1. Forward Stepwise Selection

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```r
# mlbench 패키지의 BostonHousing 데이터에 대하여 Forward Stepwise Selection을 해봅시다.


install.packages("mlbench")
library(mlbench)

data("BostonHousing")
head(BostonHousing)
dim(BostonHousing)
sum(is.na(BostonHousing))


install.packages("leaps")
library(leaps)


regfit.fwd = regsubsets(medv~ ., data = BostonHousing, nvmax=13, method="forward")
summary(regfit.fwd)



coef(regfit.fwd, 3)
coef(regfit.fwd, 4)
summary(regfit.fwd)$adjr2


# 1번. 예측변수가 4개인 모델에서 새로 선택된 변수 이름은? dis
# 그 변수의 추정된 계수 값과 해당 모델의 결정계수 R^2는 무엇인가요? -0.5519263, 0.6878351
```

19:1 (Top Level)

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R 4.1.0 · C:/Users/User/Desktop/

```
11  ( 1 ) "*"  "*" " "  "*"  "*" "*" " " "*" "*" "*" "*"   "*" "*"
12  ( 1 ) "*"  "*" "*"  "*"  "*" "*" " " "*" "*" "*" "*"   "*" "*"
13  ( 1 ) "*"  "*" "*"  "*"  "*" "*" "*" "*" "*" "*" "*"   "*" "*"
>
>
>
> coef(regfit.fwd, 3)
(Intercept)          rm     ptratio       lstat
 18.5671115   4.5154209  -0.9307226  -0.5718057
> coef(regfit.fwd, 4)
(Intercept)          rm         dis     ptratio       lstat
 24.4713576   4.2237922  -0.5519263  -0.9736458  -0.6654360
> summary(regfit.fwd)$adjr2
 [1] 0.5432418 0.6371245 0.6767036 0.6878351 0.7051702 0.7123567 0.7182560 0.7222072 0.7239046 0.7288066
[11] 0.7348058 0.7343282 0.7337897
>
>
> # 1번. 예측변수가 4개인 모델에서 새로 선택된 변수 이름은? dis
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```

•

2. ESL 7.4

$op = Err_{in} - \overline{err}$

$w = E_y(op) = \frac{2}{N}\sum_{i=1}^{N} Cov(\hat{y}_i, y_i)$

① $Err_{in} = \frac{1}{N}\sum_{i=1}^{N} E_{Y^0}(Y_i^0 - \hat{f}(x_i))^2$

$(a+b+c)^2$
$= a^2 + b^2 + c^2$
$+2ab + 2bc + 2ca$

$Y_i^0 - \hat{f}(x_i) = Y_i^0 \underline{- f(x_i) + f(x_i)} \underline{- E\hat{f}(x_i) + E\hat{f}(x_i)} - \hat{f}(x_i)$

$$Err_{in} = \frac{1}{N}\sum_{i=1}^{N} E_{Y^0}(Y_i^0 - f(x_i) + f(x_i) - E\hat{f}(x_i) + E\hat{f}(x_i) - \hat{f}(x_i))^2$$

$$= \frac{1}{N}\sum_{i=1}^{N}\Big[E_{Y_0}(Y_i^0 - f(x_i))^2 + \underbrace{E_{Y_0}(f(x_i) - E\hat{f}(x_i))^2}_{\to (f(x_i) - E\hat{f}(x_i))^2} + \underbrace{E_{Y_0}(E\hat{f}(x_i) - \hat{f}(x_i))^2}_{\to (E\hat{f}(x_i) - \hat{f}(x_i))^2}$$
$$+ 2E_{Y_0}(Y_i^0 - f(x_i))(f(x_i) - E\hat{f}(x_i)) + 2E_{Y_0}(Y_i^0 - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))$$
$$+ \underbrace{2E_{Y_0}(f(x_i) - E\hat{f}(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))}_{\to 2(f(x_i) - E\hat{f}(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))}\Big]$$

② $\overline{err} = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{f}(x_i))^2$

$y_i - \hat{f}(x_i) = y_i \underline{- f(x_i) + f(x_i)} \underline{- E\hat{f}(x_i) + E\hat{f}(x_i)} - \hat{f}(x_i)$

$$\overline{err} = \frac{1}{N}\sum_{i=1}^{N}(y_i - f(x_i) + f(x_i) - E\hat{f}(x_i) + E\hat{f}(x_i) - \hat{f}(x_i))^2$$

$$= \frac{1}{N}\sum_{i=1}^{N}\Big[(y_i - f(x_i))^2 + (f(x_i) - E\hat{f}(x_i))^2 + (E\hat{f}(x_i) - \hat{f}(x_i))^2$$
$$+ 2(y_i - f(x_i))(f(x_i) - E\hat{f}(x_i)) + 2(y_i - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))$$

$$+ 2(f(x_i) - E\hat{f}(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))\Big]$$

$$E_y(op) = E_y(Err_{in} - \overline{err})$$
$$= \frac{1}{N}\sum_{i=1}^{N} E_y\Big[\cancelto{0}{E_{Y_0}(Y_i^0 - f(x_i))^2 - (y_i - f(x_i))^2}$$
$$+ \cancelto{0}{2E_{Y_0}(Y_i^0 - f(x_i))(f(x_i) - E\hat{f}(x_i))} - \cancelto{0}{2(y_i - f(x_i))(f(x_i) - E\hat{f}(x_i))}$$
$$+ \cancelto{0}{2E_{Y_0}(Y_i^0 - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))} - 2(y_i - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))\Big]$$

$$E_y(op) = \frac{1}{N}\sum E(-2(y_i - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))) = \frac{2}{N}\sum E((y_i - f(x_i))(\hat{f}(x_i) - E\hat{f}(x_i)))$$
$$= \frac{2}{N}\sum Cov(y_i, \hat{y}_i)$$

① $E_y\left[E_{Y_0}(Y_i^0 - f(x_i))^2\right] - E_y(y_i - f(x_i))^2$
$= E_{Y_0}(Y_i^0 - f(x_i))^2 - E_y(y_i - f(x_i))^2 = 0$

$f(x_i) = E(Y_i^0)$
$f(x_i) = E(y_i)$

$Y = f(X) + \epsilon$

② $E_y\left[(y_i - f(x_i))(f(x_i) - E\hat{f}(x_i))\right] = (E(y_i) - f(x_i))(f(x_i) - E\hat{f}(x_i)) = 0$

③ $E_y\left[E_{Y_0}(Y_i^0 - f(x_i))(f(x_i) - E\hat{f}(x_i))\right] = (E(Y_i^0) - f(x_i))(f(x_i) - E\hat{f}(x_i)) = 0$

④ $2E_y(E_{Y_0}[(Y_i^0 - f(x_i))(E\hat{f}(x_i) - \hat{f}(x_i))]) = -2E_{Y_0}([(Y_i^0 - E(Y_i^0))(\hat{y}_i - E\hat{y}_i)]) = 0$ Y_i^0, $\hat{y}_i$ independent $\to$ $Cov = 0$