Course: Machine Learning
Assignment: Week 6 _ Programming Assignment
Student: Han Yun Chen (112652010)

1. Introduction

This report presents the implementation and results of Week 5 Machine Learning assignment, which includes two major tasks: (1) classification using Gaussian Discriminant Analysis (GDA), and (2) regression-based piecewise function modeling. The datasets used are derived from the Week 4 assignment.

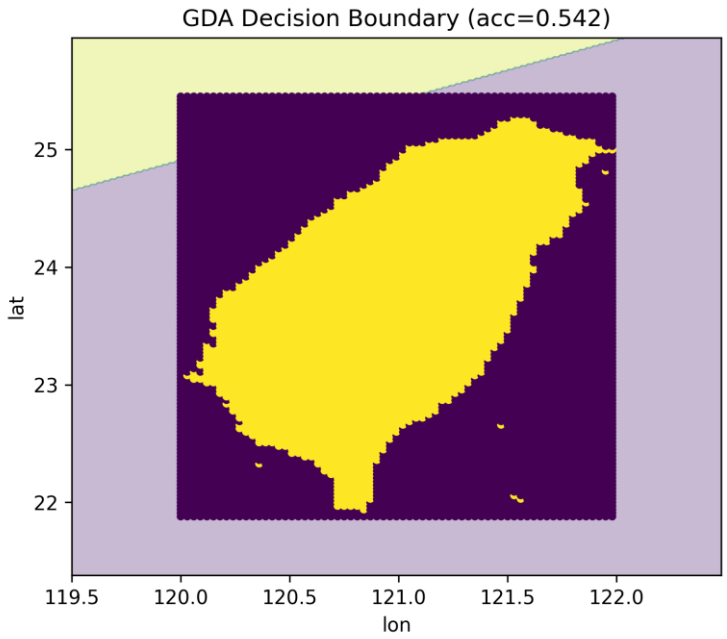
2. Classification using Gaussian Discriminant Analysis (GDA)

The Gaussian Discriminant Analysis (GDA) assumes that each class follows a multivariate normal distribution with shared covariance. Parameters are estimated using Maximum Likelihood Estimation (MLE):

$\phi = P(y=1)$, $\mu_0 = \text{mean}(x|y=0)$, $\mu_1 = \text{mean}(x|y=1)$, Σ = shared covariance matrix.

The decision boundary is defined as $\theta^T x + \theta_0 = 0$, where:
$\theta = \Sigma^{-1}(\mu_1 - \mu_0)$, $\theta_0 = -\frac{1}{2}\mu_1^T\Sigma^{-1}\mu_1 + \frac{1}{2}\mu_0^T\Sigma^{-1}\mu_0 + \log(\phi / (1 - \phi))$.

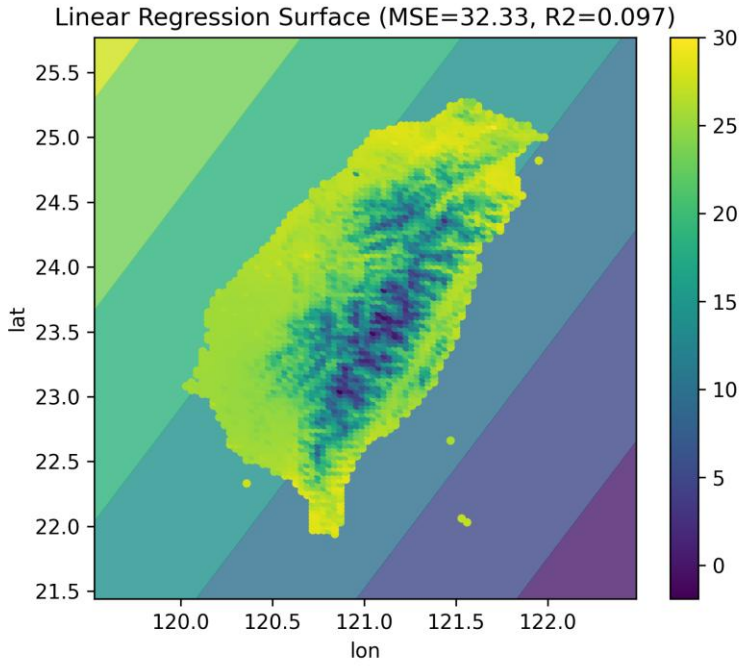
The model was trained on 80% of the dataset, achieving an accuracy of approximately 0.54. The resulting decision boundary visualization is shown below.



3. Regression Model

The regression task uses a linear regression model solved with the Normal Equation: $\theta = (X^T X)^{-1} X^T y$.

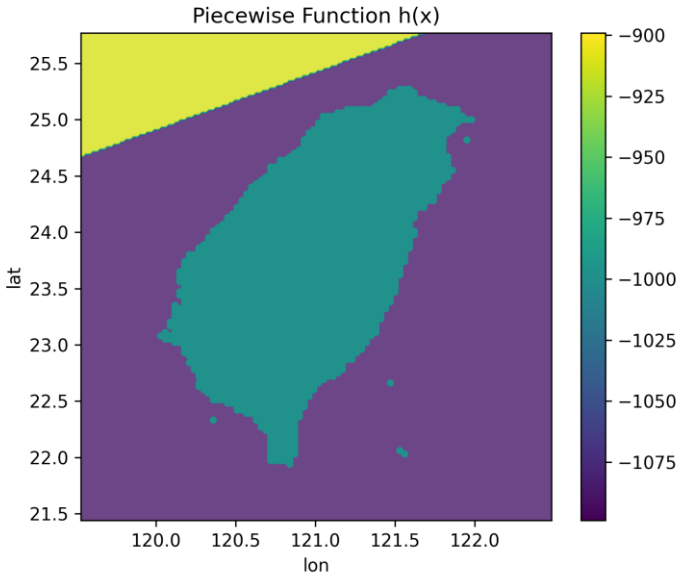
The model was trained on the regression dataset with 80/20 train-test split. Performance metrics were: MSE ≈ 32.33 and $R^2 \approx 0.097$.



4. Piecewise Function

The piecewise model combines the classification and regression outputs as:
$h(x) = \{ R(x), \text{if } C(x) = 1;\ -999, \text{if } C(x) = 0 \}$

This function returns regression predictions only for the positive class region, and assigns −999 otherwise. The visualization below illustrates this piecewise behavior.



5. Discussion and Conclusion

The GDA classifier demonstrated moderate performance, which may be attributed to overlapping class distributions or non-Gaussian data. The regression model yielded a relatively low R^2, suggesting that the temperature (or target variable) may not follow a simple linear relationship with the input features. The piecewise model successfully integrates classification and regression logic, producing distinct output regions as expected. Future improvements may include using non-linear kernels or feature transformations to better capture the data structure.