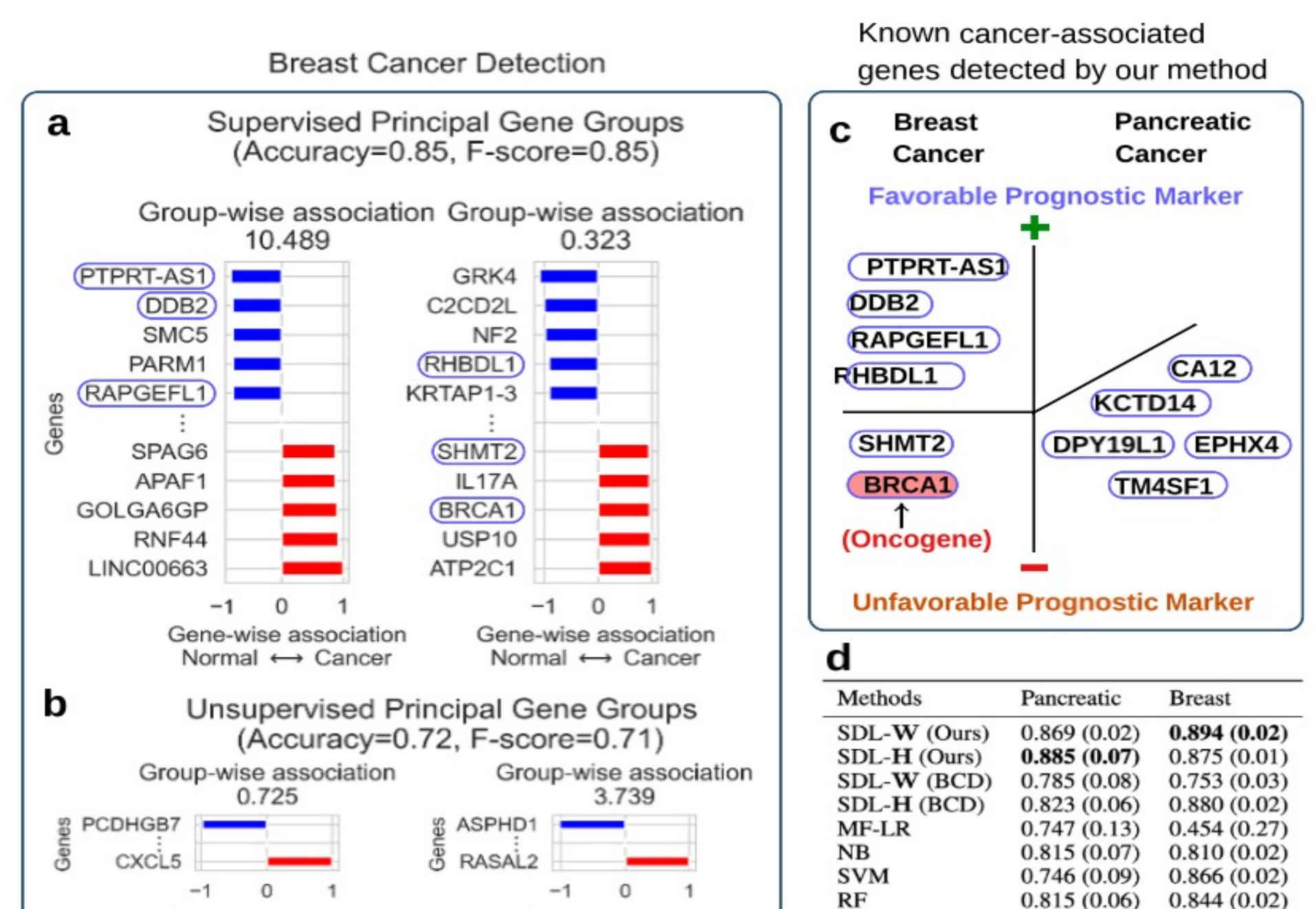
- Obtain convex objective function with two blocks by suitably stacking up the matrices.
- Apply Low-rank Projected Gradient Descent (LPGD).
 - projected gradient descent to convex constraint set \rightarrow Rank-r projection via truncated SVD.
- Decompose the lifted solution.
 - Recover original 3 factors from the stacked matrices via rank-r SVD.

Computational guarantee

- Converges exponentially to the global minimizer of the objective.
- Achieves ϵ -accurate global optimum with $O(\log \epsilon^{-1})$ complexity comparable to nonconvex SDL problem to achieve at best ϵ -stationary point with $O(\epsilon^{-1})$.

Application

Microarray analysis for cancer classification



- Successfully identifies discriminative gene groups that include well-known cancer-associated genes.

Reference

Joowon Lee, Hanbaek Lyu, and Weixin Yao. "Supervised Dictionary Learning with Auxiliary Covariates". In: arXiv preprint arXiv:2206.06774 (2022).