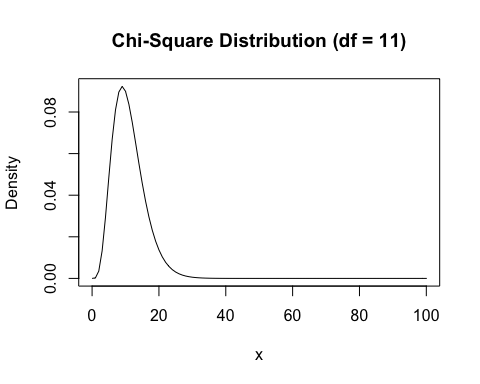
statistics

## Working with data in R environment

### a: consider Chi-Square distribution

#### i: The density function of it is shown below:

curve(dchisq(x, df = 11), from = 0, to = 100,  
 main = 'Chi-Square Distribution (df = 11)', #title  
 ylab = 'Density')



#### ii: Let’s produce n = 10, 100 and 1000 samples of size 50 from this distribution. To do so, we generate n \* 50 samples and store them in a matrix with n rows and 50 columns.

##### for n = 10:

samples\_1 = rchisq(500, df = 11)  
matrix\_1 = matrix(samples\_1, nrow = 10, ncol = 50)

##### for n = 100:

samples\_2 = rchisq(5000, df = 11)  
matrix\_2 = matrix(samples\_2, nrow = 100, ncol = 50)

##### for n = 1000:

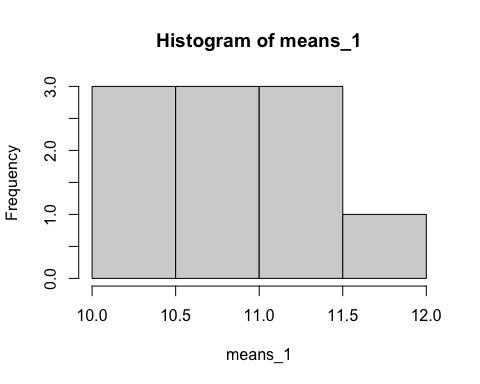
samples\_3 = rchisq(50000, df = 11)  
matrix\_3 = matrix(samples\_3, nrow = 1000, ncol = 50)

##### Then calculate the means of each of them and plot their histograms (note that we should calculate the sample means of each row):

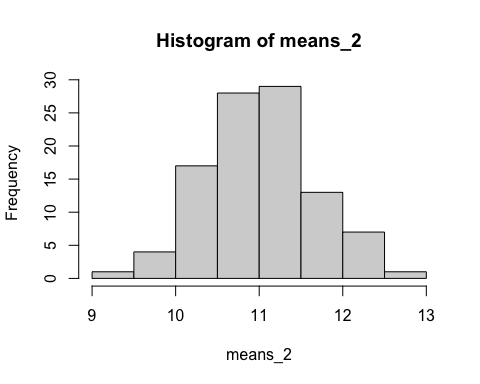
means\_1 = apply(matrix\_1, 1, mean) # use 1 to apply it row wise  
means\_2 = apply(matrix\_2, 1, mean)  
means\_3 = apply(matrix\_3, 1, mean)

##### plot the histograms with hist function

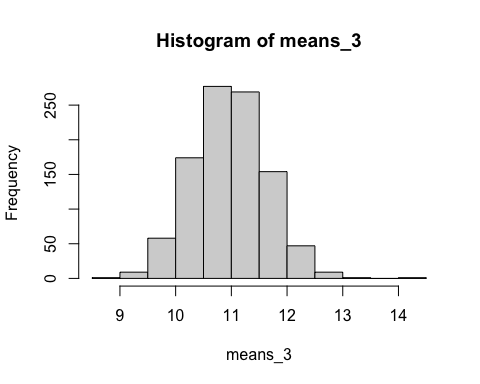
hist(means\_1)



hist(means\_2)



hist(means\_3)



#### iii: Let’s calculate the mean and variance of these samples and compare the histogram of their means with the normal distribution:

mean\_1 = mean(means\_1)  
mean\_2 = mean(means\_2)  
mean\_3 = mean(means\_3)  
mean\_1

## [1] 10.95602

mean\_2

## [1] 10.96297

mean\_3

## [1] 10.9729

var\_1 = var(means\_1)  
var\_2 = var(means\_2)  
var\_3 = var(means\_3)  
var\_1

## [1] 0.2468927

var\_2

## [1] 0.4250179

var\_3

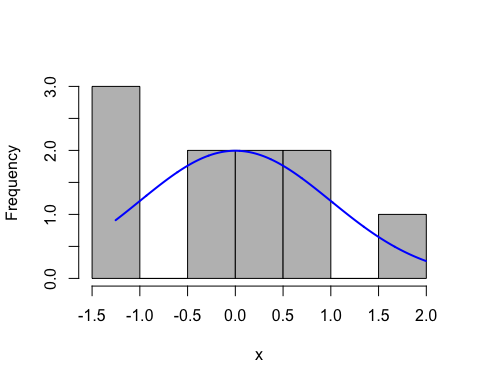
## [1] 0.4379258

##### Next, normalize the means:

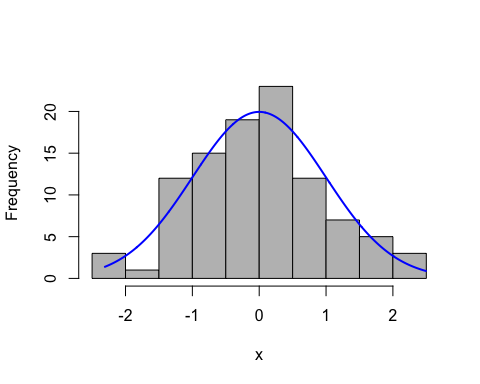
normalized\_mean\_1 = (means\_1 - mean\_1)/sqrt(var\_1)  
normalized\_mean\_2 = (means\_2 - mean\_2)/sqrt(var\_2)  
normalized\_mean\_3 = (means\_3 - mean\_3)/sqrt(var\_3)

##### comapre their histogram with the normal dirtribution’s hist:

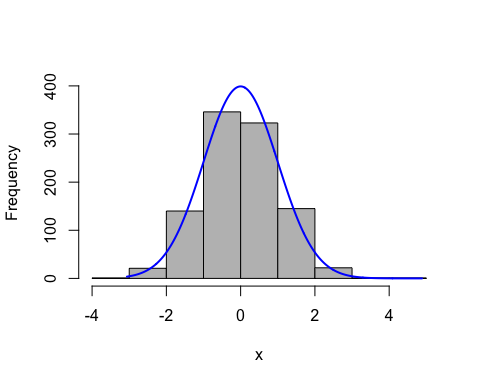
#hist(normalized\_mean\_1)  
#lines(seq(-2, 1.5, by=.001), dnorm(seq(-2, 1.5, by=.001), mean\_1, sqrt(var\_1)), col="blue")  
#hist(normalized\_mean\_2)  
#lines(seq(-3, 2.5, by=.1), dnorm(seq(-3, 2.5, by=.1), mean\_2, sqrt(var\_2)), col="blue")  
#hist(normalized\_mean\_3)  
#lines(seq(-4, 4, by=.1), dnorm(seq(-4, 4, by=.1), mean\_3, sqrt(var\_3)), col="blue")  
plotNormalHistogram( normalized\_mean\_1, prob = FALSE, length = 1000 )



plotNormalHistogram( normalized\_mean\_2, prob = FALSE, length = 1000 )



plotNormalHistogram( normalized\_mean\_3, prob = FALSE, length = 1000 )



##### we can see that as the n gets larger, the coresponding histogram gets more similar to the histogram of normal distribution. This results is algined with the central limit theorem which states that if you have a population with mean μ and standard deviation σ and take sufficiently large random samples from the population with replacement , then the distribution of the sample means will be approximately normally distributed.

### b: consider the Births data set from fastR2 package (contains inforamtion about the number of birth in each day during a time interval of 20 years in America)

#### i: Find the days with least and most number of average births:

##### first let’s view Births

View(Births)

##### we can see that it has a column births and data in it. We iterate over the days in those years, find the mean number of births and use which to indicate the place min/max occurs.

days\_avr <- matrix(0, 1, 365)  
for (i in 1:365) {  
 days\_avr[i] = mean(Births$births[Births$day\_of\_year == i])  
}  
  
which.min(days\_avr)

## [1] 360

which.max(days\_avr)

## [1] 260

#### the mean value of each month is obtained as follows:

months\_means <- matrix(0, 1, 12)  
for (i in 1:12) {  
 months\_means[i] = mean(Births$births[Births$month == i])  
}  
months\_means

## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9288.976 9491.301 9464.742 9267.958 9331 9597.618 10032.73 10177.04  
## [,9] [,10] [,11] [,12]  
## [1,] 10343.29 9766.729 9492.122 9523.187

##### also lets sort the array obove (ascending):

order(months\_means)

## [1] 4 1 5 3 2 11 12 6 10 7 8 9

##### to have it descending consider

order(-months\_means)

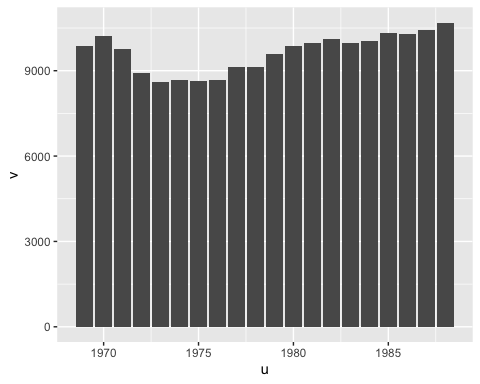
## [1] 9 8 7 10 6 12 11 2 3 5 1 4

#### also find the average value of each year this way:

years\_avr <- matrix(0, 1, 20)  
  
#colnames(years\_avr)=c('1969', '1970', '1971', '1972', '1973', '1974', '1975', '1976', '1977', '1978', '1979', '1980', '1981', '1982', '1983', '1984', '1985', '1986', '1987', '1988')  
for (i in 1:20) {  
 years\_avr[i] = mean(Births$births[Births$year == i + 1968])  
}  
years\_avr

## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 9859.118 10231.8 9761.847 8923.123 8618.274 8685.77 8639.359 8678.322  
## [,9] [,10] [,11] [,12] [,13] [,14] [,15] [,16]  
## [1,] 9128.899 9145.745 9588.321 9885.104 9960.219 10096.92 9980.085 10036.97  
## [,17] [,18] [,19] [,20]  
## [1,] 10315.22 10303.24 10447.15 10693.4

# plot the result  
ggplot(data=data.frame(u=1969:1988,v=as.vector(years\_avr))  
 ,aes(x=u,y=v))+geom\_bar(stat = "identity")



### c: consider the storms data set from dplyr package.

View(storms)

#### sort them based on the time they occured and save them in a file (q1\_3.txt)

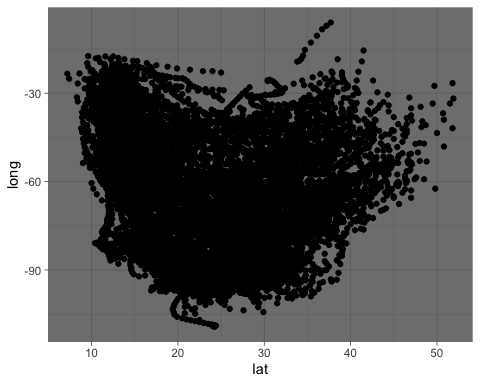
sorted =   
 storms[with(storms, order(storms$year, storms$month, storms$day , storms$hour)),]  
sorted

## # A tibble: 10,010 × 13  
## name year month day hour lat long status category wind pressure  
## <chr> <dbl> <dbl> <int> <dbl> <dbl> <dbl> <chr> <ord> <int> <int>  
## 1 Amy 1975 6 27 0 27.5 -79 tropical d… -1 25 1013  
## 2 Amy 1975 6 27 6 28.5 -79 tropical d… -1 25 1013  
## 3 Amy 1975 6 27 12 29.5 -79 tropical d… -1 25 1013  
## 4 Amy 1975 6 27 18 30.5 -79 tropical d… -1 25 1013  
## 5 Amy 1975 6 28 0 31.5 -78.8 tropical d… -1 25 1012  
## 6 Amy 1975 6 28 6 32.4 -78.7 tropical d… -1 25 1012  
## 7 Amy 1975 6 28 12 33.3 -78 tropical d… -1 25 1011  
## 8 Amy 1975 6 28 18 34 -77 tropical d… -1 30 1006  
## 9 Amy 1975 6 29 0 34.4 -75.8 tropical s… 0 35 1004  
## 10 Amy 1975 6 29 6 34 -74.8 tropical s… 0 40 1002  
## # … with 10,000 more rows, and 2 more variables: ts\_diameter <dbl>,  
## # hu\_diameter <dbl>

write.table(sorted, file="q1\_3.txt", append = FALSE, sep = " ", dec = ".",  
 row.names = TRUE, col.names = TRUE)

#### plot the coordinates (lat, long) of the place storms occurred

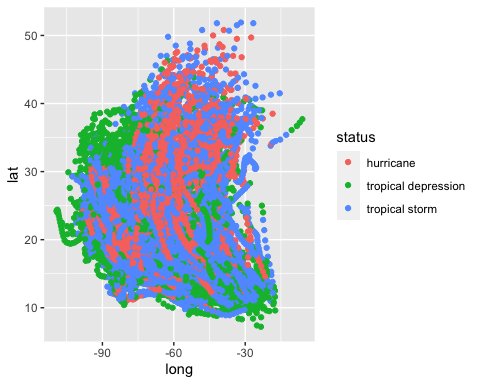
p=ggplot(data=storms)+geom\_point(aes(lat,long))  
p+theme\_dark()



#map <- get\_stamenmap(bbox = c(left= -11 , bottom = -11 , right = 11 , top = -11 ), maptype = "terrain" , zoom = 5)

#### also color them based on the status

ggplot(data = storms)+geom\_point(mapping = aes(x=long,y=lat,color=status))



## Heart Attack Prevention

### a: Loading the data set and getting it ready

#### load the data set from “had.txt”

heartAttackData <- read.delim("had.txt", header=F)

#### i: Separate the last(result) column and store it in a variable called label. Store the first 6 columns as features.

label = heartAttackData[,ncol(heartAttackData)]  
features = heartAttackData[,1:6]

#### ii: separate the data into test(20%) and train(80%) sets.

n = length(label)  
test\_ind <- sample(1:n, as.integer(n \* 0.2))  
test\_label = label[test\_ind]  
test\_feature = features[test\_ind,]  
train\_label = label[-test\_ind]  
train\_feature = features[-test\_ind,]

#### save test and train sets in separate files

write.table(test\_label, file="test\_label.txt")  
write.table(test\_feature, file="test\_feature.txt")  
write.table(train\_label, file="train\_label.txt")  
write.table(train\_feature, file="train\_feature.txt")

### b: regresssion

#### i: use the train data set and apply regression on them to obtain the corresponding coefficients.

model <- lm(as.vector(train\_label) ~ as.vector(train\_feature[,1]) + as.vector(train\_feature[,2]) + as.vector(train\_feature[,3]) + as.vector(train\_feature[,4]) + as.vector(train\_feature[,5]) + as.vector(train\_feature[,6]))  
summary(model)

##   
## Call:  
## lm(formula = as.vector(train\_label) ~ as.vector(train\_feature[,   
## 1]) + as.vector(train\_feature[, 2]) + as.vector(train\_feature[,   
## 3]) + as.vector(train\_feature[, 4]) + as.vector(train\_feature[,   
## 5]) + as.vector(train\_feature[, 6]))  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2.1283 -0.5899 -0.0556 0.6369 1.9641   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.5140876 0.5139081 4.892 1.85e-06 \*\*\*  
## as.vector(train\_feature[, 1]) -0.0224248 0.0062891 -3.566 0.000439 \*\*\*  
## as.vector(train\_feature[, 2]) -0.6477519 0.1139664 -5.684 3.87e-08 \*\*\*  
## as.vector(train\_feature[, 3]) 0.3802529 0.0515677 7.374 2.79e-12 \*\*\*  
## as.vector(train\_feature[, 4]) -0.0081120 0.0032366 -2.506 0.012873 \*   
## as.vector(train\_feature[, 5]) -0.0002304 0.0010589 -0.218 0.827948   
## as.vector(train\_feature[, 6]) -0.0189041 0.1487117 -0.127 0.898954   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.8213 on 236 degrees of freedom  
## Multiple R-squared: 0.3379, Adjusted R-squared: 0.321   
## F-statistic: 20.07 on 6 and 236 DF, p-value: < 2.2e-16

##### Call: shows us the formula that R used to fit the regression model. label is our dependent variable and we are using the 6 features as independent variables (to predict).

##### Residuals: The residuals are the difference between the actual values and the predicted ones. we’d definitely want our median value to be centered around zero as this would tell us our residuals were somewhat symmetrical and that our model was predicting evenly at both the high and low ends of our dataset. Looking at the output above, it looks like our distribution is slightly right-skewed but again it is also near 0 so we can be hopeful that our model is predicting quite well.

##### Coefficients: These are estimations of coefficients in the equation of form , where is the intercept and s are the coefficient(slope) of each factor. Because we often don’t have enough information or data to know the exact equation that exists in the wild, we have to build this equation by generating estimates for both the slopes and the intercept. These estimates are most often generated through the ordinary least squares (where regression model finds the line that fits the points in such a way that it minimizes the distance between each point and the line).

###### estimations of each one of s described above are as follows:

###### , , , , , ,

###### To ilustrate this in our example, I constructed a data frame.

# label=as.vector(train\_label)  
# f1=as.vector(train\_feature[, 1])  
# f2=as.vector(train\_feature[, 2])  
# f3=as.vector(train\_feature[, 3])  
# f4=as.vector(train\_feature[, 4])  
# f5=as.vector(train\_feature[, 5])  
# f6=as.vector(train\_feature[, 6])  
# class\_df = data.frame(label, f1, f2, f3, f4, f5, f6, stringsAsFactors = F)   
#   
# ggplt <- ggplot(class\_df,aes(x=,y=age,shape=Tree))+  
# geom\_point()+  
# theme\_classic()  
#   
# ggplt  
#   
# # Plotting multiple Regression Lines  
# ggplt+geom\_smooth(method=lm,se=FALSE,fullrange=TRUE,  
# aes(color=Tree))

###### Coefficients — Std. Error: The standard error of the coefficient is an estimate of the standard deviation of the coefficient. In effect, it is telling us how much uncertainty there is with our coefficient. The standard error is often used to create confidence intervals.

###### Coefficients — t value: The t-statistic is simply the coefficient divided by the standard error. In general, we want our coefficients to have large t-statistics.

###### Coefficients — Pr(>|t|) and Signif. codes The p-value is calculated using the t-statistic from the T distribution. The p-value, in association with the t-statistic, help us to understand how significant our coefficient is to the model. In practice, any p-value below 0.05 is usually deemed as significant. The coefficient codes give us a quick way to visually see which coefficients are significant to the model.

##### Residual standard error: The residual standard error is a measure of how well the model fits the data.The residual standard error tells us the average amount that the actual values of Y differ from the predictions. In general, we want the smallest residual standard error possible.

##### Multiple R-squared and Adjusted R-squared: The Multiple R-squared value is most often used for simple linear regression (one predictor). It tells us what percentage of the variation within our dependent variable that the independent variable is explaining. it’s another method to determine how well our model is fitting the data. Which in our example is a bit high and shows that our model isn’t fitting the data very well. The Adjusted R-squared value is used when running multiple linear regression and can conceptually be thought of in the same way we described Multiple R-squared. The Adjusted R-squared value shows what percentage of the variation within our dependent variable that all predictors are explaining. Which is also 32% in this example and considered to be almost high.

##### The F-statistic and overall p-value help us determine the result of this test. If you have a lot of independent variables, it’s common for an F-statistic to be close to one and to still produce a p-value where we would reject the null hypothesis. However, for smaller models, a larger F-statistic generally indicates that the null hypothesis should be rejected.

#### ii: Indentify the importance of coeffs:

##### Althogh the coeffs show us the amount of importance, we can not just compare their amounts with each other since they don’t have the same scales they are not scaled the same. We should first normalize them (for example between 0 and 1) and then compare them with each other.

##### Regression analysis is a form of inferential statistics. The p-values help determine whether the relationships that you observe in your sample also exist in the larger population. The p-value for each independent variable tests the null hypothesis that the variable has no correlation with the dependent variable. If there is no correlation, there is no association between the changes in the independent variable and the shifts in the dependent variable.

##### If the p-value for a variable is less than your significance level, your sample data provide enough evidence to reject the null hypothesis for the entire population. On the other hand, a p-value that is greater than the significance level indicates that there is insufficient evidence in your sample to conclude that a non-zero correlation exists.

##### Recall the p-value in the coefficients part for our example:

summary(model)

##   
## Call:  
## lm(formula = as.vector(train\_label) ~ as.vector(train\_feature[,   
## 1]) + as.vector(train\_feature[, 2]) + as.vector(train\_feature[,   
## 3]) + as.vector(train\_feature[, 4]) + as.vector(train\_feature[,   
## 5]) + as.vector(train\_feature[, 6]))  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2.1283 -0.5899 -0.0556 0.6369 1.9641   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.5140876 0.5139081 4.892 1.85e-06 \*\*\*  
## as.vector(train\_feature[, 1]) -0.0224248 0.0062891 -3.566 0.000439 \*\*\*  
## as.vector(train\_feature[, 2]) -0.6477519 0.1139664 -5.684 3.87e-08 \*\*\*  
## as.vector(train\_feature[, 3]) 0.3802529 0.0515677 7.374 2.79e-12 \*\*\*  
## as.vector(train\_feature[, 4]) -0.0081120 0.0032366 -2.506 0.012873 \*   
## as.vector(train\_feature[, 5]) -0.0002304 0.0010589 -0.218 0.827948   
## as.vector(train\_feature[, 6]) -0.0189041 0.1487117 -0.127 0.898954   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.8213 on 236 degrees of freedom  
## Multiple R-squared: 0.3379, Adjusted R-squared: 0.321   
## F-statistic: 20.07 on 6 and 236 DF, p-value: < 2.2e-16

##### We can see that f5 and f4 are fairly large compared to a 0.05 significance level and maybe we should reconsider using them.

### b: evaluate the coeffs on test set

#### apply the coeffs on test (, , , , , , ):

test\_result = test\_feature[,1]\*-0.0214786 + test\_feature[,2]\*-0.6194578 +  
 test\_feature[,3]\*0.4163637 + test\_feature[,4]\*-0.0087373 +  
 test\_feature[,5]\*-0.0003125 + test\_feature[,6]\*0.0893647 + 2.4708939  
test\_result

## [1] -0.6698029 -0.2917221 0.4691683 0.3970443 0.9372113 0.2896387  
## [7] -0.1949108 -0.4386346 0.1294458 -0.6063178 -0.3373754 -0.0106659  
## [13] 0.0335518 0.7468383 -0.3582108 -0.3445121 0.6200041 -0.3485869  
## [19] -0.6109791 -0.1628249 -0.0305184 -0.6943358 -0.1677513 0.6988563  
## [25] -0.0095170 0.6551034 0.8290556 0.4459882 0.5304436 -0.8035834  
## [31] 0.1071340 0.2739051 1.1914585 -0.3060210 -0.1759322 -0.5487570  
## [37] 0.2055154 -0.8563528 -0.4569890 -0.2001619 0.2250351 0.8240899  
## [43] 0.1443238 -0.7169397 0.1442042 -0.5935230 0.4424456 1.0903872  
## [49] -0.0991842 0.9031365 0.1208081 0.4251191 -0.6580437 1.3606711  
## [55] -0.5431651 -0.3853306 -0.5908552 -0.6752835 0.0244155 -0.2628680

apply\_limit <- function(result, limit){  
 result[result > limit] = 1  
 result[result <= limit] = -1  
 return(result)  
}  
res\_0 = apply\_limit(test\_result, limit = 0)  
res\_0

## [1] -1 -1 1 1 1 1 -1 -1 1 -1 -1 -1 1 1 -1 -1 1 -1 -1 -1 -1 -1 -1 1 -1  
## [26] 1 1 1 1 -1 1 1 1 -1 -1 -1 1 -1 -1 -1 1 1 1 -1 1 -1 1 1 -1 1  
## [51] 1 1 -1 1 -1 -1 -1 -1 1 -1

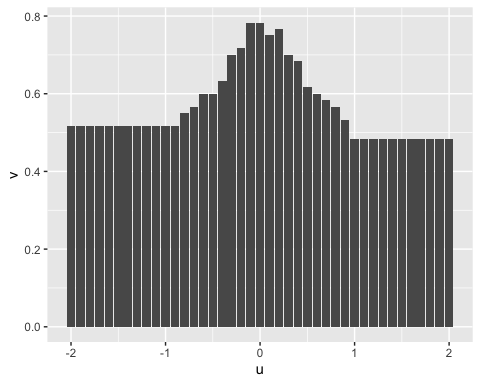
##### compare the test\_result with actual labels to see how many are correct:

check\_correctness <- function(result){  
 corrects = 0  
 for (i in 1:length(result)) {  
 if (result[i] == test\_label[i]) {  
 corrects = corrects + 1  
 }  
 }  
 return(corrects/length(result))  
}  
  
check\_correctness(res\_0)

## [1] 0.7833333

#### ii: find the maximum correcness rate for different values of limit in [-2, 2]:

limit\_seq = seq(-2, 2, by = 0.1)  
fracs = c()  
max\_limit = 0  
max\_val = 0  
for (i in limit\_seq){  
 frac = check\_correctness(apply\_limit(test\_result, limit = i))  
 fracs = c(fracs, frac)  
 if (frac > max\_val) {  
 max\_val = frac  
 max\_limit = i  
 }  
}  
  
ggplot(data=data.frame(u=as.vector(limit\_seq),v=fracs)  
 ,aes(x=u,y=v))+geom\_bar(stat = "identity")



print(max\_val)

## [1] 0.7833333

print(max\_limit)

## [1] -0.1

##### hence we can see that the max occurs for both 0 and -0.3 with the correcness ratio of 0.73

## a:

housing\_data <- read\_excel("housing.xlsx", sheet = "price of land")

## New names:  
## \* `` -> ...4  
## \* `` -> ...5  
## \* `` -> ...6  
## \* `` -> ...8  
## \* `` -> ...9  
## \* ...

### i: I started by calculating all the invalid enteries in each column(the ones that were not in a numeric format or where NA or zero). Then I ignored the columns with large number of undefined enteries(NAs). I used a threshold of 5 and deleted those columns using subset function. Also, for all the cells with a wrong format, I changed their contents to be NA. This way, they will get ignored in upcoming calculations.

invalid\_ones <- matrix(0, 1, ncol(housing\_data))  
for (i in 2: ncol(housing\_data)){  
 invalid\_ones[i] = 0  
 for (j in 3: nrow(housing\_data)){  
 if (is.na(suppressWarnings(as.numeric(as.character(housing\_data[j, i])))) | is.na(housing\_data[j, i]) | suppressWarnings(housing\_data[j, i]==0)){  
 invalid\_ones[i] = invalid\_ones[i] + 1  
 housing\_data[j, i] = NA  
 }  
 }  
}  
invalid\_ones

## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13] [,14]  
## [1,] 0 0 0 0 2 0 0 0 1 0 0 0 1 2  
## [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25] [,26]  
## [1,] 0 0 0 0 0 0 0 0 0 0 0 0  
## [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37] [,38]  
## [1,] 0 0 0 0 0 1 0 0 0 1 1 4  
## [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46]  
## [1,] 4 6 13 9 19 18 19 8

print(as.vector(which(invalid\_ones > 5)))

## [1] 40 41 42 43 44 45 46

housing\_data = subset(housing\_data, select = -as.vector(which(invalid\_ones > 5)))  
  
# iii: save the modified data set to a new file  
write\_xlsx( housing\_data,   
 path = "housing\_modified.xlsx",  
 col\_names = TRUE,  
 format\_headers = TRUE,  
 use\_zip64 = FALSE)

#### ii: The reason why I decided to delete some of the columns and cells instead of substituting them with mean or similar data, was that when a data is unknown its better to ignore it. Specially that we have a good amount of data and ignoring a fraction of them wouldn’t hurt so much.

### b:

k = 98110179%%22   
k

## [1] 13

price = housing\_data[k+3, -1]  
time = seq(2, 39, by=1)  
  
model <- lm(as.numeric(price) ~ time)  
summary(model)

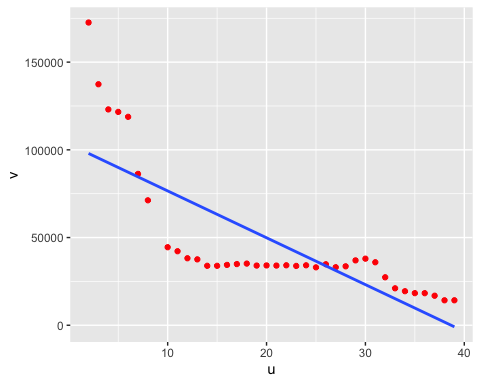
##   
## Call:  
## lm(formula = as.numeric(price) ~ time)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -33045 -18518 1686 12373 74637   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 103291.2 8540.4 12.094 4.69e-14 \*\*\*  
## time -2671.2 363.2 -7.355 1.34e-08 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 24180 on 35 degrees of freedom  
## (1 observation deleted due to missingness)  
## Multiple R-squared: 0.6071, Adjusted R-squared: 0.5959   
## F-statistic: 54.09 on 1 and 35 DF, p-value: 1.339e-08

ggplot(data=data.frame(u=time,v=as.numeric(price)), aes(x=u,y=v)) +  
 geom\_point(color='red') +  
 geom\_smooth(method = "lm", se = FALSE)

## `geom\_smooth()` using formula 'y ~ x'

## Warning: Removed 1 rows containing non-finite values (stat\_smooth).

## Warning: Removed 1 rows containing missing values (geom\_point).



price = housing\_data[-1, -1]  
time = seq(2, 39, by=1)  
district = seq(2, 24, by=1)  
times = c()  
districts = c()  
prices = c()  
  
for (d in district){  
 for (t in time){  
 districts = c(districts, d)  
 prices = c(prices, as.numeric(housing\_data[d, t]))  
 }   
 times = c(times, as.vector(time))  
}  
  
  
  
#my\_data = data.frame(p=prices, d=districts, t=times)  
model <- lm(prices ~ times + districts)  
summary(model)

##   
## Call:  
## lm(formula = prices ~ times + districts)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -84339 -29152 -7844 16866 388060   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 189545.4 5069.7 37.39 <2e-16 \*\*\*  
## times -3669.9 161.8 -22.69 <2e-16 \*\*\*  
## districts -4205.0 264.6 -15.89 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 51430 on 854 degrees of freedom  
## (17 observations deleted due to missingness)  
## Multiple R-squared: 0.4721, Adjusted R-squared: 0.4709   
## F-statistic: 381.9 on 2 and 854 DF, p-value: < 2.2e-16

# ggplt <- ggplot(data=data.frame(price=prices, time=times, district=districts),aes(x=time,y=price,shape=district))+  
# geom\_point()+  
# theme\_classic()  
#   
# ggplt+geom\_smooth(method=lm,se=FALSE,fullrange=TRUE,aes(color=district))

time = seq(2, 39, by=1)  
district = seq(1, 23, by=1)  
df = data.frame(p=prices, t=times)  
zeros = integer(length(prices))  
t = length(time)  
for (d in district) {  
 if (d != k+2) {  
 d\_i = zeros  
 s = (d-1)\*t  
 e = d\*t  
 d\_i[s:e] = d\_i[s:e] + 1  
 df[paste0("dist",d)] = d\_i  
 }  
}  
df

## p t dist1 dist2 dist3 dist4 dist5 dist6 dist7 dist8 dist9 dist10  
## 1 255109.224 2 1 0 0 0 0 0 0 0 0 0  
## 2 208150.250 3 1 0 0 0 0 0 0 0 0 0  
## 3 187330.130 4 1 0 0 0 0 0 0 0 0 0  
## 4 186604.435 5 1 0 0 0 0 0 0 0 0 0  
## 5 169566.609 6 1 0 0 0 0 0 0 0 0 0  
## 6 145466.368 7 1 0 0 0 0 0 0 0 0 0  
## 7 100578.761 8 1 0 0 0 0 0 0 0 0 0  
## 8 80544.580 9 1 0 0 0 0 0 0 0 0 0  
## 9 61755.546 10 1 0 0 0 0 0 0 0 0 0  
## 10 59922.497 11 1 0 0 0 0 0 0 0 0 0  
## 11 52757.425 12 1 0 0 0 0 0 0 0 0 0  
## 12 52067.373 13 1 0 0 0 0 0 0 0 0 0  
## 13 46194.836 14 1 0 0 0 0 0 0 0 0 0  
## 14 44898.794 15 1 0 0 0 0 0 0 0 0 0  
## 15 44736.426 16 1 0 0 0 0 0 0 0 0 0  
## 16 45698.361 17 1 0 0 0 0 0 0 0 0 0  
## 17 45778.524 18 1 0 0 0 0 0 0 0 0 0  
## 18 44408.349 19 1 0 0 0 0 0 0 0 0 0  
## 19 44102.339 20 1 0 0 0 0 0 0 0 0 0  
## 20 43948.141 21 1 0 0 0 0 0 0 0 0 0  
## 21 44083.959 22 1 0 0 0 0 0 0 0 0 0  
## 22 44149.582 23 1 0 0 0 0 0 0 0 0 0  
## 23 44104.219 24 1 0 0 0 0 0 0 0 0 0  
## 24 42060.263 25 1 0 0 0 0 0 0 0 0 0  
## 25 44104.313 26 1 0 0 0 0 0 0 0 0 0  
## 26 42469.262 27 1 0 0 0 0 0 0 0 0 0  
## 27 43620.955 28 1 0 0 0 0 0 0 0 0 0  
## 28 48360.175 29 1 0 0 0 0 0 0 0 0 0  
## 29 49046.758 30 1 0 0 0 0 0 0 0 0 0  
## 30 47454.633 31 1 0 0 0 0 0 0 0 0 0  
## 31 34346.993 32 1 0 0 0 0 0 0 0 0 0  
## 32 24460.447 33 1 0 0 0 0 0 0 0 0 0  
## 33 22600.931 34 1 0 0 0 0 0 0 0 0 0  
## 34 20032.245 35 1 0 0 0 0 0 0 0 0 0  
## 35 19438.847 36 1 0 0 0 0 0 0 0 0 0  
## 36 18227.775 37 1 0 0 0 0 0 0 0 0 0  
## 37 16098.867 38 1 0 0 0 0 0 0 0 0 0  
## 38 16802.558 39 1 1 0 0 0 0 0 0 0 0  
## 39 536515.503 2 0 1 0 0 0 0 0 0 0 0  
## 40 436363.994 3 0 1 0 0 0 0 0 0 0 0  
## 41 386496.035 4 0 1 0 0 0 0 0 0 0 0  
## 42 374740.995 5 0 1 0 0 0 0 0 0 0 0  
## 43 337304.032 6 0 1 0 0 0 0 0 0 0 0  
## 44 311466.467 7 0 1 0 0 0 0 0 0 0 0  
## 45 196143.267 8 0 1 0 0 0 0 0 0 0 0  
## 46 161253.204 9 0 1 0 0 0 0 0 0 0 0  
## 47 117251.480 10 0 1 0 0 0 0 0 0 0 0  
## 48 115317.686 11 0 1 0 0 0 0 0 0 0 0  
## 49 99521.729 12 0 1 0 0 0 0 0 0 0 0  
## 50 97236.000 13 0 1 0 0 0 0 0 0 0 0  
## 51 82778.896 14 0 1 0 0 0 0 0 0 0 0  
## 52 82204.448 15 0 1 0 0 0 0 0 0 0 0  
## 53 80430.908 16 0 1 0 0 0 0 0 0 0 0  
## 54 82316.219 17 0 1 0 0 0 0 0 0 0 0  
## 55 82270.775 18 0 1 0 0 0 0 0 0 0 0  
## 56 82170.160 19 0 1 0 0 0 0 0 0 0 0  
## 57 80210.513 20 0 1 0 0 0 0 0 0 0 0  
## 58 79026.437 21 0 1 0 0 0 0 0 0 0 0  
## 59 78650.049 22 0 1 0 0 0 0 0 0 0 0  
## 60 81587.618 23 0 1 0 0 0 0 0 0 0 0  
## 61 80291.694 24 0 1 0 0 0 0 0 0 0 0  
## 62 74810.510 25 0 1 0 0 0 0 0 0 0 0  
## 63 77498.275 26 0 1 0 0 0 0 0 0 0 0  
## 64 74679.857 27 0 1 0 0 0 0 0 0 0 0  
## 65 75631.233 28 0 1 0 0 0 0 0 0 0 0  
## 66 84340.451 29 0 1 0 0 0 0 0 0 0 0  
## 67 85097.070 30 0 1 0 0 0 0 0 0 0 0  
## 68 84552.030 31 0 1 0 0 0 0 0 0 0 0  
## 69 59108.354 32 0 1 0 0 0 0 0 0 0 0  
## 70 36766.560 33 0 1 0 0 0 0 0 0 0 0  
## 71 33799.216 34 0 1 0 0 0 0 0 0 0 0  
## 72 29332.744 35 0 1 0 0 0 0 0 0 0 0  
## 73 28489.910 36 0 1 0 0 0 0 0 0 0 0  
## 74 27031.021 37 0 1 0 0 0 0 0 0 0 0  
## 75 22046.178 38 0 1 0 0 0 0 0 0 0 0  
## 76 21561.140 39 0 1 1 0 0 0 0 0 0 0  
## 77 493610.067 2 0 0 1 0 0 0 0 0 0 0  
## 78 409758.278 3 0 0 1 0 0 0 0 0 0 0  
## 79 367990.344 4 0 0 1 0 0 0 0 0 0 0  
## 80 354481.252 5 0 0 1 0 0 0 0 0 0 0  
## 81 317353.155 6 0 0 1 0 0 0 0 0 0 0  
## 82 295660.385 7 0 0 1 0 0 0 0 0 0 0  
## 83 187648.457 8 0 0 1 0 0 0 0 0 0 0  
## 84 151252.725 9 0 0 1 0 0 0 0 0 0 0  
## 85 110990.603 10 0 0 1 0 0 0 0 0 0 0  
## 86 110187.419 11 0 0 1 0 0 0 0 0 0 0  
## 87 95139.071 12 0 0 1 0 0 0 0 0 0 0  
## 88 91180.530 13 0 0 1 0 0 0 0 0 0 0  
## 89 77557.081 14 0 0 1 0 0 0 0 0 0 0  
## 90 77272.817 15 0 0 1 0 0 0 0 0 0 0  
## 91 75995.100 16 0 0 1 0 0 0 0 0 0 0  
## 92 77938.099 17 0 0 1 0 0 0 0 0 0 0  
## 93 77487.995 18 0 0 1 0 0 0 0 0 0 0  
## 94 76417.633 19 0 0 1 0 0 0 0 0 0 0  
## 95 75689.997 20 0 0 1 0 0 0 0 0 0 0  
## 96 75410.727 21 0 0 1 0 0 0 0 0 0 0  
## 97 75309.013 22 0 0 1 0 0 0 0 0 0 0  
## 98 74712.995 23 0 0 1 0 0 0 0 0 0 0  
## 99 73830.598 24 0 0 1 0 0 0 0 0 0 0  
## 100 70257.214 25 0 0 1 0 0 0 0 0 0 0  
## 101 73755.734 26 0 0 1 0 0 0 0 0 0 0  
## 102 70321.459 27 0 0 1 0 0 0 0 0 0 0  
## 103 71916.392 28 0 0 1 0 0 0 0 0 0 0  
## 104 79448.714 29 0 0 1 0 0 0 0 0 0 0  
## 105 79640.799 30 0 0 1 0 0 0 0 0 0 0  
## 106 77433.534 31 0 0 1 0 0 0 0 0 0 0  
## 107 52882.599 32 0 0 1 0 0 0 0 0 0 0  
## 108 33031.405 33 0 0 1 0 0 0 0 0 0 0  
## 109 30727.577 34 0 0 1 0 0 0 0 0 0 0  
## 110 27112.781 35 0 0 1 0 0 0 0 0 0 0  
## 111 26093.313 36 0 0 1 0 0 0 0 0 0 0  
## 112 24672.645 37 0 0 1 0 0 0 0 0 0 0  
## 113 20074.061 38 0 0 1 0 0 0 0 0 0 0  
## 114 19467.560 39 0 0 1 1 0 0 0 0 0 0  
## 115 549241.111 2 0 0 0 1 0 0 0 0 0 0  
## 116 448995.415 3 0 0 0 1 0 0 0 0 0 0  
## 117 399399.648 4 0 0 0 1 0 0 0 0 0 0  
## 118 381033.675 5 0 0 0 1 0 0 0 0 0 0  
## 119 342643.940 6 0 0 0 1 0 0 0 0 0 0  
## 120 317395.450 7 0 0 0 1 0 0 0 0 0 0  
## 121 198805.943 8 0 0 0 1 0 0 0 0 0 0  
## 122 168582.080 9 0 0 0 1 0 0 0 0 0 0  
## 123 128156.114 10 0 0 0 1 0 0 0 0 0 0  
## 124 127317.812 11 0 0 0 1 0 0 0 0 0 0  
## 125 110700.578 12 0 0 0 1 0 0 0 0 0 0  
## 126 107493.094 13 0 0 0 1 0 0 0 0 0 0  
## 127 91872.298 14 0 0 0 1 0 0 0 0 0 0  
## 128 91153.730 15 0 0 0 1 0 0 0 0 0 0  
## 129 89523.737 16 0 0 0 1 0 0 0 0 0 0  
## 130 92226.577 17 0 0 0 1 0 0 0 0 0 0  
## 131 92120.043 18 0 0 0 1 0 0 0 0 0 0  
## 132 90858.859 19 0 0 0 1 0 0 0 0 0 0  
## 133 88863.687 20 0 0 0 1 0 0 0 0 0 0  
## 134 88356.937 21 0 0 0 1 0 0 0 0 0 0  
## 135 89043.747 22 0 0 0 1 0 0 0 0 0 0  
## 136 90855.840 23 0 0 0 1 0 0 0 0 0 0  
## 137 89593.503 24 0 0 0 1 0 0 0 0 0 0  
## 138 84255.243 25 0 0 0 1 0 0 0 0 0 0  
## 139 87878.367 26 0 0 0 1 0 0 0 0 0 0  
## 140 84091.132 27 0 0 0 1 0 0 0 0 0 0  
## 141 85803.282 28 0 0 0 1 0 0 0 0 0 0  
## 142 94054.676 29 0 0 0 1 0 0 0 0 0 0  
## 143 94680.803 30 0 0 0 1 0 0 0 0 0 0  
## 144 92368.769 31 0 0 0 1 0 0 0 0 0 0  
## 145 63321.324 32 0 0 0 1 0 0 0 0 0 0  
## 146 39628.893 33 0 0 0 1 0 0 0 0 0 0  
## 147 37019.159 34 0 0 0 1 0 0 0 0 0 0  
## 148 31945.414 35 0 0 0 1 0 0 0 0 0 0  
## 149 29286.634 36 0 0 0 1 0 0 0 0 0 0  
## 150 28309.483 37 0 0 0 1 0 0 0 0 0 0  
## 151 24528.105 38 0 0 0 1 0 0 0 0 0 0  
## 152 23822.613 39 0 0 0 1 1 0 0 0 0 0  
## 153 339262.666 2 0 0 0 0 1 0 0 0 0 0  
## 154 278281.432 3 0 0 0 0 1 0 0 0 0 0  
## 155 253328.317 4 0 0 0 0 1 0 0 0 0 0  
## 156 242756.326 5 0 0 0 0 1 0 0 0 0 0  
## 157 217745.928 6 0 0 0 0 1 0 0 0 0 0  
## 158 194430.403 7 0 0 0 0 1 0 0 0 0 0  
## 159 129240.326 8 0 0 0 0 1 0 0 0 0 0  
## 160 97015.851 9 0 0 0 0 1 0 0 0 0 0  
## 161 76448.614 10 0 0 0 0 1 0 0 0 0 0  
## 162 74718.385 11 0 0 0 0 1 0 0 0 0 0  
## 163 65242.920 12 0 0 0 0 1 0 0 0 0 0  
## 164 63121.801 13 0 0 0 0 1 0 0 0 0 0  
## 165 55868.694 14 0 0 0 0 1 0 0 0 0 0  
## 166 55825.337 15 0 0 0 0 1 0 0 0 0 0  
## 167 55667.920 16 0 0 0 0 1 0 0 0 0 0  
## 168 57222.465 17 0 0 0 0 1 0 0 0 0 0  
## 169 57425.747 18 0 0 0 0 1 0 0 0 0 0  
## 170 55786.762 19 0 0 0 0 1 0 0 0 0 0  
## 171 55194.679 20 0 0 0 0 1 0 0 0 0 0  
## 172 54958.395 21 0 0 0 0 1 0 0 0 0 0  
## 173 55860.975 22 0 0 0 0 1 0 0 0 0 0  
## 174 55337.611 23 0 0 0 0 1 0 0 0 0 0  
## 175 55037.480 24 0 0 0 0 1 0 0 0 0 0  
## 176 51408.818 25 0 0 0 0 1 0 0 0 0 0  
## 177 54326.590 26 0 0 0 0 1 0 0 0 0 0  
## 178 53031.384 27 0 0 0 0 1 0 0 0 0 0  
## 179 54500.775 28 0 0 0 0 1 0 0 0 0 0  
## 180 61460.721 29 0 0 0 0 1 0 0 0 0 0  
## 181 61607.560 30 0 0 0 0 1 0 0 0 0 0  
## 182 59395.570 31 0 0 0 0 1 0 0 0 0 0  
## 183 46096.684 32 0 0 0 0 1 0 0 0 0 0  
## 184 29014.788 33 0 0 0 0 1 0 0 0 0 0  
## 185 25710.348 34 0 0 0 0 1 0 0 0 0 0  
## 186 23286.977 35 0 0 0 0 1 0 0 0 0 0  
## 187 22161.811 36 0 0 0 0 1 0 0 0 0 0  
## 188 20544.886 37 0 0 0 0 1 0 0 0 0 0  
## 189 17263.304 38 0 0 0 0 1 0 0 0 0 0  
## 190 17202.471 39 0 0 0 0 1 1 0 0 0 0  
## 191 267408.148 2 0 0 0 0 0 1 0 0 0 0  
## 192 222945.257 3 0 0 0 0 0 1 0 0 0 0  
## 193 204017.147 4 0 0 0 0 0 1 0 0 0 0  
## 194 199147.567 5 0 0 0 0 0 1 0 0 0 0  
## 195 191008.304 6 0 0 0 0 0 1 0 0 0 0  
## 196 155140.631 7 0 0 0 0 0 1 0 0 0 0  
## 197 117121.720 8 0 0 0 0 0 1 0 0 0 0  
## 198 98416.862 9 0 0 0 0 0 1 0 0 0 0  
## 199 70256.830 10 0 0 0 0 0 1 0 0 0 0  
## 200 66114.843 11 0 0 0 0 0 1 0 0 0 0  
## 201 59106.641 12 0 0 0 0 0 1 0 0 0 0  
## 202 58902.414 13 0 0 0 0 0 1 0 0 0 0  
## 203 50198.590 14 0 0 0 0 0 1 0 0 0 0  
## 204 50050.021 15 0 0 0 0 0 1 0 0 0 0  
## 205 49798.797 16 0 0 0 0 0 1 0 0 0 0  
## 206 50927.254 17 0 0 0 0 0 1 0 0 0 0  
## 207 50963.517 18 0 0 0 0 0 1 0 0 0 0  
## 208 49145.527 19 0 0 0 0 0 1 0 0 0 0  
## 209 48973.101 20 0 0 0 0 0 1 0 0 0 0  
## 210 48898.675 21 0 0 0 0 0 1 0 0 0 0  
## 211 49150.129 22 0 0 0 0 0 1 0 0 0 0  
## 212 48909.095 23 0 0 0 0 0 1 0 0 0 0  
## 213 48543.884 24 0 0 0 0 0 1 0 0 0 0  
## 214 45994.210 25 0 0 0 0 0 1 0 0 0 0  
## 215 48713.951 26 0 0 0 0 0 1 0 0 0 0  
## 216 46527.252 27 0 0 0 0 0 1 0 0 0 0  
## 217 47985.538 28 0 0 0 0 0 1 0 0 0 0  
## 218 53945.078 29 0 0 0 0 0 1 0 0 0 0  
## 219 54621.774 30 0 0 0 0 0 1 0 0 0 0  
## 220 54058.059 31 0 0 0 0 0 1 0 0 0 0  
## 221 34916.157 32 0 0 0 0 0 1 0 0 0 0  
## 222 28414.515 33 0 0 0 0 0 1 0 0 0 0  
## 223 25672.687 34 0 0 0 0 0 1 0 0 0 0  
## 224 22666.466 35 0 0 0 0 0 1 0 0 0 0  
## 225 21615.792 36 0 0 0 0 0 1 0 0 0 0  
## 226 20318.491 37 0 0 0 0 0 1 0 0 0 0  
## 227 17886.767 38 0 0 0 0 0 1 0 0 0 0  
## 228 17204.395 39 0 0 0 0 0 1 1 0 0 0  
## 229 411897.157 2 0 0 0 0 0 0 1 0 0 0  
## 230 342570.007 3 0 0 0 0 0 0 1 0 0 0  
## 231 311526.898 4 0 0 0 0 0 0 1 0 0 0  
## 232 299756.509 5 0 0 0 0 0 0 1 0 0 0  
## 233 291550.083 6 0 0 0 0 0 0 1 0 0 0  
## 234 253211.273 7 0 0 0 0 0 0 1 0 0 0  
## 235 169671.179 8 0 0 0 0 0 0 1 0 0 0  
## 236 128919.798 9 0 0 0 0 0 0 1 0 0 0  
## 237 103869.156 10 0 0 0 0 0 0 1 0 0 0  
## 238 98644.910 11 0 0 0 0 0 0 1 0 0 0  
## 239 85169.297 12 0 0 0 0 0 0 1 0 0 0  
## 240 82743.851 13 0 0 0 0 0 0 1 0 0 0  
## 241 73625.189 14 0 0 0 0 0 0 1 0 0 0  
## 242 73190.895 15 0 0 0 0 0 0 1 0 0 0  
## 243 72695.778 16 0 0 0 0 0 0 1 0 0 0  
## 244 74286.788 17 0 0 0 0 0 0 1 0 0 0  
## 245 74695.484 18 0 0 0 0 0 0 1 0 0 0  
## 246 72833.401 19 0 0 0 0 0 0 1 0 0 0  
## 247 71891.977 20 0 0 0 0 0 0 1 0 0 0  
## 248 72130.712 21 0 0 0 0 0 0 1 0 0 0  
## 249 71823.450 22 0 0 0 0 0 0 1 0 0 0  
## 250 72072.541 23 0 0 0 0 0 0 1 0 0 0  
## 251 71660.889 24 0 0 0 0 0 0 1 0 0 0  
## 252 67805.246 25 0 0 0 0 0 0 1 0 0 0  
## 253 70892.772 26 0 0 0 0 0 0 1 0 0 0  
## 254 67970.129 27 0 0 0 0 0 0 1 0 0 0  
## 255 69535.826 28 0 0 0 0 0 0 1 0 0 0  
## 256 74906.173 29 0 0 0 0 0 0 1 0 0 0  
## 257 76268.621 30 0 0 0 0 0 0 1 0 0 0  
## 258 74973.503 31 0 0 0 0 0 0 1 0 0 0  
## 259 51904.025 32 0 0 0 0 0 0 1 0 0 0  
## 260 36478.865 33 0 0 0 0 0 0 1 0 0 0  
## 261 34909.840 34 0 0 0 0 0 0 1 0 0 0  
## 262 30189.110 35 0 0 0 0 0 0 1 0 0 0  
## 263 29316.597 36 0 0 0 0 0 0 1 0 0 0  
## 264 27017.401 37 0 0 0 0 0 0 1 0 0 0  
## 265 22024.105 38 0 0 0 0 0 0 1 0 0 0  
## 266 21492.029 39 0 0 0 0 0 0 1 1 0 0  
## 267 264772.248 2 0 0 0 0 0 0 0 1 0 0  
## 268 222703.622 3 0 0 0 0 0 0 0 1 0 0  
## 269 201878.598 4 0 0 0 0 0 0 0 1 0 0  
## 270 196932.171 5 0 0 0 0 0 0 0 1 0 0  
## 271 192606.605 6 0 0 0 0 0 0 0 1 0 0  
## 272 159777.553 7 0 0 0 0 0 0 0 1 0 0  
## 273 131663.189 8 0 0 0 0 0 0 0 1 0 0  
## 274 101033.860 9 0 0 0 0 0 0 0 1 0 0  
## 275 77710.398 10 0 0 0 0 0 0 0 1 0 0  
## 276 77308.299 11 0 0 0 0 0 0 0 1 0 0  
## 277 68273.339 12 0 0 0 0 0 0 0 1 0 0  
## 278 68149.640 13 0 0 0 0 0 0 0 1 0 0  
## 279 57894.295 14 0 0 0 0 0 0 0 1 0 0  
## 280 57815.768 15 0 0 0 0 0 0 0 1 0 0  
## 281 57638.186 16 0 0 0 0 0 0 0 1 0 0  
## 282 59160.203 17 0 0 0 0 0 0 0 1 0 0  
## 283 59294.246 18 0 0 0 0 0 0 0 1 0 0  
## 284 58170.887 19 0 0 0 0 0 0 0 1 0 0  
## 285 57204.090 20 0 0 0 0 0 0 0 1 0 0  
## 286 56901.899 21 0 0 0 0 0 0 0 1 0 0  
## 287 57262.232 22 0 0 0 0 0 0 0 1 0 0  
## 288 58513.667 23 0 0 0 0 0 0 0 1 0 0  
## 289 58253.153 24 0 0 0 0 0 0 0 1 0 0  
## 290 54213.348 25 0 0 0 0 0 0 0 1 0 0  
## 291 56805.385 26 0 0 0 0 0 0 0 1 0 0  
## 292 53835.517 27 0 0 0 0 0 0 0 1 0 0  
## 293 54492.010 28 0 0 0 0 0 0 0 1 0 0  
## 294 61337.674 29 0 0 0 0 0 0 0 1 0 0  
## 295 62750.222 30 0 0 0 0 0 0 0 1 0 0  
## 296 61505.936 31 0 0 0 0 0 0 0 1 0 0  
## 297 42378.120 32 0 0 0 0 0 0 0 1 0 0  
## 298 29972.087 33 0 0 0 0 0 0 0 1 0 0  
## 299 29942.015 34 0 0 0 0 0 0 0 1 0 0  
## 300 25225.178 35 0 0 0 0 0 0 0 1 0 0  
## 301 24792.881 36 0 0 0 0 0 0 0 1 0 0  
## 302 22576.863 37 0 0 0 0 0 0 0 1 0 0  
## 303 19417.893 38 0 0 0 0 0 0 0 1 0 0  
## 304 18418.094 39 0 0 0 0 0 0 0 1 1 0  
## 305 252832.318 2 0 0 0 0 0 0 0 0 1 0  
## 306 200059.091 3 0 0 0 0 0 0 0 0 1 0  
## 307 183459.689 4 0 0 0 0 0 0 0 0 1 0  
## 308 181895.224 5 0 0 0 0 0 0 0 0 1 0  
## 309 180932.322 6 0 0 0 0 0 0 0 0 1 0  
## 310 148047.270 7 0 0 0 0 0 0 0 0 1 0  
## 311 98198.120 8 0 0 0 0 0 0 0 0 1 0  
## 312 80449.356 9 0 0 0 0 0 0 0 0 1 0  
## 313 62930.987 10 0 0 0 0 0 0 0 0 1 0  
## 314 62654.173 11 0 0 0 0 0 0 0 0 1 0  
## 315 55005.451 12 0 0 0 0 0 0 0 0 1 0  
## 316 53248.965 13 0 0 0 0 0 0 0 0 1 0  
## 317 46132.825 14 0 0 0 0 0 0 0 0 1 0  
## 318 46093.652 15 0 0 0 0 0 0 0 0 1 0  
## 319 46151.788 16 0 0 0 0 0 0 0 0 1 0  
## 320 47209.158 17 0 0 0 0 0 0 0 0 1 0  
## 321 47371.688 18 0 0 0 0 0 0 0 0 1 0  
## 322 45740.544 19 0 0 0 0 0 0 0 0 1 0  
## 323 45925.873 20 0 0 0 0 0 0 0 0 1 0  
## 324 46075.662 21 0 0 0 0 0 0 0 0 1 0  
## 325 45837.209 22 0 0 0 0 0 0 0 0 1 0  
## 326 45320.447 23 0 0 0 0 0 0 0 0 1 0  
## 327 45831.130 24 0 0 0 0 0 0 0 0 1 0  
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model <- lm(p~., df)  
summary(model)

##   
## Call:  
## lm(formula = p ~ ., data = df)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -110063 -31722 -7794 19889 347406   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 126059.35 7133.14 17.672 < 2e-16 \*\*\*  
## t -3752.89 152.95 -24.536 < 2e-16 \*\*\*  
## dist1 15745.31 10264.75 1.534 0.125429   
## dist2 76008.98 10088.54 7.534 1.28e-13 \*\*\*  
## dist3 66552.13 10091.07 6.595 7.54e-11 \*\*\*  
## dist4 83281.84 10091.00 8.253 6.01e-16 \*\*\*  
## dist5 33703.89 10091.01 3.340 0.000875 \*\*\*  
## dist6 22433.22 10091.01 2.223 0.026477 \*   
## dist7 57841.62 10091.00 5.732 1.39e-08 \*\*\*  
## dist8 28622.08 10091.06 2.836 0.004673 \*\*   
## dist9 19523.08 10089.23 1.935 0.053323 .   
## dist10 -11894.52 10498.55 -1.133 0.257554   
## dist11 -7609.51 10264.75 -0.741 0.458706   
## dist12 -7318.85 10088.61 -0.725 0.468376   
## dist13 -12961.77 10088.31 -1.285 0.199209   
## dist14 10512.88 10197.34 1.031 0.302866   
## dist16 -17003.21 10264.89 -1.656 0.098009 .   
## dist17 -15182.52 10333.54 -1.469 0.142143   
## dist18 -26616.67 10607.33 -2.509 0.012287 \*   
## dist19 -24044.25 10262.58 -2.343 0.019369 \*   
## dist20 -21643.19 10506.57 -2.060 0.039712 \*   
## dist21 -28915.71 10265.03 -2.817 0.004963 \*\*   
## dist22 -10727.07 10241.92 -1.047 0.295233   
## dist23 75.97 10197.59 0.007 0.994058   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 48170 on 833 degrees of freedom  
## (17 observations deleted due to missingness)  
## Multiple R-squared: 0.5484, Adjusted R-squared: 0.5359   
## F-statistic: 43.98 on 23 and 833 DF, p-value: < 2.2e-16

#### iv: The second approach is better. Because in the first one, we used numbers to indicate the district and also applied that number to the regression we used. Since there isn’t any meaningful relation between a district and its number(name), it’s better to keep its number out of our calculations. Hence, using separate indicators for each district, results in more reliable results. Moreover, we know that the Adjusted R-squared reflects the fit of the model, where a higher value generally indicates a better fit. We can see that it is higher in the second part, meaning it has generated a better fit.

### c:

k = 98110179%%33  
k

## [1] 24

#### i:

##### winter of 90 is 0 since it is in the 35th column, we find th kth and kth+1 seasons using that:

x\_i = as.numeric(unlist(housing\_data[-1,35-k]))  
y\_i = as.numeric(unlist(housing\_data[-1,35-k-1]))

##### calculate their means and variance:

print(mean(x\_i))

## [1] 53664.19

print(mean(y\_i))

## [1] 55482.62

print(paste("difference between means", mean(x\_i) - mean(y\_i)))

## [1] "difference between means -1818.42507108178"

print(var(x\_i))

## [1] 1080633587

print(var(y\_i))

## [1] 1087871103

##### find t and p values:

print(t.test(x\_i, y\_i))

##   
## Welch Two Sample t-test  
##   
## data: x\_i and y\_i  
## t = -0.18727, df = 44, p-value = 0.8523  
## alternative hypothesis: true difference in means is not equal to 0  
## 95 percent confidence interval:  
## -21387.52 17750.67  
## sample estimates:  
## mean of x mean of y   
## 53664.19 55482.62

##### p-value is 0.8532 which is larger than 0.05 (significance level). So we can not reject the null hypothesis and say that the prices have changed.

z\_i = x\_i - y\_i  
print(t.test(z\_i))

##   
## One Sample t-test  
##   
## data: z\_i  
## t = -6.9218, df = 22, p-value = 5.977e-07  
## alternative hypothesis: true mean is not equal to 0  
## 95 percent confidence interval:  
## -2363.249 -1273.602  
## sample estimates:  
## mean of x   
## -1818.425

##### we can see that it has a much lower p-value which results in the rejection of the null hypothesis.