

# The Bootstrap

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## 1 Estimating the Accuracy of a Statistic of Interest

```
require(ISLR2)

## Loading required package: ISLR2
require(boot)

## Loading required package: boot
alpha.fn <- function(data, index) {
  X <- data$X[index]
  Y <- data$Y[index]
  (var(Y) - cov(X, Y)) / (var(X) + var(Y) - 2 * cov(X, Y))
}

# Using sample() function to randomly select 100 observations from range 1 to 100 with replacement
set.seed(7)
alpha.fn(Portfolio, sample(100, 100, replace = T))

## [1] 0.5385326
boot(Portfolio, alpha.fn, R = 1000)

##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = Portfolio, statistic = alpha.fn, R = 1000)
##
##
## Bootstrap Statistics :
##      original      bias    std. error
## t1* 0.5758321 0.0007959475 0.08969074
?Portfolio
```

## 2 Estimating the Accuracy of a Linear Regression Model

```

boot.fn <- function(data, index) {
  coef(lm(mpg ~ horsepower, data = data, subset = index))
}
boot.fn(Auto, 1:392)

## (Intercept)  horsepower
## 39.9358610   -0.1578447

set.seed(1)
boot.fn(Auto, sample(392, 392, replace = T))

## (Intercept)  horsepower
## 40.3404517   -0.1634868

set.seed(1)
boot.fn(Auto, sample(392, 392, replace = T))

## (Intercept)  horsepower
## 40.3404517   -0.1634868

boot(Auto, boot.fn, 1000)

##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
## Call:
## boot(data = Auto, statistic = boot.fn, R = 1000)
##
##
## Bootstrap Statistics :
##      original      bias    std. error
## t1* 39.9358610  0.0549915227 0.841925746
## t2* -0.1578447 -0.0006210818 0.007348956

summary(lm(mpg ~ horsepower, data = Auto))$coef

##              Estimate Std. Error  t value    Pr(>|t|)
## (Intercept) 39.9358610 0.717498656  55.65984 1.220362e-187
## horsepower  -0.1578447 0.006445501 -24.48914 7.031989e-81

#Fitting a quadratic model
boot.fn <- function(data, index) {
  coef(
    lm(mpg ~ horsepower + I(horsepower^2),
      data = data, subset = index)
  )
}
set.seed(1)
boot(Auto, boot.fn, 1000)

##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
## Call:
## boot(data = Auto, statistic = boot.fn, R = 1000)
##

```

```
##
## Bootstrap Statistics :
##      original      bias      std. error
## t1* 56.900099702  3.511640e-02 2.0300222526
## t2* -0.466189630 -7.080834e-04 0.0324241984
## t3*  0.001230536  2.840324e-06 0.0001172164

summary(lm(mpg ~ horsepower + I(horsepower^2),
           data = Auto))$coef
```

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	56.900099702	1.8004268063	31.60367	1.740911e-109
horsepower	-0.466189630	0.0311246171	-14.97816	2.289429e-40
I(horsepower^2)	0.001230536	0.0001220759	10.08009	2.196340e-21