GR5291 Advanced Data Analysis Problem Set glm 1

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Question

Consider the ChickWeight data in R. The body weights of the chicks were measured at birth (i.e., time=0) and every second day thereafter until day 20. They were also measured on day 21. There were four groups of chicks on different protein diets.

Categorize 'weight' as a binary variable, with WeightGroup = 1 (or Low), if weight < 170 g, and 0, Otherwise.

1.Consider comparing Diet Levels 1 and 2 on Day 21.

a)Determine whether there is association between Diet and WeightGroup, using logistic regression, without adjusting for Birth Weight. Interpret what the estimated parameters denote.

b)Repeat (a) adjusting for Birth Weight. Interpret what the estimated parameters denote.

2.Repeat 1a and 1b for all 4 Diet Levels

3.Repeat 1b (i.e. compare diet levels 1 and 2, adjusting for birthweight) using the L-1 regularized logistic regression

When using cross validation to choose shrinkage parameter lambda, you will need to change the "nfolds" argument in the cv.glmnet function. The default is 10, but that is too large for a dataset this small. Try cv.glmnet(X, y, nfolds=5) instead.

Solution

Question 1

Data Preparation

```
# Load the dataset
data("ChickWeight")

# Filter for Day 21 only
day21_data <- subset(ChickWeight, Time == 21)

# Categorize weight as binary (WeightGroup)
day21_data$WeightGroup <- ifelse(day21_data$weight < 170, 1, 0)
day21_data
```

```
##     weight Time Chick Diet WeightGroup
## 12     205   21     1    1           0
## 24     215   21     2    1           0
## 36     202   21     3    1           0
## 48     157   21     4    1           1
## 60     223   21     5    1           0
## 72     157   21     6    1           1
```

```
## 84     305   21     7    1           0
## 107     98   21     9    1           1
## 119    124   21    10    1           1
## 131    175   21    11    1           0
## 143    205   21    12    1           0
## 155     96   21    13    1           1
## 167    266   21    14    1           0
## 194    142   21    17    1           1
## 208    157   21    19    1           1
## 220    117   21    20    1           1
## 232    331   21    21    2           0
## 244    167   21    22    2           1
## 256    175   21    23    2           0
## 268     74   21    24    2           1
## 280    265   21    25    2           0
## 292    251   21    26    2           0
## 304    192   21    27    2           0
## 316    233   21    28    2           0
## 328    309   21    29    2           0
## 340    150   21    30    2           1
## 352    256   21    31    3           0
## 364    305   21    32    3           0
## 376    147   21    33    3           1
## 388    341   21    34    3           0
## 400    373   21    35    3           0
## 412    220   21    36    3           0
## 424    178   21    37    3           0
## 436    290   21    38    3           0
## 448    272   21    39    3           0
## 460    321   21    40    3           0
## 472    204   21    41    4           0
## 484    281   21    42    4           0
## 496    200   21    43    4           0
## 518    196   21    45    4           0
## 530    238   21    46    4           0
## 542    205   21    47    4           0
## 554    322   21    48    4           0
## 566    237   21    49    4           0
## 578    264   21    50    4           0
```

a) Logistic Regression for Diet Levels 1 and 2 (Without Adjusting for Birth Weight)

```r
# Filter data for Diet levels 1 and 2
day21_diet12 <- subset(day21_data, Diet %in% c(1, 2))
day21_diet12
```

```
##     weight Time Chick Diet WeightGroup
## 12     205   21     1    1           0
## 24     215   21     2    1           0
## 36     202   21     3    1           0
## 48     157   21     4    1           1
## 60     223   21     5    1           0
## 72     157   21     6    1           1
## 84     305   21     7    1           0
```

```
## 107     98   21     9    1           1
## 119    124   21    10    1           1
## 131    175   21    11    1           0
## 143    205   21    12    1           0
## 155     96   21    13    1           1
## 167    266   21    14    1           0
## 194    142   21    17    1           1
## 208    157   21    19    1           1
## 220    117   21    20    1           1
## 232    331   21    21    2           0
## 244    167   21    22    2           1
## 256    175   21    23    2           0
## 268     74   21    24    2           1
## 280    265   21    25    2           0
## 292    251   21    26    2           0
## 304    192   21    27    2           0
## 316    233   21    28    2           0
## 328    309   21    29    2           0
## 340    150   21    30    2           1
```

```r
# Fit the logistic regression model without birth weight
logit_model <- glm(WeightGroup ~ Diet, family = binomial, data = day21_diet12)

# Summary of the model
summary(logit_model)
```

```
##
## Call:
## glm(formula = WeightGroup ~ Diet, family = binomial, data = day21_diet12)
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.248e-16  5.000e-01   0.000     1.00
## Diet2       -8.473e-01  8.522e-01  -0.994     0.32
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 35.426  on 25  degrees of freedom
## Residual deviance: 34.398  on 24  degrees of freedom
## AIC: 38.398
##
## Number of Fisher Scoring iterations: 4
```

The logistic regression analysis indicates that there is no statistically significant association between diet level and being in the low weight group for chicks on Day 21. Specifically, the comparison between Diet 1 and Diet 2 yields a coefficient of -0.8473 for Diet 2, with a p-value of 0.32, implying that the difference is not significant at the conventional 0.05 level.

b) Logistic Regression for Diet Levels 1 and 2 (Adjusting for Birth Weight)

```r
# Extract birth weight data
birth_weight <- ChickWeight[ChickWeight$Time == 0, c("Chick", "weight")]
colnames(birth_weight)[2] <- "birth_weight"

# Merge birth weight with day 21 data for Diet 1 and 2
```

```r
day21_diet12_adjusted <- merge(day21_diet12, birth_weight, by = "Chick")

# Fit the logistic regression model adjusting for birth weight
logit_model_adj <- glm(WeightGroup ~ Diet + birth_weight,
                       family = binomial, data = day21_diet12_adjusted)

# Summary of the adjusted model
summary(logit_model_adj)
```

```
##
## Call:
## glm(formula = WeightGroup ~ Diet + birth_weight, family = binomial,
##     data = day21_diet12_adjusted)
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -20.5054    16.6424  -1.232    0.218
## Diet2         -0.5194     0.9064  -0.573    0.567
## birth_weight   0.4934     0.4004   1.232    0.218
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 35.426  on 25  degrees of freedom
## Residual deviance: 32.761  on 23  degrees of freedom
## AIC: 38.761
##
## Number of Fisher Scoring iterations: 4
```

The logistic regression model adjusting for birth weight indicates that there is no significant difference between Diet 2 and Diet 1 regarding the odds of being in the low weight group on Day 21, as the p-value for Diet 2 is 0.567. Additionally, the birth weight variable does not show a significant impact, with a p-value of 0.218.

Question 2

```r
# Fit logistic regression for all 4 diet levels
# without adjusting for birth weight
logit_model_all <- glm(WeightGroup ~ Diet, family = binomial, data = day21_data)
summary(logit_model_all)
```

```
##
## Call:
## glm(formula = WeightGroup ~ Diet, family = binomial, data = day21_data)
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.201e-15  5.000e-01   0.000   1.0000
## Diet2       -8.473e-01  8.522e-01  -0.994   0.3201
## Diet3       -2.197e+00  1.167e+00  -1.883   0.0597 .
## Diet4       -1.857e+01  2.174e+03  -0.009   0.9932
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
```

```
##     Null deviance: 52.192  on 44  degrees of freedom
## Residual deviance: 40.900  on 41  degrees of freedom
## AIC: 48.9
##
## Number of Fisher Scoring iterations: 17
```

```
# Merge birth weight with day 21 data
day21_data_adjusted <- merge(day21_data, birth_weight, by = "Chick")

# Fit logistic regression for all 4 diet levels adjusting for birth weight
logit_model_all_adj <- glm(WeightGroup ~ Diet + birth_weight,
                           family = binomial, data = day21_data_adjusted)
summary(logit_model_all_adj)
```

```
##
## Call:
## glm(formula = WeightGroup ~ Diet + birth_weight, family = binomial,
##     data = day21_data_adjusted)
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -8.3444    14.8878  -0.560   0.5751
## Diet2          -0.6904     0.8940  -0.772   0.4400
## Diet3          -2.0592     1.1894  -1.731   0.0834 .
## Diet4         -18.4417  2164.9693  -0.009   0.9932
## birth_weight    0.2008     0.3580   0.561   0.5749
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 52.192  on 44  degrees of freedom
## Residual deviance: 40.580  on 40  degrees of freedom
## AIC: 50.58
##
## Number of Fisher Scoring iterations: 17
```

The analysis of the logistic regression models, both with and without adjusting for birth weight, indicates that there is no significant difference between Diet 2, Diet 3, or Diet 4 when compared to Diet 1 in terms of the odds of being in the low weight group on Day 21. While Diet 3 approaches significance with p-values of 0.0597 (unadjusted) and 0.0834 (adjusted), it does not meet the conventional threshold of 0.05. The birth weight variable, when included in the model, also does not show a significant impact ($p = 0.5749$), suggesting that it does not contribute to the likelihood of being in the low weight group.

Question 3

```
library(glmnet)
```

```
## Loading required package: Matrix
```

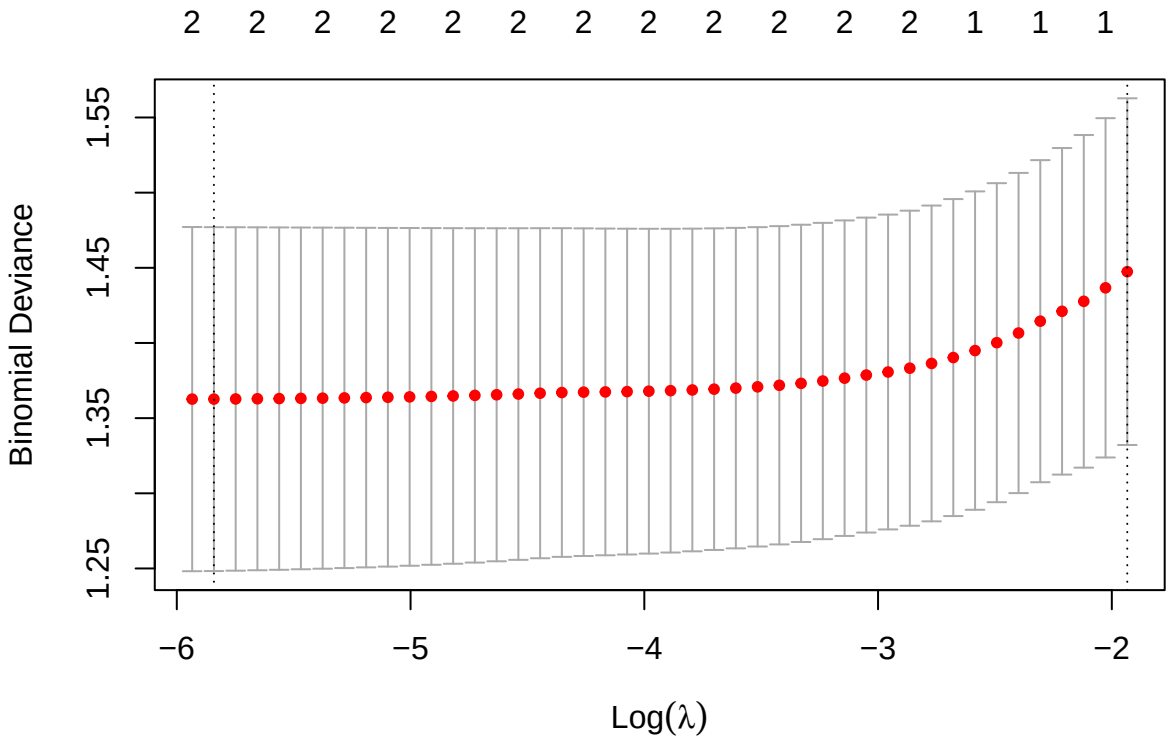
```
## Loaded glmnet 4.1-8
```

```
# Create model matrix and response variable for LASSO
X <- model.matrix(WeightGroup ~ Diet + birth_weight,
                  data = day21_diet12_adjusted)[, -1]
y <- day21_diet12_adjusted$WeightGroup
```

```r
# Fit LASSO with cross-validation
lasso_model <- cv.glmnet(X, y, family = "binomial", alpha = 1, nfolds = 5)
```

```
## Warning in lognet(xd, is.sparse, ix, jx, y, weights, offset, alpha, nobs, : one
## multinomial or binomial class has fewer than 8 observations; dangerous ground
```

```r
# Plot cross-validation curve to choose lambda
plot(lasso_model)
```




```r
# Best lambda
best_lambda <- lasso_model$lambda.min
print(best_lambda)
```

```
## [1] 0.002905337
```

```r
# Coefficients at best lambda
lasso_coefs <- coef(lasso_model, s = best_lambda)
print(lasso_coefs)
```

```
## 5 x 1 sparse Matrix of class "dgCMatrix"
##                       s1
## (Intercept)  -20.0376148
## Diet2         -0.4960623
## Diet3          .
## Diet4          .
## birth_weight   0.4819334
```

Based on the LASSO regression results, only the intercept remains as a non-zero coefficient when selecting the best lambda (0.1445993), indicating that none of the diet levels or birth weight significantly contribute to predicting the WeightGroup for the data of Diet 1 and 2 after regularization. This suggests that there may be limited predictive power for these features in distinguishing weight categories under this model.