COMP6247 Final Assignment: Learning Controller

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1 Introduction

This report presents the findings and results for the final assignment of COMP6247 [1]. The code implementation is stored in a Github repository [2].

2 Radial Basis Functions

In this section, we explore the use of Radial Basis Functions (RBF) on Reinforcement and Online Learning problems.

2.1 Regression

First, RBF is used to solve a non-linear regression problem. The Airfoil Self-noise Dataset [3] from the UCI repository of machine learning is used as the problem of interest for regression. The dataset consists of samples of aerodynamic and acoustic tests of airfoil blades conducted in a wind tunnel. The features given include:

1. Frequency, in Hertz
2. Angle of attack, in degrees
3. Chord length, in meters
4. Free-stream velocity, in metres per second
5. Suction side displacement thickness, in metres

The output to be predicted is the scaled sound pressure level, in decibels.

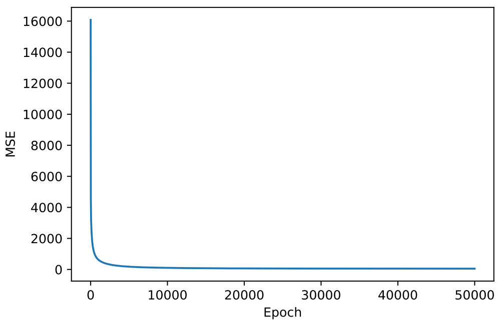
First, we attempt to solve the problem with a linear regression in closed form, $\boldsymbol{W} = (X^T X)^{-1} X^T \boldsymbol{y}$. We then proceed to apply an RBF kernel with Gaussian function. Three approaches were used to solve for the RBF regression parameters:

- Closed form, $\boldsymbol{W} = (U^T U)^{-1} U^T \boldsymbol{y}$
- Gradient Descent (GD), epochs = 50000
- Mini-batch Stochastic Gradient Descent (SGD), batch size = 64, epochs = 10000

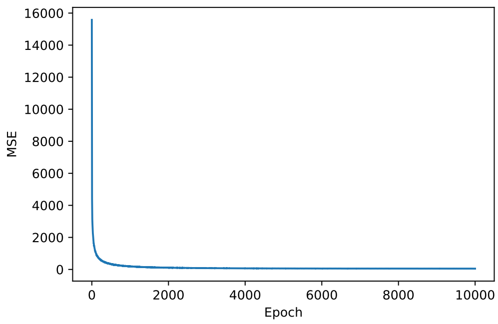
The Mean Squared Error (MSE) results are shown in Table 1. Linear regression is shown to be insufficient in solving this problem, as the MSE calculated is substantially higher than RBF regression solutions. The RBF closed form solution provided the optimal solution. Both gradient descent methods show convergence of the loss function and also provided similar results, as illustrated in Fig. 1. However, it is shown that SGD required less number of epochs before convergence. The loss of the gradient descent methods can be further optimised by lowering the learning rate or using adaptive methods or learning rate schedulers.

Table 1: Mean squared error for regression problem.

Model	MSE
Linear	915.288358
RBF Closed Form	33.754672
RBF GD	49.234992
RBF SGD	48.822703



(a) Gradient Descent



(b) Stochastic Gradient Descent

Figure 1: Loss curves for regression using gradient descent approaches.

2.2 Mountain Car Learning Controller

References

[1] Mahesan Niranjan and Christine Evers. *COMP6247(2020/21): Reinforcement and Online Learning - Final Assignment*. School of Electronics and Computer Science, University of Southampton.

[2] Eugene Teoh. *Eugeneteoh/COMP6247-Reinforcement-Online-Learning*. May 7, 2021. URL: `https://github.com/eugeneteoh/COMP6247-Reinforcement-Online-Learning` (visited on 05/27/2021).

[3] *UCI Machine Learning Repository: Airfoil Self-Noise Data Set*. URL: `https://archive.ics.uci.edu/ml/datasets/Airfoil+Self-Noise` (visited on 05/27/2021).