# Assignment 3

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***Abstract*— This document is assignment 3 of MAE263F class.**

## I. Problem 1 result

By using the given parameter and code, with 10000 epochs nad learning rate = 0.001, the result of difference between actual number and predicted number is shown below:

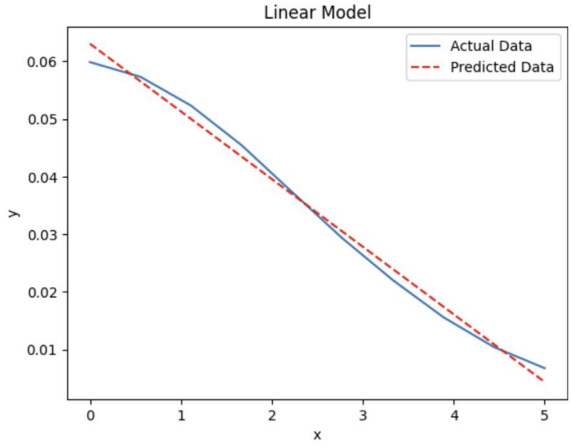


Fig. 1: Difference between actual and predict value-liner

By revising the epochs number and learning rate, the result should be different. The following pictures show the result of difference between actual number and predicted number with same learning rate (learning rate = 0.001) but different epochs:

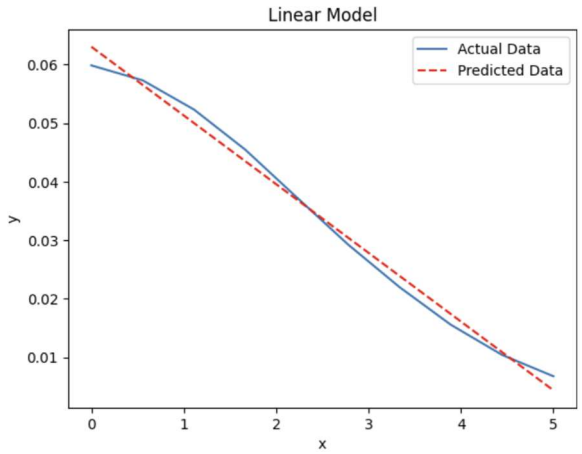


Fig. 2: Difference between actual and predict value-linear-epochs=100000

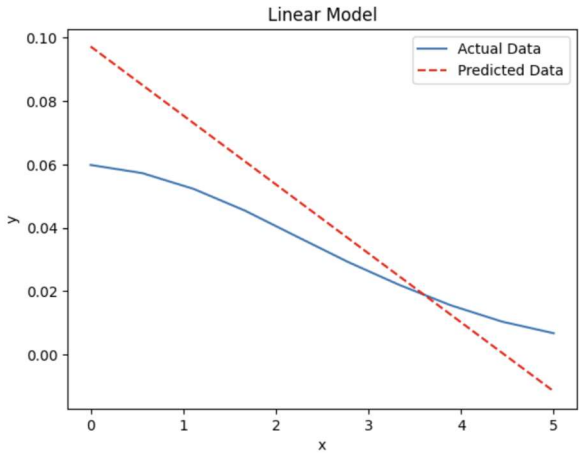


Fig. 3: Difference between actual and predict value-linear-epochs=1000

Based on the above results, the accuracy generally improves as the number of epochs increases, leading to more convergent results and reduced loss. However, when the number of epochs is set to 1000, the predicted result does not fit the actual data well, indicating a lack of convergence and a high loss. Conversely, when the number of epochs reaches a certain threshold, the improvement in accuracy becomes negligible. For example, the result graphs for epochs = 1000 and epochs = 10000 appear very similar.

The following pictures show the result of difference between actual number and predicted number with same epochs (epochs = 10000 ) but different learning rate:

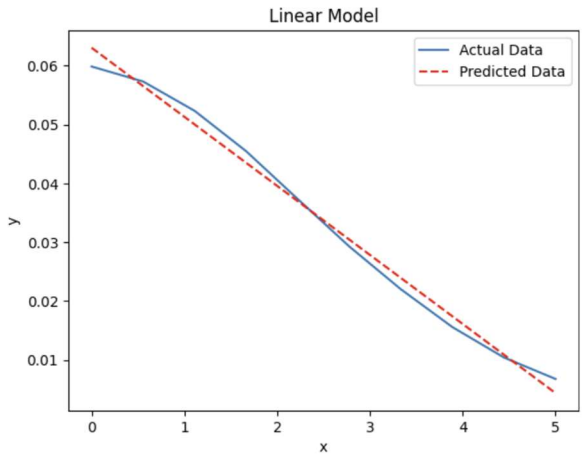


Fig. 4: Difference between actual and predict value-linear-learning rate = 0.01

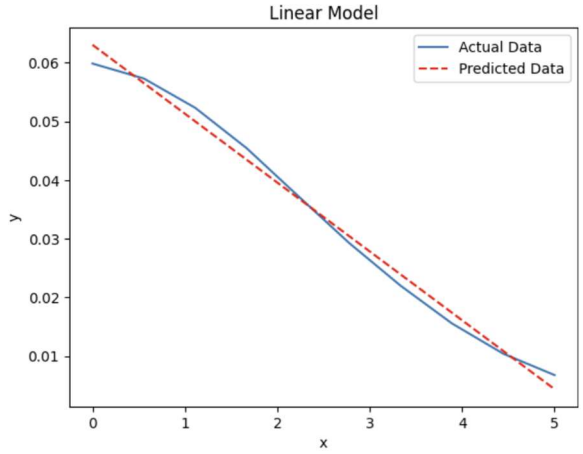


Fig. 5: Difference between actual and predict value-linear-learning rate = 0.1

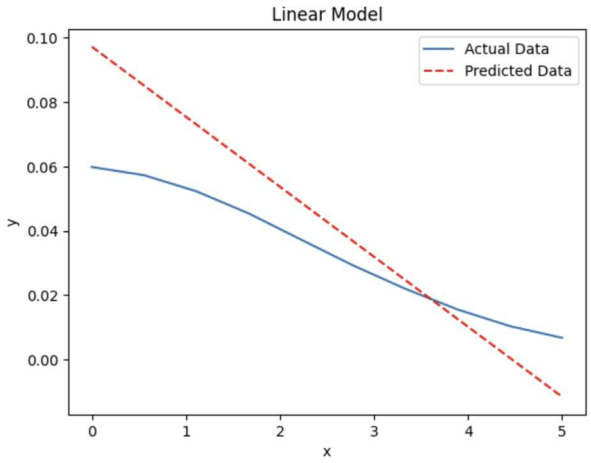


Fig. 6: Difference between actual and predict value-linear-learning rate = 0.0001

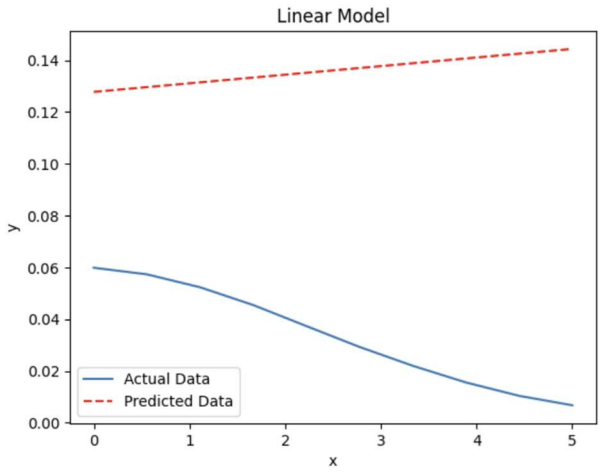


Fig. 7: Difference between actual and predict value-linear-learning rate = 0.00001

In contrast to epochs, the accuracy generally decreases as the value of learning rate increases, leading to less convergent results and increased loss. When learning rate equal to 0.01 and 0.1, the result is similar, which is convergent results. When the learning rate equal to 0.0001, the graph starts to become non convergent. Furthermore, when the learning rate is decreased to 0.00001, the predicted result is significantly different from the actual value, making the result extremely non convergent. As a result, by considering the running time of the program, the best combination should be epochs = 10000 and learning rate = 0.01.

## II. Problem 2

By using the given parameter and code, with 10000 epochs nad learning rate = 0.001, the result of difference between actual number and predicted number is shown below:

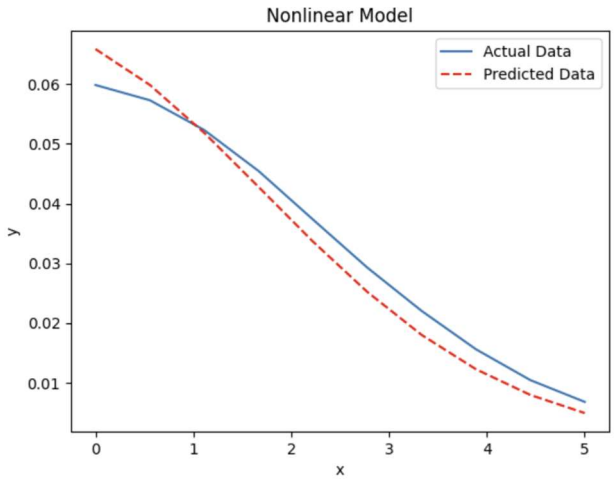


Fig. 8: Difference between actual and predict value-nonlinear

By revising the epochs number and learning rate, the result should be different. The following pictures show the result of difference between actual number and predicted number with same learning rate (learning rate = 0.001) but different epochs:

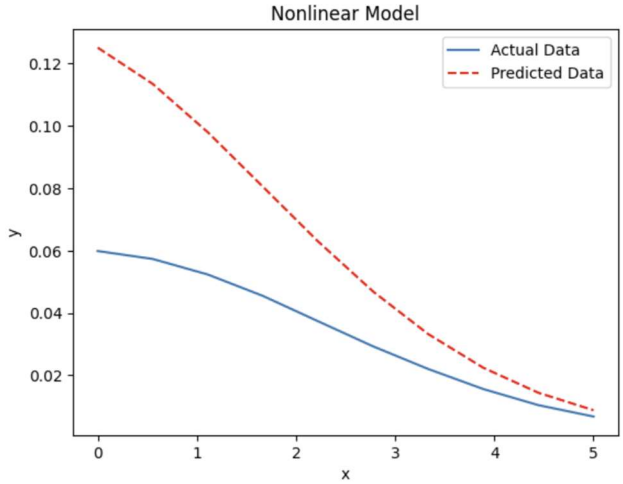


Fig. 9: Difference between actual and predict value-nonlinear-epochs=1000

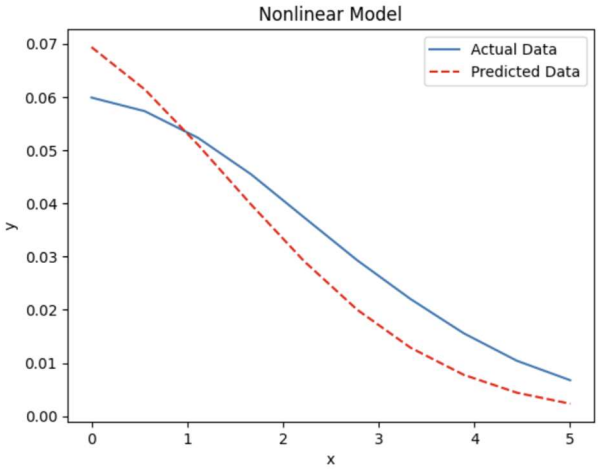


Fig. 10: Difference between actual and predict value-nonlinear-epochs=100000

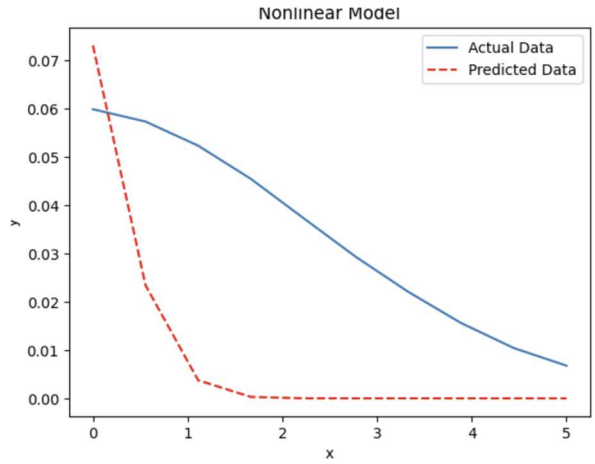


Fig. 11: Difference between actual and predict value-nonlinear-epochs=1000000

When the number of epochs is small, the results become non-convergent, leading to higher loss. Unlike linear models, accuracy does not necessarily increase as the number of epochs increases. When the number of epochs becomes excessively large, the results also start to lose convergence. In extreme cases, the predicted results may overshoot, resulting in significant loss.

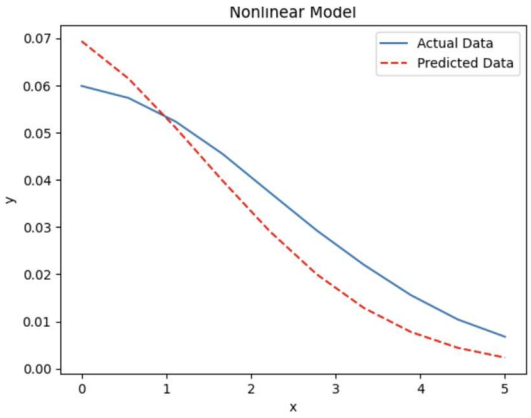


Fig. 12: Difference between actual and predict value-linear-learning rate = 0.01

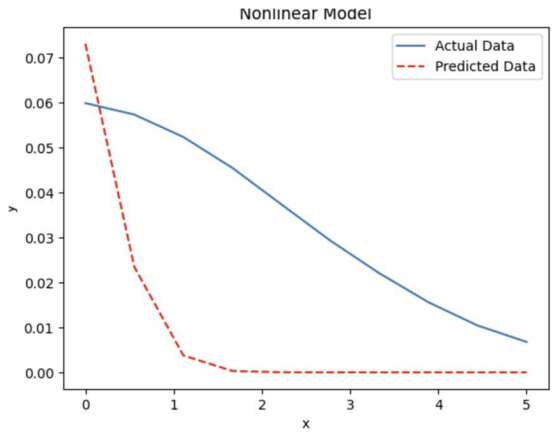


Fig. 13: Difference between actual and predict value-linear-learning rate = 0.1

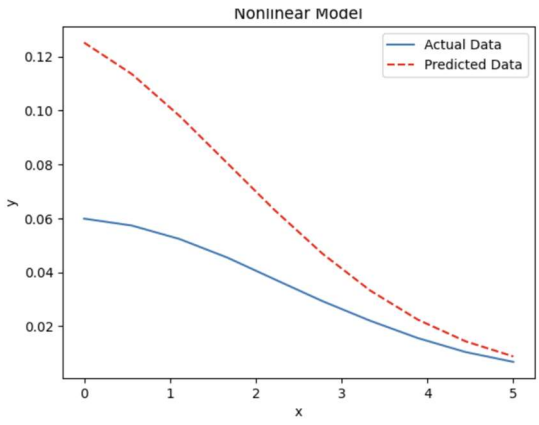


Fig. 14: Difference between actual and predict value-linear-learning rate = 0.0001

When the learning rate decreases, the results become non-convergent, leading to higher loss. Unlike in linear models, when the learning rate increases, the results also start to lose convergence. In extreme cases, a high learning rate can cause the predicted results to overshoot, resulting in significant loss.

As a result, the best combination for nonlinear model should be the given settings which is epochs = 10000 and learning rate = 0.001.

## III. Discussion

The performance of the two models is different from what I initially expected. In the linear model, convergence improves as the number of epochs increases, which contrasts with the behavior of the non-linear model. Simply increasing the number of epochs in the non-linear model can lead to overshooting, resulting in reduced convergence and higher loss.

As for the learning rate, the convergence decreases as the learning rate is reduced in the linear model, which is similar to the behavior observed in the non-linear model. However, if the learning rate is increased too much, it can cause overshooting in the non-linear model as well.

## References

[1] M. K. Jawed and S. Lim, *Discrete Simulation of Slender Structures*. 2022.