Data Analysis for SNP’s to look for associations with a phenotype

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3/31/2020

setwd (getwd())  
  
library(ggplot2)  
library(pscl)

## Classes and Methods for R developed in the  
## Political Science Computational Laboratory  
## Department of Political Science  
## Stanford University  
## Simon Jackman  
## hurdle and zeroinfl functions by Achim Zeileis

snp <- read.csv("disease2a.csv", header = T)  
summary(snp)

## location1 location2 location3 location4 location5   
## Min. :0.0000 Min. :0.000 Min. :0.00 Min. :0.00 Min. :0.000   
## 1st Qu.:0.0000 1st Qu.:0.000 1st Qu.:0.00 1st Qu.:0.00 1st Qu.:1.000   
## Median :0.0000 Median :0.000 Median :1.00 Median :0.00 Median :1.000   
## Mean :0.5735 Mean :0.483 Mean :0.75 Mean :0.38 Mean :1.011   
## 3rd Qu.:1.0000 3rd Qu.:1.000 3rd Qu.:1.00 3rd Qu.:1.00 3rd Qu.:1.000   
## Max. :2.0000 Max. :2.000 Max. :2.00 Max. :2.00 Max. :2.000   
## location6 location7 location8 location9   
## Min. :0.000 Min. :0.000 Min. :0.0000 Min. :0.0000   
## 1st Qu.:0.000 1st Qu.:0.000 1st Qu.:0.0000 1st Qu.:0.0000   
## Median :1.000 Median :0.000 Median :0.0000 Median :1.0000   
## Mean :0.688 Mean :0.489 Mean :0.3175 Mean :0.6525   
## 3rd Qu.:1.000 3rd Qu.:1.000 3rd Qu.:1.0000 3rd Qu.:1.0000   
## Max. :2.000 Max. :2.000 Max. :2.0000 Max. :2.0000   
## location10 class   
## Min. :0.000 Min. :0.000   
## 1st Qu.:1.000 1st Qu.:0.000   
## Median :1.000 Median :1.000   
## Mean :0.981 Mean :0.525   
## 3rd Qu.:1.000 3rd Qu.:1.000   
## Max. :2.000 Max. :1.000

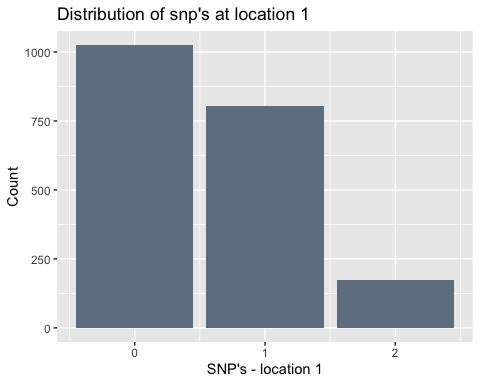
# correlation  
cor(snp, use = "pairwise.complete.obs", method = "spearman")

## location1 location2 location3 location4 location5  
## location1 1.0000000000 0.038507686 -0.038114770 0.0107649507 0.021750493  
## location2 0.0385076860 1.000000000 -0.024196290 -0.0407371979 0.012647608  
## location3 -0.0381147700 -0.024196290 1.000000000 0.0159196292 -0.025888045  
## location4 0.0107649507 -0.040737198 0.015919629 1.0000000000 -0.038569913  
## location5 0.0217504926 0.012647608 -0.025888045 -0.0385699125 1.000000000  
## location6 -0.0080751636 0.027926715 -0.017068001 -0.0061542735 0.029875030  
## location7 0.0001100174 0.027010349 0.025450661 -0.0235118375 -0.024129201  
## location8 -0.0116235653 -0.070152592 -0.004597441 -0.0108162419 -0.002719267  
## location9 0.0035355896 -0.018203940 0.027376689 0.0001196691 0.014675934  
## location10 0.0183682458 0.003034406 -0.009200885 0.0349048001 -0.394952530  
## class -0.0397577159 0.022921040 0.002548052 0.0006167129 0.064614792  
## location6 location7 location8 location9 location10  
## location1 -0.008075164 0.0001100174 -0.011623565 0.0035355896 0.018368246  
## location2 0.027926715 0.0270103492 -0.070152592 -0.0182039401 0.003034406  
## location3 -0.017068001 0.0254506613 -0.004597441 0.0273766891 -0.009200885  
## location4 -0.006154273 -0.0235118375 -0.010816242 0.0001196691 0.034904800  
## location5 0.029875030 -0.0241292012 -0.002719267 0.0146759337 -0.394952530  
## location6 1.000000000 -0.0379950525 -0.048860588 0.0295930397 -0.003797342  
## location7 -0.037995053 1.0000000000 0.034286381 -0.0063050640 0.002155520  
## location8 -0.048860588 0.0342863808 1.000000000 -0.0118704117 0.002434026  
## location9 0.029593040 -0.0063050640 -0.011870412 1.0000000000 0.042149044  
## location10 -0.003797342 0.0021555202 0.002434026 0.0421490436 1.000000000  
## class 0.026895856 0.0092947535 0.005485573 -0.0055128352 0.024388796  
## class  
## location1 -0.0397577159  
## location2 0.0229210398  
## location3 0.0025480515  
## location4 0.0006167129  
## location5 0.0646147922  
## location6 0.0268958563  
## location7 0.0092947535  
## location8 0.0054855729  
## location9 -0.0055128352  
## location10 0.0243887955  
## class 1.0000000000

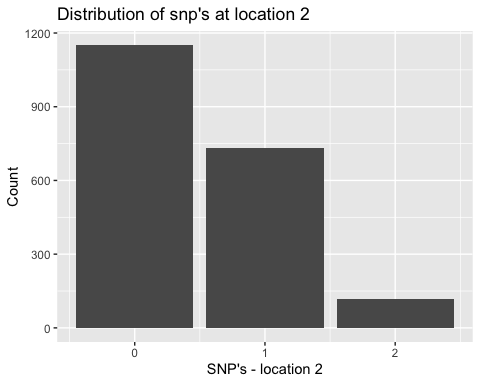
# location5 has higher positive correlation (0.0646147922) with class than any other location variables.  
  
snp$class <- factor(snp$class)  
summary(snp)

## location1 location2 location3 location4 location5   
## Min. :0.0000 Min. :0.000 Min. :0.00 Min. :0.00 Min. :0.000   
## 1st Qu.:0.0000 1st Qu.:0.000 1st Qu.:0.00 1st Qu.:0.00 1st Qu.:1.000   
## Median :0.0000 Median :0.000 Median :1.00 Median :0.00 Median :1.000   
## Mean :0.5735 Mean :0.483 Mean :0.75 Mean :0.38 Mean :1.011   
## 3rd Qu.:1.0000 3rd Qu.:1.000 3rd Qu.:1.00 3rd Qu.:1.00 3rd Qu.:1.000   
## Max. :2.0000 Max. :2.000 Max. :2.00 Max. :2.00 Max. :2.000   
## location6 location7 location8 location9   
## Min. :0.000 Min. :0.000 Min. :0.0000 Min. :0.0000   
## 1st Qu.:0.000 1st Qu.:0.000 1st Qu.:0.0000 1st Qu.:0.0000   
## Median :1.000 Median :0.000 Median :0.0000 Median :1.0000   
## Mean :0.688 Mean :0.489 Mean :0.3175 Mean :0.6525   
## 3rd Qu.:1.000 3rd Qu.:1.000 3rd Qu.:1.0000 3rd Qu.:1.0000   
## Max. :2.000 Max. :2.000 Max. :2.0000 Max. :2.0000   
## location10 class   
## Min. :0.000 0: 950   
## 1st Qu.:1.000 1:1050   
## Median :1.000   
## Mean :0.981   
## 3rd Qu.:1.000   
## Max. :2.000

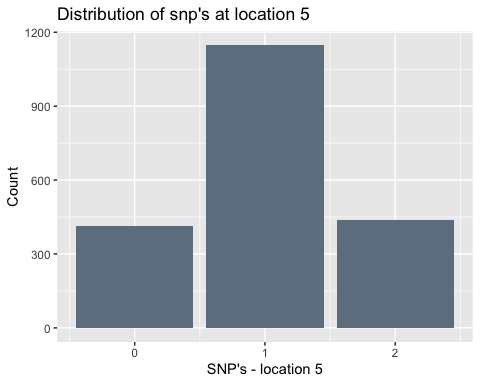
# summary statistics includes centrality measures - mean & median  
# except for class variable, it includes counts  
  
# vizualizations  
g <- ggplot(data=snp)  
  
#univariate plots  
g + geom\_bar(aes(x=location1), fill = "slategrey")+ ggtitle("Distribution of snp's at location 1") +   
 xlab("SNP's - location 1") + ylab("Count")



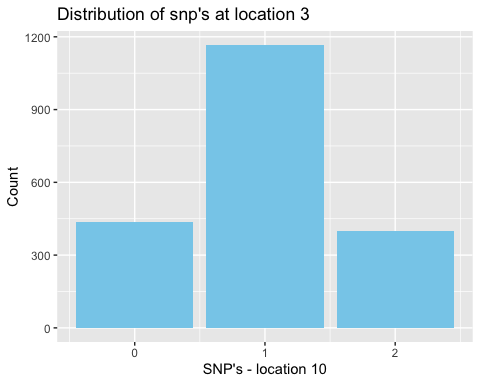
# alleles (0 to 2) are in decreasing order of counts at location 1 of an snp  
  
g + geom\_bar(aes(x=location2))+ ggtitle("Distribution of snp's at location 2") +   
 xlab("SNP's - location 2") + ylab("Count")



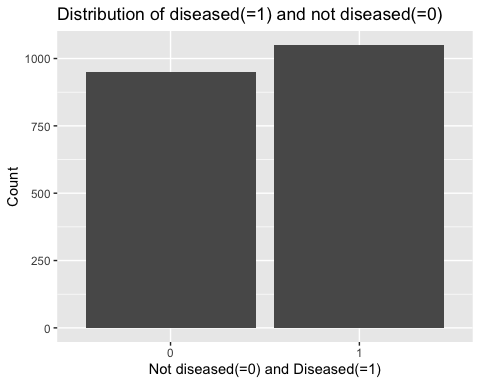
# alleles (0 to 2) are in decreasing order of counts at location 2 of an snp  
  
g + geom\_bar(aes(x=location5), fill = "slategrey")+ ggtitle("Distribution of snp's at location 5") +   
 xlab("SNP's - location 5") + ylab("Count")



# allele - 1 has maxiumum counts at location 5. 0 & 1 are almost at similiar counts.  
  
g + geom\_bar(aes(x=location10), fill = "skyblue")+ ggtitle("Distribution of snp's at location 3") +   
 xlab("SNP's - location 10") + ylab("Count")

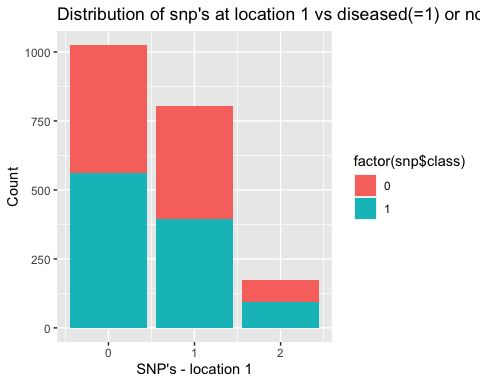


# allele - 1 has maxiumum counts at location 10. 0 & 1 are almost at similiar counts.  
  
g + geom\_bar(aes(x=factor(class)))+ ggtitle("Distribution of diseased(=1) and not diseased(=0)") +   
 xlab("Not diseased(=0) and Diseased(=1)") + ylab("Count")



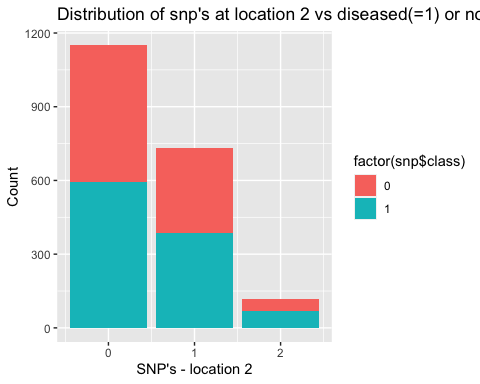
# there are more observations which are classified as having the disease (=1) than others that don't have the disease(=0)  
  
#bivariate plots  
g + geom\_bar(aes(x=location1, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 1 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 1") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



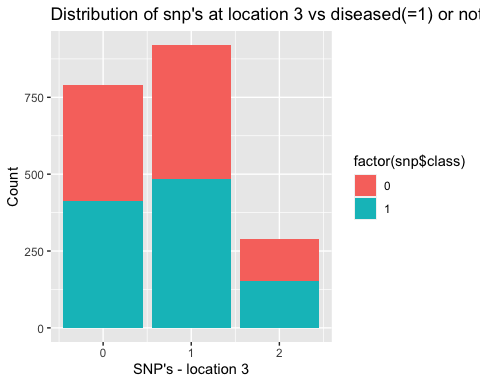
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location1  
  
g + geom\_bar(aes(x=location2, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 2 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 2") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



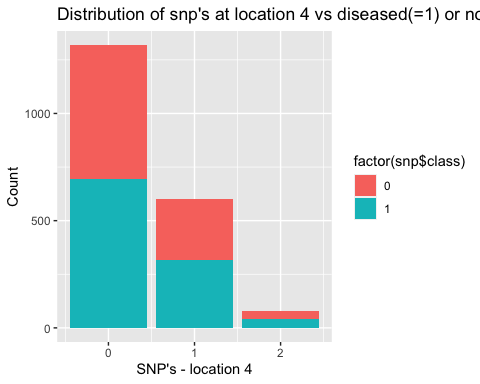
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location2  
  
g + geom\_bar(aes(x=location3, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 3 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 3") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



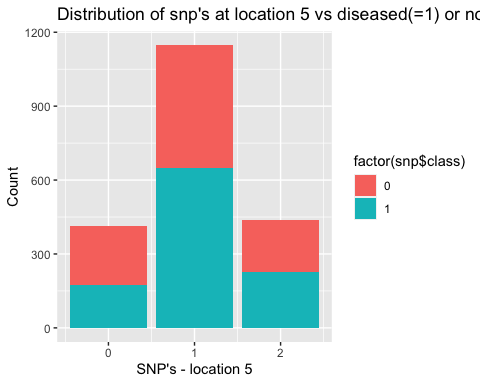
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location3  
  
g + geom\_bar(aes(x=location4, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 4 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 4") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



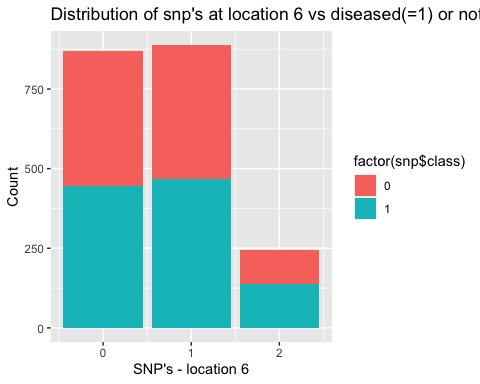
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location4  
  
g + geom\_bar(aes(x=location5, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 5 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 5") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



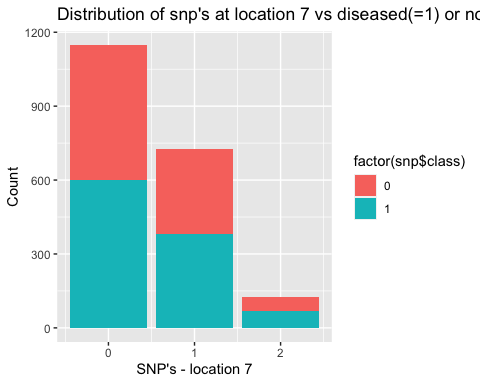
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location5  
# allele = 1 is higher in count than 0 & 2, for location 5  
  
g + geom\_bar(aes(x=location6, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 6 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 6") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



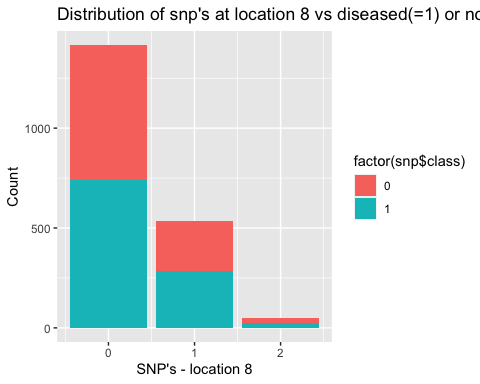
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location6  
# for alleles - 1, the count is high than in other locations and almost equal to count of allele=0  
  
g + geom\_bar(aes(x=location7, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 7 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 7") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



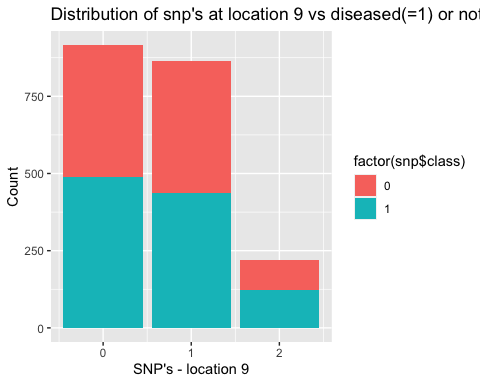
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location7  
  
g + geom\_bar(aes(x=location8, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 8 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 8") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



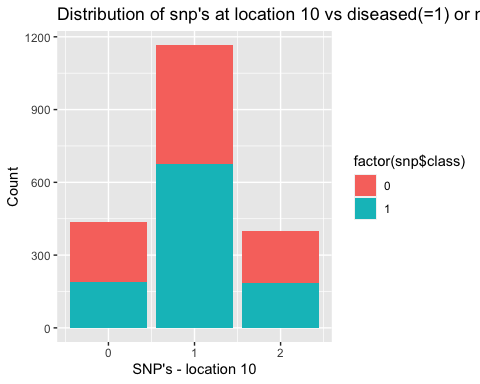
# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location8  
  
g + geom\_bar(aes(x=location9, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 9 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 9") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location9  
  
g + geom\_bar(aes(x=location10, fill=factor(snp$class)))+ ggtitle("Distribution of snp's at location 10 vs diseased(=1) or not(=0)") +   
 xlab("SNP's - location 10") + ylab("Count")

## Warning: Use of `snp$class` is discouraged. Use `class` instead.



# for alleles - 0,1 or 2, the class of disease or no disease assigned to them is almost half at snp location10  
# allele with 1 mutation is more than allele with 0 or 2 mutations at this location  
  
###############################################################################################################  
# main effects only model  
fit1\_full <- glm(class ~ ., family = binomial(), data=snp)  
summary(fit1\_full)

##   
## Call:  
## glm(formula = class ~ ., family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.549 -1.205 1.037 1.130 1.302   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.41991 0.17344 -2.421 0.015476 \*   
## location1 -0.11388 0.06986 -1.630 0.103051   
## location2 0.08415 0.07480 1.125 0.260543   
## location3 0.01268 0.06527 0.194 0.845952   
## location4 0.01089 0.08043 0.135 0.892334   
## location5 0.27558 0.07590 3.631 0.000282 \*\*\*  
## location6 0.07885 0.06668 1.182 0.237045   
## location7 0.04248 0.07361 0.577 0.563852   
## location8 0.01326 0.08740 0.152 0.879391   
## location9 -0.01226 0.06741 -0.182 0.855645   
## location10 0.18566 0.07662 2.423 0.015383 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2747.6 on 1989 degrees of freedom  
## AIC: 2769.6  
##   
## Number of Fisher Scoring iterations: 4

# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2747.6 on 1989 degrees of freedom  
# AIC: 2769.6  
# location5 and 10 are significant  
  
fit\_null <- glm(class ~ 1, family = binomial(), data=snp)  
summary(fit\_null)

##   
## Call:  
## glm(formula = class ~ 1, family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.220 -1.220 1.135 1.135 1.135   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) 0.10008 0.04478 2.235 0.0254 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2767.6 on 1999 degrees of freedom  
## AIC: 2769.6  
##   
## Number of Fisher Scoring iterations: 3

# AIC: 2769.6  
  
fit1\_step = step(fit\_null, scope=list(lower=fit\_null, upper=fit1\_full),direction="both")

## Start: AIC=2769.59  
## class ~ 1  
##   
## Df Deviance AIC  
## + location5 1 2759.1 2763.1  
## + location1 1 2765.4 2769.4  
## <none> 2767.6 2769.6  
## + location6 1 2765.9 2769.9  
## + location2 1 2766.2 2770.2  
## + location10 1 2766.5 2770.5  
## + location7 1 2767.4 2771.4  
## + location3 1 2767.6 2771.6  
## + location8 1 2767.6 2771.6  
## + location9 1 2767.6 2771.6  
## + location4 1 2767.6 2771.6  
##   
## Step: AIC=2763.09  
## class ~ location5  
##   
## Df Deviance AIC  
## + location10 1 2753.4 2759.4  
## + location1 1 2756.7 2762.7  
## <none> 2759.1 2763.1  
## + location6 1 2757.6 2763.6  
## + location2 1 2757.8 2763.8  
## + location7 1 2758.8 2764.8  
## + location3 1 2759.1 2765.1  
## + location4 1 2759.1 2765.1  
## + location8 1 2759.1 2765.1  
## + location9 1 2759.1 2765.1  
## - location5 1 2767.6 2769.6  
##   
## Step: AIC=2759.37  
## class ~ location5 + location10  
##   
## Df Deviance AIC  
## + location1 1 2750.8 2758.8  
## <none> 2753.4 2759.4  
## + location6 1 2751.9 2759.9  
## + location2 1 2752.1 2760.1  
## + location7 1 2753.0 2761.0  
## + location3 1 2753.3 2761.3  
## + location9 1 2753.3 2761.3  
## + location8 1 2753.4 2761.4  
## + location4 1 2753.4 2761.4  
## - location10 1 2759.1 2763.1  
## - location5 1 2766.5 2770.5  
##   
## Step: AIC=2758.76  
## class ~ location5 + location10 + location1  
##   
## Df Deviance AIC  
## <none> 2750.8 2758.8  
## + location6 1 2749.3 2759.3  
## - location1 1 2753.4 2759.4  
## + location2 1 2749.4 2759.4  
## + location7 1 2750.4 2760.4  
## + location3 1 2750.7 2760.7  
## + location9 1 2750.7 2760.7  
## + location4 1 2750.8 2760.8  
## + location8 1 2750.8 2760.8  
## - location10 1 2756.7 2762.7  
## - location5 1 2764.3 2770.3

summary(fit1\_step)

##   
## Call:  
## glm(formula = class ~ location5 + location10 + location1, family = binomial(),   
## data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.453 -1.200 1.070 1.117 1.242   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.29685 0.13871 -2.140 0.032348 \*   
## location5 0.27688 0.07570 3.658 0.000255 \*\*\*  
## location10 0.18589 0.07641 2.433 0.014980 \*   
## location1 -0.11252 0.06969 -1.615 0.106405   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2750.8 on 1996 degrees of freedom  
## AIC: 2758.8  
##   
## Number of Fisher Scoring iterations: 4

# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2750.8 on 1996 degrees of freedom  
# AIC: 2758.8  
# includes variables - location5, location10, location1  
# location5 and 10 are significant  
  
fit1\_final <- glm(class ~ location5 + location10, family = binomial(), data=snp)  
summary(fit1\_final)

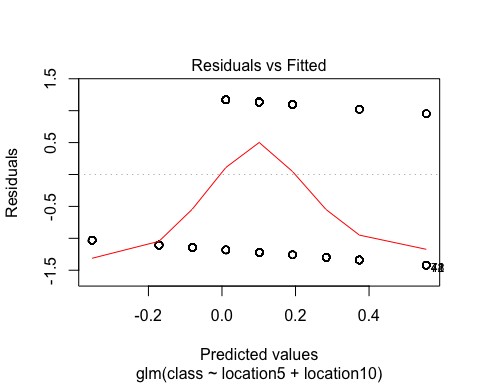
##   
## Call:  
## glm(formula = class ~ location5 + location10, family = binomial(),   
## data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.421 -1.221 1.097 1.135 1.173   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.35323 0.13425 -2.631 0.008509 \*\*   
## location5 0.27253 0.07560 3.605 0.000312 \*\*\*  
## location10 0.18195 0.07632 2.384 0.017130 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2753.4 on 1997 degrees of freedom  
## AIC: 2759.4  
##   
## Number of Fisher Scoring iterations: 4

# both the predictors are statistifically significant and have their p-values less than threshold of 0.05  
#### AIC: 2759.4 ####  
pR2(fit1\_final)

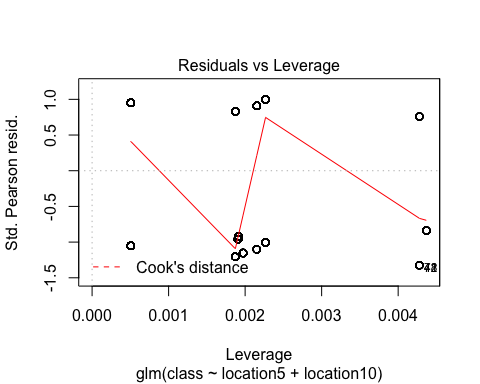
## fitting null model for pseudo-r2

## llh llhNull G2 McFadden r2ML   
## -1.376684e+03 -1.383793e+03 1.421848e+01 5.137500e-03 7.084027e-03   
## r2CU   
## 9.453260e-03

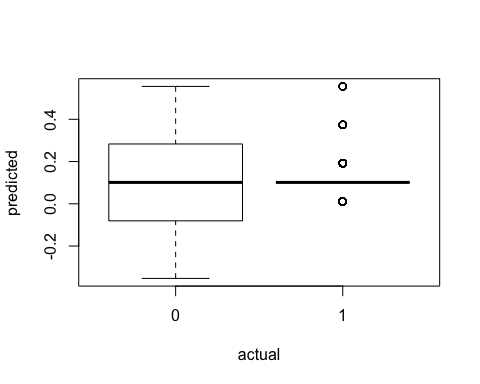
# llh llhNull G2 McFadden r2ML r2CU   
# -1.376684e+03 -1.383793e+03 1.421848e+01 5.137500e-03 7.084027e-03 9.453260e-03   
plot(fit1\_final, 1)



plot(fit1\_final, 5)



# residual plots do not show a good fit for this model  
plot(x=snp$class,y=predict(fit1\_final),xlab="actual",ylab="predicted")



# the model predicts not having the disease (actual=0) more precisely than being able to predict having the disease(actual=1)  
# the accuracy of the model is not that good for predicting class of the disease  
  
# interpreting the coefficients:  
# class = 0.27253\*location5 + 0.18195\*location10 - 0.35323  
# For every 1 allele increase in location5, the log odds of having the disease  
# increases by 0.27253 on average, when all other variables in the model are held constant  
# For every 1 allele increase in location10, the log odds of having the disease  
# increases by 0.18195 on average, when all other variables in the model are held constant  
exp(fit1\_final$coef)

## (Intercept) location5 location10   
## 0.7024184 1.3132767 1.1995492

# For every one allele increase in location5 the odds of having the disease is  
# multiplied by 1.3132767 (exp(coef)= 1.3132767) on average,  
# when all other variables in the model are held constant  
# For every one allele increase in location10 the odds of having the disease is  
# multiplied by 1.1995492 (exp(coef)= 1.1995492) on average,  
# when all other variables in the model are held constant  
###############################################################################################################  
# 2nd order interactions only model  
fit2\_full <- glm(class ~ (.)^2 - (.), family = binomial(), data=snp)  
summary(fit2\_full)

##   
## Call:  
## glm(formula = class ~ (.)^2 - (.), family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.1353 -1.1370 0.6438 1.1033 2.0658   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.206383 0.099097 -2.083 0.037284 \*   
## location1:location2 -0.219326 0.118395 -1.852 0.063956 .   
## location1:location3 -0.258586 0.101016 -2.560 0.010472 \*   
## location1:location4 -0.416241 0.130611 -3.187 0.001438 \*\*   
## location1:location5 0.150642 0.092607 1.627 0.103805   
## location1:location6 -0.037472 0.105526 -0.355 0.722521   
## location1:location7 -0.102618 0.117580 -0.873 0.382802   
## location1:location8 -0.168384 0.144393 -1.166 0.243554   
## location1:location9 0.132067 0.105563 1.251 0.210910   
## location1:location10 0.243132 0.099197 2.451 0.014246 \*   
## location2:location3 -0.060510 0.105972 -0.571 0.568001   
## location2:location4 -0.110159 0.141575 -0.778 0.436511   
## location2:location5 0.183924 0.102668 1.791 0.073223 .   
## location2:location6 -0.172498 0.109601 -1.574 0.115518   
## location2:location7 -0.112354 0.124652 -0.901 0.367404   
## location2:location8 0.032229 0.160797 0.200 0.841144   
## location2:location9 0.039282 0.111762 0.351 0.725232   
## location2:location10 0.334193 0.110198 3.033 0.002424 \*\*   
## location3:location4 -0.095707 0.115949 -0.825 0.409134   
## location3:location5 0.271260 0.086423 3.139 0.001697 \*\*   
## location3:location6 -0.035855 0.096391 -0.372 0.709910   
## location3:location7 -0.229303 0.106594 -2.151 0.031462 \*   
## location3:location8 -0.235477 0.129865 -1.813 0.069794 .   
## location3:location9 -0.106334 0.093854 -1.133 0.257228   
## location3:location10 0.295755 0.085809 3.447 0.000568 \*\*\*  
## location4:location5 0.231855 0.113108 2.050 0.040379 \*   
## location4:location6 -0.146308 0.122696 -1.192 0.233087   
## location4:location7 -0.044386 0.137182 -0.324 0.746278   
## location4:location8 0.093416 0.158878 0.588 0.556550   
## location4:location9 -0.018829 0.123980 -0.152 0.879286   
## location4:location10 0.345006 0.113288 3.045 0.002324 \*\*   
## location5:location6 0.313482 0.091705 3.418 0.000630 \*\*\*  
## location5:location7 0.351711 0.105572 3.331 0.000864 \*\*\*  
## location5:location8 0.327299 0.126844 2.580 0.009871 \*\*   
## location5:location9 0.150780 0.096424 1.564 0.117881   
## location5:location10 -1.079450 0.095097 -11.351 < 2e-16 \*\*\*  
## location6:location7 -0.225529 0.110413 -2.043 0.041092 \*   
## location6:location8 -0.031260 0.138233 -0.226 0.821092   
## location6:location9 -0.208495 0.100853 -2.067 0.038704 \*   
## location6:location10 0.274134 0.090763 3.020 0.002525 \*\*   
## location7:location8 -0.322289 0.148148 -2.175 0.029597 \*   
## location7:location9 0.166236 0.111181 1.495 0.134867   
## location7:location10 0.237983 0.104011 2.288 0.022134 \*   
## location8:location9 -0.190418 0.135704 -1.403 0.160562   
## location8:location10 0.277442 0.125669 2.208 0.027263 \*   
## location9:location10 -0.005164 0.093679 -0.055 0.956041   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2559.8 on 1954 degrees of freedom  
## AIC: 2651.8  
##   
## Number of Fisher Scoring iterations: 4

# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2559.8 on 1954 degrees of freedom  
# AIC: 2651.8  
# many interactions are significant  
  
fit2\_step = step(fit\_null, scope=list(lower=fit\_null, upper=fit2\_full),direction="both")

## Start: AIC=2769.59  
## class ~ 1  
##   
## Df Deviance AIC  
## + location5:location10 1 2730.0 2734.0  
## + location5:location6 1 2762.4 2766.4  
## + location5:location7 1 2762.9 2766.9  
## + location2:location9 1 2764.0 2768.0  
## + location3:location6 1 2764.1 2768.1  
## + location2:location10 1 2764.8 2768.8  
## + location3:location5 1 2764.9 2768.9  
## + location7:location9 1 2765.0 2769.0  
## + location2:location3 1 2765.4 2769.4  
## + location2:location5 1 2765.4 2769.4  
## + location1:location4 1 2765.4 2769.4  
## + location4:location10 1 2765.5 2769.5  
## <none> 2767.6 2769.6  
## + location2:location6 1 2765.8 2769.8  
## + location5:location8 1 2766.0 2770.0  
## + location1:location3 1 2766.2 2770.2  
## + location3:location10 1 2766.4 2770.4  
## + location2:location7 1 2766.4 2770.4  
## + location6:location10 1 2766.4 2770.4  
## + location3:location4 1 2766.4 2770.4  
## + location1:location8 1 2766.6 2770.6  
## + location7:location10 1 2766.6 2770.6  
## + location7:location8 1 2766.7 2770.7  
## + location2:location8 1 2766.7 2770.7  
## + location2:location4 1 2766.8 2770.8  
## + location1:location5 1 2766.8 2770.8  
## + location4:location7 1 2766.8 2770.8  
## + location5:location9 1 2766.8 2770.8  
## + location6:location8 1 2766.9 2770.9  
## + location4:location8 1 2766.9 2770.9  
## + location1:location10 1 2767.0 2771.0  
## + location4:location6 1 2767.1 2771.1  
## + location3:location8 1 2767.2 2771.2  
## + location4:location5 1 2767.2 2771.2  
## + location9:location10 1 2767.2 2771.2  
## + location1:location2 1 2767.3 2771.3  
## + location8:location9 1 2767.3 2771.3  
## + location8:location10 1 2767.3 2771.3  
## + location6:location7 1 2767.4 2771.4  
## + location1:location7 1 2767.4 2771.4  
## + location6:location9 1 2767.5 2771.5  
## + location4:location9 1 2767.5 2771.5  
## + location3:location9 1 2767.5 2771.5  
## + location1:location9 1 2767.5 2771.5  
## + location1:location6 1 2767.5 2771.5  
## + location3:location7 1 2767.6 2771.6  
##   
## Step: AIC=2733.97  
## class ~ location5:location10  
##   
## Df Deviance AIC  
## + location5:location6 1 2714.8 2720.8  
## + location5:location7 1 2719.5 2725.5  
## + location3:location5 1 2721.2 2727.2  
## + location6:location10 1 2721.9 2727.9  
## + location2:location10 1 2722.2 2728.2  
## + location3:location10 1 2723.7 2729.7  
## + location2:location5 1 2723.8 2729.8  
## + location4:location10 1 2723.8 2729.8  
## + location5:location9 1 2724.3 2730.3  
## + location5:location8 1 2725.3 2731.3  
## + location7:location10 1 2725.5 2731.5  
## + location2:location9 1 2725.9 2731.9  
## + location4:location5 1 2726.4 2732.4  
## + location3:location6 1 2726.6 2732.6  
## + location8:location10 1 2727.2 2733.2  
## + location7:location9 1 2727.4 2733.4  
## + location1:location4 1 2727.9 2733.9  
## + location2:location3 1 2727.9 2733.9  
## <none> 2730.0 2734.0  
## + location2:location6 1 2728.0 2734.0  
## + location1:location3 1 2728.3 2734.3  
## + location3:location4 1 2728.9 2734.9  
## + location6:location8 1 2729.0 2735.0  
## + location2:location7 1 2729.0 2735.0  
## + location2:location8 1 2729.1 2735.1  
## + location4:location7 1 2729.1 2735.1  
## + location1:location8 1 2729.2 2735.2  
## + location7:location8 1 2729.2 2735.2  
## + location9:location10 1 2729.2 2735.2  
## + location2:location4 1 2729.3 2735.3  
## + location4:location8 1 2729.3 2735.3  
## + location4:location6 1 2729.3 2735.3  
## + location1:location10 1 2729.5 2735.5  
## + location3:location8 1 2729.6 2735.6  
## + location1:location2 1 2729.7 2735.7  
## + location6:location9 1 2729.7 2735.7  
## + location6:location7 1 2729.8 2735.8  
## + location1:location5 1 2729.8 2735.8  
## + location1:location9 1 2729.8 2735.8  
## + location8:location9 1 2729.8 2735.8  
## + location3:location9 1 2729.8 2735.8  
## + location4:location9 1 2729.9 2735.9  
## + location3:location7 1 2729.9 2735.9  
## + location1:location6 1 2729.9 2735.9  
## + location1:location7 1 2729.9 2735.9  
## - location5:location10 1 2767.6 2769.6  
##   
## Step: AIC=2720.75  
## class ~ location5:location10 + location5:location6  
##   
## Df Deviance AIC  
## + location2:location10 1 2704.3 2712.3  
## + location3:location10 1 2704.3 2712.3  
## + location4:location10 1 2706.2 2714.2  
## + location5:location7 1 2707.2 2715.2  
## + location7:location10 1 2707.4 2715.4  
## + location3:location5 1 2709.9 2717.9  
## + location8:location10 1 2710.2 2718.2  
## + location2:location9 1 2710.9 2718.9  
## + location5:location8 1 2711.3 2719.3  
## + location2:location5 1 2711.5 2719.5  
## + location7:location9 1 2711.9 2719.9  
## + location5:location9 1 2712.0 2720.0  
## + location1:location6 1 2712.2 2720.2  
## + location6:location10 1 2712.3 2720.3  
## + location9:location10 1 2712.6 2720.6  
## + location4:location5 1 2712.7 2720.7  
## <none> 2714.8 2720.8  
## + location1:location4 1 2712.8 2720.8  
## + location6:location9 1 2713.0 2721.0  
## + location2:location3 1 2713.1 2721.1  
## + location1:location3 1 2713.4 2721.4  
## + location1:location10 1 2713.4 2721.4  
## + location4:location7 1 2713.5 2721.5  
## + location3:location4 1 2713.6 2721.6  
## + location2:location7 1 2713.8 2721.8  
## + location2:location8 1 2713.8 2721.8  
## + location6:location7 1 2713.9 2721.9  
## + location4:location8 1 2714.0 2722.0  
## + location2:location4 1 2714.1 2722.1  
## + location1:location8 1 2714.2 2722.2  
## + location7:location8 1 2714.2 2722.2  
## + location1:location2 1 2714.4 2722.4  
## + location3:location8 1 2714.5 2722.5  
## + location1:location9 1 2714.6 2722.6  
## + location8:location9 1 2714.6 2722.6  
## + location4:location6 1 2714.6 2722.6  
## + location4:location9 1 2714.7 2722.7  
## + location3:location9 1 2714.7 2722.7  
## + location1:location5 1 2714.7 2722.7  
## + location6:location8 1 2714.7 2722.7  
## + location2:location6 1 2714.7 2722.7  
## + location3:location7 1 2714.7 2722.7  
## + location1:location7 1 2714.7 2722.7  
## + location3:location6 1 2714.8 2722.8  
## - location5:location6 1 2730.0 2734.0  
## - location5:location10 1 2762.4 2766.4  
##   
## Step: AIC=2712.33  
## class ~ location5:location10 + location5:location6 + location10:location2  
##   
## Df Deviance AIC  
## + location5:location7 1 2695.2 2705.2  
## + location3:location10 1 2696.3 2706.3  
## + location4:location10 1 2697.2 2707.2  
## + location2:location6 1 2697.2 2707.2  
## + location3:location5 1 2697.6 2707.6  
## + location7:location10 1 2698.8 2708.8  
## + location1:location2 1 2698.9 2708.9  
## + location5:location8 1 2699.4 2709.4  
## + location8:location10 1 2700.4 2710.4  
## + location5:location9 1 2700.5 2710.5  
## + location1:location6 1 2701.0 2711.0  
## + location4:location5 1 2701.2 2711.2  
## + location7:location9 1 2701.5 2711.5  
## + location6:location9 1 2701.6 2711.6  
## <none> 2704.3 2712.3  
## + location1:location4 1 2702.4 2712.4  
## + location1:location3 1 2703.0 2713.0  
## + location6:location7 1 2703.0 2713.0  
## + location3:location4 1 2703.2 2713.2  
## + location4:location7 1 2703.2 2713.2  
## + location9:location10 1 2703.4 2713.4  
## + location4:location8 1 2703.5 2713.5  
## + location6:location10 1 2703.5 2713.5  
## + location1:location8 1 2703.7 2713.7  
## + location1:location10 1 2703.8 2713.8  
## + location7:location8 1 2703.8 2713.8  
## + location2:location4 1 2704.1 2714.1  
## + location2:location3 1 2704.1 2714.1  
## + location2:location7 1 2704.1 2714.1  
## + location4:location6 1 2704.1 2714.1  
## + location1:location9 1 2704.1 2714.1  
## + location3:location8 1 2704.2 2714.2  
## + location2:location5 1 2704.2 2714.2  
## + location8:location9 1 2704.2 2714.2  
## + location2:location9 1 2704.2 2714.2  
## + location3:location6 1 2704.2 2714.2  
## + location3:location9 1 2704.2 2714.2  
## + location4:location9 1 2704.3 2714.3  
## + location6:location8 1 2704.3 2714.3  
## + location1:location7 1 2704.3 2714.3  
## + location3:location7 1 2704.3 2714.3  
## + location2:location8 1 2704.3 2714.3  
## + location1:location5 1 2704.3 2714.3  
## - location10:location2 1 2714.8 2720.8  
## - location5:location6 1 2722.2 2728.2  
## - location5:location10 1 2759.1 2765.1  
##   
## Step: AIC=2705.18  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7  
##   
## Df Deviance AIC  
## + location6:location7 1 2685.4 2697.4  
## + location3:location10 1 2685.6 2697.6  
## + location4:location10 1 2686.6 2698.6  
## + location2:location6 1 2688.2 2700.2  
## + location1:location2 1 2688.4 2700.4  
## + location2:location7 1 2689.8 2701.8  
## + location3:location5 1 2690.3 2702.3  
## + location8:location10 1 2690.9 2702.9  
## + location3:location7 1 2691.1 2703.1  
## + location7:location8 1 2691.5 2703.5  
## + location1:location7 1 2691.6 2703.6  
## + location5:location8 1 2691.6 2703.6  
## + location1:location6 1 2692.3 2704.3  
## + location4:location5 1 2692.3 2704.3  
## + location5:location9 1 2692.4 2704.4  
## + location6:location10 1 2693.0 2705.0  
## <none> 2695.2 2705.2  
## + location6:location9 1 2693.2 2705.2  
## + location1:location4 1 2693.4 2705.4  
## + location9:location10 1 2693.5 2705.5  
## + location1:location3 1 2693.6 2705.6  
## + location3:location4 1 2693.8 2705.8  
## + location7:location10 1 2694.1 2706.1  
## + location4:location8 1 2694.3 2706.3  
## + location1:location8 1 2694.3 2706.3  
## + location1:location10 1 2694.5 2706.5  
## + location2:location3 1 2694.7 2706.7  
## + location2:location4 1 2694.8 2706.8  
## + location3:location8 1 2695.0 2707.0  
## + location1:location9 1 2695.0 2707.0  
## + location4:location9 1 2695.0 2707.0  
## + location8:location9 1 2695.1 2707.1  
## + location7:location9 1 2695.1 2707.1  
## + location1:location5 1 2695.1 2707.1  
## + location3:location9 1 2695.1 2707.1  
## + location2:location8 1 2695.1 2707.1  
## + location2:location9 1 2695.1 2707.1  
## + location4:location6 1 2695.2 2707.2  
## + location6:location8 1 2695.2 2707.2  
## + location2:location5 1 2695.2 2707.2  
## + location4:location7 1 2695.2 2707.2  
## + location3:location6 1 2695.2 2707.2  
## - location5:location7 1 2704.3 2712.3  
## - location10:location2 1 2707.2 2715.2  
## - location5:location6 1 2709.9 2717.9  
## - location5:location10 1 2755.6 2763.6  
##   
## Step: AIC=2697.43  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7  
##   
## Df Deviance AIC  
## + location3:location10 1 2673.9 2687.9  
## + location4:location10 1 2675.4 2689.4  
## + location6:location10 1 2676.7 2690.7  
## + location1:location2 1 2678.0 2692.0  
## + location7:location10 1 2678.8 2692.8  
## + location8:location10 1 2680.2 2694.2  
## + location2:location6 1 2680.8 2694.8  
## + location2:location7 1 2682.4 2696.4  
## + location3:location5 1 2682.5 2696.5  
## + location9:location10 1 2682.5 2696.5  
## + location5:location8 1 2682.9 2696.9  
## + location7:location8 1 2683.3 2697.3  
## <none> 2685.4 2697.4  
## + location4:location5 1 2683.6 2697.6  
## + location3:location7 1 2683.7 2697.7  
## + location1:location3 1 2683.7 2697.7  
## + location1:location4 1 2683.7 2697.7  
## + location1:location7 1 2683.8 2697.8  
## + location5:location9 1 2683.9 2697.9  
## + location7:location9 1 2684.1 2698.1  
## + location1:location6 1 2684.2 2698.2  
## + location3:location4 1 2684.2 2698.2  
## + location1:location10 1 2684.3 2698.3  
## + location4:location8 1 2684.5 2698.5  
## + location1:location8 1 2684.7 2698.7  
## + location2:location3 1 2684.8 2698.8  
## + location2:location5 1 2684.8 2698.8  
## + location6:location9 1 2684.8 2698.8  
## + location1:location5 1 2684.9 2698.9  
## + location4:location7 1 2685.0 2699.0  
## + location3:location6 1 2685.0 2699.0  
## + location2:location4 1 2685.1 2699.1  
## + location4:location9 1 2685.2 2699.2  
## + location3:location8 1 2685.2 2699.2  
## + location1:location9 1 2685.2 2699.2  
## + location6:location8 1 2685.3 2699.3  
## + location8:location9 1 2685.3 2699.3  
## + location3:location9 1 2685.3 2699.3  
## + location4:location6 1 2685.4 2699.4  
## + location2:location8 1 2685.4 2699.4  
## + location2:location9 1 2685.4 2699.4  
## - location6:location7 1 2695.2 2705.2  
## - location10:location2 1 2700.1 2710.1  
## - location5:location7 1 2703.0 2713.0  
## - location5:location6 1 2707.0 2717.0  
## - location5:location10 1 2753.2 2763.2  
##   
## Step: AIC=2687.92  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3  
##   
## Df Deviance AIC  
## + location3:location7 1 2663.7 2679.7  
## + location1:location3 1 2665.7 2681.7  
## + location4:location10 1 2666.3 2682.3  
## + location1:location2 1 2667.9 2683.9  
## + location6:location10 1 2668.3 2684.3  
## + location2:location3 1 2669.3 2685.3  
## + location2:location6 1 2669.3 2685.3  
## + location7:location10 1 2669.8 2685.8  
## + location8:location10 1 2670.2 2686.2  
## + location5:location8 1 2670.8 2686.8  
## + location2:location7 1 2671.4 2687.4  
## + location4:location5 1 2671.5 2687.5  
## + location3:location8 1 2671.7 2687.7  
## + location7:location8 1 2671.7 2687.7  
## + location5:location9 1 2671.8 2687.8  
## <none> 2673.9 2687.9  
## + location3:location6 1 2672.1 2688.1  
## + location1:location7 1 2672.1 2688.1  
## + location1:location4 1 2672.2 2688.2  
## + location3:location9 1 2672.3 2688.3  
## + location9:location10 1 2672.5 2688.5  
## + location1:location6 1 2672.8 2688.8  
## + location4:location8 1 2673.0 2689.0  
## + location7:location9 1 2673.0 2689.0  
## + location6:location9 1 2673.0 2689.0  
## + location1:location8 1 2673.1 2689.1  
## + location1:location10 1 2673.5 2689.5  
## + location2:location4 1 2673.6 2689.6  
## + location4:location7 1 2673.6 2689.6  
## + location1:location9 1 2673.7 2689.7  
## + location8:location9 1 2673.8 2689.8  
## + location4:location9 1 2673.8 2689.8  
## + location3:location5 1 2673.8 2689.8  
## + location6:location8 1 2673.8 2689.8  
## + location1:location5 1 2673.8 2689.8  
## + location2:location9 1 2673.8 2689.8  
## + location2:location5 1 2673.9 2689.9  
## + location3:location4 1 2673.9 2689.9  
## + location2:location8 1 2673.9 2689.9  
## + location4:location6 1 2673.9 2689.9  
## - location10:location3 1 2685.4 2697.4  
## - location10:location2 1 2685.6 2697.6  
## - location6:location7 1 2685.6 2697.6  
## - location5:location7 1 2694.8 2706.8  
## - location5:location6 1 2700.6 2712.6  
## - location5:location10 1 2751.6 2763.6  
##   
## Step: AIC=2679.73  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3  
##   
## Df Deviance AIC  
## + location7:location10 1 2655.9 2673.9  
## + location4:location10 1 2656.6 2674.6  
## + location1:location2 1 2657.6 2675.6  
## + location1:location3 1 2657.8 2675.8  
## + location2:location6 1 2659.2 2677.2  
## + location6:location10 1 2659.6 2677.6  
## + location8:location10 1 2660.4 2678.4  
## + location5:location8 1 2660.7 2678.7  
## + location2:location3 1 2661.0 2679.0  
## + location4:location5 1 2661.3 2679.3  
## + location7:location9 1 2661.4 2679.4  
## + location5:location9 1 2661.5 2679.5  
## <none> 2663.7 2679.7  
## + location1:location4 1 2661.8 2679.8  
## + location2:location7 1 2662.2 2680.2  
## + location1:location6 1 2662.2 2680.2  
## + location3:location5 1 2662.4 2680.4  
## + location3:location8 1 2662.5 2680.5  
## + location9:location10 1 2662.5 2680.5  
## + location7:location8 1 2662.6 2680.6  
## + location1:location7 1 2662.8 2680.8  
## + location4:location8 1 2662.8 2680.8  
## + location6:location9 1 2662.8 2680.8  
## + location1:location8 1 2662.9 2680.9  
## + location3:location6 1 2662.9 2680.9  
## + location4:location7 1 2662.9 2680.9  
## + location3:location9 1 2663.0 2681.0  
## + location1:location10 1 2663.5 2681.5  
## + location2:location4 1 2663.5 2681.5  
## + location1:location9 1 2663.5 2681.5  
## + location4:location9 1 2663.6 2681.6  
## + location2:location9 1 2663.6 2681.6  
## + location6:location8 1 2663.6 2681.6  
## + location1:location5 1 2663.6 2681.6  
## + location3:location4 1 2663.7 2681.7  
## + location8:location9 1 2663.7 2681.7  
## + location2:location5 1 2663.7 2681.7  
## + location4:location6 1 2663.7 2681.7  
## + location2:location8 1 2663.7 2681.7  
## - location6:location7 1 2670.7 2684.7  
## - location7:location3 1 2673.9 2687.9  
## - location10:location2 1 2674.7 2688.7  
## - location10:location3 1 2683.7 2697.7  
## - location5:location6 1 2686.3 2700.3  
## - location5:location7 1 2694.3 2708.3  
## - location5:location10 1 2749.3 2763.3  
##   
## Step: AIC=2673.92  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7  
##   
## Df Deviance AIC  
## + location4:location10 1 2650.4 2670.4  
## + location1:location2 1 2650.5 2670.5  
## + location1:location3 1 2651.1 2671.1  
## + location3:location5 1 2651.9 2671.9  
## + location2:location6 1 2652.3 2672.3  
## + location5:location8 1 2652.5 2672.5  
## + location5:location9 1 2652.5 2672.5  
## + location1:location7 1 2652.9 2672.9  
## + location4:location5 1 2653.0 2673.0  
## + location6:location10 1 2653.1 2673.1  
## + location2:location7 1 2653.3 2673.3  
## + location7:location8 1 2653.3 2673.3  
## + location1:location4 1 2653.7 2673.7  
## <none> 2655.9 2673.9  
## + location8:location10 1 2654.0 2674.0  
## + location1:location6 1 2654.3 2674.3  
## + location2:location3 1 2654.6 2674.6  
## + location1:location8 1 2654.9 2674.9  
## + location7:location9 1 2655.0 2675.0  
## + location3:location8 1 2655.0 2675.0  
## + location6:location9 1 2655.0 2675.0  
## + location4:location8 1 2655.1 2675.1  
## + location9:location10 1 2655.3 2675.3  
## + location2:location9 1 2655.6 2675.6  
## + location3:location9 1 2655.6 2675.6  
## + location3:location6 1 2655.7 2675.7  
## + location2:location4 1 2655.7 2675.7  
## + location3:location4 1 2655.8 2675.8  
## + location1:location9 1 2655.8 2675.8  
## + location4:location9 1 2655.8 2675.8  
## + location8:location9 1 2655.8 2675.8  
## + location2:location5 1 2655.8 2675.8  
## + location6:location8 1 2655.8 2675.8  
## + location4:location7 1 2655.9 2675.9  
## + location4:location6 1 2655.9 2675.9  
## + location1:location5 1 2655.9 2675.9  
## + location2:location8 1 2655.9 2675.9  
## + location1:location10 1 2655.9 2675.9  
## - location10:location7 1 2663.7 2679.7  
## - location10:location2 1 2664.4 2680.4  
## - location6:location7 1 2668.1 2684.1  
## - location7:location3 1 2669.8 2685.8  
## - location10:location3 1 2674.4 2690.4  
## - location5:location7 1 2680.7 2696.7  
## - location5:location6 1 2684.9 2700.9  
## - location5:location10 1 2748.8 2764.8  
##   
## Step: AIC=2670.39  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4  
##   
## Df Deviance AIC  
## + location1:location4 1 2640.8 2662.8  
## + location1:location2 1 2645.4 2667.4  
## + location3:location5 1 2645.4 2667.4  
## + location1:location3 1 2645.8 2667.8  
## + location5:location9 1 2646.5 2668.5  
## + location4:location6 1 2646.6 2668.6  
## + location5:location8 1 2646.7 2668.7  
## + location2:location6 1 2647.0 2669.0  
## + location1:location7 1 2647.3 2669.3  
## + location2:location4 1 2647.6 2669.6  
## + location7:location8 1 2647.9 2669.9  
## + location2:location7 1 2647.9 2669.9  
## <none> 2650.4 2670.4  
## + location6:location10 1 2648.4 2670.4  
## + location1:location6 1 2648.6 2670.6  
## + location8:location10 1 2648.7 2670.7  
## + location1:location8 1 2649.3 2671.3  
## + location4:location7 1 2649.3 2671.3  
## + location6:location9 1 2649.3 2671.3  
## + location2:location3 1 2649.3 2671.3  
## + location3:location4 1 2649.4 2671.4  
## + location7:location9 1 2649.5 2671.5  
## + location4:location9 1 2649.6 2671.6  
## + location3:location8 1 2649.6 2671.6  
## + location9:location10 1 2649.9 2671.9  
## + location2:location9 1 2650.0 2672.0  
## + location2:location5 1 2650.1 2672.1  
## + location4:location5 1 2650.1 2672.1  
## + location3:location6 1 2650.2 2672.2  
## + location3:location9 1 2650.2 2672.2  
## + location1:location9 1 2650.2 2672.2  
## + location8:location9 1 2650.3 2672.3  
## + location6:location8 1 2650.3 2672.3  
## + location1:location10 1 2650.4 2672.4  
## + location2:location8 1 2650.4 2672.4  
## + location4:location8 1 2650.4 2672.4  
## + location1:location5 1 2650.4 2672.4  
## - location10:location4 1 2655.9 2673.9  
## - location10:location7 1 2656.6 2674.6  
## - location10:location2 1 2658.3 2676.3  
## - location6:location7 1 2662.9 2680.9  
## - location7:location3 1 2663.3 2681.3  
## - location10:location3 1 2666.3 2684.3  
## - location5:location7 1 2677.0 2695.0  
## - location5:location6 1 2680.6 2698.6  
## - location5:location10 1 2747.3 2765.3  
##   
## Step: AIC=2662.75  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1  
##   
## Df Deviance AIC  
## + location3:location5 1 2634.9 2658.9  
## + location5:location9 1 2636.4 2660.4  
## + location2:location6 1 2637.1 2661.1  
## + location5:location8 1 2637.2 2661.2  
## + location4:location5 1 2637.9 2661.9  
## + location2:location7 1 2638.3 2662.3  
## + location7:location8 1 2638.4 2662.4  
## + location1:location5 1 2638.6 2662.6  
## + location1:location9 1 2638.7 2662.7  
## + location1:location2 1 2638.7 2662.7  
## <none> 2640.8 2662.8  
## + location4:location6 1 2638.8 2662.8  
## + location6:location10 1 2639.2 2663.2  
## + location8:location10 1 2639.3 2663.3  
## + location2:location4 1 2639.4 2663.4  
## + location1:location3 1 2639.5 2663.5  
## + location7:location9 1 2639.5 2663.5  
## + location1:location10 1 2639.5 2663.5  
## + location6:location9 1 2639.7 2663.7  
## + location1:location7 1 2639.9 2663.9  
## + location2:location3 1 2640.0 2664.0  
## + location3:location8 1 2640.0 2664.0  
## + location3:location6 1 2640.2 2664.2  
## + location2:location5 1 2640.2 2664.2  
## + location4:location7 1 2640.4 2664.4  
## + location2:location9 1 2640.4 2664.4  
## + location9:location10 1 2640.4 2664.4  
## + location1:location8 1 2640.5 2664.5  
## + location3:location4 1 2640.5 2664.5  
## + location4:location8 1 2640.5 2664.5  
## + location1:location6 1 2640.6 2664.6  
## + location3:location9 1 2640.6 2664.6  
## + location4:location9 1 2640.6 2664.6  
## + location8:location9 1 2640.7 2664.7  
## + location6:location8 1 2640.7 2664.7  
## + location2:location8 1 2640.7 2664.7  
## - location10:location7 1 2646.4 2666.4  
## - location10:location2 1 2648.0 2668.0  
## - location4:location1 1 2650.4 2670.4  
## - location6:location7 1 2653.6 2673.6  
## - location7:location3 1 2653.6 2673.6  
## - location10:location4 1 2653.7 2673.7  
## - location10:location3 1 2655.1 2675.1  
## - location5:location7 1 2668.5 2688.5  
## - location5:location6 1 2672.1 2692.1  
## - location5:location10 1 2741.5 2761.5  
##   
## Step: AIC=2658.91  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3  
##   
## Df Deviance AIC  
## + location2:location6 1 2631.2 2657.2  
## + location6:location10 1 2631.6 2657.6  
## + location2:location3 1 2631.7 2657.7  
## + location1:location3 1 2631.8 2657.8  
## + location5:location8 1 2632.2 2658.2  
## + location5:location9 1 2632.2 2658.2  
## + location2:location7 1 2632.3 2658.3  
## + location1:location10 1 2632.5 2658.5  
## + location3:location6 1 2632.6 2658.6  
## + location1:location9 1 2632.6 2658.6  
## + location7:location8 1 2632.8 2658.8  
## + location1:location2 1 2632.8 2658.8  
## <none> 2634.9 2658.9  
## + location2:location4 1 2632.9 2658.9  
## + location8:location10 1 2633.0 2659.0  
## + location4:location6 1 2633.1 2659.1  
## + location3:location4 1 2633.2 2659.2  
## + location3:location9 1 2633.5 2659.5  
## + location1:location5 1 2633.5 2659.5  
## + location7:location9 1 2633.5 2659.5  
## + location4:location5 1 2633.5 2659.5  
## + location3:location8 1 2633.6 2659.6  
## + location6:location9 1 2634.1 2660.1  
## + location9:location10 1 2634.2 2660.2  
## + location1:location7 1 2634.2 2660.2  
## + location4:location7 1 2634.4 2660.4  
## + location4:location9 1 2634.7 2660.7  
## + location1:location8 1 2634.7 2660.7  
## + location2:location9 1 2634.7 2660.7  
## + location4:location8 1 2634.7 2660.7  
## + location6:location8 1 2634.8 2660.8  
## + location2:location5 1 2634.8 2660.8  
## + location8:location9 1 2634.8 2660.8  
## + location2:location8 1 2634.9 2660.9  
## + location1:location6 1 2634.9 2660.9  
## - location5:location3 1 2640.8 2662.8  
## - location10:location3 1 2642.8 2664.8  
## - location10:location2 1 2643.5 2665.5  
## - location10:location7 1 2643.7 2665.7  
## - location6:location7 1 2645.0 2667.0  
## - location4:location1 1 2645.4 2667.4  
## - location10:location4 1 2649.7 2671.7  
## - location7:location3 1 2652.0 2674.0  
## - location5:location7 1 2657.4 2679.4  
## - location5:location6 1 2658.2 2680.2  
## - location5:location10 1 2740.5 2762.5  
##   
## Step: AIC=2657.17  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2  
##   
## Df Deviance AIC  
## + location6:location10 1 2626.6 2654.6  
## + location1:location3 1 2628.1 2656.1  
## + location5:location9 1 2628.5 2656.5  
## + location5:location8 1 2628.6 2656.6  
## + location1:location9 1 2628.8 2656.8  
## + location1:location10 1 2628.9 2656.9  
## + location2:location3 1 2629.1 2657.1  
## + location7:location8 1 2629.1 2657.1  
## <none> 2631.2 2657.2  
## + location8:location10 1 2629.4 2657.4  
## + location2:location7 1 2629.4 2657.4  
## + location3:location6 1 2629.5 2657.5  
## + location3:location4 1 2629.6 2657.6  
## + location4:location5 1 2629.7 2657.7  
## + location1:location5 1 2629.7 2657.7  
## + location4:location6 1 2629.8 2657.8  
## + location3:location8 1 2629.8 2657.8  
## + location7:location9 1 2629.8 2657.8  
## + location3:location9 1 2629.8 2657.8  
## + location1:location2 1 2629.9 2657.9  
## + location2:location4 1 2630.0 2658.0  
## + location2:location5 1 2630.1 2658.1  
## + location9:location10 1 2630.5 2658.5  
## + location2:location9 1 2630.5 2658.5  
## + location6:location9 1 2630.6 2658.6  
## + location1:location7 1 2630.6 2658.6  
## + location4:location7 1 2630.8 2658.8  
## - location6:location2 1 2634.9 2658.9  
## + location1:location8 1 2630.9 2658.9  
## + location4:location9 1 2631.0 2659.0  
## + location4:location8 1 2631.1 2659.1  
## + location8:location9 1 2631.1 2659.1  
## + location2:location8 1 2631.1 2659.1  
## + location6:location8 1 2631.1 2659.1  
## + location1:location6 1 2631.1 2659.1  
## - location5:location3 1 2637.1 2661.1  
## - location10:location3 1 2638.9 2662.9  
## - location6:location7 1 2639.1 2663.1  
## - location10:location7 1 2639.1 2663.1  
## - location4:location1 1 2642.0 2666.0  
## - location10:location2 1 2643.4 2667.4  
## - location10:location4 1 2645.8 2669.8  
## - location7:location3 1 2647.9 2671.9  
## - location5:location7 1 2652.2 2676.2  
## - location5:location6 1 2658.1 2682.1  
## - location5:location10 1 2740.5 2764.5  
##   
## Step: AIC=2654.64  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6  
##   
## Df Deviance AIC  
## + location3:location6 1 2622.5 2652.5  
## + location5:location9 1 2623.4 2653.4  
## + location1:location3 1 2623.6 2653.6  
## + location5:location8 1 2623.8 2653.8  
## + location4:location6 1 2624.1 2654.1  
## + location2:location5 1 2624.1 2654.1  
## + location4:location5 1 2624.3 2654.3  
## + location1:location9 1 2624.4 2654.4  
## + location6:location9 1 2624.6 2654.6  
## <none> 2626.6 2654.6  
## + location7:location8 1 2624.7 2654.7  
## + location1:location5 1 2624.8 2654.8  
## + location8:location10 1 2625.0 2655.0  
## + location1:location10 1 2625.0 2655.0  
## + location2:location3 1 2625.1 2655.1  
## + location3:location4 1 2625.2 2655.2  
## + location7:location9 1 2625.3 2655.3  
## + location3:location9 1 2625.3 2655.3  
## + location3:location8 1 2625.4 2655.4  
## + location2:location7 1 2625.4 2655.4  
## + location1:location2 1 2625.7 2655.7  
## + location2:location9 1 2625.8 2655.8  
## + location2:location4 1 2625.9 2655.9  
## + location1:location7 1 2626.2 2656.2  
## + location9:location10 1 2626.4 2656.4  
## + location4:location8 1 2626.4 2656.4  
## + location4:location7 1 2626.4 2656.4  
## + location1:location8 1 2626.4 2656.4  
## + location2:location8 1 2626.5 2656.5  
## + location4:location9 1 2626.5 2656.5  
## + location1:location6 1 2626.5 2656.5  
## + location8:location9 1 2626.6 2656.6  
## + location6:location8 1 2626.6 2656.6  
## - location10:location6 1 2631.2 2657.2  
## - location10:location3 1 2631.3 2657.3  
## - location6:location2 1 2631.6 2657.6  
## - location10:location7 1 2633.7 2659.7  
## - location5:location3 1 2634.8 2660.8  
## - location4:location1 1 2636.9 2662.9  
## - location6:location7 1 2637.6 2663.6  
## - location10:location2 1 2639.0 2665.0  
## - location10:location4 1 2639.2 2665.2  
## - location7:location3 1 2642.2 2668.2  
## - location5:location6 1 2645.2 2671.2  
## - location5:location7 1 2651.3 2677.3  
## - location5:location10 1 2740.5 2766.5  
##   
## Step: AIC=2652.47  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3  
##   
## Df Deviance AIC  
## + location5:location9 1 2619.5 2651.5  
## + location5:location8 1 2619.8 2651.8  
## + location1:location3 1 2619.9 2651.9  
## + location2:location5 1 2620.1 2652.1  
## + location4:location5 1 2620.3 2652.3  
## + location1:location9 1 2620.3 2652.3  
## + location7:location8 1 2620.4 2652.4  
## <none> 2622.5 2652.5  
## + location4:location6 1 2620.7 2652.7  
## + location8:location10 1 2621.0 2653.0  
## + location1:location10 1 2621.0 2653.0  
## + location6:location9 1 2621.0 2653.0  
## + location7:location9 1 2621.0 2653.0  
## + location1:location5 1 2621.1 2653.1  
## + location3:location8 1 2621.2 2653.2  
## + location2:location7 1 2621.2 2653.2  
## + location2:location3 1 2621.4 2653.4  
## + location1:location2 1 2621.5 2653.5  
## + location3:location9 1 2621.5 2653.5  
## + location3:location4 1 2621.5 2653.5  
## + location2:location9 1 2621.7 2653.7  
## + location2:location4 1 2621.8 2653.8  
## + location1:location7 1 2621.9 2653.9  
## + location1:location8 1 2622.2 2654.2  
## + location4:location7 1 2622.2 2654.2  
## + location4:location8 1 2622.3 2654.3  
## + location2:location8 1 2622.3 2654.3  
## + location9:location10 1 2622.3 2654.3  
## + location1:location6 1 2622.4 2654.4  
## + location4:location9 1 2622.4 2654.4  
## + location8:location9 1 2622.4 2654.4  
## + location6:location8 1 2622.5 2654.5  
## - location6:location3 1 2626.6 2654.6  
## - location6:location2 1 2626.7 2654.7  
## - location10:location7 1 2628.5 2656.5  
## - location10:location6 1 2629.5 2657.5  
## - location10:location3 1 2629.7 2657.7  
## - location6:location7 1 2630.9 2658.9  
## - location4:location1 1 2633.8 2661.8  
## - location5:location3 1 2634.1 2662.1  
## - location10:location2 1 2634.5 2662.5  
## - location10:location4 1 2635.9 2663.9  
## - location7:location3 1 2636.1 2664.1  
## - location5:location7 1 2644.1 2672.1  
## - location5:location6 1 2644.8 2672.8  
## - location5:location10 1 2739.2 2767.2  
##   
## Step: AIC=2651.47  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3 + location5:location9  
##   
## Df Deviance AIC  
## + location6:location9 1 2612.1 2646.1  
## + location3:location9 1 2613.6 2647.6  
## + location5:location8 1 2617.1 2651.1  
## + location1:location3 1 2617.1 2651.1  
## + location2:location5 1 2617.4 2651.4  
## <none> 2619.5 2651.5  
## + location4:location5 1 2617.5 2651.5  
## + location7:location8 1 2617.5 2651.5  
## + location4:location6 1 2617.6 2651.6  
## + location1:location10 1 2617.8 2651.8  
## + location8:location10 1 2617.9 2651.9  
## + location4:location9 1 2618.1 2652.1  
## + location1:location5 1 2618.3 2652.3  
## + location3:location8 1 2618.3 2652.3  
## + location2:location7 1 2618.3 2652.3  
## + location2:location3 1 2618.4 2652.4  
## - location5:location9 1 2622.5 2652.5  
## + location3:location4 1 2618.5 2652.5  
## + location1:location2 1 2618.5 2652.5  
## + location8:location9 1 2618.6 2652.6  
## + location2:location4 1 2618.7 2652.7  
## + location1:location7 1 2618.9 2652.9  
## + location1:location9 1 2619.0 2653.0  
## + location9:location10 1 2619.0 2653.0  
## + location4:location7 1 2619.2 2653.2  
## + location1:location8 1 2619.2 2653.2  
## + location4:location8 1 2619.3 2653.3  
## + location7:location9 1 2619.3 2653.3  
## + location2:location8 1 2619.3 2653.3  
## + location1:location6 1 2619.4 2653.4  
## - location6:location3 1 2623.4 2653.4  
## + location6:location8 1 2619.5 2653.5  
## + location2:location9 1 2619.5 2653.5  
## - location6:location2 1 2623.7 2653.7  
## - location10:location7 1 2625.9 2655.9  
## - location10:location6 1 2627.1 2657.1  
## - location10:location3 1 2627.3 2657.3  
## - location6:location7 1 2627.7 2657.7  
## - location5:location3 1 2628.9 2658.9  
## - location4:location1 1 2631.0 2661.0  
## - location10:location2 1 2631.6 2661.6  
## - location7:location3 1 2632.8 2662.8  
## - location10:location4 1 2633.3 2663.3  
## - location5:location6 1 2639.5 2669.5  
## - location5:location7 1 2639.6 2669.6  
## - location5:location10 1 2739.2 2769.2  
##   
## Step: AIC=2646.07  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3 + location5:location9 +   
## location6:location9  
##   
## Df Deviance AIC  
## + location3:location9 1 2608.8 2644.8  
## + location1:location3 1 2609.3 2645.3  
## + location5:location8 1 2609.9 2645.9  
## + location7:location8 1 2609.9 2645.9  
## <none> 2612.1 2646.1  
## + location8:location10 1 2610.4 2646.4  
## + location4:location5 1 2610.4 2646.4  
## - location6:location3 1 2614.4 2646.4  
## + location1:location10 1 2610.6 2646.6  
## + location2:location7 1 2610.6 2646.6  
## + location2:location5 1 2610.7 2646.7  
## + location4:location6 1 2610.8 2646.8  
## + location1:location2 1 2610.8 2646.8  
## + location1:location9 1 2610.9 2646.9  
## + location2:location3 1 2610.9 2646.9  
## + location3:location8 1 2610.9 2646.9  
## + location3:location4 1 2611.1 2647.1  
## + location2:location4 1 2611.2 2647.2  
## + location1:location5 1 2611.3 2647.3  
## + location7:location9 1 2611.3 2647.3  
## + location1:location7 1 2611.5 2647.5  
## + location8:location9 1 2611.6 2647.6  
## + location4:location8 1 2611.7 2647.7  
## + location2:location9 1 2611.8 2647.8  
## + location4:location7 1 2611.8 2647.8  
## + location1:location8 1 2611.8 2647.8  
## + location4:location9 1 2611.8 2647.8  
## + location9:location10 1 2611.8 2647.8  
## + location2:location8 1 2612.0 2648.0  
## + location1:location6 1 2612.0 2648.0  
## + location6:location8 1 2612.1 2648.1  
## - location6:location2 1 2616.1 2648.1  
## - location10:location7 1 2618.9 2650.9  
## - location5:location3 1 2619.1 2651.1  
## - location6:location7 1 2619.2 2651.2  
## - location10:location3 1 2619.4 2651.4  
## - location6:location9 1 2619.5 2651.5  
## - location5:location9 1 2621.0 2653.0  
## - location4:location1 1 2623.0 2655.0  
## - location10:location6 1 2624.4 2656.4  
## - location7:location3 1 2624.5 2656.5  
## - location10:location2 1 2624.5 2656.5  
## - location10:location4 1 2625.9 2657.9  
## - location5:location7 1 2629.1 2661.1  
## - location5:location6 1 2635.0 2667.0  
## - location5:location10 1 2739.0 2771.0  
##   
## Step: AIC=2644.83  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3 + location5:location9 +   
## location6:location9 + location3:location9  
##   
## Df Deviance AIC  
## + location1:location3 1 2606.3 2644.3  
## - location6:location3 1 2610.8 2644.8  
## <none> 2608.8 2644.8  
## + location5:location8 1 2606.9 2644.9  
## + location7:location8 1 2607.0 2645.0  
## + location1:location9 1 2607.0 2645.0  
## + location7:location9 1 2607.1 2645.1  
## + location8:location10 1 2607.2 2645.2  
## + location4:location5 1 2607.3 2645.3  
## + location1:location10 1 2607.3 2645.3  
## + location2:location7 1 2607.4 2645.4  
## + location9:location10 1 2607.4 2645.4  
## + location1:location2 1 2607.5 2645.5  
## + location4:location6 1 2607.6 2645.6  
## + location2:location5 1 2607.7 2645.7  
## + location2:location3 1 2607.7 2645.7  
## + location3:location8 1 2607.9 2645.9  
## + location3:location4 1 2608.0 2646.0  
## + location2:location4 1 2608.1 2646.1  
## - location3:location9 1 2612.1 2646.1  
## + location1:location7 1 2608.2 2646.2  
## + location1:location5 1 2608.2 2646.2  
## + location2:location9 1 2608.3 2646.3  
## + location4:location8 1 2608.4 2646.4  
## + location1:location8 1 2608.6 2646.6  
## + location4:location7 1 2608.6 2646.6  
## + location8:location9 1 2608.6 2646.6  
## + location1:location6 1 2608.7 2646.7  
## + location4:location9 1 2608.7 2646.7  
## - location6:location2 1 2612.7 2646.7  
## + location2:location8 1 2608.8 2646.8  
## + location6:location8 1 2608.8 2646.8  
## - location6:location9 1 2613.6 2647.6  
## - location6:location7 1 2615.7 2649.7  
## - location10:location7 1 2615.9 2649.9  
## - location5:location3 1 2617.8 2651.8  
## - location10:location3 1 2618.9 2652.9  
## - location4:location1 1 2620.0 2654.0  
## - location10:location6 1 2620.1 2654.1  
## - location7:location3 1 2620.4 2654.4  
## - location5:location9 1 2620.8 2654.8  
## - location10:location2 1 2621.0 2655.0  
## - location10:location4 1 2622.8 2656.8  
## - location5:location7 1 2624.4 2658.4  
## - location5:location6 1 2628.2 2662.2  
## - location5:location10 1 2739.0 2773.0  
##   
## Step: AIC=2644.26  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3 + location5:location9 +   
## location6:location9 + location3:location9 + location3:location1  
##   
## Df Deviance AIC  
## + location1:location10 1 2600.1 2640.1  
## + location1:location9 1 2601.3 2641.3  
## + location1:location5 1 2602.6 2642.6  
## - location6:location3 1 2607.8 2643.8  
## <none> 2606.3 2644.3  
## + location7:location8 1 2604.4 2644.4  
## + location5:location8 1 2604.4 2644.4  
## + location4:location6 1 2604.5 2644.5  
## + location8:location10 1 2604.6 2644.6  
## + location7:location9 1 2604.6 2644.6  
## + location9:location10 1 2604.8 2644.8  
## - location3:location1 1 2608.8 2644.8  
## + location2:location7 1 2604.8 2644.8  
## + location4:location5 1 2605.2 2645.2  
## + location2:location5 1 2605.2 2645.2  
## + location3:location4 1 2605.3 2645.3  
## + location2:location3 1 2605.3 2645.3  
## + location2:location4 1 2605.3 2645.3  
## - location3:location9 1 2609.3 2645.3  
## + location3:location8 1 2605.4 2645.4  
## + location2:location9 1 2605.8 2645.8  
## + location4:location8 1 2605.9 2645.9  
## + location4:location7 1 2605.9 2645.9  
## + location1:location2 1 2605.9 2645.9  
## + location8:location9 1 2606.0 2646.0  
## + location4:location9 1 2606.1 2646.1  
## + location1:location6 1 2606.1 2646.1  
## - location6:location2 1 2610.2 2646.2  
## + location2:location8 1 2606.2 2646.2  
## + location1:location7 1 2606.2 2646.2  
## + location1:location8 1 2606.2 2646.2  
## + location6:location8 1 2606.3 2646.3  
## - location6:location9 1 2611.4 2647.4  
## - location4:location1 1 2612.7 2648.7  
## - location10:location7 1 2613.4 2649.4  
## - location6:location7 1 2613.4 2649.4  
## - location5:location3 1 2616.7 2652.7  
## - location7:location3 1 2616.9 2652.9  
## - location10:location4 1 2617.4 2653.4  
## - location10:location6 1 2617.5 2653.5  
## - location10:location3 1 2618.1 2654.1  
## - location5:location9 1 2618.1 2654.1  
## - location10:location2 1 2618.6 2654.6  
## - location5:location7 1 2621.7 2657.7  
## - location5:location6 1 2624.9 2660.9  
## - location5:location10 1 2738.0 2774.0  
##   
## Step: AIC=2640.1  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location6:location3 + location5:location9 +   
## location6:location9 + location3:location9 + location3:location1 +   
## location10:location1  
##   
## Df Deviance AIC  
## - location6:location3 1 2601.2 2639.2  
## + location4:location5 1 2597.7 2639.7  
## <none> 2600.1 2640.1  
## + location5:location8 1 2598.1 2640.1  
## + location7:location8 1 2598.1 2640.1  
## + location1:location2 1 2598.3 2640.3  
## + location1:location5 1 2598.3 2640.3  
## + location1:location9 1 2598.4 2640.4  
## + location2:location5 1 2598.5 2640.5  
## + location7:location9 1 2598.6 2640.6  
## + location8:location10 1 2598.7 2640.7  
## + location4:location6 1 2598.7 2640.7  
## + location2:location7 1 2598.8 2640.8  
## + location1:location7 1 2599.0 2641.0  
## - location3:location9 1 2603.0 2641.0  
## + location3:location8 1 2599.2 2641.2  
## - location6:location2 1 2603.4 2641.4  
## + location2:location9 1 2599.5 2641.5  
## + location9:location10 1 2599.5 2641.5  
## + location3:location4 1 2599.5 2641.5  
## + location4:location8 1 2599.5 2641.5  
## + location2:location3 1 2599.5 2641.5  
## + location2:location4 1 2599.6 2641.6  
## + location1:location8 1 2599.8 2641.8  
## + location1:location6 1 2599.8 2641.8  
## + location8:location9 1 2599.8 2641.8  
## + location4:location7 1 2599.9 2641.9  
## + location2:location8 1 2600.0 2642.0  
## + location4:location9 1 2600.0 2642.0  
## + location6:location8 1 2600.1 2642.1  
## - location10:location7 1 2605.4 2643.4  
## - location6:location9 1 2605.4 2643.4  
## - location10:location1 1 2606.3 2644.3  
## - location6:location7 1 2606.9 2644.9  
## - location3:location1 1 2607.3 2645.3  
## - location10:location6 1 2609.1 2647.1  
## - location4:location1 1 2609.2 2647.2  
## - location7:location3 1 2609.6 2647.6  
## - location10:location2 1 2610.4 2648.4  
## - location10:location3 1 2610.9 2648.9  
## - location5:location9 1 2612.0 2650.0  
## - location10:location4 1 2612.3 2650.3  
## - location5:location3 1 2614.3 2652.3  
## - location5:location7 1 2615.7 2653.7  
## - location5:location6 1 2618.1 2656.1  
## - location5:location10 1 2738.0 2776.0  
##   
## Step: AIC=2639.16  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1  
##   
## Df Deviance AIC  
## + location4:location5 1 2598.7 2638.7  
## + location1:location5 1 2599.1 2639.1  
## + location5:location8 1 2599.1 2639.1  
## <none> 2601.2 2639.2  
## + location7:location8 1 2599.2 2639.2  
## + location1:location9 1 2599.3 2639.3  
## + location1:location2 1 2599.4 2639.4  
## + location4:location6 1 2599.4 2639.4  
## + location2:location5 1 2599.5 2639.5  
## + location7:location9 1 2599.6 2639.6  
## + location8:location10 1 2599.6 2639.6  
## + location2:location7 1 2599.9 2639.9  
## + location3:location6 1 2600.1 2640.1  
## + location1:location7 1 2600.1 2640.1  
## + location9:location10 1 2600.3 2640.3  
## + location3:location8 1 2600.3 2640.3  
## - location3:location9 1 2604.4 2640.4  
## + location3:location4 1 2600.4 2640.4  
## + location2:location3 1 2600.4 2640.4  
## + location2:location9 1 2600.5 2640.5  
## + location4:location8 1 2600.6 2640.6  
## + location2:location4 1 2600.7 2640.7  
## - location6:location2 1 2604.8 2640.8  
## + location1:location6 1 2600.8 2640.8  
## + location1:location8 1 2600.9 2640.9  
## + location8:location9 1 2600.9 2640.9  
## + location4:location7 1 2601.0 2641.0  
## + location2:location8 1 2601.0 2641.0  
## + location4:location9 1 2601.1 2641.1  
## + location6:location8 1 2601.2 2641.2  
## - location10:location7 1 2606.9 2642.9  
## - location6:location9 1 2607.2 2643.2  
## - location10:location1 1 2607.8 2643.8  
## - location6:location7 1 2609.0 2645.0  
## - location3:location1 1 2609.2 2645.2  
## - location10:location6 1 2609.2 2645.2  
## - location4:location1 1 2609.7 2645.7  
## - location10:location3 1 2611.0 2647.0  
## - location7:location3 1 2611.2 2647.2  
## - location10:location2 1 2611.6 2647.6  
## - location10:location4 1 2613.0 2649.0  
## - location5:location3 1 2614.3 2650.3  
## - location5:location9 1 2614.3 2650.3  
## - location5:location7 1 2617.9 2653.9  
## - location5:location6 1 2618.2 2654.2  
## - location5:location10 1 2739.6 2775.6  
##   
## Step: AIC=2638.74  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4  
##   
## Df Deviance AIC  
## + location4:location6 1 2595.2 2637.2  
## + location3:location4 1 2596.5 2638.5  
## + location1:location9 1 2596.7 2638.7  
## <none> 2598.7 2638.7  
## + location7:location8 1 2596.8 2638.8  
## + location1:location2 1 2596.8 2638.8  
## + location5:location8 1 2596.9 2638.9  
## + location1:location5 1 2597.0 2639.0  
## + location8:location10 1 2597.1 2639.1  
## + location7:location9 1 2597.1 2639.1  
## - location5:location4 1 2601.2 2639.2  
## + location2:location5 1 2597.2 2639.2  
## + location2:location4 1 2597.5 2639.5  
## + location2:location7 1 2597.5 2639.5  
## + location1:location7 1 2597.7 2639.7  
## + location3:location6 1 2597.7 2639.7  
## + location9:location10 1 2597.8 2639.8  
## - location3:location9 1 2601.8 2639.8  
## + location3:location8 1 2597.8 2639.8  
## + location2:location3 1 2598.0 2640.0  
## + location2:location9 1 2598.1 2640.1  
## + location4:location7 1 2598.2 2640.2  
## + location4:location9 1 2598.2 2640.2  
## + location1:location6 1 2598.4 2640.4  
## + location1:location8 1 2598.4 2640.4  
## + location8:location9 1 2598.5 2640.5  
## + location4:location8 1 2598.5 2640.5  
## - location6:location2 1 2602.6 2640.6  
## + location2:location8 1 2598.6 2640.6  
## + location6:location8 1 2598.7 2640.7  
## - location6:location9 1 2604.4 2642.4  
## - location10:location7 1 2604.7 2642.7  
## - location10:location4 1 2605.5 2643.5  
## - location6:location7 1 2606.1 2644.1  
## - location3:location1 1 2606.7 2644.7  
## - location10:location1 1 2606.7 2644.7  
## - location10:location6 1 2607.5 2645.5  
## - location7:location3 1 2608.6 2646.6  
## - location10:location3 1 2609.4 2647.4  
## - location4:location1 1 2609.7 2647.7  
## - location10:location2 1 2609.8 2647.8  
## - location5:location3 1 2610.1 2648.1  
## - location5:location9 1 2611.1 2649.1  
## - location5:location6 1 2614.4 2652.4  
## - location5:location7 1 2614.8 2652.8  
## - location5:location10 1 2739.5 2777.5  
##   
## Step: AIC=2637.17  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4  
##   
## Df Deviance AIC  
## + location1:location9 1 2593.0 2637.0  
## + location1:location2 1 2593.2 2637.2  
## <none> 2595.2 2637.2  
## + location5:location8 1 2593.2 2637.2  
## + location7:location8 1 2593.2 2637.2  
## + location3:location4 1 2593.5 2637.5  
## + location1:location5 1 2593.5 2637.5  
## + location7:location9 1 2593.6 2637.6  
## + location2:location5 1 2593.7 2637.7  
## + location8:location10 1 2593.7 2637.7  
## - location3:location9 1 2598.0 2638.0  
## + location2:location7 1 2594.1 2638.1  
## + location1:location7 1 2594.2 2638.2  
## + location3:location8 1 2594.3 2638.3  
## + location2:location4 1 2594.4 2638.4  
## + location9:location10 1 2594.5 2638.5  
## + location2:location9 1 2594.5 2638.5  
## + location2:location3 1 2594.5 2638.5  
## + location3:location6 1 2594.6 2638.6  
## - location6:location2 1 2598.6 2638.6  
## - location6:location4 1 2598.7 2638.7  
## + location4:location7 1 2594.8 2638.8  
## + location4:location8 1 2594.8 2638.8  
## + location1:location8 1 2594.9 2638.9  
## + location8:location9 1 2595.0 2639.0  
## + location4:location9 1 2595.0 2639.0  
## + location1:location6 1 2595.0 2639.0  
## + location2:location8 1 2595.1 2639.1  
## + location6:location8 1 2595.2 2639.2  
## - location5:location4 1 2599.4 2639.4  
## - location6:location9 1 2599.8 2639.8  
## - location10:location7 1 2600.9 2640.9  
## - location6:location7 1 2602.3 2642.3  
## - location10:location1 1 2603.0 2643.0  
## - location3:location1 1 2603.7 2643.7  
## - location10:location4 1 2604.6 2644.6  
## - location4:location1 1 2604.7 2644.7  
## - location7:location3 1 2605.1 2645.1  
## - location10:location2 1 2605.6 2645.6  
## - location10:location6 1 2605.7 2645.7  
## - location10:location3 1 2606.0 2646.0  
## - location5:location3 1 2606.3 2646.3  
## - location5:location9 1 2606.4 2646.4  
## - location5:location7 1 2610.8 2650.8  
## - location5:location6 1 2612.9 2652.9  
## - location5:location10 1 2739.5 2779.5  
##   
## Step: AIC=2636.97  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9  
##   
## Df Deviance AIC  
## + location1:location2 1 2590.7 2636.7  
## + location5:location8 1 2590.9 2636.9  
## <none> 2593.0 2637.0  
## + location7:location8 1 2591.1 2637.1  
## - location1:location9 1 2595.2 2637.2  
## + location3:location4 1 2591.4 2637.4  
## + location2:location5 1 2591.4 2637.4  
## + location8:location10 1 2591.5 2637.5  
## + location1:location7 1 2591.6 2637.6  
## + location7:location9 1 2591.8 2637.8  
## + location2:location7 1 2591.9 2637.9  
## + location3:location8 1 2592.1 2638.1  
## + location1:location5 1 2592.1 2638.1  
## + location2:location4 1 2592.3 2638.3  
## + location2:location3 1 2592.3 2638.3  
## + location2:location9 1 2592.4 2638.4  
## + location3:location6 1 2592.5 2638.5  
## + location1:location8 1 2592.5 2638.5  
## - location6:location2 1 2596.5 2638.5  
## + location4:location7 1 2592.5 2638.5  
## - location3:location9 1 2596.5 2638.5  
## + location1:location6 1 2592.6 2638.6  
## + location4:location8 1 2592.7 2638.7  
## + location4:location9 1 2592.7 2638.7  
## + location9:location10 1 2592.7 2638.7  
## - location6:location4 1 2596.7 2638.7  
## + location8:location9 1 2592.7 2638.7  
## - location10:location1 1 2596.7 2638.7  
## + location2:location8 1 2592.9 2638.9  
## + location6:location8 1 2592.9 2638.9  
## - location5:location4 1 2597.5 2639.5  
## - location6:location9 1 2598.4 2640.4  
## - location10:location7 1 2598.7 2640.7  
## - location5:location9 1 2599.8 2641.8  
## - location6:location7 1 2600.2 2642.2  
## - location7:location3 1 2602.6 2644.6  
## - location3:location1 1 2602.9 2644.9  
## - location10:location4 1 2603.0 2645.0  
## - location4:location1 1 2603.6 2645.6  
## - location10:location2 1 2603.8 2645.8  
## - location10:location6 1 2603.9 2645.9  
## - location10:location3 1 2604.9 2646.9  
## - location5:location3 1 2605.2 2647.2  
## - location5:location7 1 2608.5 2650.5  
## - location5:location6 1 2611.6 2653.6  
## - location5:location10 1 2735.3 2777.3  
##   
## Step: AIC=2636.73  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1  
##   
## Df Deviance AIC  
## + location2:location5 1 2587.3 2635.3  
## + location1:location5 1 2588.6 2636.6  
## + location5:location8 1 2588.7 2636.7  
## <none> 2590.7 2636.7  
## + location7:location8 1 2589.0 2637.0  
## - location2:location1 1 2593.0 2637.0  
## - location6:location2 1 2593.0 2637.0  
## - location1:location9 1 2593.2 2637.2  
## + location3:location4 1 2589.2 2637.2  
## + location8:location10 1 2589.3 2637.3  
## + location7:location9 1 2589.6 2637.6  
## + location1:location7 1 2589.9 2637.9  
## + location3:location8 1 2589.9 2637.9  
## + location2:location9 1 2590.1 2638.1  
## + location2:location7 1 2590.2 2638.2  
## + location3:location6 1 2590.2 2638.2  
## + location4:location7 1 2590.3 2638.3  
## + location2:location4 1 2590.3 2638.3  
## + location4:location9 1 2590.3 2638.3  
## + location1:location8 1 2590.4 2638.4  
## + location4:location8 1 2590.4 2638.4  
## + location2:location3 1 2590.4 2638.4  
## + location8:location9 1 2590.5 2638.5  
## - location3:location9 1 2594.5 2638.5  
## + location2:location8 1 2590.6 2638.6  
## + location9:location10 1 2590.6 2638.6  
## - location6:location4 1 2594.6 2638.6  
## + location1:location6 1 2590.6 2638.6  
## + location6:location8 1 2590.7 2638.7  
## - location5:location4 1 2595.5 2639.5  
## - location10:location1 1 2595.8 2639.8  
## - location10:location7 1 2596.1 2640.1  
## - location6:location9 1 2596.4 2640.4  
## - location5:location9 1 2597.6 2641.6  
## - location6:location7 1 2597.9 2641.9  
## - location3:location1 1 2598.7 2642.7  
## - location10:location4 1 2599.9 2643.9  
## - location7:location3 1 2600.6 2644.6  
## - location4:location1 1 2600.6 2644.6  
## - location10:location6 1 2600.7 2644.7  
## - location10:location3 1 2601.3 2645.3  
## - location5:location3 1 2602.9 2646.9  
## - location10:location2 1 2603.8 2647.8  
## - location5:location7 1 2607.0 2651.0  
## - location5:location6 1 2609.5 2653.5  
## - location5:location10 1 2734.8 2778.8  
##   
## Step: AIC=2635.34  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1 + location5:location2  
##   
## Df Deviance AIC  
## + location5:location8 1 2585.1 2635.1  
## <none> 2587.3 2635.3  
## + location1:location5 1 2585.5 2635.5  
## + location8:location10 1 2585.6 2635.6  
## + location7:location8 1 2585.8 2635.8  
## + location3:location4 1 2585.9 2635.9  
## - location1:location9 1 2589.9 2635.9  
## + location2:location7 1 2585.9 2635.9  
## + location7:location9 1 2586.1 2636.1  
## + location2:location3 1 2586.2 2636.2  
## + location1:location7 1 2586.5 2636.5  
## + location2:location4 1 2586.6 2636.6  
## + location3:location8 1 2586.7 2636.7  
## - location5:location2 1 2590.7 2636.7  
## - location3:location9 1 2590.9 2636.9  
## + location3:location6 1 2586.9 2636.9  
## + location4:location7 1 2586.9 2636.9  
## + location4:location8 1 2587.0 2637.0  
## + location4:location9 1 2587.0 2637.0  
## + location1:location8 1 2587.0 2637.0  
## + location8:location9 1 2587.2 2637.2  
## + location9:location10 1 2587.2 2637.2  
## + location2:location9 1 2587.2 2637.2  
## + location2:location8 1 2587.3 2637.3  
## + location6:location8 1 2587.3 2637.3  
## - location6:location4 1 2591.3 2637.3  
## + location1:location6 1 2587.3 2637.3  
## - location2:location1 1 2591.4 2637.4  
## - location6:location2 1 2591.5 2637.5  
## - location5:location4 1 2592.0 2638.0  
## - location6:location9 1 2592.3 2638.3  
## - location5:location9 1 2593.0 2639.0  
## - location10:location7 1 2593.1 2639.1  
## - location10:location1 1 2593.6 2639.6  
## - location6:location7 1 2593.6 2639.6  
## - location3:location1 1 2595.0 2641.0  
## - location7:location3 1 2596.8 2642.8  
## - location10:location2 1 2596.8 2642.8  
## - location10:location4 1 2597.2 2643.2  
## - location4:location1 1 2597.6 2643.6  
## - location5:location3 1 2598.3 2644.3  
## - location10:location3 1 2598.5 2644.5  
## - location10:location6 1 2598.9 2644.9  
## - location5:location7 1 2601.4 2647.4  
## - location5:location6 1 2604.7 2650.7  
## - location5:location10 1 2734.8 2780.8  
##   
## Step: AIC=2635.05  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1 + location5:location2 + location5:location8  
##   
## Df Deviance AIC  
## + location7:location8 1 2579.3 2631.3  
## + location3:location8 1 2580.4 2632.4  
## + location8:location9 1 2582.4 2634.4  
## + location1:location8 1 2582.5 2634.5  
## <none> 2585.1 2635.1  
## + location1:location5 1 2583.1 2635.1  
## - location5:location8 1 2587.3 2635.3  
## + location3:location4 1 2583.6 2635.6  
## + location2:location7 1 2583.7 2635.7  
## + location7:location9 1 2583.7 2635.7  
## - location1:location9 1 2587.7 2635.7  
## + location2:location3 1 2584.0 2636.0  
## + location1:location7 1 2584.1 2636.1  
## + location2:location4 1 2584.3 2636.3  
## - location3:location9 1 2588.3 2636.3  
## + location6:location8 1 2584.3 2636.3  
## - location5:location2 1 2588.7 2636.7  
## + location4:location7 1 2584.7 2636.7  
## + location3:location6 1 2584.7 2636.7  
## + location4:location9 1 2584.7 2636.7  
## + location2:location8 1 2584.7 2636.7  
## + location8:location10 1 2584.8 2636.8  
## + location9:location10 1 2584.9 2636.9  
## + location2:location9 1 2584.9 2636.9  
## + location1:location6 1 2585.0 2637.0  
## + location4:location8 1 2585.0 2637.0  
## - location6:location4 1 2589.1 2637.1  
## - location6:location2 1 2589.2 2637.2  
## - location2:location1 1 2589.3 2637.3  
## - location5:location4 1 2589.5 2637.5  
## - location6:location9 1 2589.9 2637.9  
## - location5:location9 1 2590.1 2638.1  
## - location10:location7 1 2590.9 2638.9  
## - location6:location7 1 2591.1 2639.1  
## - location10:location1 1 2591.4 2639.4  
## - location3:location1 1 2592.7 2640.7  
## - location7:location3 1 2594.2 2642.2  
## - location10:location2 1 2594.8 2642.8  
## - location4:location1 1 2595.0 2643.0  
## - location10:location4 1 2595.1 2643.1  
## - location5:location3 1 2595.3 2643.3  
## - location10:location3 1 2596.4 2644.4  
## - location10:location6 1 2596.8 2644.8  
## - location5:location7 1 2598.0 2646.0  
## - location5:location6 1 2601.9 2649.9  
## - location5:location10 1 2734.4 2782.4  
##   
## Step: AIC=2631.28  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1 + location5:location2 + location5:location8 +   
## location7:location8  
##   
## Df Deviance AIC  
## + location3:location8 1 2576.6 2630.6  
## + location1:location5 1 2577.3 2631.3  
## <none> 2579.3 2631.3  
## + location7:location9 1 2577.4 2631.4  
## + location8:location10 1 2577.6 2631.6  
## - location3:location9 1 2581.8 2631.8  
## - location1:location9 1 2581.8 2631.8  
## + location3:location4 1 2577.8 2631.8  
## + location2:location7 1 2577.9 2631.9  
## + location8:location9 1 2577.9 2631.9  
## + location1:location8 1 2577.9 2631.9  
## + location2:location3 1 2578.2 2632.2  
## + location2:location4 1 2578.4 2632.4  
## + location1:location7 1 2578.6 2632.6  
## - location5:location2 1 2582.6 2632.6  
## + location4:location7 1 2578.9 2632.9  
## + location3:location6 1 2578.9 2632.9  
## + location4:location9 1 2579.0 2633.0  
## - location6:location2 1 2583.1 2633.1  
## + location9:location10 1 2579.1 2633.1  
## + location6:location8 1 2579.1 2633.1  
## + location2:location9 1 2579.2 2633.2  
## + location4:location8 1 2579.2 2633.2  
## - location6:location4 1 2583.3 2633.3  
## + location2:location8 1 2579.3 2633.3  
## + location1:location6 1 2579.3 2633.3  
## - location2:location1 1 2583.3 2633.3  
## - location5:location4 1 2583.5 2633.5  
## - location5:location9 1 2583.8 2633.8  
## - location6:location9 1 2584.4 2634.4  
## - location6:location7 1 2584.8 2634.8  
## - location7:location8 1 2585.1 2635.1  
## - location5:location8 1 2585.8 2635.8  
## - location10:location1 1 2585.9 2635.9  
## - location7:location3 1 2586.6 2636.6  
## - location3:location1 1 2587.1 2637.1  
## - location10:location7 1 2587.5 2637.5  
## - location5:location3 1 2588.2 2638.2  
## - location4:location1 1 2588.8 2638.8  
## - location10:location2 1 2588.8 2638.8  
## - location10:location4 1 2589.1 2639.1  
## - location10:location3 1 2589.8 2639.8  
## - location10:location6 1 2590.9 2640.9  
## - location5:location7 1 2593.8 2643.8  
## - location5:location6 1 2595.3 2645.3  
## - location5:location10 1 2731.2 2781.2  
##   
## Step: AIC=2630.56  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1 + location5:location2 + location5:location8 +   
## location7:location8 + location3:location8  
##   
## Df Deviance AIC  
## + location8:location10 1 2572.8 2628.8  
## <none> 2576.6 2630.6  
## - location3:location9 1 2578.6 2630.6  
## + location7:location9 1 2574.6 2630.6  
## + location1:location5 1 2574.7 2630.7  
## - location1:location9 1 2579.2 2631.2  
## + location3:location4 1 2575.2 2631.2  
## + location2:location7 1 2575.2 2631.2  
## - location3:location8 1 2579.3 2631.3  
## + location2:location3 1 2575.6 2631.6  
## - location5:location2 1 2579.7 2631.7  
## + location2:location4 1 2575.7 2631.7  
## + location1:location8 1 2575.8 2631.8  
## + location1:location7 1 2575.8 2631.8  
## + location8:location9 1 2575.9 2631.9  
## + location4:location7 1 2576.2 2632.2  
## + location3:location6 1 2576.2 2632.2  
## + location4:location8 1 2576.3 2632.3  
## - location6:location2 1 2580.3 2632.3  
## + location4:location9 1 2576.3 2632.3  
## - location7:location8 1 2580.4 2632.4  
## + location9:location10 1 2576.4 2632.4  
## - location5:location9 1 2580.4 2632.4  
## + location2:location9 1 2576.4 2632.4  
## - location2:location1 1 2580.4 2632.4  
## + location6:location8 1 2576.6 2632.6  
## + location1:location6 1 2576.6 2632.6  
## + location2:location8 1 2576.6 2632.6  
## - location6:location4 1 2580.7 2632.7  
## - location5:location4 1 2580.8 2632.8  
## - location6:location9 1 2581.7 2633.7  
## - location6:location7 1 2582.1 2634.1  
## - location10:location1 1 2583.1 2635.1  
## - location7:location3 1 2583.2 2635.2  
## - location10:location7 1 2584.2 2636.2  
## - location3:location1 1 2584.3 2636.3  
## - location5:location8 1 2585.7 2637.7  
## - location4:location1 1 2585.9 2637.9  
## - location10:location2 1 2586.0 2638.0  
## - location5:location3 1 2586.2 2638.2  
## - location10:location4 1 2586.3 2638.3  
## - location10:location6 1 2588.0 2640.0  
## - location10:location3 1 2589.0 2641.0  
## - location5:location7 1 2589.7 2641.7  
## - location5:location6 1 2592.5 2644.5  
## - location5:location10 1 2730.3 2782.3  
##   
## Step: AIC=2628.84  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location1:location9 +   
## location2:location1 + location5:location2 + location5:location8 +   
## location7:location8 + location3:location8 + location10:location8  
##   
## Df Deviance AIC  
## - location3:location9 1 2574.7 2628.7  
## + location1:location5 1 2570.7 2628.7  
## + location7:location9 1 2570.8 2628.8  
## <none> 2572.8 2628.8  
## + location8:location9 1 2571.0 2629.0  
## + location1:location8 1 2571.1 2629.1  
## - location1:location9 1 2575.3 2629.3  
## + location2:location7 1 2571.6 2629.6  
## + location3:location4 1 2571.7 2629.7  
## + location2:location4 1 2572.0 2630.0  
## + location2:location3 1 2572.0 2630.0  
## - location5:location2 1 2576.1 2630.1  
## + location1:location7 1 2572.2 2630.2  
## - location6:location2 1 2576.5 2630.5  
## + location6:location8 1 2572.5 2630.5  
## + location3:location6 1 2572.5 2630.5  
## + location4:location7 1 2572.5 2630.5  
## - location6:location4 1 2576.6 2630.6  
## - location10:location8 1 2576.6 2630.6  
## - location2:location1 1 2576.6 2630.6  
## + location4:location9 1 2572.6 2630.6  
## + location2:location8 1 2572.7 2630.7  
## + location2:location9 1 2572.8 2630.8  
## + location9:location10 1 2572.8 2630.8  
## + location4:location8 1 2572.8 2630.8  
## + location1:location6 1 2572.8 2630.8  
## - location5:location9 1 2576.9 2630.9  
## - location5:location4 1 2577.4 2631.4  
## - location3:location8 1 2577.6 2631.6  
## - location5:location8 1 2578.0 2632.0  
## - location6:location9 1 2578.1 2632.1  
## - location6:location7 1 2578.3 2632.3  
## - location7:location3 1 2578.5 2632.5  
## - location7:location8 1 2578.5 2632.5  
## - location10:location1 1 2579.0 2633.0  
## - location10:location7 1 2579.3 2633.3  
## - location3:location1 1 2580.3 2634.3  
## - location10:location4 1 2581.3 2635.3  
## - location10:location2 1 2581.6 2635.6  
## - location4:location1 1 2582.1 2636.1  
## - location5:location3 1 2583.7 2637.7  
## - location10:location6 1 2583.9 2637.9  
## - location10:location3 1 2583.9 2637.9  
## - location5:location7 1 2587.4 2641.4  
## - location5:location6 1 2589.1 2643.1  
## - location5:location10 1 2730.1 2784.1  
##   
## Step: AIC=2628.66  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location1 + location10:location1 + location5:location4 +   
## location6:location4 + location1:location9 + location2:location1 +   
## location5:location2 + location5:location8 + location7:location8 +   
## location3:location8 + location10:location8  
##   
## Df Deviance AIC  
## + location1:location5 1 2572.1 2628.1  
## + location8:location9 1 2572.4 2628.4  
## - location1:location9 1 2576.6 2628.6  
## <none> 2574.7 2628.7  
## + location3:location9 1 2572.8 2628.8  
## + location1:location8 1 2572.9 2628.9  
## + location7:location9 1 2573.3 2629.3  
## + location2:location7 1 2573.3 2629.3  
## + location3:location4 1 2573.4 2629.4  
## - location5:location9 1 2577.4 2629.4  
## + location2:location4 1 2573.7 2629.7  
## + location2:location3 1 2573.7 2629.7  
## - location5:location2 1 2578.0 2630.0  
## + location1:location7 1 2574.1 2630.1  
## + location3:location6 1 2574.2 2630.2  
## - location2:location1 1 2578.3 2630.3  
## + location4:location9 1 2574.3 2630.3  
## + location6:location8 1 2574.3 2630.3  
## + location4:location7 1 2574.3 2630.3  
## - location6:location2 1 2578.4 2630.4  
## - location6:location4 1 2578.5 2630.5  
## + location2:location8 1 2574.5 2630.5  
## - location10:location8 1 2578.6 2630.6  
## + location9:location10 1 2574.6 2630.6  
## + location2:location9 1 2574.6 2630.6  
## + location4:location8 1 2574.7 2630.7  
## + location1:location6 1 2574.7 2630.7  
## - location5:location4 1 2579.4 2631.4  
## - location3:location8 1 2580.1 2632.1  
## - location6:location7 1 2580.3 2632.3  
## - location5:location8 1 2580.6 2632.6  
## - location7:location3 1 2580.6 2632.6  
## - location7:location8 1 2580.8 2632.8  
## - location10:location7 1 2581.1 2633.1  
## - location10:location1 1 2581.4 2633.4  
## - location6:location9 1 2581.8 2633.8  
## - location3:location1 1 2582.3 2634.3  
## - location10:location4 1 2583.0 2635.0  
## - location10:location2 1 2583.4 2635.4  
## - location4:location1 1 2583.6 2635.6  
## - location5:location3 1 2584.0 2636.0  
## - location10:location3 1 2584.0 2636.0  
## - location10:location6 1 2586.3 2638.3  
## - location5:location7 1 2590.3 2642.3  
## - location5:location6 1 2592.8 2644.8  
## - location5:location10 1 2730.1 2782.1  
##   
## Step: AIC=2628.09  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location1 + location10:location1 + location5:location4 +   
## location6:location4 + location1:location9 + location2:location1 +   
## location5:location2 + location5:location8 + location7:location8 +   
## location3:location8 + location10:location8 + location5:location1  
##   
## Df Deviance AIC  
## - location1:location9 1 2573.1 2627.1  
## + location1:location8 1 2569.8 2627.8  
## + location8:location9 1 2570.1 2628.1  
## <none> 2572.1 2628.1  
## + location7:location9 1 2570.5 2628.5  
## - location5:location1 1 2574.7 2628.7  
## + location3:location9 1 2570.7 2628.7  
## + location2:location7 1 2570.8 2628.8  
## - location5:location9 1 2574.9 2628.9  
## + location1:location7 1 2570.9 2628.9  
## + location3:location4 1 2571.0 2629.0  
## - location5:location2 1 2575.0 2629.0  
## + location2:location4 1 2571.2 2629.2  
## + location2:location3 1 2571.4 2629.4  
## - location6:location2 1 2575.5 2629.5  
## - location6:location4 1 2575.7 2629.7  
## + location3:location6 1 2571.8 2629.8  
## + location6:location8 1 2571.8 2629.8  
## + location4:location7 1 2571.8 2629.8  
## + location4:location9 1 2571.8 2629.8  
## + location1:location6 1 2571.9 2629.9  
## + location2:location8 1 2572.0 2630.0  
## + location2:location9 1 2572.0 2630.0  
## + location4:location8 1 2572.1 2630.1  
## + location9:location10 1 2572.1 2630.1  
## - location10:location8 1 2576.2 2630.2  
## - location5:location4 1 2576.2 2630.2  
## - location2:location1 1 2577.2 2631.2  
## - location3:location8 1 2577.3 2631.3  
## - location6:location7 1 2577.5 2631.5  
## - location7:location3 1 2577.7 2631.7  
## - location5:location8 1 2578.0 2632.0  
## - location10:location1 1 2578.0 2632.0  
## - location7:location8 1 2578.4 2632.4  
## - location6:location9 1 2578.4 2632.4  
## - location10:location7 1 2578.6 2632.6  
## - location5:location3 1 2580.8 2634.8  
## - location10:location4 1 2581.6 2635.6  
## - location3:location1 1 2581.8 2635.8  
## - location10:location2 1 2582.1 2636.1  
## - location4:location1 1 2582.5 2636.5  
## - location10:location3 1 2583.1 2637.1  
## - location10:location6 1 2583.6 2637.6  
## - location5:location7 1 2586.8 2640.8  
## - location5:location6 1 2587.6 2641.6  
## - location5:location10 1 2729.0 2783.0  
##   
## Step: AIC=2627.06  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location1 + location10:location1 + location5:location4 +   
## location6:location4 + location2:location1 + location5:location2 +   
## location5:location8 + location7:location8 + location3:location8 +   
## location10:location8 + location5:location1  
##   
## Df Deviance AIC  
## + location1:location8 1 2571.0 2627.0  
## <none> 2573.1 2627.1  
## + location7:location9 1 2571.2 2627.2  
## + location8:location9 1 2571.4 2627.4  
## - location5:location2 1 2575.8 2627.8  
## + location2:location7 1 2571.9 2627.9  
## + location3:location4 1 2571.9 2627.9  
## + location1:location7 1 2572.1 2628.1  
## + location3:location9 1 2572.1 2628.1  
## + location1:location9 1 2572.1 2628.1  
## + location2:location4 1 2572.2 2628.2  
## - location6:location2 1 2576.4 2628.4  
## + location2:location3 1 2572.4 2628.4  
## - location6:location4 1 2576.5 2628.5  
## - location5:location1 1 2576.6 2628.6  
## + location3:location6 1 2572.7 2628.7  
## + location6:location8 1 2572.8 2628.8  
## + location4:location7 1 2572.8 2628.8  
## + location1:location6 1 2572.9 2628.9  
## + location4:location9 1 2572.9 2628.9  
## - location5:location4 1 2577.0 2629.0  
## + location2:location8 1 2573.0 2629.0  
## + location2:location9 1 2573.0 2629.0  
## + location9:location10 1 2573.0 2629.0  
## + location4:location8 1 2573.0 2629.0  
## - location10:location8 1 2577.3 2629.3  
## - location3:location8 1 2578.2 2630.2  
## - location2:location1 1 2578.2 2630.2  
## - location6:location7 1 2578.4 2630.4  
## - location5:location9 1 2578.4 2630.4  
## - location7:location3 1 2578.7 2630.7  
## - location6:location9 1 2578.7 2630.7  
## - location5:location8 1 2578.8 2630.8  
## - location7:location8 1 2579.5 2631.5  
## - location10:location7 1 2579.6 2631.6  
## - location5:location3 1 2581.3 2633.3  
## - location10:location1 1 2581.6 2633.6  
## - location3:location1 1 2582.2 2634.2  
## - location10:location4 1 2582.4 2634.4  
## - location10:location2 1 2582.9 2634.9  
## - location4:location1 1 2583.0 2635.0  
## - location10:location3 1 2583.9 2635.9  
## - location10:location6 1 2584.2 2636.2  
## - location5:location7 1 2587.7 2639.7  
## - location5:location6 1 2587.8 2639.8  
## - location5:location10 1 2734.2 2786.2  
##   
## Step: AIC=2627.02  
## class ~ location5:location10 + location5:location6 + location10:location2 +   
## location5:location7 + location6:location7 + location10:location3 +   
## location7:location3 + location10:location7 + location10:location4 +   
## location4:location1 + location5:location3 + location6:location2 +   
## location10:location6 + location5:location9 + location6:location9 +   
## location3:location1 + location10:location1 + location5:location4 +   
## location6:location4 + location2:location1 + location5:location2 +   
## location5:location8 + location7:location8 + location3:location8 +   
## location10:location8 + location5:location1 + location1:location8  
##   
## Df Deviance AIC  
## <none> 2571.0 2627.0  
## - location1:location8 1 2573.1 2627.1  
## + location7:location9 1 2569.2 2627.2  
## + location8:location9 1 2569.7 2627.7  
## + location1:location9 1 2569.8 2627.8  
## - location5:location2 1 2573.8 2627.8  
## + location2:location7 1 2569.9 2627.9  
## + location3:location4 1 2569.9 2627.9  
## + location3:location9 1 2570.1 2628.1  
## + location2:location4 1 2570.1 2628.1  
## - location6:location2 1 2574.2 2628.2  
## + location1:location7 1 2570.4 2628.4  
## + location2:location3 1 2570.4 2628.4  
## - location6:location4 1 2574.4 2628.4  
## + location3:location6 1 2570.7 2628.7  
## - location5:location4 1 2574.8 2628.8  
## + location4:location7 1 2570.8 2628.8  
## + location6:location8 1 2570.9 2628.9  
## + location4:location8 1 2570.9 2628.9  
## + location2:location9 1 2570.9 2628.9  
## + location4:location9 1 2570.9 2628.9  
## + location1:location6 1 2571.0 2629.0  
## + location9:location10 1 2571.0 2629.0  
## + location2:location8 1 2571.0 2629.0  
## - location5:location1 1 2575.3 2629.3  
## - location3:location8 1 2575.5 2629.5  
## - location6:location7 1 2576.1 2630.1  
## - location2:location1 1 2576.1 2630.1  
## - location5:location9 1 2576.3 2630.3  
## - location10:location8 1 2576.5 2630.5  
## - location6:location9 1 2576.5 2630.5  
## - location7:location8 1 2576.7 2630.7  
## - location7:location3 1 2576.8 2630.8  
## - location10:location7 1 2577.3 2631.3  
## - location5:location8 1 2578.0 2632.0  
## - location5:location3 1 2578.9 2632.9  
## - location3:location1 1 2579.4 2633.4  
## - location10:location4 1 2580.4 2634.4  
## - location10:location1 1 2580.9 2634.9  
## - location10:location2 1 2580.9 2634.9  
## - location4:location1 1 2581.0 2635.0  
## - location10:location3 1 2581.4 2635.4  
## - location10:location6 1 2581.9 2635.9  
## - location5:location6 1 2585.2 2639.2  
## - location5:location7 1 2585.5 2639.5  
## - location5:location10 1 2734.1 2788.1

summary(fit2\_step)

##   
## Call:  
## glm(formula = class ~ location5:location10 + location5:location6 +   
## location10:location2 + location5:location7 + location6:location7 +   
## location10:location3 + location7:location3 + location10:location7 +   
## location10:location4 + location4:location1 + location5:location3 +   
## location6:location2 + location10:location6 + location5:location9 +   
## location6:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location2:location1 +   
## location5:location2 + location5:location8 + location7:location8 +   
## location3:location8 + location10:location8 + location5:location1 +   
## location1:location8, family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.1148 -1.1402 0.6485 1.1090 2.0360   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.18761 0.09701 -1.934 0.053132 .   
## location5:location10 -1.04141 0.08893 -11.711 < 2e-16 \*\*\*  
## location5:location6 0.29791 0.08033 3.709 0.000208 \*\*\*  
## location10:location2 0.29183 0.09438 3.092 0.001988 \*\*   
## location5:location7 0.36182 0.09710 3.726 0.000194 \*\*\*  
## location6:location7 -0.23835 0.10611 -2.246 0.024684 \*   
## location10:location3 0.24323 0.07637 3.185 0.001448 \*\*   
## location7:location3 -0.24815 0.10340 -2.400 0.016404 \*   
## location10:location7 0.23278 0.09388 2.480 0.013156 \*   
## location10:location4 0.30304 0.10079 3.007 0.002641 \*\*   
## location4:location1 -0.39888 0.12754 -3.127 0.001764 \*\*   
## location5:location3 0.21049 0.07566 2.782 0.005401 \*\*   
## location6:location2 -0.19079 0.10619 -1.797 0.072393 .   
## location10:location6 0.27050 0.08307 3.256 0.001129 \*\*   
## location5:location9 0.17236 0.07544 2.285 0.022334 \*   
## location6:location9 -0.20730 0.08863 -2.339 0.019344 \*   
## location3:location1 -0.28202 0.09772 -2.886 0.003903 \*\*   
## location10:location1 0.27551 0.08903 3.094 0.001972 \*\*   
## location5:location4 0.19602 0.10141 1.933 0.053246 .   
## location6:location4 -0.21352 0.11581 -1.844 0.065222 .   
## location2:location1 -0.25964 0.11509 -2.256 0.024077 \*   
## location5:location2 0.15425 0.09300 1.659 0.097198 .   
## location5:location8 0.29495 0.11320 2.606 0.009173 \*\*   
## location7:location8 -0.34086 0.14444 -2.360 0.018277 \*   
## location3:location8 -0.26349 0.12519 -2.105 0.035317 \*   
## location10:location8 0.26872 0.11579 2.321 0.020304 \*   
## location5:location1 0.17537 0.08499 2.063 0.039076 \*   
## location1:location8 -0.19740 0.13873 -1.423 0.154757   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2571.0 on 1972 degrees of freedom  
## AIC: 2627  
##   
## Number of Fisher Scoring iterations: 4

# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2571.0 on 1972 degrees of freedom  
# AIC: 2627  
  
# significant interactions are: location5:location10 + location5:location6 +   
# location10:location2 + location5:location7 + location6:location7 +   
# location10:location3 + location7:location3 + location10:location7 +   
# location10:location4 + location4:location1 + location5:location3 +   
# location6:location2 + location10:location6 + location5:location9 +   
# location6:location9 + location3:location1 + location10:location1 +   
# location5:location4 + location6:location4 + location2:location1 +   
# location5:location2 + location5:location8 + location7:location8 +   
# location3:location8 + location10:location8 + location5:location1 +   
# location1:location8  
  
# removing location1:location8 from fit2\_step  
fit2\_final <- glm(class ~ location5:location10 + location5:location6 + location10:location2 + location5:location7 +   
 location6:location7 + location10:location3 + location7:location3 + location10:location7 +   
 location10:location4 + location4:location1 + location5:location3 +   
 location6:location2 + location10:location6 + location5:location9 +   
 location6:location9 + location3:location1 + location10:location1 +   
 location5:location4 + location6:location4 + location2:location1 +   
 location5:location2 + location5:location8 + location7:location8 +   
 location3:location8 + location10:location8 + location5:location1, family = binomial(), data=snp)  
summary(fit2\_final)

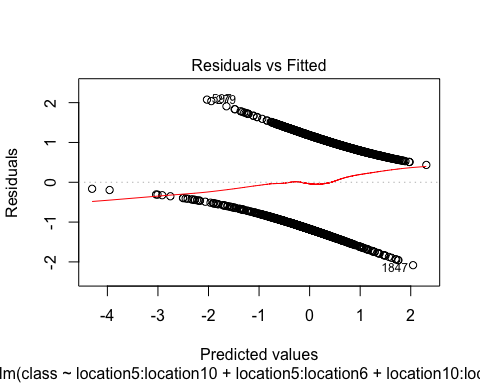
##   
## Call:  
## glm(formula = class ~ location5:location10 + location5:location6 +   
## location10:location2 + location5:location7 + location6:location7 +   
## location10:location3 + location7:location3 + location10:location7 +   
## location10:location4 + location4:location1 + location5:location3 +   
## location6:location2 + location10:location6 + location5:location9 +   
## location6:location9 + location3:location1 + location10:location1 +   
## location5:location4 + location6:location4 + location2:location1 +   
## location5:location2 + location5:location8 + location7:location8 +   
## location3:location8 + location10:location8 + location5:location1,   
## family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.082 -1.137 0.654 1.107 2.075   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.18408 0.09688 -1.900 0.057412 .   
## location5:location10 -1.02959 0.08834 -11.655 < 2e-16 \*\*\*  
## location5:location6 0.30256 0.08016 3.774 0.000160 \*\*\*  
## location10:location2 0.29073 0.09417 3.087 0.002020 \*\*   
## location5:location7 0.36343 0.09697 3.748 0.000178 \*\*\*  
## location6:location7 -0.24443 0.10617 -2.302 0.021314 \*   
## location10:location3 0.24778 0.07626 3.249 0.001157 \*\*   
## location7:location3 -0.24517 0.10353 -2.368 0.017877 \*   
## location10:location7 0.23726 0.09378 2.530 0.011404 \*   
## location10:location4 0.30214 0.10075 2.999 0.002709 \*\*   
## location4:location1 -0.39797 0.12744 -3.123 0.001792 \*\*   
## location5:location3 0.21491 0.07558 2.843 0.004464 \*\*   
## location6:location2 -0.19331 0.10614 -1.821 0.068566 .   
## location10:location6 0.27358 0.08295 3.298 0.000973 \*\*\*  
## location5:location9 0.17326 0.07538 2.298 0.021541 \*   
## location6:location9 -0.20992 0.08859 -2.370 0.017811 \*   
## location3:location1 -0.29339 0.09737 -3.013 0.002586 \*\*   
## location10:location1 0.25231 0.08725 2.892 0.003830 \*\*   
## location5:location4 0.19847 0.10120 1.961 0.049864 \*   
## location6:location4 -0.21543 0.11567 -1.862 0.062548 .   
## location2:location1 -0.26030 0.11492 -2.265 0.023513 \*   
## location5:location2 0.15370 0.09283 1.656 0.097771 .   
## location5:location8 0.25912 0.10975 2.361 0.018230 \*   
## location7:location8 -0.36275 0.14387 -2.521 0.011689 \*   
## location3:location8 -0.27982 0.12432 -2.251 0.024394 \*   
## location10:location8 0.23130 0.11246 2.057 0.039705 \*   
## location5:location1 0.15648 0.08378 1.868 0.061781 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2573.1 on 1973 degrees of freedom  
## AIC: 2627.1  
##   
## Number of Fisher Scoring iterations: 4

# shows many interactions that are significant  
#### AIC: 2627.1 ####  
pR2(fit2\_final)

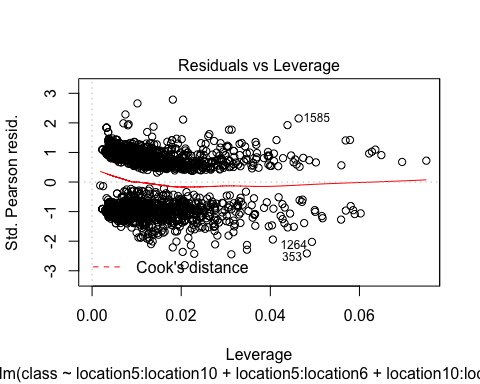
## fitting null model for pseudo-r2

## llh llhNull G2 McFadden r2ML   
## -1.286530e+03 -1.383793e+03 1.945272e+02 7.028765e-02 9.268318e-02   
## r2CU   
## 1.236808e-01

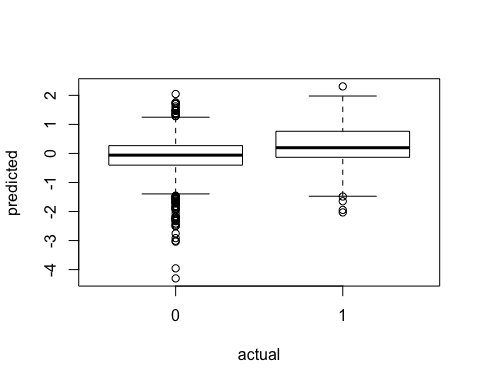
# llh llhNull G2 McFadden r2ML r2CU   
# -1.286530e+03 -1.383793e+03 1.945272e+02 7.028765e-02 9.268318e-02 1.236808e-01   
plot(fit2\_final, 1)



plot(fit2\_final, 5)



# the residual plots signifies that this model is not a very good fit  
# the values are not randomly distributed above and below the regression line  
plot(x=snp$class,y=predict(fit2\_final),xlab="actual",ylab="predicted")



# the predicted values for having the disease (class=1) has a median higher than the values with no disease (class=0)  
  
###############################################################################################################  
# full model - main effects and 2nd order interactions model  
fit3\_full <- glm(class ~ (.)^2, family = binomial(), data=snp)  
summary(fit3\_full)

##   
## Call:  
## glm(formula = class ~ (.)^2, family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.7341 -1.0703 0.5069 1.1460 1.9299   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -2.650101 0.504868 -5.249 1.53e-07 \*\*\*  
## location1 0.354890 0.312491 1.136 0.25609   
## location2 -0.190857 0.334002 -0.571 0.56771   
## location3 -0.330001 0.285080 -1.158 0.24704   
## location4 -0.598224 0.360415 -1.660 0.09695 .   
## location5 2.249374 0.276188 8.144 3.81e-16 \*\*\*  
## location6 0.236069 0.287381 0.821 0.41139   
## location7 -0.208504 0.328424 -0.635 0.52552   
## location8 0.433403 0.371928 1.165 0.24390   
## location9 0.426223 0.309794 1.376 0.16888   
## location10 1.980210 0.284956 6.949 3.67e-12 \*\*\*  
## location1:location2 -0.097118 0.128635 -0.755 0.45025   
## location1:location3 -0.132524 0.112327 -1.180 0.23808   
## location1:location4 -0.261894 0.141750 -1.848 0.06466 .   
## location1:location5 -0.288277 0.141524 -2.037 0.04166 \*   
## location1:location6 0.095061 0.115898 0.820 0.41209   
## location1:location7 0.016941 0.124276 0.136 0.89157   
## location1:location8 -0.128526 0.155067 -0.829 0.40720   
## location1:location9 0.166384 0.115013 1.447 0.14800   
## location1:location10 -0.083393 0.144259 -0.578 0.56321   
## location2:location3 0.123270 0.116728 1.056 0.29095   
## location2:location4 0.046130 0.150465 0.307 0.75916   
## location2:location5 -0.077150 0.157108 -0.491 0.62338   
## location2:location6 -0.032992 0.120598 -0.274 0.78442   
## location2:location7 0.027161 0.135014 0.201 0.84057   
## location2:location8 0.134132 0.169654 0.791 0.42917   
## location2:location9 0.124363 0.120901 1.029 0.30365   
## location2:location10 0.187279 0.157828 1.187 0.23539   
## location3:location4 0.169506 0.130062 1.303 0.19248   
## location3:location5 0.071234 0.129013 0.552 0.58085   
## location3:location6 0.157566 0.109740 1.436 0.15106   
## location3:location7 -0.026711 0.119482 -0.224 0.82310   
## location3:location8 -0.113248 0.142764 -0.793 0.42763   
## location3:location9 0.007304 0.106685 0.068 0.94542   
## location3:location10 0.155822 0.132247 1.178 0.23869   
## location4:location5 0.144528 0.155682 0.928 0.35322   
## location4:location6 0.008585 0.133414 0.064 0.94869   
## location4:location7 0.167469 0.148271 1.129 0.25870   
## location4:location8 0.235416 0.167861 1.402 0.16078   
## location4:location9 0.047560 0.134673 0.353 0.72398   
## location4:location10 0.279616 0.166845 1.676 0.09376 .   
## location5:location6 -0.091715 0.136017 -0.674 0.50013   
## location5:location7 0.160963 0.151375 1.063 0.28763   
## location5:location8 -0.117300 0.182394 -0.643 0.52015   
## location5:location9 -0.200568 0.138213 -1.451 0.14674   
## location5:location10 -1.695804 0.119727 -14.164 < 2e-16 \*\*\*  
## location6:location7 -0.125333 0.119233 -1.051 0.29319   
## location6:location8 0.094965 0.147937 0.642 0.52092   
## location6:location9 -0.161740 0.110467 -1.464 0.14315   
## location6:location10 -0.046501 0.135936 -0.342 0.73229   
## location7:location8 -0.272568 0.156271 -1.744 0.08113 .   
## location7:location9 0.256830 0.120360 2.134 0.03285 \*   
## location7:location10 0.074409 0.152735 0.487 0.62613   
## location8:location9 -0.139549 0.144964 -0.963 0.33573   
## location8:location10 -0.099226 0.172026 -0.577 0.56407   
## location9:location10 -0.383739 0.143595 -2.672 0.00753 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2431.2 on 1944 degrees of freedom  
## AIC: 2543.2  
##   
## Number of Fisher Scoring iterations: 4

# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2431.2 on 1944 degrees of freedom  
# AIC: 2543.2  
# significant variables: location4, 5,10   
# significant interactions: location1:location4, location1:location5, location4:location10, location5:location10,  
# location7:location8, location7:location9, location9:location10  
  
fit3\_step = step(fit\_null, scope=list(lower=fit\_null, upper=fit3\_full),direction="both")

## Start: AIC=2769.59  
## class ~ 1  
##   
## Df Deviance AIC  
## + location5 1 2759.1 2763.1  
## + location1 1 2765.4 2769.4  
## <none> 2767.6 2769.6  
## + location6 1 2765.9 2769.9  
## + location2 1 2766.2 2770.2  
## + location10 1 2766.5 2770.5  
## + location7 1 2767.4 2771.4  
## + location3 1 2767.6 2771.6  
## + location8 1 2767.6 2771.6  
## + location9 1 2767.6 2771.6  
## + location4 1 2767.6 2771.6  
##   
## Step: AIC=2763.09  
## class ~ location5  
##   
## Df Deviance AIC  
## + location10 1 2753.4 2759.4  
## + location1 1 2756.7 2762.7  
## <none> 2759.1 2763.1  
## + location6 1 2757.6 2763.6  
## + location2 1 2757.8 2763.8  
## + location7 1 2758.8 2764.8  
## + location3 1 2759.1 2765.1  
## + location4 1 2759.1 2765.1  
## + location8 1 2759.1 2765.1  
## + location9 1 2759.1 2765.1  
## - location5 1 2767.6 2769.6  
##   
## Step: AIC=2759.37  
## class ~ location5 + location10  
##   
## Df Deviance AIC  
## + location5:location10 1 2492.6 2500.6  
## + location1 1 2750.8 2758.8  
## <none> 2753.4 2759.4  
## + location6 1 2751.9 2759.9  
## + location2 1 2752.1 2760.1  
## + location7 1 2753.0 2761.0  
## + location3 1 2753.3 2761.3  
## + location9 1 2753.3 2761.3  
## + location8 1 2753.4 2761.4  
## + location4 1 2753.4 2761.4  
## - location10 1 2759.1 2763.1  
## - location5 1 2766.5 2770.5  
##   
## Step: AIC=2500.57  
## class ~ location5 + location10 + location5:location10  
##   
## Df Deviance AIC  
## + location6 1 2489.6 2499.6  
## + location1 1 2489.9 2499.9  
## <none> 2492.6 2500.6  
## + location7 1 2491.9 2501.9  
## + location2 1 2491.9 2501.9  
## + location8 1 2492.3 2502.3  
## + location4 1 2492.5 2502.5  
## + location9 1 2492.5 2502.5  
## + location3 1 2492.5 2502.5  
## - location5:location10 1 2753.4 2759.4  
##   
## Step: AIC=2499.59  
## class ~ location5 + location10 + location6 + location5:location10  
##   
## Df Deviance AIC  
## + location1 1 2486.9 2498.9  
## <none> 2489.6 2499.6  
## - location6 1 2492.6 2500.6  
## + location7 1 2488.8 2500.8  
## + location2 1 2489.0 2501.0  
## + location8 1 2489.2 2501.2  
## + location5:location6 1 2489.4 2501.4  
## + location6:location10 1 2489.4 2501.4  
## + location9 1 2489.5 2501.5  
## + location4 1 2489.5 2501.5  
## + location3 1 2489.5 2501.5  
## - location5:location10 1 2751.9 2759.9  
##   
## Step: AIC=2498.92  
## class ~ location5 + location10 + location6 + location1 + location5:location10  
##   
## Df Deviance AIC  
## + location1:location5 1 2482.4 2496.4  
## <none> 2486.9 2498.9  
## - location1 1 2489.6 2499.6  
## - location6 1 2489.9 2499.9  
## + location7 1 2486.1 2500.1  
## + location2 1 2486.3 2500.3  
## + location1:location6 1 2486.6 2500.6  
## + location8 1 2486.6 2500.6  
## + location1:location10 1 2486.7 2500.7  
## + location6:location10 1 2486.8 2500.8  
## + location5:location6 1 2486.8 2500.8  
## + location9 1 2486.8 2500.8  
## + location4 1 2486.8 2500.8  
## + location3 1 2486.9 2500.9  
## - location5:location10 1 2749.3 2759.3  
##   
## Step: AIC=2496.4  
## class ~ location5 + location10 + location6 + location1 + location5:location10 +   
## location5:location1  
##   
## Df Deviance AIC  
## <none> 2482.4 2496.4  
## + location7 1 2481.5 2497.5  
## - location6 1 2485.5 2497.5  
## + location2 1 2481.8 2497.8  
## + location1:location6 1 2482.0 2498.0  
## + location8 1 2482.2 2498.2  
## + location5:location6 1 2482.2 2498.2  
## + location1:location10 1 2482.3 2498.3  
## + location9 1 2482.3 2498.3  
## + location6:location10 1 2482.3 2498.3  
## + location4 1 2482.3 2498.3  
## + location3 1 2482.4 2498.4  
## - location5:location1 1 2486.9 2498.9  
## - location5:location10 1 2744.9 2756.9

summary(fit3\_step)

##   
## Call:  
## glm(formula = class ~ location5 + location10 + location6 + location1 +   
## location5:location10 + location5:location1, family = binomial(),   
## data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.0358 -1.0960 0.5501 1.1939 1.8275   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -2.53025 0.23743 -10.657 <2e-16 \*\*\*  
## location5 2.10805 0.17187 12.266 <2e-16 \*\*\*  
## location10 1.89843 0.15191 12.497 <2e-16 \*\*\*  
## location6 0.12589 0.07117 1.769 0.0769 .   
## location1 0.15577 0.15058 1.034 0.3009   
## location5:location10 -1.64075 0.11515 -14.248 <2e-16 \*\*\*  
## location5:location1 -0.26838 0.12666 -2.119 0.0341 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2482.4 on 1993 degrees of freedom  
## AIC: 2496.4  
##   
## Number of Fisher Scoring iterations: 4

# significant variables are : location5, location10, location6, location1, location5:location10, location5:location1  
# Null deviance: 2767.6 on 1999 degrees of freedom  
# Residual deviance: 2482.4 on 1993 degrees of freedom  
# AIC: 2496.4  
  
# removing location1 from fit3\_step  
fit3\_final <- glm(class ~ location5 + location10 + location6 + location5:location10 + location5:location1,   
 family = binomial(), data=snp)  
summary(fit3\_final)

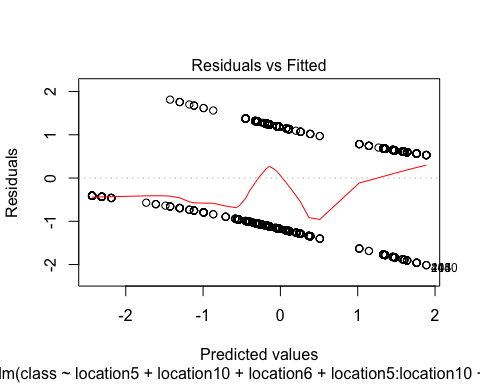
##   
## Call:  
## glm(formula = class ~ location5 + location10 + location6 + location5:location10 +   
## location5:location1, family = binomial(), data = snp)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.0141 -1.0802 0.5627 1.1841 1.8119   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -2.43541 0.21726 -11.210 <2e-16 \*\*\*  
## location5 2.03695 0.15577 13.077 <2e-16 \*\*\*  
## location10 1.89472 0.15151 12.506 <2e-16 \*\*\*  
## location6 0.12433 0.07112 1.748 0.0804 .   
## location5:location10 -1.63631 0.11473 -14.262 <2e-16 \*\*\*  
## location5:location1 -0.15451 0.06249 -2.473 0.0134 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 2767.6 on 1999 degrees of freedom  
## Residual deviance: 2483.5 on 1994 degrees of freedom  
## AIC: 2495.5  
##   
## Number of Fisher Scoring iterations: 3

# significant variables are location5, location10, location6, location5:location10, location5:location1  
#### AIC: 2495.5 ####  
pR2(fit3\_final)

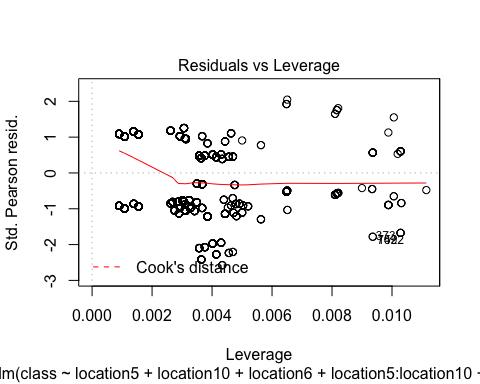
## fitting null model for pseudo-r2

## llh llhNull G2 McFadden r2ML   
## -1241.7350827 -1383.7933184 284.1164715 0.1026586 0.1324293   
## r2CU   
## 0.1767199

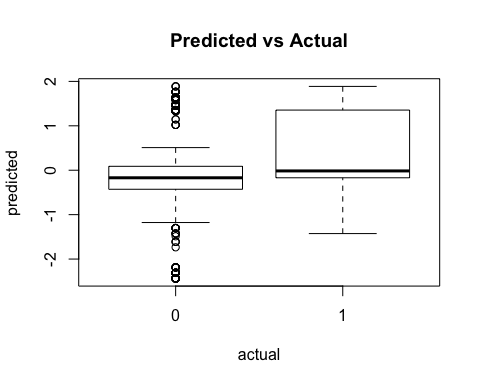
# llh llhNull G2 McFadden r2ML r2CU   
# -1241.7350827 -1383.7933184 284.1164715 0.1026586 0.1324293 0.1767199   
plot(fit3\_final, 1)



plot(fit3\_final, 5)



# the residual vs leverage plot shows a good fit of the model  
# the regression line is close to the fit line and the values are distributed randomly above & below the fit line  
plot(x=snp$class,y=predict(fit3\_final),xlab="actual",ylab="predicted", main="Predicted vs Actual")



# this plot shows that the median for having the disease(actual=1) is higher than not having the disease(actual=0)  
# the inter-quartile range (IQR) for no disease vs disease is also very different  
# IQR for not having the disease is much lower than IQR for having the disease  
  
# interpreting the coefficients:  
# class = 2.03695\*location5 + 1.89472\*location10 + 0.12433\*location6 - 1.63631\*location5:location10 - 0.15451\*location5:location1 - 2.43541  
# For every 1 allele increase in location5, the log odds of having the disease  
# increases by 2.03695 on average, when all other variables in the model are held constant  
# For every 1 allele increase in location10, the log odds of having the disease  
# increases by 1.89472 on average, when all other variables in the model are held constant  
# For every 1 allele increase in location6, the log odds of having the disease  
# increases by 0.12433 on average, when all other variables in the model are held constant  
# For every 1 unit increase in the product of location5 & location10, the log odds of having the disease  
# decreases by 1.63631 on average, when all other variables in the model are held constant  
# For every 1 unit increase in the product of location5 & location1, the log odds of having the disease  
# decreases by 0.15451 on average, when all other variables in the model are held constant  
exp(fit3\_final$coef)

## (Intercept) location5 location10   
## 0.08756214 7.66719979 6.65070378   
## location6 location5:location10 location5:location1   
## 1.13239421 0.19469705 0.85683469

# For every one allele increase in location5 the odds of having the disease is  
# multiplied by 7.66719979 on average,  
# when all other variables in the model are held constant  
# For every one allele increase in location10 the odds of having the disease is  
# multiplied by 6.65070378 on average,  
# when all other variables in the model are held constant  
# For every one allele increase in location6 the odds of having the disease is  
# multiplied by 1.13239421 on average,  
# when all other variables in the model are held constant  
# For every one allele increase in the product of location5 and location10, the odds of having the disease is  
# multiplied by 0.19469705 on average,  
# when all other variables in the model are held constant  
# For every one allele increase in the product of location5 and location1, the odds of having the disease is  
# multiplied by 0.85683469 on average,  
# when all other variables in the model are held constant  
  
###############################################################################################################  
# final best model:  
# fit3\_final (final full model with main effects and 2nd order interactions model) is the best model among the three above   
# it has the lowest AIC among all three models above (fit1\_final, fit2\_final and fit3\_final)  
# fit3\_final also has few variables in the model and are all significant  
# it's Mcfadden's R2 value is also the highest (0.1026586) among the three models  
# the residuals vs leverage plot also indicates a good fit model