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CptS 437: Homework #2

4. Logistic Regression for Handwritten Digit Recognition

(a) The logistic\_regression() function learns a weight for each feature and returns the weights. The function initializes weights to zero and, for each iteration up to a maximum number of iterations, computes the gradient,



and updates weights by adding the product of the negative gradient and learning rate,

 where 

(b) The accuracy() function classifies data according to a logistic regression model and returns the percentage of correctly-classified data. The function classifies data by passing the product of transposed weights and features,



into the logistic function,



in order to compute a probability between zero and 1. If the probability is greater than 0.5, the data classifies as 1; otherwise, the data classifies as -1.

(c) The thirdorder() function applies a third-order transform to data and returns the transformed data. For data containing two features and a bias, the function generates ten features,



(d) The results of the accuracy trials show that the third-order polynomial model has equivalent or superior accuracy to the linear model for both training and test data. Therefore, the third-order polynomial model has better fit to the data and is recommended.

**Table 1.** The accuracy of the linear model for training and test data with varying parameters.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **Max\_iter** | **Learning\_rate** | **Train acc** | **Test acc** |
| Max\_iter test 0 | 100 | 0.2 | 0.835 | 0.828 |
| Max\_iter test 1 | 200 | 0.2 | 0.924 | 0.901 |
| Max\_iter test 2 | 500 | 0.2 | 0.966 | 0.941 |
| Max\_iter test 3 | 1000 | 0.2 | 0.974 | 0.950 |
| Learning\_rate test 0 | 1000 | 0.1 | 0.966 | 0.941 |
| Learning\_rate test 1 | 1000 | 0.2 | 0.974 | 0.950 |
| Learning\_rate test 2 | 1000 | 0.5 | 0.979 | 0.962 |

**Table 2.** The accuracy of the third-order model for training and test data with varying parameters.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **Max\_iter** | **Learning\_rate** | **Train acc** | **Test acc** |
| Max\_iter test 0 | 100 | 0.2 | 0.924 | 0.899 |
| Max\_iter test 1 | 200 | 0.2 | 0.958 | 0.941 |
| Max\_iter test 2 | 500 | 0.2 | 0.970 | 0.948 |
| Max\_iter test 3 | 1000 | 0.2 | 0.975 | 0.955 |
| Learning\_rate test 0 | 1000 | 0.1 | 0.971 | 0.948 |
| Learning\_rate test 1 | 1000 | 0.2 | 0.975 | 0.955 |
| Learning\_rate test 2 | 1000 | 0.5 | 0.978 | 0.965 |