

Deep Learning Homework 1

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Question 1 - Gradient Descent/Ascent Implementation

This question implements gradient descent and gradient ascent algorithms for a complex objective function. The implementation includes:

- A new objective function with similar complexity but different characteristics
- Momentum-based gradient descent/ascent for better convergence
- Improved visualization with gradient paths
- Numerical gradient computation for robustness

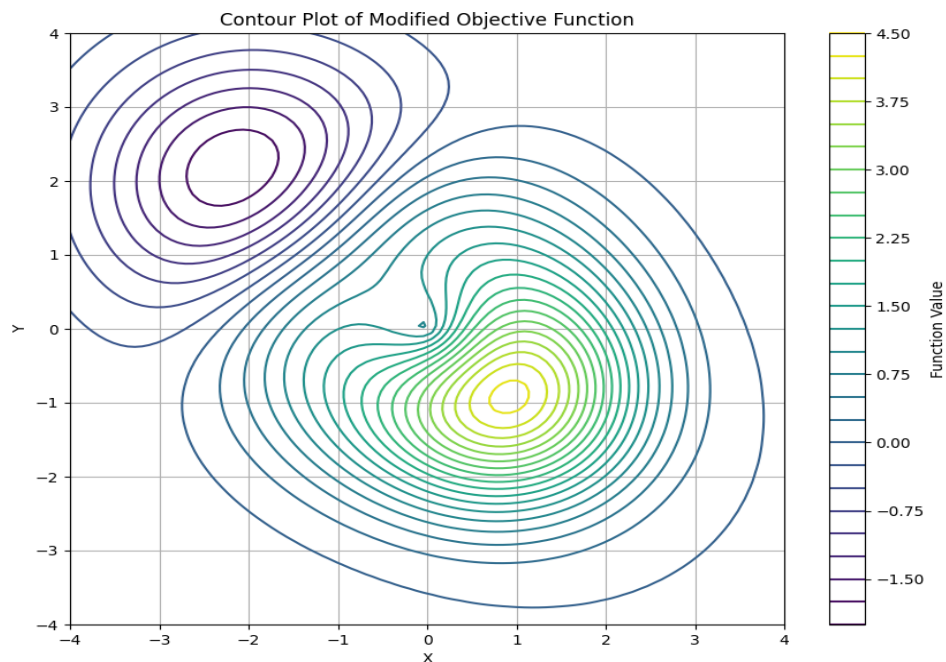


Figure 1: Contour plot of the objective function

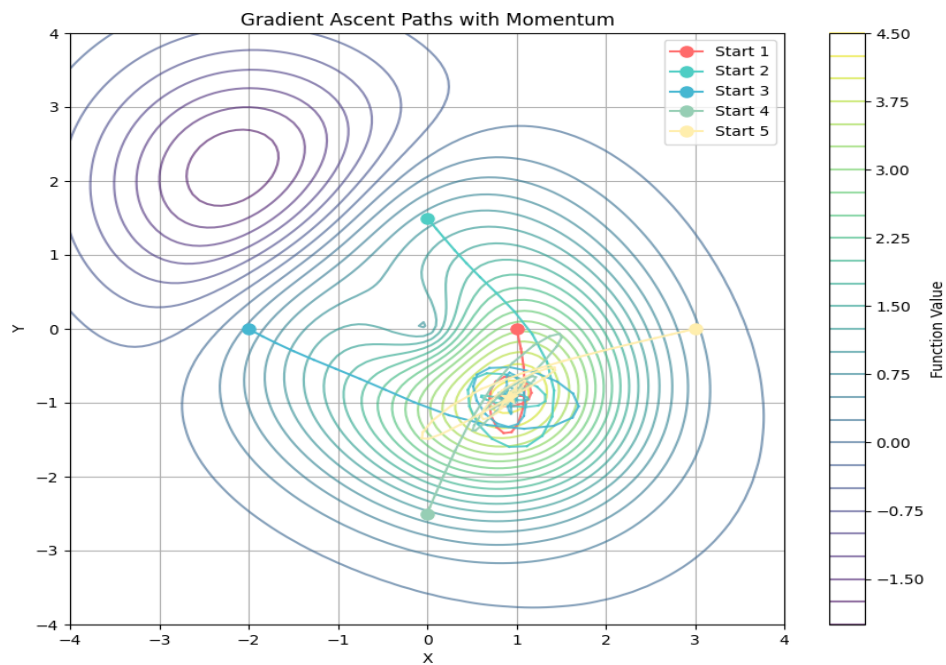


Figure 2: Gradient ascent paths with momentum

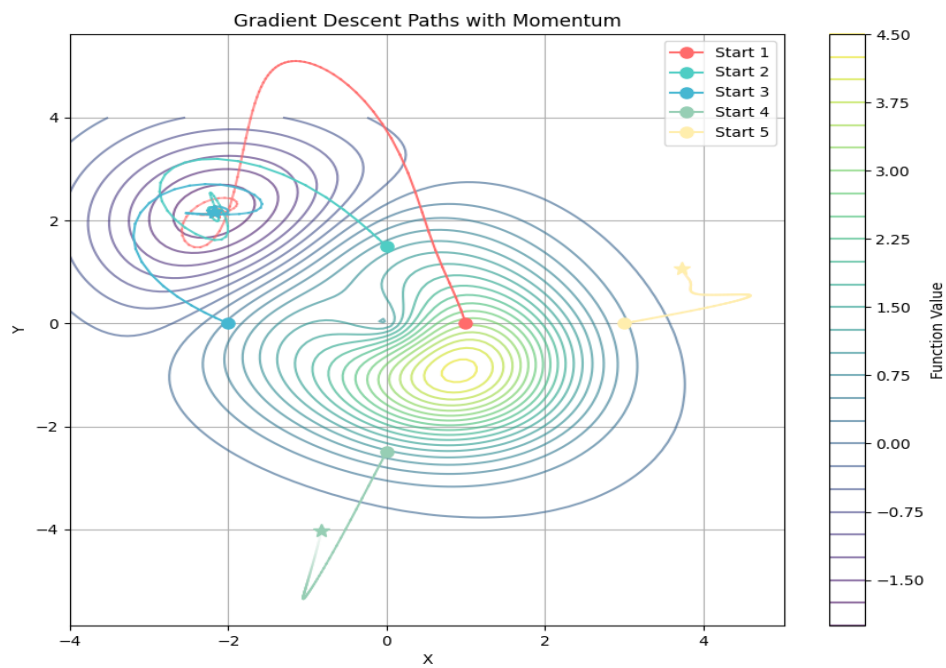


Figure 3: Gradient descent paths with momentum

Question 2 - Polynomial Regression

This question implements polynomial regression with different degrees and regularization techniques. The implementation includes:

- Linear regression (1st degree polynomial)
- 10th degree polynomial regression
- Lasso regularization with coordinate descent
- Cross-validation for model selection
- Feature normalization for numerical stability

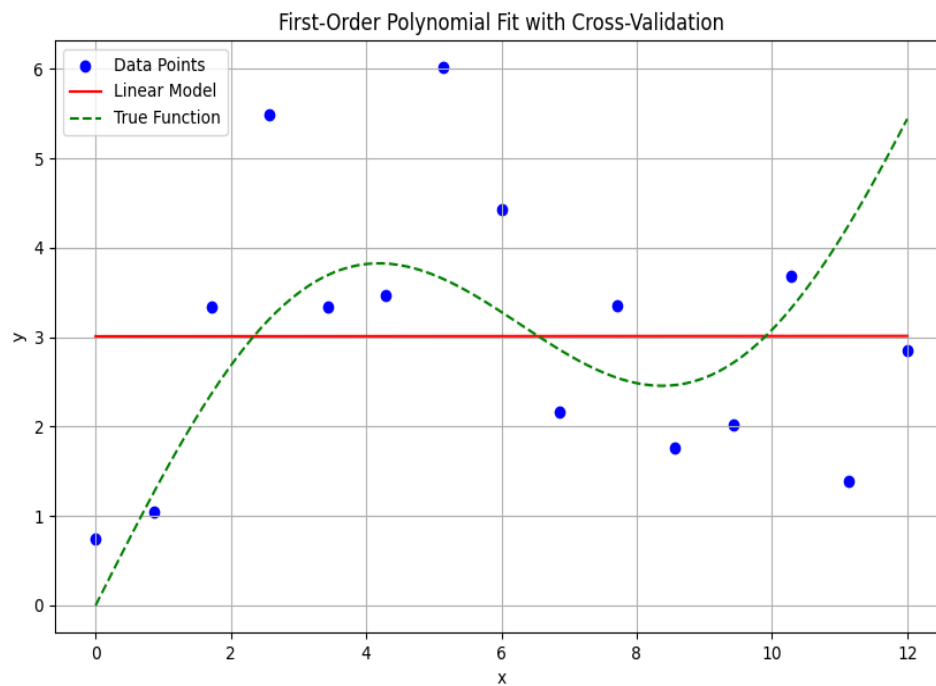


Figure 4: First-order polynomial fit with cross-validation

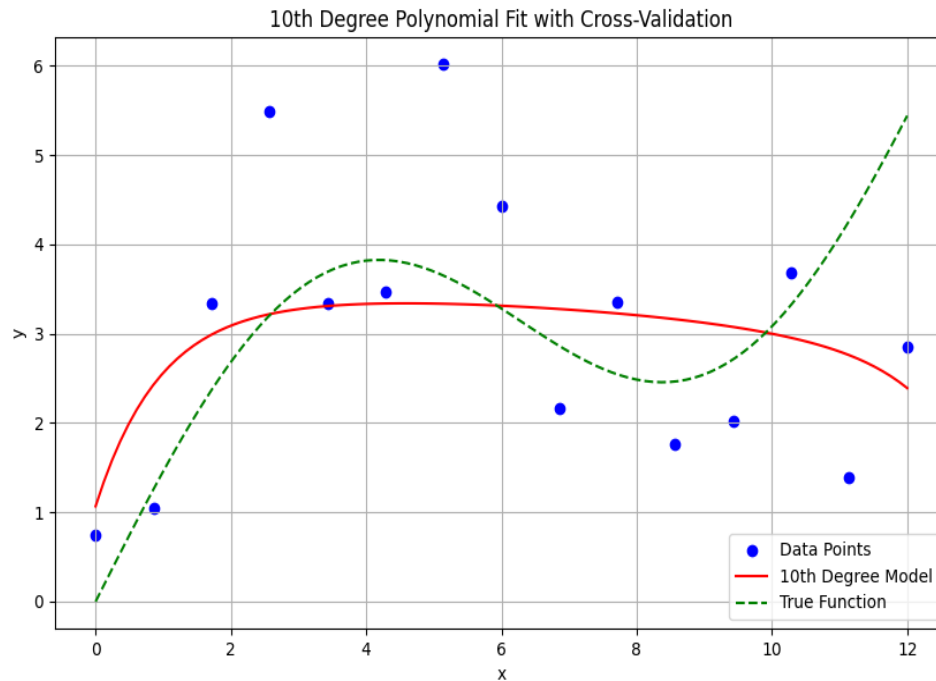


Figure 5: 10th degree polynomial fit with cross-validation

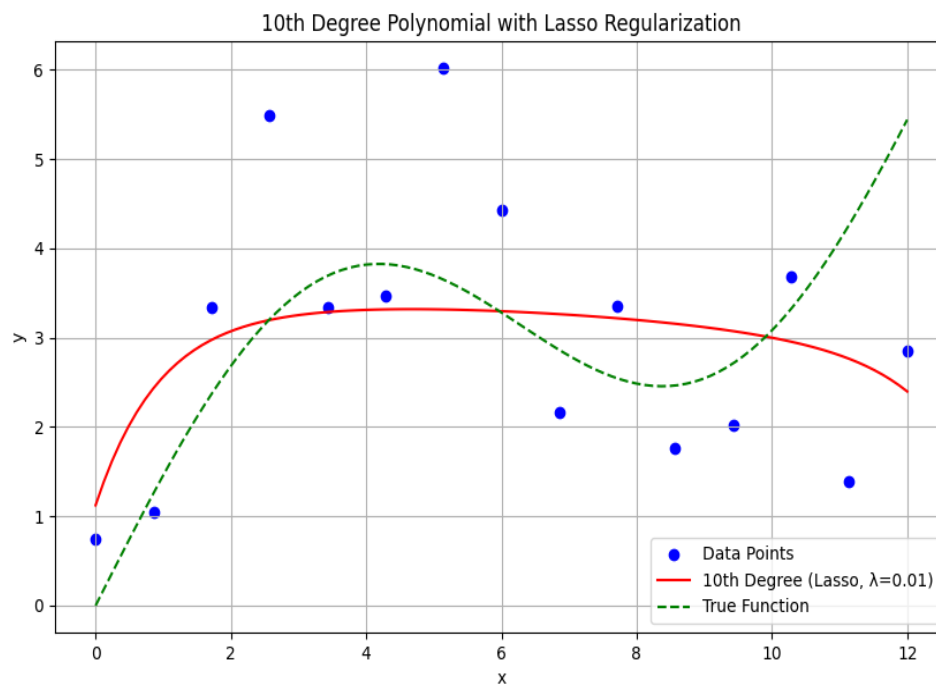


Figure 6: 10th degree polynomial with Lasso regularization

Question 3 - Logistic Regression

This question implements logistic regression with various improvements:

- Mini-batch gradient descent
- L2 regularization
- Early stopping
- Learning rate decay
- Multiple evaluation metrics

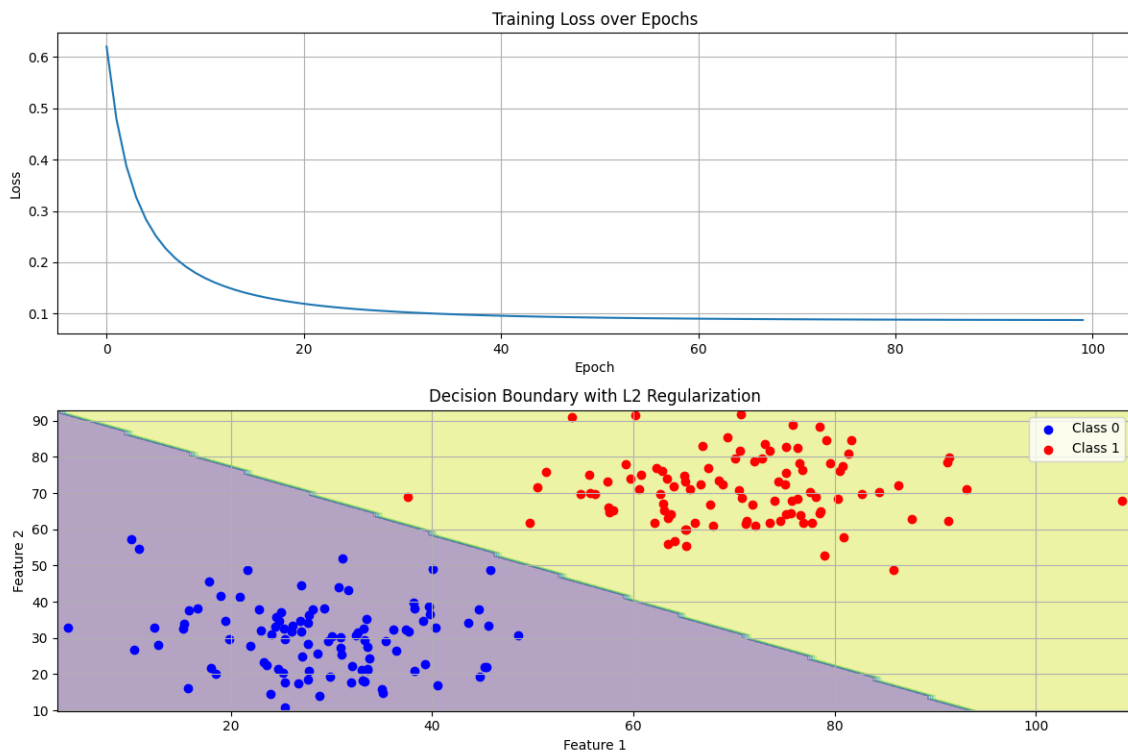


Figure 7: Logistic regression decision boundary and training loss