CSCD 496-040 Prog 4

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Sub-project 5

Dataset & Pre-Processing

For the following experiments, the `houseprice` dataset is used. To normalize our dataset, the "0-1" normalization method is used. This is all that constitutes the pre-processing phase.

Methodology

For both Closed-form and Gradient Descent learning approaches, we use an automated script to train our model for many different combinations of hyperparameters.

For Closed-form, these hyperparameters are

- The degree of Z-space
- λ (regularization)

For Gradient Descent, our tunable hyperparameters are

- The degree of Z-space
- λ (regularization)
- η (learning rate)
- The number of epochs

As mentioned above, we will use automated scripts to train our model for every unique combination of our hyperparameters. In the below section we will examine the results for our test conducted with hyperparameters:

- Z-transform Degree: $\{1, 2, 3, 4\}$
- λ: $\{0.01, 0.001, 0\}$
- η: $\{0.01, 0.001, 0.0001\}$ (Gradient Descent only)
- epochs: 100,000 (Gradient Descent only)

Results

For both Gradient Descent and Closed-Form approaches, we query our recorded output for each training run to find the optimal hyperparameters. This is the run with the least validation mean squared error (MSE).

For our **Closed-form** training runs, we found that the run that yielded the least validation error is:

- Validation MSE: 0.014868
- Z-transform Degree: 4
- λ: 0.01
- η: 0.01

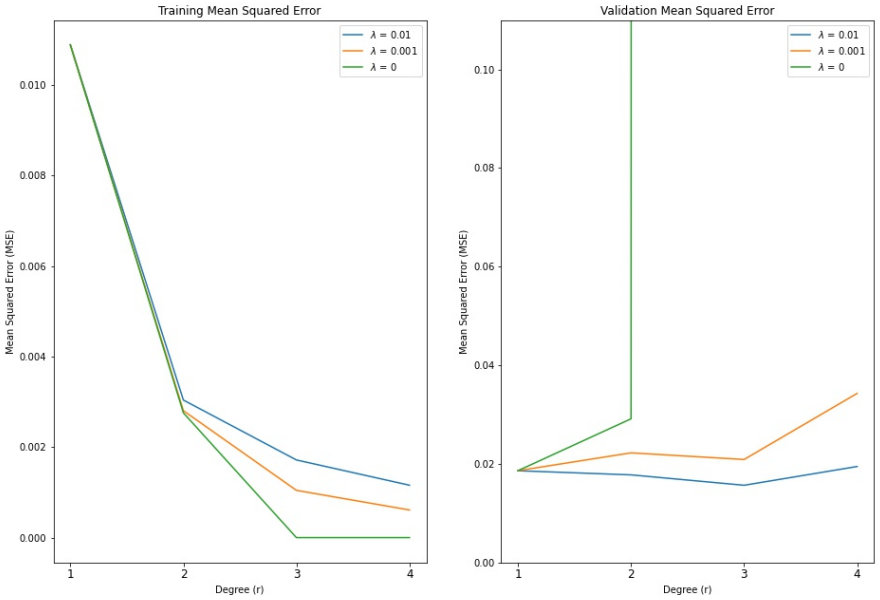
For our **Gradient Descent** training runs, we found that the run that yielded the least validation error is:

- Validation MSE: 0.0156215
- Z-transform Degree: 3
- λ: 0.01

Visualization

Closed-Form Method

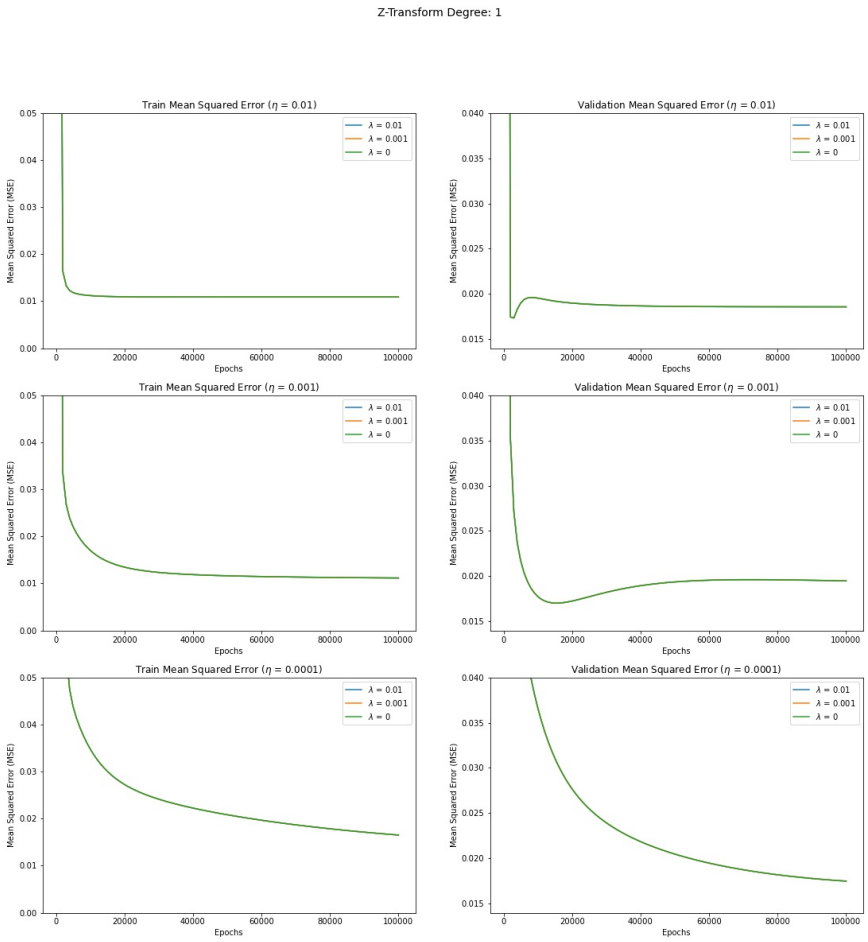
In the following figures, we examine the relationship between regularization (λ) and MSE. Note that our x-axis will be our Z-transform degree values.

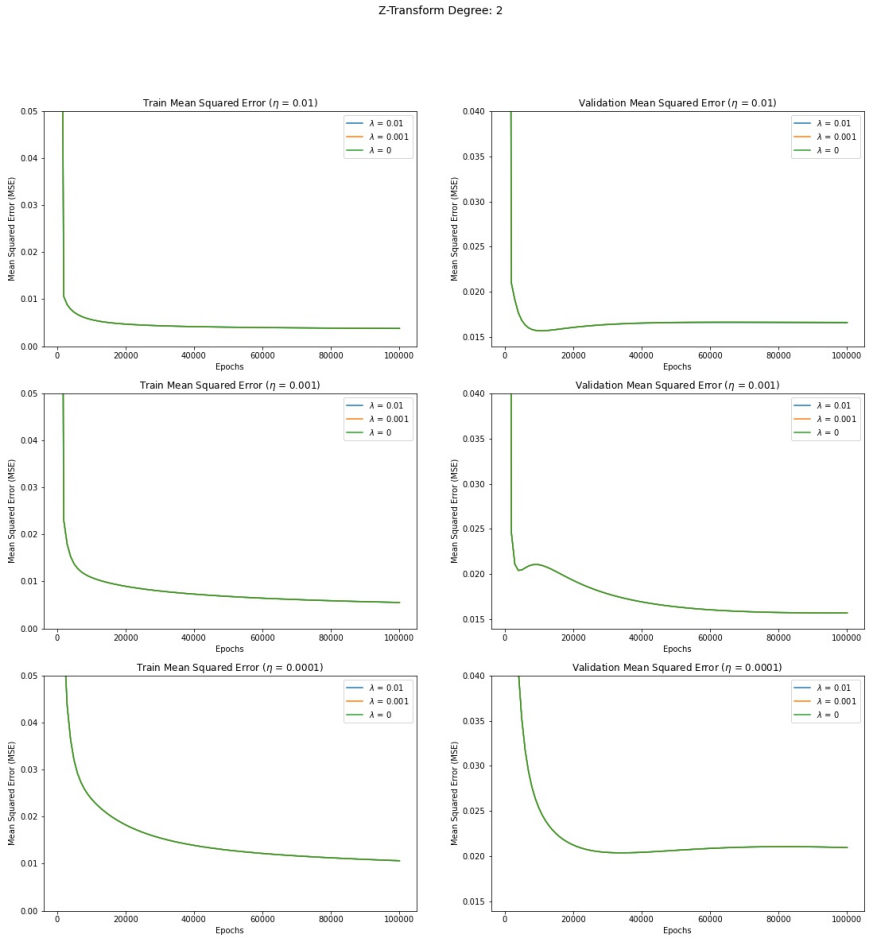


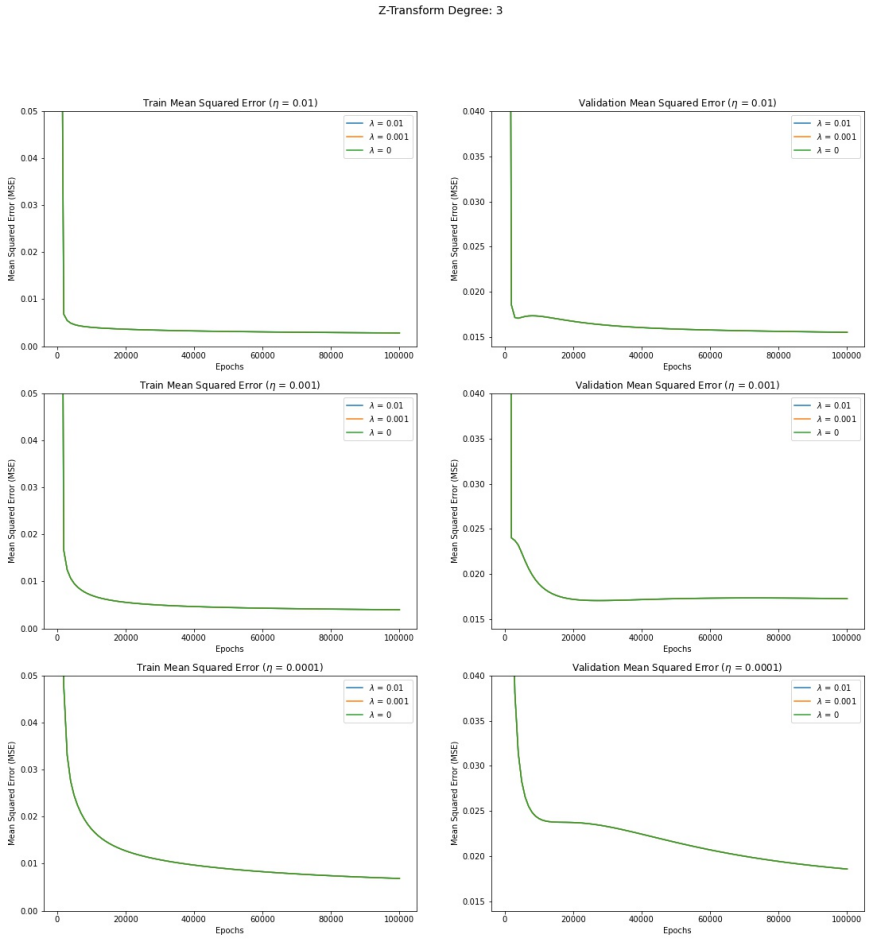
Gradient-Descent Method

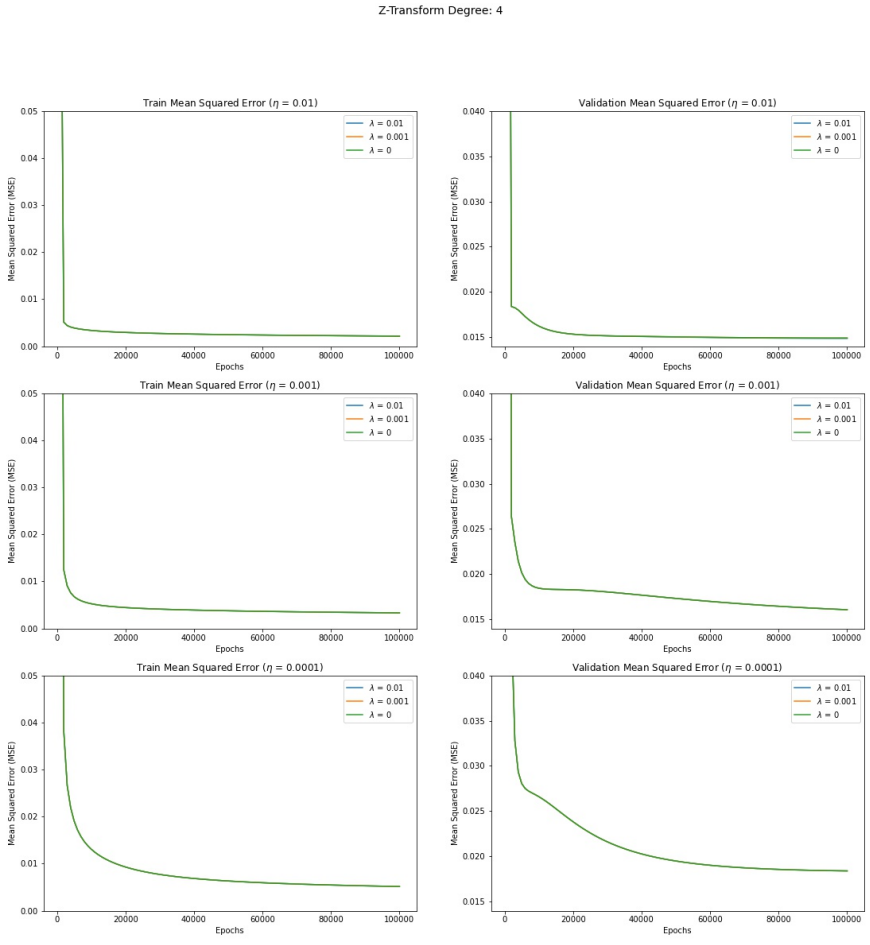
Note: For each Z-transform degree, we will generate a new figure. Within this figure it will consist of two columns of sub-figures. The left column will examine training MSE, and the right validation MSE.

In the first set of figures, we examine the relationship between regularization (λ) and MSE. Note that for each pair of subplots, we fix the learning rate (η).

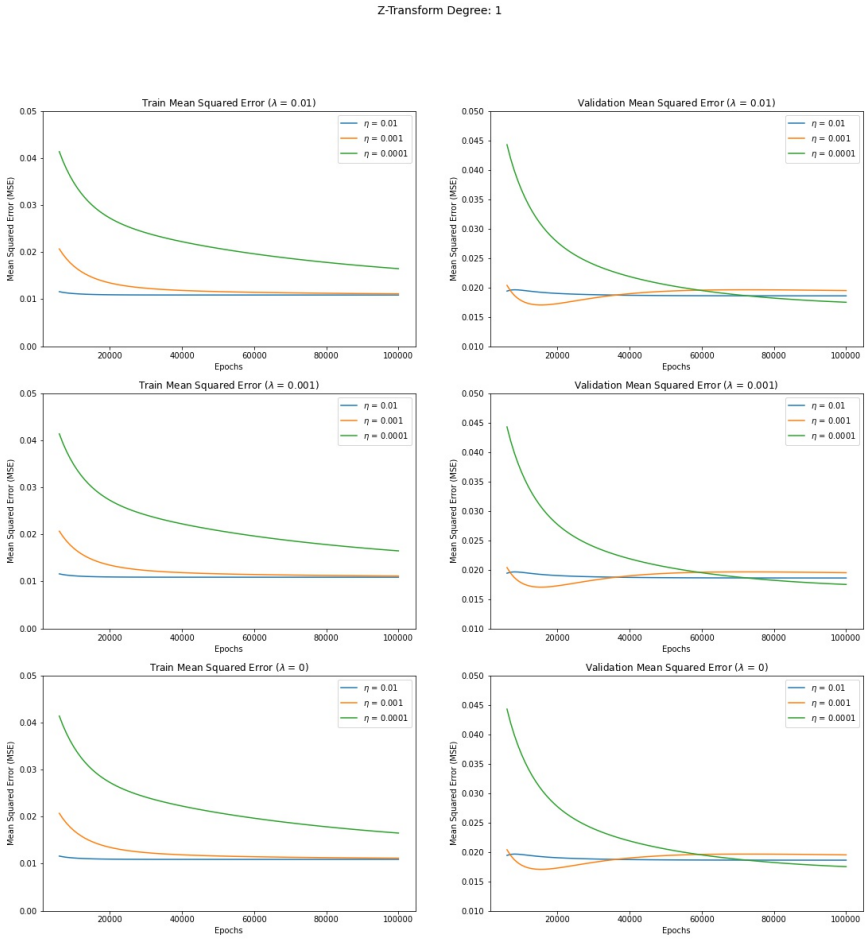


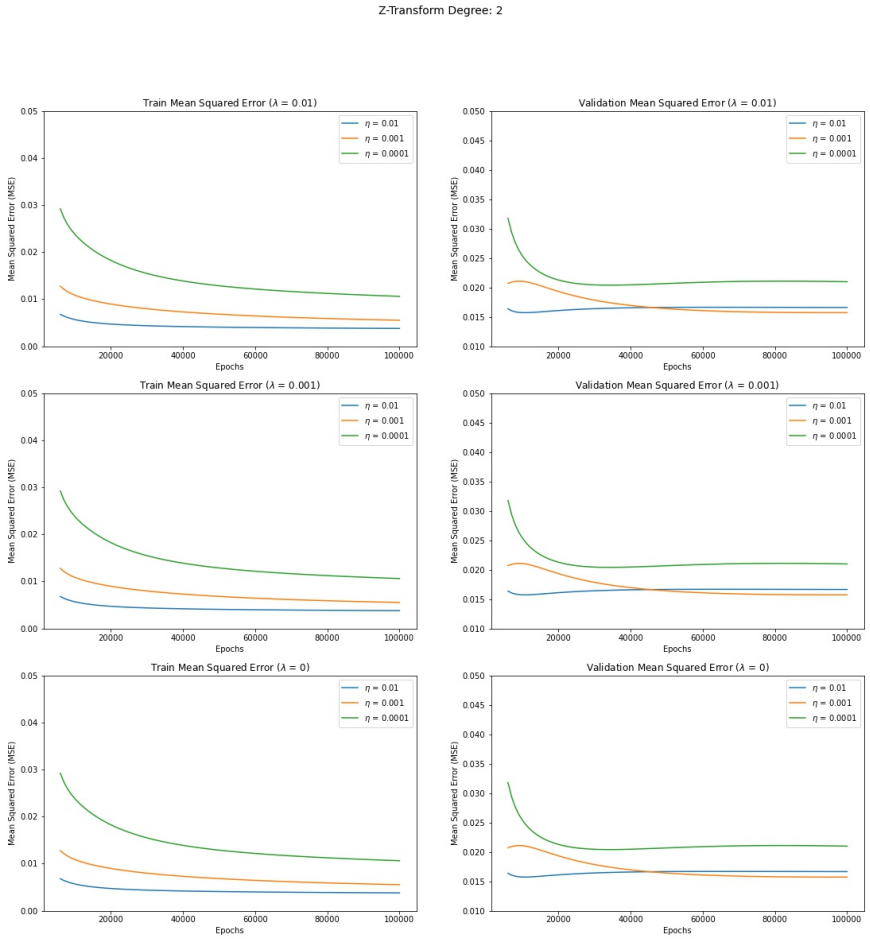

Z-Transform Degree: 2
Train Mean Squared Error (η = 0.01)
Validation Mean Squared Error (η = 0.01)
Train Mean Squared Error (η = 0.001)
Validation Mean Squared Error (η = 0.001)
Train Mean Squared Error (η = 0.0001)
Validation Mean Squared Error (η = 0.0001)
λ = 0.01
λ = 0.001
λ = 0
Mean Squared Error (MSE)
Epochs

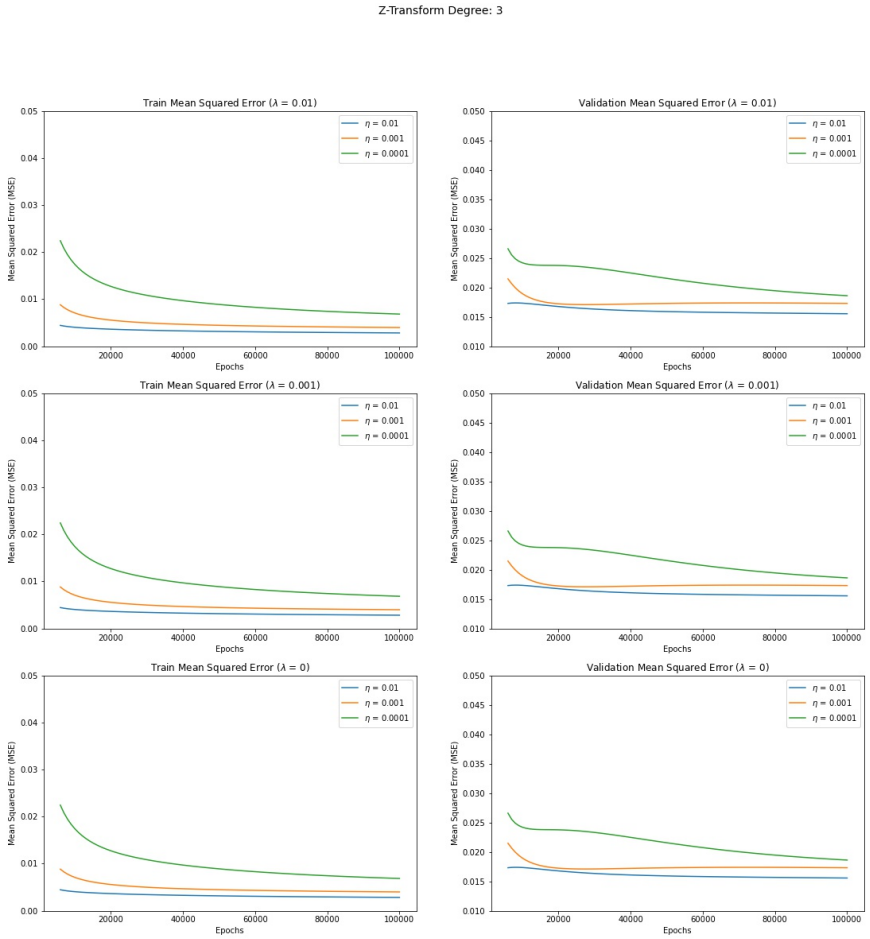

Z-Transform Degree: 3
Train Mean Squared Error (η = 0.01)
Validation Mean Squared Error (η = 0.01)
Train Mean Squared Error (η = 0.001)
Validation Mean Squared Error (η = 0.001)
Train Mean Squared Error (η = 0.0001)
Validation Mean Squared Error (η = 0.0001)
λ = 0.01
λ = 0.001
λ = 0
Mean Squared Error (MSE)
Epochs

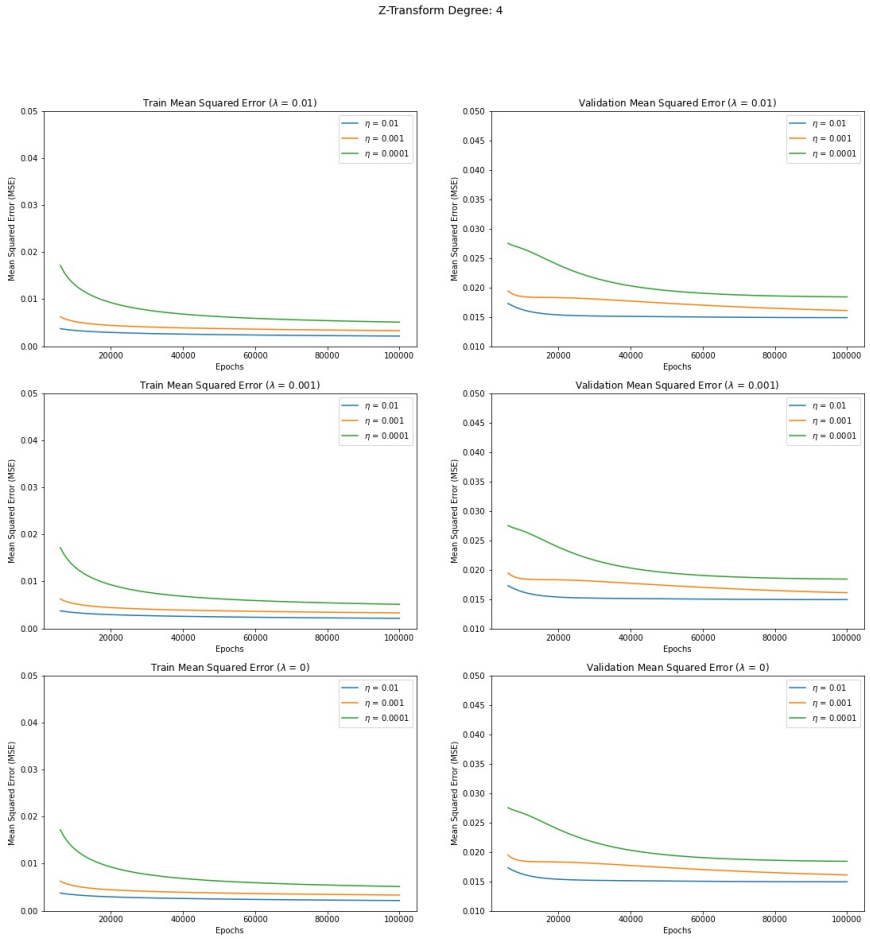

Z-Transform Degree: 4
Train Mean Squared Error (η = 0.01)
Validation Mean Squared Error (η = 0.01)
Train Mean Squared Error (η = 0.001)
Validation Mean Squared Error (η = 0.001)
Train Mean Squared Error (η = 0.0001)
Validation Mean Squared Error (η = 0.0001)
λ = 0.01
λ = 0.001
λ = 0
Mean Squared Error (MSE)
Epochs

In the next set of figures, we examine the relationship between learning rate (η) and MSE. Note that for each pair of subplots, we fix the regularization (λ).




Z-Transform Degree: 2
Train Mean Squared Error (λ = 0.01)
Validation Mean Squared Error (λ = 0.01)
Train Mean Squared Error (λ = 0.001)
Validation Mean Squared Error (λ = 0.001)
Train Mean Squared Error (λ = 0)
Validation Mean Squared Error (λ = 0)
η = 0.01
η = 0.001
η = 0.0001
Mean Squared Error (MSE)
Epochs


Z-Transform Degree: 3
Train Mean Squared Error (λ = 0.01)
Validation Mean Squared Error (λ = 0.01)
Train Mean Squared Error (λ = 0.001)
Validation Mean Squared Error (λ = 0.001)
Train Mean Squared Error (λ = 0)
Validation Mean Squared Error (λ = 0)
η = 0.01
η = 0.001
η = 0.0001
Mean Squared Error (MSE)
Epochs


Z-Transform Degree: 4
Train Mean Squared Error (λ = 0.01)
Validation Mean Squared Error (λ = 0.01)
Train Mean Squared Error (λ = 0.001)
Validation Mean Squared Error (λ = 0.001)
Train Mean Squared Error (λ = 0)
Validation Mean Squared Error (λ = 0)
η = 0.01
η = 0.001
η = 0.0001
Mean Squared Error (MSE)
Epochs