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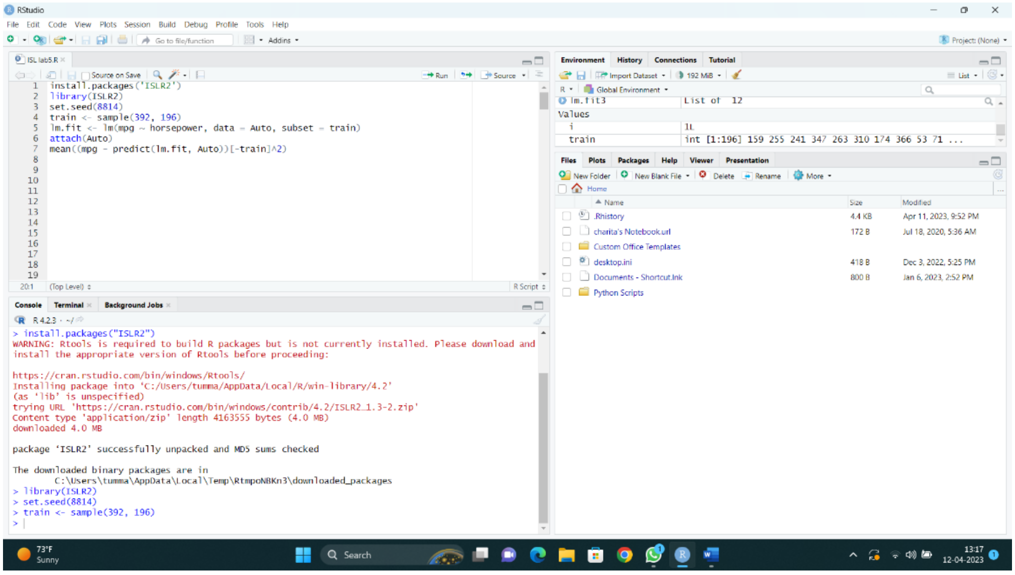
ISL ASSIGNMENT

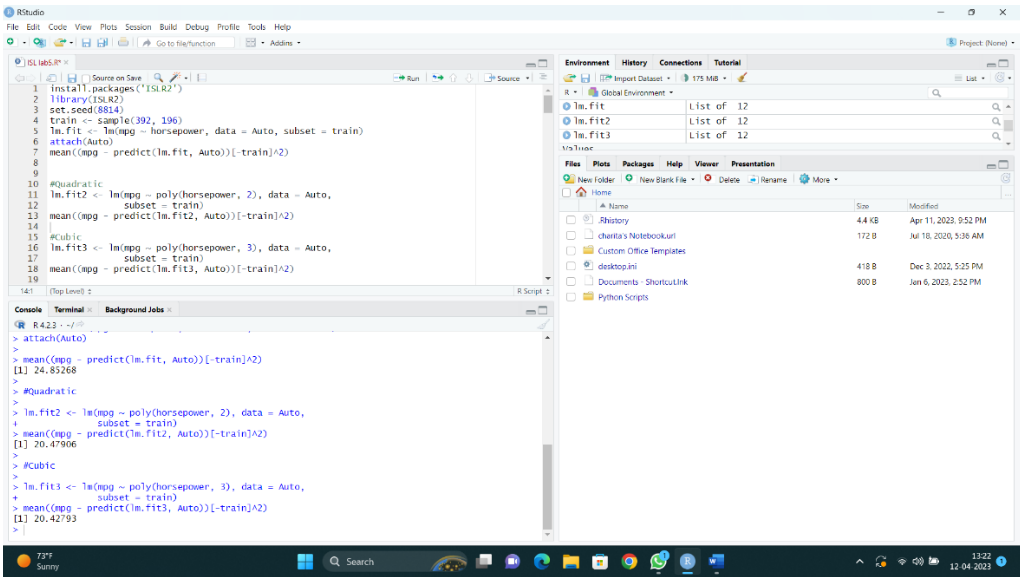
STAT LEARNING LAB: BOOTSTRAP AND CROSS VALIDATION

1) Change the value of the seed for (Validation Set Approach) part 1 to the **last 4 numbers of your student ID** . **Report** the **test rates** for a Poly fit **quadratic** and **cubic** using the seed.

- last 4 digits of the id number is 8814



Install ISLR2 packages and set seed as last four digits of UMKC ID



The poly quadratic and cubic values for the data using the seed(8814) is 20.47906, 20.42793

lm.fit	List of 12
lm.fit2	List of 12
lm.fit3	List of 12
Values	
i	1L
train	int [1:196] 159 255 241 347 263 310 174 366 53 71 ...

```
>
>
> boot.fn <- function(data,index)
+     coef(lm(mpg ~ horsepower, data = data, subset = index))
>
> boot.fn(Auto,1:392)
(Intercept)  horsepower
 39.9358610  -0.1578447
>
```

2) Change the ratio of train/test to a new percentage. (original was 50/50) Select **3 new ratios** and compute and **report** the **test performance** for each using the **<u>best</u> performing of the two Poly fit values from task 1**.

to create a 60/40 split:

- The ratio of train/test is 392/235

```
> set.seed(8814)
> train <- sample(392, 235)
> lm.fit <- lm(mpg ~ horsepower,data = Auto, subset = train)
> mean((mpg - predict(lm.fit, Auto))[-train]^2)
[1] 27.25061
> lm.fit2 <- lm(mpg ~ poly(horsepower, 2), data = Auto,
+              subset = train)
> mean((mpg - predict(lm.fit2, Auto))[-train]^2)
[1] 22.17392
> lm.fit3 <- lm(mpg ~ poly(horsepower, 3), data = Auto,
+              subset = train)
> mean((mpg - predict(lm.fit3, Auto))[-train]^2)
[1] 22.12438
> |
```

to create a 70/30 split:

- The ratio of train/test is 392/274.

```
> set.seed(8814)
> train <- sample(392, 274)
> lm.fit <- lm(mpg ~ horsepower,data = Auto, subset = train)
> mean((mpg - predict(lm.fit, Auto))[-train]^2)
[1] 27.66704
> lm.fit2 <- lm(mpg ~ poly(horsepower, 2),
+              subset = train)
> mean((mpg - predict(lm.fit2, Auto))[-train]^2)
[1] 21.98854
> lm.fit3 <- lm(mpg ~ poly(horsepower, 3), data = Auto,
+              subset = train)
> mean((mpg - predict(lm.fit3, Auto))[-train]^2)
[1] 21.9517
> |
```

to create a 80/20 split:

- The ratio of train/test is 392/314.

```
> set.seed(8814)
> train <- sample(392, 314)
> lm.fit <- lm(mpg ~ horsepower,data = Auto, subset = train)
> mean((mpg - predict(lm.fit, Auto))[-train]^2)
[1] 27.77654
> lm.fit2 <- lm(mpg ~ poly(horsepower, 2), data = Auto, subset = train)
>
> mean((mpg - predict(lm.fit2, Auto))[-train]^2)
[1] 21.75094
> lm.fit3 <- lm(mpg ~ poly(horsepower, 3), data = Auto, subset = train)
> mean((mpg - predict(lm.fit3, Auto))[-train]^2)
[1] 21.67995
>
```

Both the linear and cubic values in the data using the seed (8814) are rising. The quadratic values, on the other hand, are falling.

3) The LOOCV used in the lab compares poly order using horsepower for mpg prediction. Compute and **report** the overall performance of **Poly** for orders **1:8** for any **one** of the other features in the Auto dataset (**acceleration**, **cylinders**, **displacement**, **weight**) to **mpg**.

Here, In this step I have used <u>displacement</u> feature from the AUTO dataset for the LOOCV,

```
>
> glm.fit <- glm(mpg ~ displacement, data = Auto)
> coef(glm.fit)
 (Intercept) displacement
 35.12063594  -0.06005143
> lm.fit <- lm(mpg ~ displacement, data = Auto)
> coef(lm.fit)
 (Intercept) displacement
 35.12063594  -0.06005143
> library(boot)
> glm.fit <- glm(mpg ~ displacement, data = Auto)
>
> cv.err <- cv.glm(Auto,glm.fit)
> cv.err$delta
[1] 21.59246 21.59218
> cv.error <- rep(0,8)
> for(i in 1:8){
+ glm.fit<-glm(mpg ~ poly(displacement, i),data = Auto)
+ cv.error[i] <- cv.glm(Auto,glm.fit)$delta[1]
+ }
> cv.error
[1] 21.59246 19.15356 19.19299 19.29885
[5] 19.36118 19.17039 18.73462 18.35266
>
```

The report for the overall performance of poly for orders 1:8 (Original is 1:10 in the given LAB-5 code)

Standard deviation is rising, and there is no clear pattern in bias.

4) Select a **different** feature form Auto than you did in task 3 and perform a **5** fold and **10** fold **k-fold cross validation.**

- I have selected <u>year</u> feature from the AUTO dataset and performed 5 fold and 10 fold K-fold cross validation.

```
> set.seed(8814)
> cv.error.5 <- rep(0,5)
> for(i in 1:5){
+ glm.fit <- glm(mpg ~ poly(year, i),data = Auto)
+ cv.error.5[i] <- cv.glm(Auto,glm.fit,K = 5)$delta[1]
+ }
> cv.error.5
[1] 40.67819 38.89804 39.61127 38.88682
[5] 39.13951
>
```

```
> set.seed(8814)
> cv.error.10 <- rep(0,10)
> for(i in 1:10){
+ glm.fit <- glm(mpg ~ poly(year, i),data = Auto)
+ cv.error.10[i] <- cv.glm(Auto,glm.fit,K = 10)$delta[1]
+ }
> cv.error.10
 [1] 40.49991 38.91699 39.16581 38.99626
 [5] 39.19729 38.87759 38.20843 39.10293
 [9] 38.18710 36.93303
>
```

Values	
cv.error	num [1:8] 21.6 19.2 19.2 19.3 19.4 ...
cv.error.10	num [1:10] 40.5 38.9 39.2 39 39.2 ...
cv.error.5	num [1:5] 40.7 38.9 39.6 38.9 39.1

5) Compute the last bootstrap exercise (the quadratic fit for horsepower) from the lab **3 more times**, using a **new number of samples {250, 500, 2500}.** The goal of this task will be to **compare** the **error estimates** of the increasing number of samples. **Report** your **observations** about the **error** as the number of bootstrap sets **increases**.

```
> boot.fn <- function(data, index)
+ coef(
+ lm(mpg ~ horsepower + I(horsepower^2),
+ data = data,subset = index)
+ )
> set.seed(8814)
> boot(Auto, boot.fn, 250)

ORDINARY NONPARAMETRIC BOOTSTRAP


Call:
boot(data = Auto, statistic = boot.fn, R = 250)


Bootstrap Statistics :
        original        bias     std. error
t1* 56.900099702  5.894938e-02 2.1378396034
t2* -0.466189630 -2.599251e-04 0.0337456010
t3*  0.001230536 -1.214037e-06 0.0001202822
>
```

```
> boot.fn <- function(data, index)
+ coef(
+ lm(mpg ~ horsepower + I(horsepower^2),
+    data = data,subset = index)
+ )
> set.seed(8814)
> boot(Auto, boot.fn, 500)

ORDINARY NONPARAMETRIC BOOTSTRAP


Call:
boot(data = Auto, statistic = boot.fn, R = 500)


Bootstrap Statistics :
        original        bias     std. error
t1* 56.900099702  7.845673e-02 2.0038933601
t2* -0.466189630 -7.230106e-04 0.0323349758
t3*  0.001230536  1.431625e-06 0.0001178305
>
```

```
> boot.fn <- function(data, index)
+ coef(
+ lm(mpg ~ horsepower + I(horsepower^2),
+    data = data,subset = index)
+ )
> set.seed(8814)
> boot(Auto, boot.fn, 2500)

ORDINARY NONPARAMETRIC BOOTSTRAP


Call:
boot(data = Auto, statistic = boot.fn, R = 2500)


Bootstrap Statistics :
        original        bias     std. error
t1* 56.900099702  8.404618e-02 2.1140203797
t2* -0.466189630 -1.396053e-03 0.0338202898
t3*  0.001230536  5.258816e-06 0.0001229194
>
```

From the three sample and from the seed(8814), I have observed that the Standard Deviation and bias of the sample 250, 2500 are higher than the 500.