

# Introduction to Machine Learning

## Lab 3: Regularized Linear Regression

Hongteng Xu

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### 1 Motivation

- Implement the commonly-used regularization methods for learning regression.
- Implement commonly-used learning algorithm, such as soft-thresholding for lasso, and iteratively reweighted least squares (IRLS) for robust linear regression.
- Quantitatively analyze the performance of different methods on model estimation and data prediction.

### 2 Tasks

**Please read Lecture 4 carefully before doing this lab work.**

1. Given the problem

$$\min_{\mathbf{w}} \|\mathbf{y} - \mathbf{X}\mathbf{w}\|_2^2 + \gamma \|\mathbf{w}\|_2^2, \quad (1)$$

implement the function “training” to achieve its closed-form solution.

2. Given the problem in (1), implement the function “training\_sgd” to learn the model via stochastic gradient descent.
3. Implement the iterative soft-thresholding algorithm to solve the lasso problem

$$\min_{\mathbf{w}} \|\mathbf{y} - \mathbf{X}\mathbf{w}\|_2^2 + \gamma \|\mathbf{w}\|_1. \quad (2)$$

4. Implement an algorithm to solve the linear regression with elastic net regularization

$$\min_{\mathbf{w}} \|\mathbf{y} - \mathbf{X}\mathbf{w}\|_2^2 + \gamma_1 \|\mathbf{w}\|_1 + \gamma_2 \|\mathbf{w}\|_2^2, \quad (3)$$

(Hint: Reformulate it to Lasso.)

5. Implement the iteratively reweighted least squares (IRLS) to solve robust linear regression:

$$\min_{\mathbf{w}} \|\mathbf{y} - \mathbf{X}\mathbf{w}\|_1 \quad (4)$$